A Reference Guide To:

ISO 11801
EN 50174
ISO 18010
ISO/IEC 24764
EN 50310
EN 50173
ANSI/TIA-568-C
ANSI/TIA-606-A
ANSI/TIA-942
IEEE 802.3af
IEEE 802.3at
IEEE 802.3an
IEEE 802.3ba
IEEE 802.11

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European Standards Reference Guide

ANIXTER®

Anixter: The Cabling System Experts

Anixter is a leading global supplier of communications and security products, electrical and electronic wire and cable, fasteners and other small components. We help our customers specify solutions and make informed purchasing decisions around technology, applications and relevant standards. Throughout the world, we provide innovative supply chain management services to reduce our customers' total cost of production and implementation.

Purpose of Industry Standards

By providing guidelines for installation, maintenance and testing to improve availability and reduce expenses associated with downtime, the telecommunications standards define cabling types, distances, connections, cable system architectures, cable termination standards, performance characteristics, installation and testing methods. The standards provide recommended best practices for the design and installation of cabling systems to support a wide variety of existing and future systems to extend the life span of the telecommunications infrastructure. A single common structured cabling system for all communications and security systems simplifies moves, adds and changes, maximises system availability and extends the usability of a cabling system. By adhering to industry standards, industrial environments can expect to fully experience the benefits of structured cabling on overall performance.

Scope of this Guide

This document is meant as a reference that highlights the key points of the ISO 11801, EN 50174, ISO 18010, ISO/IEC 24764, EN 50310, EN 50173, ANSI/TIA-568-C, ANSI/TIA-606-A, ANSI/TIA-942, IEEE 802.3af, IEEE-802.3at, IEEE 802.3an, IEEE 802.3ba and IEEE 802.11 standards.

It is not intended as a substitute for the original documents. For further information on any topic in the guide, refer to the actual standard. See the section called “Reference Documents” for instructions on how to order a copy of the standard itself.

Abbreviation References

ANSI	American National Standards Institute
EN	CENELEC
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical & Electronics Engineers
ISO	International Organisation for Standardisation
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
TIA	Telecommunications Industry Association

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Purpose of the ISO/IEC 11801 Standard

The international standard provides users with an application-independent generic cabling system capable of supporting a wide range of applications. It provides users with a flexible cabling scheme, so modifications are both easy and economical. Building professionals (architects, for example) are given guidance on the accommodation of cabling at the initial stages of development.

The international standard specifies a multimanufacturer cabling system that may be implemented with material from single and multiple sources and is related to:

- International standards for cabling components developed by committees in the IEC
- Standards for the installation and operation of information technology cabling as well as for testing of installed cabling
- Applications developed by technical committees of the IEC
- Planning and installation guides that take into account the needs of specific applications.

Generic cabling defined within this International Standard:

- Specifies a cabling structure that supports a wide variety of applications
- Specifies channel and link classes C, D, E, E_A, F and F_A, meeting the requirements of standardised applications
- Specifies channel and link classes E and F based on higher performance components to support future applications
- Specifies optical channel and link classes OF-300, OF-500 and OF-2000
- Involves component requirements and specifies cabling implementations that ensure performance of permanent links and channels that meet or exceed the requirements for cabling classes
- Specifies a generic cabling system that is anticipated to have a usable life in excess of 10 years.

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Cabling Subsystems

The three generic cabling systems' subsystems include the campus backbone, building backbone and horizontal cabling. These subsystems are connected to create a generic cabling system with a structure similar to the one shown in Figure 1.

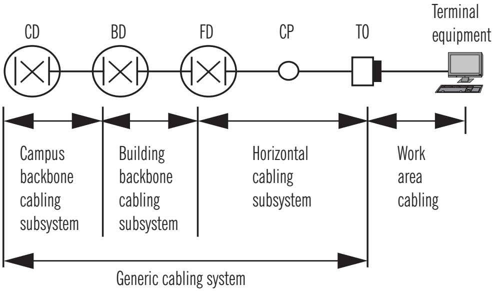

Figure 1 – Generic cable system diagram

Any connections between each of the subsystems are generally achieved using cross-connections by way of either patch cords or jumpers. In the case of centralised cabling, passive connections in the distributors are achieved by using cross-connections or interconnections.

Campus Subsystem (CD)

The campus backbone system connects the campus distributor to the building distributor, which is typically positioned in another building and may include the campus cables, the building entrance facility and the connecting hardware.

Building Backbone Subsystem (BD)

The building backbone system extends from the building distributor to the floor distributors. This location may include building backbone cables, jumpers, patch cords and connecting hardware.

Horizontal Cabling Subsystem (FD) and (TO)

The horizontal cabling system extends from the floor distributors to the telecommunications outlets. This may include the horizontal cabling, jumpers and patch cords in the floor distributor, mechanical terminations at the outlet and floor distributor, consolidation points and the telecommunications outlet.

Design Objectives

The campus, building backbone and horizontal cabling should be designed to support existing and emerging applications to enable the longest possible life of the system.

Incorporating Functional Elements

The CD and the FD can be located in equipment rooms or telecommunications rooms. Guidance for the accommodation of distributors is given in ISO/IEC TR 14763-2. All cables should be routed using pathways. Within the ISO/IEC 18010 standard, the requirements for the pathways and cable management are provided; these can include ducts, conduits and trays.

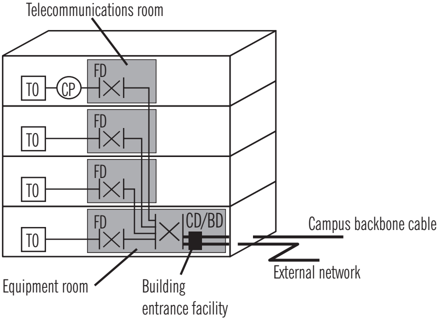

Figure 2 – Examples of how elements of the infrastructure are accommodated within a building

Balanced Cabling Performance

General

This clause specifies the minimum performance of generic balanced cabling. The performance of balanced cabling is specified for channels, permanent links and CP links (see Figure 3).

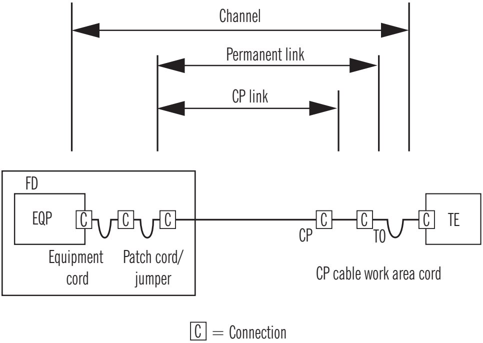

Figure 3 – Channel and permanent link diagram

The performance specifications are separated into six classes (C to F) for balanced cabling. This allows for the successful transmission of applications over a channel.

Classification of Balanced Cabling

This standard specifies the following classes for balanced cabling:

Class C is specified up to 16 MHz.
Class D is specified up to 100 MHz.
Class E is specified up to 250 MHz.
Class E_A is specified up to 500 MHz.
Class F is specified up to 600 MHz.
Class F_A is specified up to 1,000 MHz.

Return Loss

The return loss requirements are applicable only to Classes C, D, E and F.

Copper Cable Construction

The ISO standard uses a cabling scheme for the various constructions available today. The following chart defines these requirements:

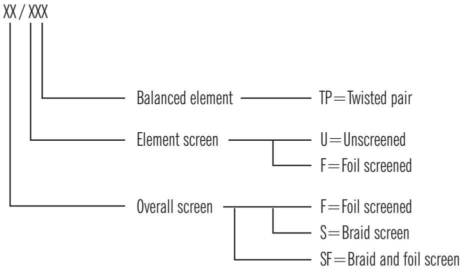

Figure 4 – Example: F/UTP – Overall foil screened cable with unscreened twisted pairs

Cabling Installation Requirements: Minimum Bend Radius

The minimum bend radius after installation for four-pair cables:

- 25 mm for four-pair cables with a diameter up to 6 mm
- 50 mm for four-pair cables with a diameter over 6 mm

For minimum bending radius requirements during installation, refer to the manufacturer's recommendations.

Comparison between ISO 11801:2002 and ANSI/TIA-568-C.1

The Subsystems of a Structured Cabling System

Campus Distributor (CD) and Building Entrance (BEF)

Building entrance facilities provide the point at which outdoor cabling interfaces with the intrabuilding backbone cabling. The physical requirements of the network interface are defined in the TIA-569-B standard. Refer to the EN 50174-1 standard for European specifications and ANSI/TIA-568-C.1 for U.S. specifications.

Building Distributor (BD) and Equipment Room Facility (ER)

The design aspects of the BD/ER room are specified in the TIA-569-B and EN 50174-1 standards. This room usually houses equipment of higher complexity that serves the entire building, such as servers and telecoms switches. Any or all of the functions of a floor distributor or telecommunications room may be provided by this room.

Backbone Cabling

Backbone cabling provides interconnection between a floor distributor and telecommunications rooms, a building distributor and equipment rooms, and a campus distributor and entrance facilities. It consists of the backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross connection.

This includes:

- Vertical connection between floors (risers)
- Cables between a BD/ER and building cable entrance facility or campus distributor
- Cables between buildings (interbuilding).

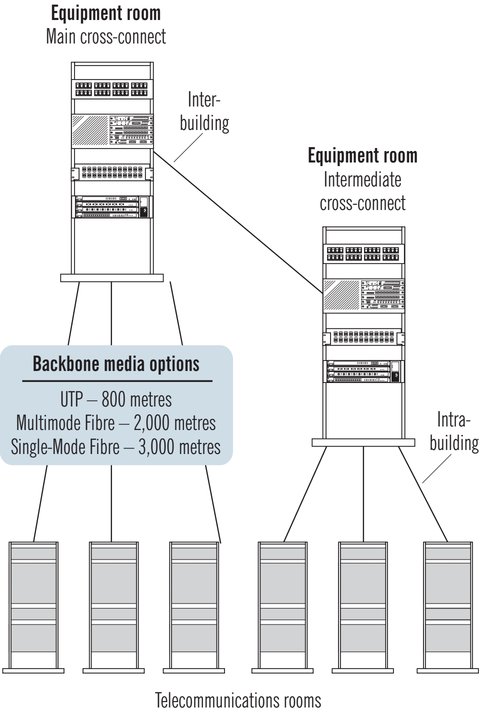

Figure 5 – Backbone star topology diagram

Other Design Requirements

- Star topology design.
- Implement no more than two hierarchical levels of backbone cross-connects.
- Do not install bridge taps.
- Main intermediate cross-connect or patch cord lengths shall not exceed 20 m (66 ft).
- Avoid areas with high levels of EMI or RFI.
- Meet grounding requirements as defined in the EN 50310 and J-STD-607-A standards.

Note: It is recommended that the user consults with equipment manufacturers, application standards and system providers for additional information when planning shared-sheath applications on copper backbone cables.

Maximum Backbone Distances			
Media Type	**Main to Horizontal Cross-Connect**	**Main to Intermediate Cross-Connect**	**Intermediate to Horizontal Cross-Connect**
Copper (Voice*)	800 m (2,264 ft.)	500 m (1,640 ft.)	300 m (984 ft.)
Multimode	2,000 m (6,560 ft.)	1,700 m (984 ft.)	300 m (984 ft.)
Single-Mode	3,000 m (8,855 ft.)	2,700 m (8,855 ft.)	300 m (984 ft.)

ISO 11801 Performance of Optical Fibre Cable
Class OF-300 channels up to 300 m
Class OF-500 channels up to 500 m
Class OF-2000 channels up to 2,000 m

Table 1 – Maximum backbone distances

***Note:** Backbone distances are application dependent. The maximum distances specified above are based on voice transmission for UTP/ScTP and data transmission over fibre. A 90 m distance applies to UTP/ScTP. Current state-of-the-art distribution facilities usually include a combination of both copper and fibre optic cables in the backbone.

Floor Distributor (FD) and Telecommunications Room (TR)

A FD/TR room is the area within a building that houses the telecommunications cabling system equipment. This includes the mechanical terminations and/or cross-connects for the horizontal and backbone cabling system. Please refer to the ISO 11801 and TIA-569-B standards for the design specifications of the FD/TR room.

Horizontal Cabling

Specified Horizontal Cabling Topology: Star

The horizontal cabling system extends from the work area telecommunications information outlet to the FD or TR room and consists of the following:

- Horizontal cabling
- Telecommunications outlet
- Cable terminations
- Cross connections
- Patch cords

Four media types are recognised as options for horizontal cabling, each extending a maximum distance of 90 m:

- Four pair, 100 ohm UTP/ScTP cable (22–24 AWG solid conductors)
- Two fibre, 62.5/125 μm or 50/125 μm optical cable

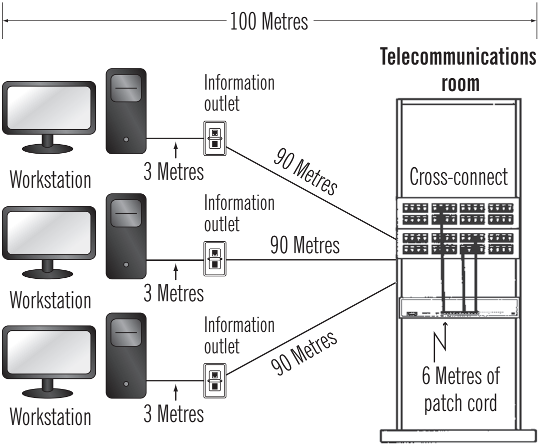

Figure 6 – Horizontal cable maximum distances and information outlets

In addition to the 90 m of horizontal cable, a total of 10 m is allowed for work area and telecommunications room patch and jumper cables.

Multiuser Telecommunications Outlet Assembly (MUTOA)

Optional practices for open office environments are specified for any horizontal telecommunications cabling recognised in ISO 11801 and ANSI/TIA-568-C.1.

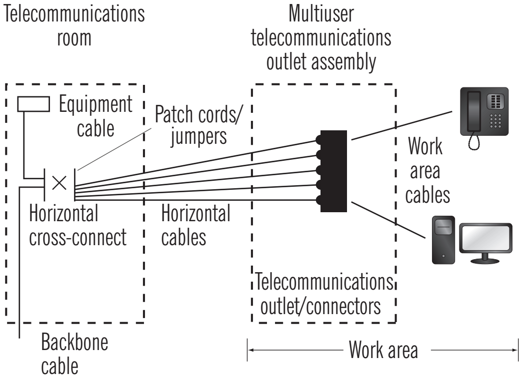

Figure 7 – MUTOA use diagram

A multiuser telecommunications outlet assembly (MUTOA or MUTO) facilitates the termination of multiple horizontal cables in a common location, for example within a column, wall or permanently secured furniture cluster. Work area cables may then be routed through furniture pathways and directly connected to work area equipment. Each furniture cluster should have one MUTOA that serves a maximum of 12 work areas. Ceiling and access floor mounting is not allowed by the ISO 11801 and ANSI/TIA-569-B standards.

Maximum Work Area Cable Length is Determined by the Following Table		
Length of Horizontal Cable m (ft.)	Maximum Length of Work Area Cable (24 AWG) m (ft.)	Maximum Combined Length of Work Area Cables, Patch Cords and Equipment Cable m (ft.)
90 (295)	5 (16)	10 (33)
85 (279)	9 (30)	14 (46)
80 (262)	13 (44)	18 (59)
75 (246)	17 (57)	22 (72)
70 (230)	22 (72)	27 (89)

Table 2 – Maximum work area cable length

Note: For optical fibre, any combination of horizontal, work area cables, patch cords and equipment cords may not exceed 100 m (328 ft.).

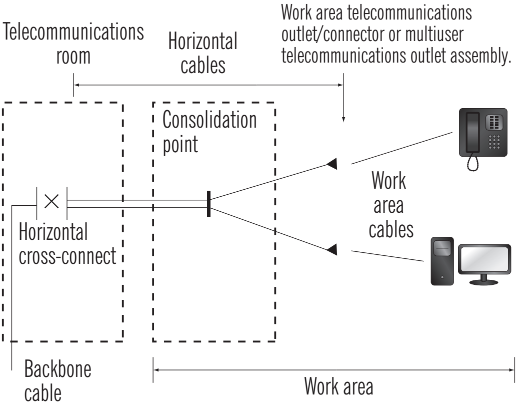

Figure 8 – Consolidation point

A consolidation point differs from a MUTOA in that it requires an additional connection for each horizontal cable run. Only one consolidation point (an interconnection point in the horizontal cabling) is allowed, at a distance of at least 15 m (49 ft.) from the FD/TR room. A transition point (e.g., transition from round to flat under-carpet cable) is not allowed. A consolidation point is installed in unobstructed building columns, permanent walls, ceilings or access floors (if accessible).

The multiuser telecommunications outlet and consolidation point methods are intended to be mutually exclusive. Labelling and allowance for spares is required. Moves, adds and changes should be administered in the telecom room.

Connecting Hardware Configuration

Copper Connectors

Figure 9a – IEC 60603-7 series interface for Category 5, 6 and 6A. Please note the categories refer to the IEC requirements and not the TIA-568 range of standards.

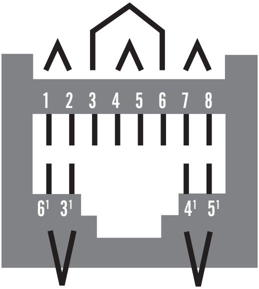

Figure 9b – IEC 60603-7 series interface for Category 7 and 7A. Please note the categories refer to the IEC requirements and not the ANSI/TIA-568 range of standards.

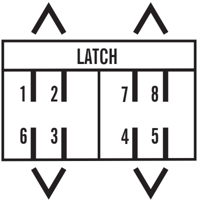

Figure 9c – IEC 61076-3-104 interface for Category 7 and 7A. Please note the categories refer to the IEC requirements and not the TIA-568 range of standards

Backward Compatibility

		Fixed Connector (Jack) Performance at the TO				
		Category 5	**Category 6**	**Category 6_A**	**Category 7**	**Category 7_A**
Free Connector (Plug)	Category 5	Category 5	Category 5	Category 5	Category 5	Category 5
	Category 6	Category 5	Category 6	Category 6	Category 6	Category 6
	Category 6A	Category 5	Category 6	Category 6A	Category 6A	Category 6A
	Category 7	Category 5	Category 6	Category 6A	Category 7	Category 7
	Category 7A	Category 5	Category 6	Category 6A	Category 7	Category 7A

Table 3 – Backward compatibility

Informative Return Loss Values for Channel at Key Frequencies
Technical Specifications of Copper Horizontal Cabling

	Minimum Return Loss (dB)					
Frequency MHz	**Class C**	**Class D**	**Class E**	**Class E_A**	**Class F**	**Class F_A**
1	15,0	17,0	19,0	19,0	19,0	19,0
16	15,0	17,0	18,0	18,0	18,0	18,0
100	N/A	10,0	12,0	12,0	12,0	12,0
250	N/A	N/A	8,0	8,0	8,0	8,0
500	N/A	N/A	N/A	6,0	8,0	8,0
600	N/A	N/A	N/A	N/A	8,0	8,0
1,000	N/A	N/A	N/A	N/A	N/A	6,0

Table 4 – Informative return loss values for channel at key frequencies

Informative Insertion Loss Values for Channel at Key Frequencies								
Frequency				Maximum Insertion Loss (dB)				
MHz	Class A	Class B	Class C	Class D	Class E	Class E_A	Class F	Class F_A
0.1	6,0	5,5	N/A	N/A	N/A	N/A	N/A	N/A
1	N/A	5,8	4,2	4,0	4,0	4,0	4,0	4,0
16	N/A	N/A	14,4	9,1	8,3	8,2	8,1	8,0
100	N/A	N/A	N/A	24,0	21,7	20,9	20,8	20,3
250	N/A	N/A	N/A	N/A	35,9	33,9	33,8	32,5
500	N/A	N/A	N/A	N/A	N/A	49,3	49,3	46,7
600	N/A	N/A	N/A	N/A	N/A	N/A	54,6	51,4
1,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	67,6

Table 5 – Informative insertion loss values for channel at key frequencies

Informative NEXT Values for Channel at Key Frequencies								
Frequency				Minimum Channel NEXT (dB)				
MHz	Class A	Class B	Class C	Class D	Class E	Class E_A	Class F	Class F_A
0.1	27,0	40,0	N/A	N/A	N/A	N/A	N/A	N/A
1	N/A	25,0	39,1	63,3	65,0	65,0	65,0	65,0
16	N/A	N/A	19,4	43,6	53,2	53,2	65,0	65,0
100	N/A	N/A	N/A	30,1	39,9	39,9	62,9	65,0
250	N/A	N/A	N/A	N/A	33,1	33,1	56,9	59,1
500	N/A	N/A	N/A	N/A	N/A	27,9	52,4	53,6
600	N/A	N/A	N/A	N/A	N/A	N/A	51,2	52,1
1,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	47,9

Table 6 – Informative NEXT values for channel at key frequencies

Informative PS NEXT Values for Channel at Key Frequencies					
			Minimum PS NEXT (dB)		
Frequency MHz	Class D	Class E	Class E_A	Class F	Class F_A
1	60,3	62,0	62,0	62,0	62,0
16	40,6	50,6	50,6	62,0	62,0
100	27,1	37,1	37,1	59,9	62,0
250	N/A	30,2	30,2	53,9	56,1
500	N/A	N/A	24,8	49,4	50,6
600	N/A	N/A	N/A	48,2	49,1
1,000	N/A	N/A	N/A	N/A	44,9

Table 7 – Informative PS NEXT values for channel at key frequencies

Informative ACR-N Values for Channel at Key Frequencies					
			Minimum ACR-N (dB)		
Frequency MHz	Class D	Class E	Class E_A	Class F	Class F_A
1	59,3	61,0	61,0	61,0	61,0
16	34,5	44,9	45,0	56,9	57,0
100	6,1	18,2	19,0	42,1	44,7
250	N/A	-2,8	-0,8	23,1	26,7
500	N/A	N/A	-21,4	3,1	6,9
600	N/A	N/A	N/A	-3,4	0,7
1,000	N/A	N/A	N/A	N/A	-19,6

Table 8 – Informative ACR-N values for channel at key frequencies

Informative PS ACR-N Values for Channel at Key Frequencies					
			Minimum PS ACR-N (dB)		
Frequency MHz	Class D	Class E	Class E_A	Class F	Class F_A
1	56,3	58,0	58,0	58,0	58,0
16	31,5	42,3	42,4	53,9	54,0
100	3,1	15,4	16,2	39,1	41,7
250	N/A	-5,8	-3,7	20,1	23,7
500	N/A	N/A	-24,5	0,1	3,9
600	N/A	N/A	N/A	-6,4	-2,3
1,000	N/A	N/A	N/A	N/A	-22,6

Table 9 – Informative PS ACR-N values for channel at key frequencies

Informative ACR-F Values for Channel at Key Frequencies					
			Minimum ACR-F (dB)		
Frequency MHz	Class D	Class E	Class E_A	Class F	Class F_A
1	57,4	63,3	63,3	65,0	65,0
16	33,3	39,2	39,2	57,5	63,3
100	17,4	23,3	23,3	44,4	47,4
250	N/A	15,3	15,3	37,8	39,4
500	N/A	N/A	9,3	32,6	33,4
600	N/A	N/A	N/A	31,3	31,8
1,000	N/A	N/A	N/A	N/A	27,4

Table 10 – Informative ACR-F values for channel at key frequencies

Informative Ps ACR-F Values for Channel at Key Frequencies					
	Minimum PS ACR-F (dB)				
Frequency MHz	Class D	Class E	Class E_A	Class F	Class F_A
1	54,4	60,3	60,3	62,0	62,0
16	30,3	36,2	36,2	54,5	60,3
100	14,4	20,3	20,3	41,4	44,4
250	N/A	12,3	12,3	34,8	36,4
500	N/A	N/A	6,3	29,6	30,4
600	N/A	N/A	N/A	28,3	28,8
1000	N/A	N/A	N/A	N/A	24,4

Table 11 – Informative PS ACR-F values for channel at key frequencies

Informative Propagation Delay Values for Channel at Key Frequencies								
Frequency	Minimum Propogation Delay (μs)							
MHz	Class A	Class B	Class C	Class D	Class E	Class E_A	Class F	Class F_A
0.1	20,000	5,000	N/A	N/A	N/A	N/A	N/A	N/A
1	N/A	5,000	0,580	0,580	0,580	0,580	0,580	0,580
16	N/A	N/A	0,553	0,553	0,553	0,553	0,553	0,533
100	N/A	N/A	N/A	0,548	0,548	0,548	0,548	0,548
250	N/A	N/A	N/A	N/A	0,546	0,546	0,546	0,546
500	N/A	N/A	N/A	N/A	N/A	0,546	0,546	0,546
600	N/A	N/A	N/A	N/A	N/A	N/A	0,545	0,545
1,000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0,545

Table 12 – Informative propagation delay values for channel at key frequencies

Delay Skew for Channel		
Class	Frequency	Maximum Delay Skew (μs)
A	$f = 0.1$	N/A
B	$0.1 \leq f \leq 1$	N/A
C	$1 \leq f \leq 16$	0,050 [a]
D	$1 \leq f \leq 100$	0,050 [a,c]
E	$1 \leq f \leq 250$	0,050 [a,c]
E_A	$1 \leq f \leq 500$	0,050 [a,c]
F	$1 \leq f \leq 600$	0,030 [b,c]
F_A	$1 \leq f \leq 1{,}000$	0,030 [b,c]

a This is the result of the calculation 0,045 ÷ 4 x 0,001 25.

b This is the result of the calculation 0,025 ÷ 4 x 0,001 25.

c Delay skew of the given installed cabling channel shall not vary by more than 0,010 (μs) within this requirement, due to effects such as daily temperature variations.

Table 13 – Delay skew for channel

Informative PS ANEXT Values for Channel at Key Frequencies		
	Minimum PS ANEXT (dB)	
Frequency MHz	Class E_A	Class F_A
1	67,0	67,0
100	60,0	67,0
250	54,0	67,0
500	49,5	64,5
1,000	N/A	60,0

Table 14 – Informative PS ANEXT values for channel at key frequencies

Informative PS $ANEXT_{avg}$ values for channel at key frequencies	
Frequency MHz	Minimum Class E_A PS ANEXTavg (dB)
1	67,0
100	62,3
250	56,3
500	51,8

Table 15 – Informative PS $ANEXT_{avg}$ values for channel at key frequencies

Class E_A/Augmented Category 6 Channel Requirements

Note: The requirements for ISO 11801 Class E_A are more demanding compared to the TIA Augmented Category 6 requirements. Anixter's Infrastructure Solutions Lab tests to the more stringent ISO 11801 standard.

ISO Compared to TIA		
Characteristics 500 MHz (dB)	ISO Class E_A	TIA Augmented Category 6
PSNEXT Loss	24,8 dB	23,2 dB
NEXT Loss	27,9 dB	26,1 dB
PSANEXT Loss	49,5 dB	49,5 dB
Return Loss	6,0 dB	6,0 dB
Insertion Loss	49,3 dB	49,3 dB
Referred to by IEEE	Yes	No

Table 16 – ISO versus TIA performance comparison

For more information, visit anixter.com

General Information on Optical Fibre

There are six optical fibre categories that are specified to support various applications; four of these are multimode fibre (OM1, OM2, OM3, OM4) and two are single-mode fibre (OS1, OS2). The following table covers the current bandwidths available.

Cabled Optical Fibre Attenuation (Maximum) dB/km							
	OM1, OM2, OM3 and OM4 Multimode		OS1 Single-Mode		OS2 Single-Mode		
Wavelength	850 nm	1,300 nm	1,310 nm	1,550 nm	1,310 nm	1,383 nm	1,550 nm
Attenuation	3,5	1,5	1,0	1,0	0,4	0,4	0,4

Table 17 – Cabled optical fibre attenuation

Optical Wavelength Categories				
		Minimum Modal Bandwidth MHz x km		
	Wavelength	Overfilled Launch Bandwidth		Effective Modal Bandwidth
Category	Nominal Core Diameter (μm)	850 nm	1,300 nm	850 nm
OM1	50 or 62,5	200	500	Not specified
OM2	50 or 62,5	500	500	Not specified
OM3	50	1,500	500	2,000
OM4	50	3,500	500	4,700

Note: Modal bandwidth requirements apply to the optical fibres used to produce the relevant cabled optical fibre category and are assured by the parameters and test methods specified in IEC 60793-2-10. Optical fibres that meet only the overfilled launch modal bandwidth may not support some applications specified in Annex F.

Table 18 – Optical wavelength categories

There are no bandwidth restrictions on single-mode fibre that can be measured in the field today.

Optical cables terminated in the work area shall be terminated using a duplexable LC connector that meets IEC 61754-20 for new installations. Existing connectivity can be extended.

Optical Fibre Connectors

Colour coding of connectors is recommended to assist with identification of the optical fibre types installed. The recommendations are:

- Multimode 50 μm and 62.5 μm: Beige or black
- Single-mode PC: Blue
- Single-mode APC: Green

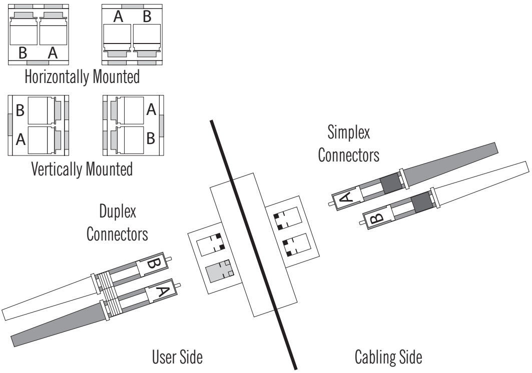

Figure 10 – Duplexable LC connectivity configuration with an example of polarity identification

Note: Shading and A/B markings are for information only.

Supported Distance and Insertion Loss for Specific Applications over Optical Fibre					
		Maximum channel length m		Insertion Loss dB	
Network application	Nominal transmission wavelength nm	50/125 µm optical fibre	62,5/125 µm optical fibre	50/125	62.5/125
ISO/IEC 8802-3: FOIRL	850	514	1000		
ISO/IEC 8802-3:10BASE-FL and FB	850	1514	2000	6,8	12,5
ISO/IEC TR 11802-4: 4 and 16 Mbps Token Ring	850	1857	2000	8,0	13,0
ATM at 155 Mbps	850	1000[b]	1000[a]	7,2	7,2
ATM at 622 Mbps	850	300[b]	300[a]	4,0	
ISO/IEC 14165-111: Fibre Channel (FC-PH) at 1062 Mbps [d]	850	500[b]	300[a]	4,0	
IEEE 802.3: 1000BASE-SX[d]	850	550[b]	275[a]	3,56	2,6
IEEE 802.3: 10GBASE-SR[d]	850	300[c]		2,6	1,6
IEEE 802.3: 40 GBASE-SR4[d]	850	100[c], 125[e]			
IEEE 802.3: 100GBASE-SR10[d]	850	100[c], 125e			
1 Gbps FC (1,0625 GBd)[d]	850	500[a]	300[b]	2,62	
2 Gbps FC (2,125 GBd)[d]	850	300[c]		3,31	2,1
4 Gbps FC (4,25 GBd)[d]	850	150[b], 380[c], 400[e]	70	4,48	1,78
8 Gbps FC (8,5 GBd)[d]	850	50[b], 150[c], 200[e2]	21	2,32	1,62
16 Gbps FC (14,025 GBd)[d]	850	35[b], 100[c], 130[e]	15		
IEEE 802.3: 100BASE-FX	1300	2000	2000		
IEEE 802.5t: 100 Mbps Token Ring	1300	2000	2000		
ATM at 52 Mbps	1300	2000	2000	5,3	10,0
ATM at 155 Mbps	1300	2000	2000	5,3	10,0
ATM at 622 Mbps	1300	330	500	2	6,0
IEEE 802.3: 1000BASE-LX[c]	1300	550[b]	550[a]	2,35	2,35
IEEE 802.3 10GBASE-LX4[d]	1300	300[a]	300[a]	2,0	2,0

a Minimum cabled optical fibre performance of category OM1 is specified

b Minimum cabled optical fibre performance of category OM2 is specified

c Minimum cabled optical fibre performance of category OM3 is specified

d These applications are bandwidth limited at the channel lengths shown. The use of lower attenuation components to produce channels exceeding the values shown cannot be recommended.

e Minimum cabled optical fibre performance of OM4 is specified

Table 19 – Maximum channel lengths and insertion loss (where specified) supported by optical fibre applications for multimode optical fibre

Supported Distance and Insertion Loss for Specific Applications over Optical Fibre			
Network application	**Nominal transmission wavelength nm**	**Maximum channel length m**	**Insertion Loss dB**
ISO/IEC 9314-4: FDDI SMF-PMD	1310	2000	
ATM at 52 Mbps	1310	2000	10,0
ATM at 155 Mbps	1310	2000	7,0
ATM at 622 Mbps	1310	2000	7,0
ISO/IEC 14165-111: Fibre Channel (FC-PH) at 1062 Mbps	1310	2000	6,0
IEEE 802.3: 1000BASE-LX	1310	2000	4,56
IEEE 802.3: 40GBASE-LR4	1310	2000	
IEEE 802.3: 100GBASE-LR4	1310	2000	
IEEE 802.3: 100GBASE-ER4	1310	2000	
1 Gbps FC (1.0625 GBd)	1310	2000	7,8
2 Gbps FC (2.125 GBd)	1310	2000	7,8
4 Gbps FC (4.25 GBd)	1310	2000	4,8
8 Gbps FC (8.5 GBd)	1310	2000	6,4
10 Gbps FC	1310	f.f.s.	
IEEE 802.3: 10GBASE-LR/LW	1310	2000	6,2
1 Gbps FC	1550	2000	
2 Gbps FC	1550	2000	
IEEE 802.3: 10GBASE-ER/EW	1550	2000	
IEEE 802.3: 40GBASE-LR4	1550	2000	f.f.s.
IEEE 802.3: 100GBASE-LR4	1550	2000	6,3
IEEE 802.3: 100GBASE-ER4	1550	2000	18,0

Table 20 – Maximum channel length and insertion loss (where specified) supported by optical fibre applications for single-mode optical fibre.

Note: EN 50173 published across Europe is harmonised with the ISO 11801 standard.

Definitions of Electrical Parameters

Return loss: A measure of the degree of impedance mismatch between two impedances. It is the ratio, expressed in decibels, of the amplitude of a reflected wave echo to the amplitude of the main wave at the junction of a transmission line and a terminating impedance.

Insertion loss: This term has replaced the term "attenuation" (ATTN). It is a measure of the decrease of signal strength as it travels down the media.

NEXT loss (near-end crosstalk): A measure of the unwanted signal coupling from a transmitter at the near-end into a neighbouring (nonenergised) pair measured at the near-end.

PSNEXT loss (powersum near-end crosstalk): A computation of the unwanted signal coupling from multiple transmitters at the near-end into a neighbouring (nonenergised) pair measured at the near-end.

FEXT loss (far-end crosstalk): A measure of the unwanted signal coupling from a transmitter at the near-end into a neighbouring pair measured at the far-end.

ACRF (attenuation to crosstalk ratio, far-end) or ELFEXT (equal-level far-end crosstalk): A measure of the unwanted signal coupling from a transmitter at the near-end into a neighbouring pair measured at the far-end, relative to the received signal level measured on that same pair.

PSFEXT loss (powersum far-end crosstalk): A computation of the unwanted signal coupling from multiple transmitters at the near-end into a neighbouring pair measured at the far-end.

PSACRF (powersum attenuation to crosstalk ratio, far-end) or PSELFEXT (powersum equal-level far-end crosstalk): A computation of the unwanted signal coupling from multiple transmitters at the near-end into a neighbouring pair measured at the far-end, relative to the received signal level measured on that same pair.

Propagation delay: The time needed for the transmission of signal to travel the length of a single pair.

Propagation delay skew: The difference between the propagation delay of any two pairs within the same cable sheath. Delay skew is caused primarily because twisted-pair cable is designed to have different twists per foot (lay lengths). Delay skew could cause data transmitted over one wire pair to arrive out of sync with data over another wire pair.

ANEXT loss (alien near-end crosstalk): A measure of signal coupling from a near-end disturbing pair into a disturbed pair of a neighbouring cable or connector pair or part thereof, measured at the near-end.

PSANEXT loss (powersum alien near-end crosstalk): A computation of signal coupling from multiple near-end disturbing pairs into a disturbed pair of a neighbouring channel, cable or connector pair or part thereof, measured at the near-end.

AFEXT loss (alien far-end crosstalk): A measure of signal coupling from a near-end disturbing pair into a disturbed pair of a neighbouring cable or connector pair or part thereof, measured at the far-end.

PSAFEXT loss (powersum alien far-end crosstalk): A computation of signal coupling from multiple near-end disturbing channel pairs into a disturbed pair of a neighbouring channel or part thereof, measured at the far-end.

PSAACRF (powersum alien attenuation to crosstalk ratio, far-end) or PSAELFEXT (powersum alien equal-level far-end crosstalk): A computation of signal coupling from multiple pairs of disturbing channels to a disturbed pair in another channel measured at the far-end and relative to the received signal level in the disturbed pair at the far-end.

Purpose of the EN 50173 Standard

This group of European standards specifies:

- The structure and configuration of the backbone cabling subsystems of generic cabling systems within the types of premises defined by the EN 50173 series of standards
- Channel performance requirements in support of the EN 50173 series of standards
- Link performance requirements in support of the EN 50173 series of standards
- Backbone cabling reference implementations in support of the standards in the EN 50173 series
- Component performance requirements in support of the standards in the EN 50173 series.

Part 1 of the 50173 family of standard covers the requirements of the environment that the cable is to be installed. This requirement is know today as the MICE designation and refers to the local conditions that the cabling components are to be exposed. With regard to temperature, the local environment is considered to be the operating temperature of the cabling.

Section Contents

EN 50173

Information Technology–Generic Cabling Systems

EN 50173 Information Technology – Generic Cabling Systems

Part 1 of the 50173 family of standards covers the environmental requirements of the location where the cable is to be installed. This requirement is known today as the MICE designation, which refers to the local conditions that the cabling components are to be exposed. With regard to temperature, the local environment is considered to be the operating temperature of the cabling.

Environmental Requirements

Increasing severity →

	Classes		
Mechanical	M_1	M_2	M_3
Ingress rating	I_1	I_2	I_3
Climatic	C_1	C_2	C_3
Electromagnetic	E_1	E_2	E_3

The MICE matrix defines environmental classes in three levels and four parameters.

Legend

$M_1I_1C_1E_1$ describes a worst-case environment according to ISO/IEC 11801

$M_2I_2C_2E_2$ describes a worst-case light industrial environment

$M_3I_3C_3E_3$ describes a worst-case industrial environment

Figure 11 – MICE designation

Industrial Areas

Industrial premises cabling may traverse from the front office through the factory floor. The factory floor may include work areas and automation islands. Typically, industrial premises encompass environments that are much harsher when compared to commercial office environments.

As such, additional performance requirements for industrial-premises telecommunications components must be considered.

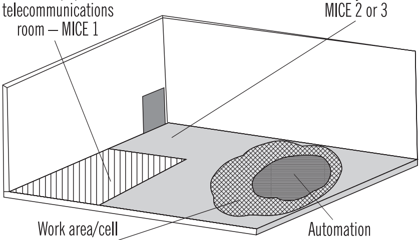

Figure 12 – Typical industrial environment

For further information on the MICE environmental requirements, please refer to the EN 50173-1:2007+A1:2009. Information Technology-Generic Cabling Systems-General requirements.

Purpose of the EN 50173 Standard Part 2

EN 50174-2 and EN 50174-3 are intended to be used by the personnel directly involved in the planning aspects of the specification phase and installation phase. EN 50174-2 is applicable inside buildings and EN 50174-3 is applicable outside buildings.

This European standard is also relevant to:

- Architects, building designers and builders
- Main contractors
- Designers, suppliers, installers, inspectors (auditors), maintainers and owners of information technology cabling
- Public network providers and local service providers
- End-users.

Other standards that may be referenced within this standard are:

- Other parts of the EN 50174 series
- Generic cabling design (EN 50173 series)
- Application dependent cabling design (e.g., EN 50098 series)
- Testing of installed cabling (EN 50346)
- Equipotential bonding requirements (EN 50310).

Section Contents

EN 50173 Part 2

Installation Planning and Practices Inside Buildings

Guidelines From CENELEC EN 50174 Cabling Installation Part 2: Installation Planning and Practices Inside Buildings

Requirements from EN 50174-2:2009

The EN 50174 Part 2 covers the requirements of copper installation within commercial premises. The following extract refers to the issue of cable installation. This is not a full extract, but it highlights some of the requirements for separation distances for various cable types and the requirements for containment.

Pathways

When it comes to a minimum bend radius, four-pair balanced cabling shall be a minimum of eight times the outside cable diameter. Optical fibre cable and coaxial cables shall have a minimum of 10 times the outside cable diameter. Within the cable containment, the stacking height of the cables is specified by the manufacturer's instructions. If these are not available, then the maximum allowable height shall not exceed 150 mm when there is continuous support (e.g., trays). For pathways that do not supply continuous support such as ladder rack, the height is reduced and the standard should be referenced under clause 4.4.

Cable Management

Cable trunking systems shall meet the following standard EN 50085-1 and the relevant Part 2. Cable tray and ladder systems shall meet the EN 61537.

Screened Cabling

When planning a screened cable installation, consider the effect that the earthing of the cable screen has on electromagnetic performance of the screened cabling. This shall be independent of the requirements for safety earthing. If the screen is only earthed at one end, the effectiveness for low-frequency interference depends on the performance of the screen within the cable. Additional screening can be provided against high-frequency electromagnetic fields if the cabling is earthed at both ends. If the cable management system is manufactured from multiple sections, the electromagnetic screening must be interconnected to ensure continuity. The bonds for this shall meet the performance requirements as specified in EN 50310. Continuity shall be maintained throughout the entire length of the installation, which includes passing through fire barriers.

Mains Power Cabling

Electrical installations shall meet the requirements of HD 374/HD 60364 and/or local regulations as appropriate. Metallic information technology cabling and mains power cabling shall be segregated as specified within clause 6 of this EN 50174-2.

Separations Requirements

The following separation distances refer to data cables installed with a known application as listed in the EN 50173 standard for Information technology, generic cabling system. Segregation of cables often depends on the construction of both the power cables and/or the copper IT cables. If either of these cables is shielded, then the separation distances can be reduced.

The requirements for separation include the following and are dependant on the cable type:

- Electromagnetic immunity
- Coupling attenuation for screened twisted-pair cables
- Transverse conversion loss (TCL) for unscreened cables
- Screening attenuation for unbalanced coaxial and twin axial cables
- The mains power cable construction, the quantity and type of electrical circuit
- Dividers between the cable types

If unshielded power cables and unshielded twisted-pair data cables are installed in an open tray, this will be the worse case. The distances should be at the maximum recommended separation. The opposite applies to shielded power and data cables installed in metal containment with a metal divider; there can be zero separation. These types of cable and containment are suitable for noise environments or where there is limited space to install the cables.

Table 21 gives examples of combinations of cables and containment along with the minimum distance apart that these should be installed. These should be used in conjunction with Table 22, which covers power factor.

Containment applied to cable types				
Segregation Classification (from Table 23)*	Separation without electromagnetic barrier	Open metallic containment [a]	Perforated metallic containment [b, c]	Solid metallic containment [d]
d	10 mm	8 mm	5 mm	0 mm
c	50 mm	38 mm	25 mm	0 mm
b	100 mm	75 mm	50 mm	0 mm
a	300 mm	225 mm	150 mm	0 mm

a Screening performance (0 MHz to 100 MHz) equivalent to welded mesh steel basket of mesh size 50 mm x 100 mm (excluding ladders). This screening performance is also achieved with steel tray (duct without cover) of less than 1 mm wall thickness and more than 20 percent equally distributed perforated area.

b Screening performance (0 MHz to 100 MHz) equivalent to steel tray (duct without cover) of 1 mm wall thickness and no more than 20 percent equally distributed perforated area. This screening performance is also achieved with screened power cables that do not meet the performance defined in note d.

c The upper surface of installed cables shall be at least 10 mm below the top of the barrier.

d Screening performance (0 MHz to 100 MHz) equivalent to a steel conduit of 1.5 mm wall thickness. Separation specified is in addition to that provided by any divider/barrier.

Table 21 – Containment applied to cable types

***Note:** It is recommended that the segregation classification is obtained from the cable manufacturer before any installation commences. This should provide an accurate guide for calculation of separation distances where required.

Power Cabling Factor for 20 Amp 230 Volt 1 Phase Circuit [a, b, c]	
Quantity of Circuits	Power Cabling Factor (P)
1 – 3	0.2
4 – 6	0.4
7 – 9	0.6
10 – 12	0.8
13 – 15	1.0
16 – 30	2
31 – 45	3
46 – 60	4
61 – 75	5
>75	6

a Three-phase cables shall be treated as three-of-one phase cables.

b More than 20 amps shall be treated as multiples of 20 amps.

c Lower voltage AC or DC power supply cables shall be treated based upon there current ratings (e.g., a 100 amp 50 volt DC cable equals 5 of 20 cables [$P = 0.4$]).

Table 22 – Power cabling factor for 20 amp 230 volt 1 phase circuit [a, b, c]

This gives the required power factor considering the amount of power cables and their current carrying capacity.

Example: Class E_A Unshielded (Segregation c) Open metallic containment = 38 mm separation from power. In addition to this, if there are 10 20-amp circuits, a one-phase the power factor rating is 0.8. Therefore, 38 mm x 0.8 = 30 mm separation.

Classification of information technology cables				
Screened Coupling attenuation at 30 MHz to 100 MHz dB	**Unscreened TCL at 30 MHz to 100 MHz** dB		**Coaxial/twinaxial Screening attenuation at 30 MHz to 100 MHz** dB	**Segregation Classification**
≥80 [a]	≥70 −10 ×	lg *f*	≥85 [d]	d
≥55 [b]	≥60 −10 ×	lg *f*	≥55	c
≥40	≥50 −10 ×	lg *f* [c]	≥40	b
<40	<50 −10 ×	lg *f*	<40	a

a Cables meeting EN 50288-4-1 (EN 50173-1:2007, Category 7) meet Segregation Classification "d."

b Cables meeting EN 50288-2-1 (EN 50173-1:2007, Category 5) and EN 50288-5-1 (EN 50173-1:2007, Category 6) meet Segregation Classification "c." These cables may deliver performance of Segregation Classification "d" provided that the relevant coupling attenuation requirements are also met.

c Cables meeting EN 50288-3-1 (EN 50173-1:2007, Category 5) and EN 50288-6-1 (EN 50173-1:2007, Category 6) meet Segregation Classification "b". These cables may deliver performance of Segregation Classification "c" or "d" provided that the relevant TCL requirements are also met.

d Cables meeting EN 50117-4-1 (EN 50173-1:2007, Category BCT-C) meet Classification "d."

Table 23 – Classification of information technology cables

The requirements for separation between information technology cables and mains power cables depend upon many different requirements:

- Electromagnetic immunity for IT can be measured as coupling attenuation for screened balanced cables
- Transverse conversion loss (TCL) for unscreened balanced cables
- Construction of the mains cable and quantity installed
- Presence of dividers between the information technology cables and the mains power cables

Full information on the requirements can be found in section 6.2 of the EN 50174-2:2009 standards document.

Specific EMI Sources	
Source of disturbance	**Minimum separation mm**
Fluorescent lamps	130 [a]
Neon lamps	130 [a]
Mercury vapour lamps	130 [a]
High-intensity discharge lamps	130 [a]
Arc welders	800 [a]
Frequency induction heating	1,000 [a]
Hospital equipment [b]	
Radio transmitter [b]	
Television transmitter [b]	
Radar [b]	

a The minimum separations may be reduced provided that appropriate cable management systems are used or product suppliers guarantees are provided.

b Where product suppliers' guarantees do not exist, analysis shall be performed regarding possible disturbances (e.g. frequency range, harmonics, transients, bursts, transmitted power).

Table 24 – Listed here are separation requirements between metallic cabling and specific EMI sources

Summary

There are many other factors that need to be taken into account, and there is not one direct answer for each cable construction type. Separation requirements can change depending on some or all of the following considerations:

- Electrical circuit type
  - 1 phase
  - 3 phase
  - 20 amps
  - Multiple circuits
- Local regulations may require a barrier
- Future expansion

The sections on cable segregation can be found within the standard under Section 6. Tables 22, 23 and 24 refer to cable separation distances. Please refer to the EN 50174 series of standard for full information.

Purpose of the ISO/IEC 18010:2002 Standard

The telecommunications infrastructure is an integral part of building design. It may include voice, data, environmental control, security, audio, television, sensing, alarms, paging and other low voltage and power limited signal systems. These systems are subject to frequent changes. Design of the pathways and spaces should accommodate this dynamic behaviour.

This standard significantly influences the design of other building services, such as electrical power and heating, ventilation and air conditioning (HVAC).

ISO/IEC 18010 generally makes no specific recommendations among the design options available for telecommunications pathways and spaces. For example, the choice between a conduit system and a tray system is not delineated. It is up to the telecommunications designer to properly select among the options based upon the applications at hand and the constraints imposed.

This standard generally imposes no specific requirements for the dimensions of pathways and spaces reference should always be made to:

- Local regulations and standards
- Telecommunications service providers' rules
- Manufacturers' guidelines.

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Section Contents

ISO/IEC 18010:2002

Pathways and Spaces

Introduction to ISO/IEC 18010:2002 Pathways and Spaces

Customer Premises Cabling

The ANSI/TIA-569-B standard is widely accepted within the data communications market and referenced extensively around the world. An international standard is also available. The following information has been extracted from the ISO/IEC 18010 standard.

Building Telecommunications Spaces

Work Area (WA)

- A minimum of two separate outlet locations should be provided in the initial design to offer maximum flexibility within the work area.

Telecommunications Room (TR) or Floor Distributor (FD)

- A telecommunications room should contain the telecommunications equipment, cables, terminations and associated cross-connect cables.
- It should be located as close as possible to the centre of the area to be served. Horizontal pathways should terminate in this location.
- The TR should not be shared with electrical installations other than those for telecommunications.
- A minimum of two electrical outlets from separate supplies shall be provided. Additional outlets shall be placed around the room at regular intervals.
- Environmental requirements apply only to cabling based on the ISO/IEC 11801 standard. HVAC should be included in the design to maintain a temperature the same as the adjacent office area.

Equipment Room (ER) or Building Distributor (BD)

Any or all of the functions of a TR or building entrance facility may alternatively be provided by an equipment room.

These factors need to be considering when building an equipment room:

- Floor loading
- Access for heavy equipment
- Located above water levels
- HVAC to be supplied and located away from sources of EMI/RFI interference

Access Floor

In new constructions, the access floor should be depressed. This depth shall be the same as the finished access floor. Where this is not possible, then suitable ramps or steps shall be installed. Care should be taken to ensure there is sufficient clearance below the access floor surface.

Pay special consideration to the following factors:

- Quantity of cables, especially in areas with restricted access
- Secondary pathway system, if any
- Crossing of cable runs
- Bend radius limitations of the cable to enable cable exit
- Sufficient space for access
- Other services

Cable Trunking Systems (Conform to IEC 61084)

These system types include:

- Wall and ceiling cable trunking systems
- Floor cable trunking systems
- Service poles made from cable trunking
- Cable tray and ladder
- Conduit systems
- Furniture pathways
- In-wall cabling
- Service poles.

Campus Pathways and Related Spaces

Campus pathways and related spaces include:

- Direct buried pathways
- Underground pathways
- Tunnels
- Aerial
- Building entrance facilities
- Maintenance holes and hand holes.

For full details, please refer to the full ISO/IEC 18010 standard.

Purpose of the ISO/IEC 24764 Standard

This standard has been designed to effectively specify the correct infrastructure for today's data centre environment. Cabling within data centres comprises both application-specific and multipurpose networks that are mission critical. Generic cabling designs in accordance with ISO/IEC 11801 have supported the development of high data rate applications based upon a defined cabling model. This international standard recognises the benefit of generic cabling to provision multiple services and to connect large quantities of equipment within the limited space of data centre premises, and it is to be used in conjunction with ISO/IEC 11801.

This international standard provides:

- An application-independent generic cabling system and an open market for cabling components
- Requirements for infrastructures that support critical applications within data centres
- A flexible cabling scheme so modifications are both easy and economical
- A scalable structure to support expansion with minimum operational disruption
- Guidance that allows for the accommodation of cabling before specific requirements are known; i.e., in the initial planning either for construction or refurbishment
- A cabling system that supports current products and provides a basis for future product development and applications standardisation.

Section Contents

ISO/IEC 24764

Generic Cabling Systems for Data Centres

Generic Cabling Systems For Data Centres ISO/IEC 24764

The ISO/IEC 24764 standard differs from other TIA standards in terminology. This should be noted when designing a data centre using standards such as ANSI/TIA-942.

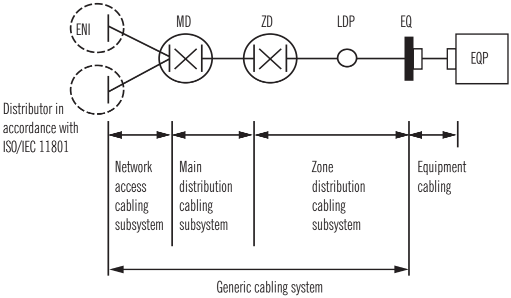

Figure 13 – Structure of generic cabling within a data centre

The minimum requirement specified in this standard for cabling includes Class E_A for copper installations and OM3 for optical fibre. Within ISO/IEC 24764, the ISO 11801 document is referenced for the infrastructure. Until the Administration ISO/IEC 14763-2 standard is published, the ISO/IEC 18010 should be referenced. Earthing and equipotential bonding refer to the EN 50130 standard. Testing of installed cable refers to the IEC 61935-1 and ISO/IEC 14763-3 standards.

The main copper cabling shall be designed to provide a minimum of Class E_A channel performance as specified in ISO/IEC 11801. Where multimode optical fibre is to be used, the main and zone distribution cabling shall provide channel performance as specified in ISO/IEC 11801 by using a minimum of Category OM3 cabled optical fibre and hardware.

Equipment Cord Restrictions		
Segment	**Minimum (m)**	**Maximum (m)**
MD-ZD	15	90
Equipment Cord at the MD	2[a]	5
Equipment Cord at the ZD	2[b]	5
Patch Cords	2	-
All Cords	-	10
a If there is no cross-connect at the MD, the minimum length of the equipment cord at the MD is 1 m.		
b If there is no cross-connect at the ZD, the minimum length of the equipment cord at the ZD is 1 m.		

Table 25 – Equipment cord restrictions

This table specifies the recommended maximum lengths at a given parameter. However, these are not fixed and should be used for reference only. The maximum length of the fixed main distribution cable will depend on the total length of cords to be supported within a channel. During the operation of the installed cable, an administration system in accordance with ISO/IEC 14763-219 shall be implemented to ensure that the length of cords used to create the channel conform to the design rules of this standard.

Fibre Connectors

Optical interfaces shall meet the requirements of IEC 61754-20 (LC interface) and will work for two single-mode or multimode optical fibres. For more than two optical fibres, the IEC 61754-7 (MPO interface) shall be used. See ISO/IEC 14763-221 regarding optical fibre polarity management. For further details and confirmation, please refer to the ISO/IEC 24764 standard document.

EN 50310 Application of Equipotential Bonding and Earthing in Buildings with Information Technology Equipment

This standard covers the earthing and bonding of the information technology equipment in building for safety, functionality and electromagnetic performance. There are different levels of complexity within grounding and bonding systems, and these depend on the size of the installation. Further information is referred to within the document including HD 384/HD EN 60364 and EN 300253.

The EN 50310 standard should be referenced in Europe and should be applied at least in the case of newly constructed buildings and whenever possible in existing buildings. All electrical building codes shall be followed in specific countries and may take precedence over EN 50310.

Please refer to the full standard for details.

Purpose of the ANSI/TIA-568-C.0 Standard

The ANSI/TIA-568-C.0 standard enables the planning and installation of a structured cabling system for all types of customer premises. It specifies a system that will support generic telecommunications cabling in a multiproduct, multimanufacturer environment. By serving as the foundation for premises telecommunications cabling infrastructure, the ANSI/TIA-568-C.0 standard provides additional requirements for other standards specific to the type of premises (e.g., ANSI/TIA-568-C.1 contains additional requirements applicable to commercial building cable).

The standard specifies requirements for generic telecommunications cabling, including:

- Cabling system structures
- Topologies and distances
- Installation, performance and testing
- Optical fibre transmission and test requirements.

This standard replaces ANSI/TIA-568-B.1 dated April 12, 2001, and its addenda. It incorporates and refines the technical content of ANSI/TIA-568-B.1-1 Addendum 1, 568-B.1-2 Addendum 2, 568-B.1-3 Addendum 3, 568-B.1-7 Addendum 7, TSB125, TSB140 and TSB153.

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Section Contents

ANSI/TIA-568-C.0

Generic Telecommunications Cabling for Customer Premises

Telecommunications Cabling System Structure

General

Figure 14 shows a representative model of the functional elements of a generic cabling system for ANSI/TIA-568-C.0. In a typical commercial building where ANSI/TIA-568-C.1 applies, Distributor C represents the main cross-connect (MC), Distributor B represents the intermediate cross-connect (IC), Distributor A represents the horizontal cross-connect (HC), and the equipment outlet (EO) represents the telecommunications outlet and connector.

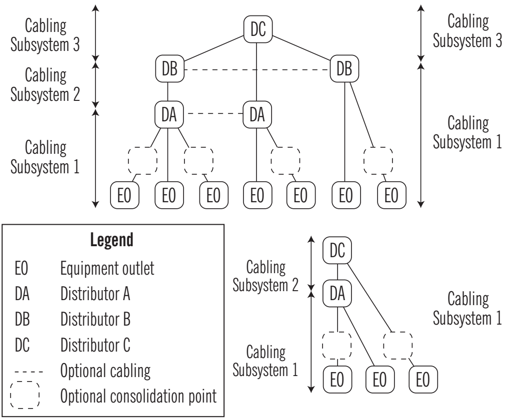


Figure 14 – Elements that comprise a generic cabling system

Topology

- Star topology
- No more than two distributors between Distributor C and an equipment outlet (EO)

Equipment Outlets (EOs)

Also called the work area (WA) in ANSI/TIA-568-C.1, equipment outlets are the outermost location to terminate the cable in a hierarchical star topology.

Distributors

Distributors provide a location for administration, reconfiguration, connection of equipment and testing. They can be either interconnections or cross-connections.

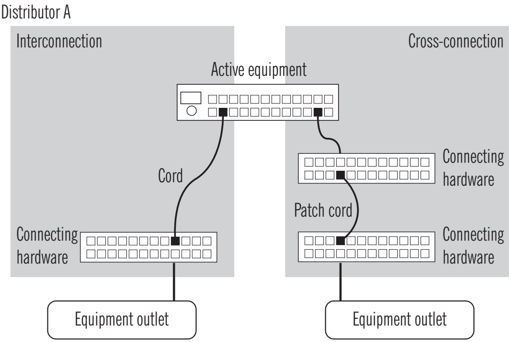


Figure 15 – Interconnections and cross-connections

Cabling Subsystem 1

- Provides a signal path between Distributor A, Distributor B or Distributor C and an EO (see Figure 15)
- Contains no more than one transition point or consolidation point
- Stipulates that splices shall not be installed as part of a balanced twisted-pair cabling subsystem and that splitters shall not be installed as part of optical fibre for Cabling Subsystem 1

Cabling Subsystem 2 and Cabling Subsystem 3

Cabling Subsystem 2 and Cabling Subsystem 3 provide signal paths between distributors (see Figure 15). The use of Distributor B is optional.

Recognised Cabling

The recognised media, which shall be used individually or in combination, are:

- 100-ohm balanced twisted-pair cabling
- Multimode optical fibre cabling
- Single-mode optical fibre cabling.

Cabling media other than those recognised above may be specified by the appropriate premises cabling standards.

Cabling Lengths

Cabling lengths are dependent upon the application and upon the specific media chosen (see following table).

Cabling Lengths			
Application	**Media**	**Distance m (ft.)**	**Comments**
Ethernet 10BASE-T	Category 3, 5e, 6, 6A	100 (328)	
Ethernet 100BASE-TX	Category 5e, 6, 6A	100 (328)	
Ethernet 1000BASE-T	Category 5e, 6, 6A	100 (328)	
Ethernet 10GBASE-T	Category 6A	100 (328)	
ASDL	Category 3, 5e, 6, 6A	5,000 (16,404)	1.5 Mbps to 9 Mbps
VDSL	Category 3, 5e, 6, 6A	5,000 (16,404)	1,500 m (4,900 ft.) for 12.9 Mbps; 300 m (1,000 ft.) for 52.8 Mbps
Analog Phone	Category 3, 5e, 6, 6A	800 (2,625)	
FAX	Category 3, 5e, 6, 6A	5,000 (16,404)	
ATM 25.6	Category 3, 5e, 6, 6A	100 (328)	
ATM 51.84	Category 3, 5e, 6, 6A	100 (328)	
ATM 155.52	Category 5e, 6, 6A	100 (328)	
ATM 1.2G	Category 6, 6A	100 (328)	
ISDN BRI	Category 3, 5e, 6, 6A	5,000 (16,404)	128 kbps
ISDN PRI	Category 3, 5e, 6, 6A	5,000 (16,404)	1.472 Mbps

Table 26 – Maximum supportable distances for balanced twisted-pair cabling by application, which includes horizontal and backbone cabling (application specific)

Cabling Installation Requirements

- Cabling installations shall comply with the authority having jurisdiction (AHJ) and applicable regulations.
- Cable stress caused by suspended cable runs and tightly cinched bundles should be minimised.
- Cable bindings, which are used to tie multiple cables together, should be irregularly spaced and should be loosely fitted (easily moveable).

Balanced Twisted-Pair Cabling

Maximum Pulling Tension

- The pulling tension for a 4-pair balanced twisted-pair cable shall not exceed 110 N (25 pound-force) during installation.
- For multipair cable, manufacturers' pulling tension guidelines shall be followed.

Minimum Bend Radius

Cable

- The minimum inside bend radius, under no-load or load, for a 4-pair balanced twisted-pair cable shall be four times the cable diameter.
- The minimum bend radius, under no-load or load, for a multipair cable shall follow the manufacturer's guidelines.

Cord Cable

- The minimum inside bend radius for a 4-pair balanced twisted-pair cord cable shall be one times the cord cable diameter.

Cable Termination

- Cables should be terminated with connecting hardware of the same performance (Category) or higher.
- The Category of the installed link should be suitably marked and noted in the administrative records.
- The cable geometry shall be maintained as close as possible to the connecting hardware and its cable termination points.
- The maximum pair untwist for the balanced twisted-pair cable termination shall be in accordance with Table 27.

Pair Untwist Lengths	
Category	**Maximum Pair Untwist mm (in.)**
3	75 (3)
5e	13 (0.5)
6	13 (0.5)
6A	13 (0.5)

Table 27 – Maximum supportable pair untwist length for Category cable termination

8-Position Modular Jack Pin-Pair Assignments

Pin-pair assignments shall be as shown in Figure 16 or, optionally, per Figure 17 if it is necessary to accommodate certain 8-pin cabling systems. The colours shown are associated with 4-pair cable.

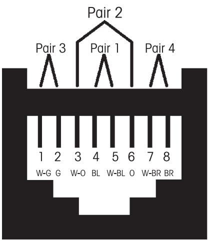


Figure 16 – Front view of 8-position jack pin-pair assignments (T568A)

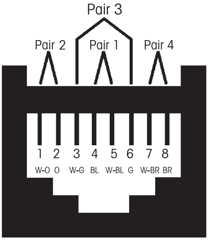


Figure 17 – Front view of optional 8-position jack pin-pair assignment (T568B)

Cords and Jumpers

Cross-connect jumpers and modular plug cords should be of the same Category or higher as the Category of the cabling to which they connect. It is recommended that modular cords be factory manufactured.

Grounding and Bonding Requirements for Screened Cabling

- The screen of screened twisted-pair (ScTP) cables shall be bonded to the telecommunications grounding busbar (TGB) or telecommunications main grounding busbar (TMGB).
- A voltage greater than 1 volt rms between the cable screen and the ground of the corresponding electrical outlet used to provide power to the equipment indicates improper grounding.

Optical Fibre Cabling

Minimum Bend Radius and Maximum Pulling Tension

Measured to the inside curvature, the bend radius is the minimum a cable can bend without any risk to kinking it, damaging it or shortening its life. The smaller the bend radius, the greater the material flexibility.

Minimum Bend Radius and Maximum Pulling Tension			
Cable Type and Installation Details	**Maximum Tensile Load During Installation**	**Minimum Bend Radii While Subjected To Maximum Tensile Load (During Installation)**	**No Tensile Load (After Installation)**
Inside Plant Cable with 2 or 4 Fibres Installed in Cabling Subsystem 1	220 N (50 lbf)	50 mm (2 in.)	25 mm (1 in.)
Inside Plant Cable with more than 4 Fibres	Per manufacturer	20 times the cable outside diameter	10 times the cable outside diameter
Indoor/Outdoor Cable with up to 12 Fibres	1335 N (300 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Indoor/Outdoor Cable with more than 12 Fibres	2670 N (600 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Outside Plant Cable	2670 N (600 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Drop Cable Installed by Pulling	1335 N (300 lbf)	20 times the cable outside diameter	10 times the cable outside diameter
Drop Cable Installed by Directly Buried, Trenched or Blown into Ducts	440 N (100 lbf)	20 times the cable outside diameter	10 times the cable outside diameter

Table 28 – Maximum and minimum pulling tension and bend radius for different cable types

Polarity

Transmit-to-receive polarity must be maintained throughout the cabling system. (Annex B of the full standard describes methods to do this.)

Purpose of the ANSI/TIA-606-A Standard

Modern buildings require an effective telecommunications infrastructure to support the wide variety of services that rely on the electronic transport of information. Administration includes basic documentation and timely updating of drawings, labels and records. Administration should be synergistic with voice, data and video telecommunications, as well as with other building signal systems, including security, audio, alarms and energy management.

Administration can be accomplished with paper records, but in today's increasingly complex telecommunications environment, effective administration is enhanced by the use of computer-based systems.

A multitenant commercial building has a life expectancy of at least 50 years. Moreover, in a multitenant environment, continuous moves, adds and changes are inevitable.

Administrative record keeping plays an increasingly necessary role in the flexibility and management of frequent moves, adds and changes. This standard concisely describes the administrative record keeping elements of a modern structured cabling system.

Section Contents

ANSI/TIA-606-A

Administration Standard for Commercial Telecommunications Infrastructure

Elements of an Administration System

- Horizontal pathways and cabling
- Backbone pathways and cabling
- Telecommunications grounding and bonding
- Spaces (e.g., entrance facility, telecommunications room, equipment room)
- Firestopping

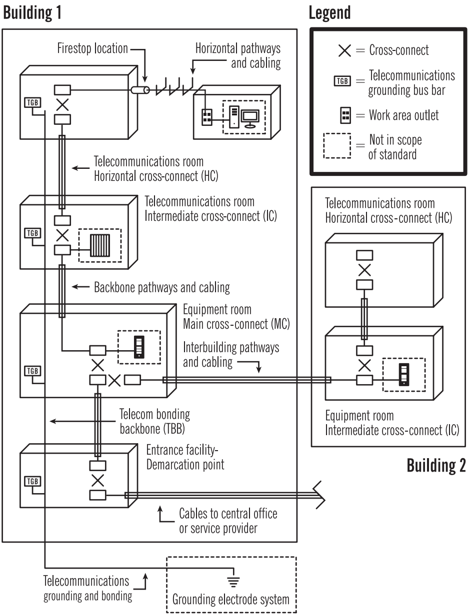


Figure 18 – A typical model for the infrastructure elements used in an administration system

Classes of Administration

Four classes of administration are specified in this standard to accommodate diverse degrees of complexity present in telecommunications infrastructure. Each class defines the administration requirements for identifiers, records and labelling. An administration system can be managed using a paper-based system, general-purpose spreadsheet software or special-purpose cable management software.

Classes of Administration					
Identifier	**Description of identifier**	**Class of administration** 1	2	3	4
fs	Telecommunications space (TS)	R	R	R	R
fs-an	Horizontal link	R	R	R	R
fs-TGMB	Telecommunications main grounding busbar (TMGB)	R	R	R	R
fs-TGB	Telecommunications grounding busbar (TGB)	R	R	R	R
fs_1 /fs_2-n	Building backbone cabling		R	R	R
fs_1 /fs_2-n.d	Building backbone pair or optical fibre		R	R	R
f-FSLn(h)	Firestop location		R	R	R
[b_1-fs_1]/[b_2-fs_2]-n	Campus backbone cable			R	R
[b_1-fs_1]/[b_2-fs_2]-n/d	Campus backbone or optical fibre			R	R
b	Building			R	R
c	Campus or site				R

Table 29 – Identifier descriptions and classes of administration

Products. Technology. Services. Delivered Globally.

Class 1 Administration

Class 1 addresses the administration requirements for a building or premise that is served by a single equipment room (ER).

The following infrastructure identifiers shall be required in Class 1 Administration when the corresponding elements are present:

- Telecommunications space (TS) identifier
- Horizontal link identifier
- Telecommunications main grounding busbar (TMGB)
- Telecommunications grounding busbar (TGB)

Class 1 Identifiers

Identifier	Description of identifier
f	Numeric character(s) identifying the floor of the building occupied by the TS
s	Alpha character(s) uniquely identifying the TS on floor f or the building area in which the space is located
fs	The TS identifier
a	One or two alpha characters uniquely identifying a single patch panel, a group of patch panels with sequentially numbered ports, or an IDC connector (punch-down block), or a group of IDC connectors, serving as part of the horizontal cross-connect
n	Two to four numeric characters designating the port on a patch panel, or the section of an IDC connector on which a four-pair horizontal cable is terminated in the TS
TMGB	Portion of an identifier designating a telecommunications main grounding busbar
TGB	Portion of an identifier designating a telecommunications grounding busbar

Table 30 – Class 1 identifiers

Class 2 Administration

Class 2 addresses the administration of infrastructure with one or more telecommunications spaces (TS) in a single building.

The following infrastructure identifiers shall be required in Class 2 Administration when the corresponding elements are present:

- Identifiers required in Class 1 Administration
- Building backbone cable identifier
- Building backbone pair or optical fibre identifier
- Firestopping location identifier

Class 2 Administration may also include pathway identifiers.

Class 2 Identifiers	
Identifier	**Description of identifier**
fs_1	TS identifier for the space containing the termination of one end of the backbone cable
fs_2	TS identifier for the space containing the termination of the other end of the backbone cable
n	One or two alphanumeric characters identifying a single cable with one end terminated in the TS designated fs_1 and the other end terminated in the TS designated FS_2
fs_1/fs_2-n	A building backbone cable identifier
d	Two to four numeric characters identifying a single copper pair or a single optical fibre
FSL	An identifier referring to a firestopping location
h	One numeric character specifying the hour rating of a firestopping system

Table 31 – Class 2 identifiers

Class 3 Administration

Class 3 Administration addresses infrastructure with multiple buildings at a single site.

The following infrastructure identifiers shall be required in Class 3 Administration:

- Identifiers required in Class 2 Administration
- Building identifier
- Campus backbone cable identifier
- Campus backbone pair or optical fibre identifier

The following infrastructure identifiers are optional in Class 3 Administration:

- Identifiers optional in Class 2 Administration
- Outside plant pathway element identifier
- Campus pathway or element identifier

Additional identifiers may be added if desired.

Class 3 Identifiers	
Identifier	**Description of identifier**
$[b_1\text{-}fs_1]/[b_2\text{-}fs_2]\text{-}n$	Campus backbone identifier
d	Two to four numeric characters identifying a single copper pair or a single optical fibre
b	One or more alphanumeric characters identifying a single building

Table 32 – Class 3 identifiers

Class 4 Administration

Class 4 Administration addresses infrastructure with multiple sites or campuses.

The following infrastructure identifiers shall be required in Class 4 Administration:

- Identifiers required in Class 3 Administration
- Campus or site identifier

The following infrastructure identifiers are optional in Class 4 Administration:

- Identifiers optional in Class 3 Administration
- Intercampus element identifier

Additional identifiers may be added if desired.

Class 4 Identifiers	
Identifier	Description of identifier
c	One or more alphanumeric characters identifying a campus or a site

Table 33 – Class 4 identifiers

Identification Formats

A unique alphanumeric identification code is created for every location, pathway, cable and termination point. The standard includes these suggestions:

Alphanumeric Identification Code			
Code	**Description**	**Code**	**Description**
BCxxx	Bonding conductor	HHxxx	Handhole
BCDxxx	Backbone conduit	ICxxx	Intermediate cross-connect
Cxxx	Cable	Jxxx	Jack
CBxxx	Backbone cable	MCxxx	Main cross-connect
CDxxx	Conduit	MHxxx	Manhole or maintenance hole
CTxxx	Cable tray	PBxxx	Pull box
ECxxx	Equipment (bonding) conductor	Sxxx	Splice
EFxxx	Entrance facility	SExxx	Service entrance
ERxxx	Equipment room	SLxxx	Sleeve
Fxxx	Fibre	TCxxx	Telecommunications closet
GBxxx	Grounding busbar	TGBxxx	Telecommunications grounding busbar
GCxxx	Grounding conductor	TMGB	Telecommunications main grounding busbar
		WAxxx	Work area

Table 34 – Alphanumeric identification codes

Identification Format Example

The actual format in the preceding chart is not mandated by the standard. However, the chosen format must be consistent and provide a unique identifier number for each system element. This method lends itself to organising and updating multiple records by the use of powerful relational database (three-dimensional spreadsheet) programs.

Identification Example

J0001	Label for an information outlet jack
D306	Designation for a work area
3A-C17-005	Termination in closet 3A, column C, row 17, block position 005

Examples like those above (taken from the ANSI/TIA-606-A text and administrative labelling map) indicate the flexibility of conventions that can be established for purposes of naming. Logical naming conventions can also convey considerable additional information about other linkages. Further examples are included in the complete standard.

Summary of Record Elements

Table 35 outlines the minimum required information and required linkages. Further information is optional. A multidimensional database or spreadsheet is helpful.

Documentation Requirements			
	Record	**Required Information**	**Required Linkages**
Pathways and Spaces	Pathway	Pathway identification # Pathway type Pathway fill Pathway load	Cable records Space records Pathway records Grounding records
	Space	Space identification # Space type Grounding records	Pathway records Cable records
Wiring	Cable	Cable identification # Cable type Unterminated pair #s Damaged pair #s Available pair #s	Termination records Splice records Pathway records Grounding records
	Termination Hardware	Termination hardware #s Termination hardware type Damaged position #s	Termination position records Space records Grounding records
	Termination Position	Termination position # Termination position type User code Cable pair/condition #s	Cable records Other termination records Termination hardware records Space records
	Splice	Splice identification # Splice type	Cable records Space records
Grounding	TMGB	TMGB identification # Busbar type Grounding conductor #s Resistance to earth Date of measurement	Bonding conductor records Space records
	Bonding Conductor	Bonding conductor ID# Conductor type Busbar identification #	Grounding busbar records Pathway records
	TGB	Busbar identification # Busbar type	Bonding conductor records Space records

Table 35 – Documentation requirements

Grounding and Bonding Administration

Telecommunications systems require a reliable electrical ground reference potential, provided by a dedicated grounding and bonding conductor network.

WARNING

IF THIS CLAMP OR CABLE IS LOOSE OR MUST BE REMOVED,
PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER.

Figure 19 – Sample label

Bonding conductor cabling shall be coloured green or labelled appropriately with an alphanumeric identifier and warning label. Grounding records are similar to cable record format.

Grounding and Bonding Terms (with abbreviation):

TMGB Telecommunications main grounding busbar
TBB Telecommunications bonding backbone
TGB Telecommunications grounding busbar
TBBIBC Telecommunications bonding backbone interconnecting bonding conductor

Label Colour Coding

Shown here are the colour codes used for termination field labels.

Field Label Color Codes		
Termination Type	Color	Comments
Demarcation point	Orange	CO terminations
Network connections	Green	Also aux. circuit terms.
Common equipment	Purple	PBX, host, LANs, Mux
First-level backbone	White	MC-IC terminations
Second-level backbone	Grey	IC-TC terminations
Station	Blue	Horizontal cable terms.
Interbuilding backbone	Brown	Campus cable terms.
Miscellaneous	Yellow	Aux., maint., security
Key telephone systems	Red	

Table 36 – Field label colour codes

The abbreviation "terms." is used in this example (for space considerations) to mean "terminations."

Purpose of the ANSI/TIA-942 Standard

Telecommunications Infrastructure Standard for Data Centres

The purpose of this standard is to provide requirements and guidelines for the design and installation of a data centre or computer room. It is intended for designers who need a comprehensive understanding of the data centre design including the facility planning, the cabling system and the network design. It facilitates the planning for data centres to occur earlier in the building development process (architectural, facilities and IT).

Data centres support a wide range of transmission protocols. Some of these protocols impose distance restrictions that are shorter than those imposed by this standard. When applying specific transmission protocols, consult standards, regulations, equipment manufacturers and system service suppliers for applicability, limitations and ancillary requirements. Consider consolidating standardised and proprietary cabling into a single structured cabling system.

The standard specifies:

- Cabling design
- Network design
- Facilities design
- Informative annexes containing best practices and availability requirements
- Spaces
- Pathways
- Racks and cabinets.

Section Contents

ANSI/TIA-942

Telecommunications Infrastructure Standard for Data Centres

Products. Technology. Services. Delivered Globally.

Data Centre Cabling Infrastructure

The basic elements of a data centre cabling system include the following:

- Horizontal cabling
- Backbone cabling
- Cross-connect in the entrance room or main distribution area
- Main cross-connect (MC) in the main distribution area
- Horizontal cross-connect (HC) in the telecommunications room, horizontal distribution area or main distribution area
- Zone outlet or consolidation point in the zone distribution area
- Outlet in the equipment distribution area

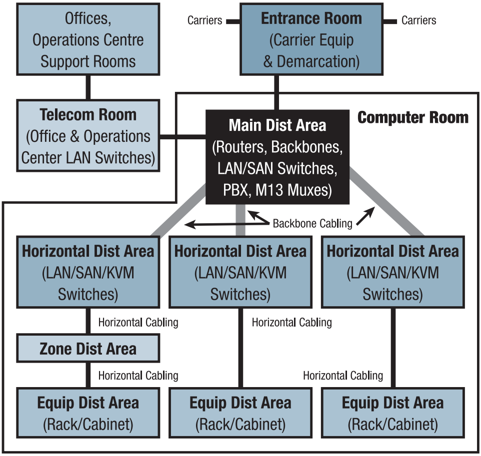


Figure 20 – Example of basic data centre topology

Note: The TIA-942 standard is currently in the process of being updated. Please check the TIA for the most recent updates.

Hot and Cold Aisles

Cabinets and racks shall be arranged in an alternating pattern, with the fronts of cabinets and racks facing each other in a row to create hot and cold aisles.

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.

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

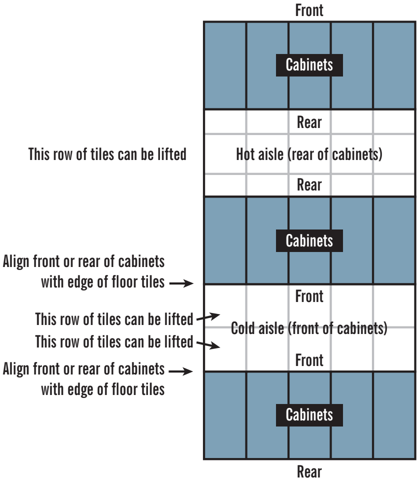


Figure 21 – Hot and cold aisles

Horizontal Cabling

The horizontal cabling is the portion of the telecommunications cabling system that extends from the mechanical termination in the equipment distribution area to either the horizontal cross-connect in the horizontal distribution area or the main cross-connect in the main distribution area. The horizontal cabling includes horizontal cables, mechanical terminations, and patch cords or jumpers. It may also include a zone outlet or a consolidation point in the zone distribution area.

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

- 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)
- Other building signalling systems (building automation systems such as fire, security, power, HVAC, etc.)

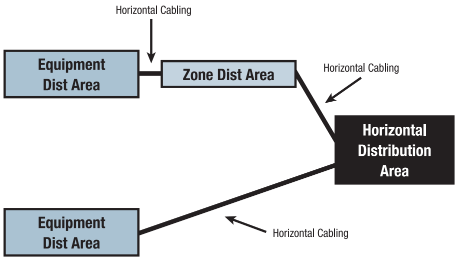


Figure 22 – Horizontal cabling using star topology

Maximum Equipment Area Cord Length				
	24 AWG UTP/24 ScTP Patch Cords		26 AWG ScTP Patch Cords	
Length of Horizontal Cable (H) m (ft.)	Maximum Length of Zone Area Cable (Z) m (ft.)	Maximum Combined Length of Zone Area Cables, Patch Cords and Equipment (C) m (ft.)	Maximum Length of Zone Area Cable (Z) m (ft.)	Maximum Combined Length of Zone Area Cables, Patch Cords and Equipment Cable (C) m (ft.)
90 (295)	5 (16)	10 (33)	4 (13)	8 (26)
85 (279)	9 (30)	14 (46)	7 (23)	11 (35)
80 (262)	13 (44)	18 (59)	11 (35)	15 (49)
75 (246)	17 (57)	22 (72)	14 (46)	18 (59)
70 (230)	22 (72)	27 (89)	17 (56)	21 (70)

Table 37 – Maximum length horizontal and equipment area cables

Backbone Cabling

The function of the backbone cabling is to provide connections between the main distribution area, the horizontal distribution area and entrance facilities in the data centre cabling system. Backbone cabling consists of the backbone cables, main cross-connects, horizontal cross-connects, mechanical terminations and patch cord or jumpers used for backbone-to-backbone cross-connections.

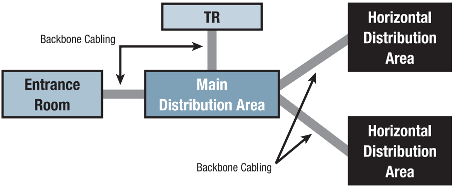


Figure 23 – Backbone cabling using star topology

Recognised Cabling Media for Horizontal and Backbone Applications

Recognised cables, associated connecting hardware, jumpers, patch cords, equipment cords and zone area cords shall meet all applicable requirements specified in ANSI/TIA-568-C.2 and ANSI/TIA-568-C.3. *

- 100-ohm twisted-pair cable **
- Multimode optical fibre cable, either 62.5/125 μ or 50/125 μ, 50/125 μ 850-nm laser-optimised multimode fibre is recommended
- Single-mode optical fibre cable
- Recognised coaxial media: 75-ohm (734 and 735 type) coaxial cable (Telcordia Technologies GR-139-CORE) and coaxial connector (ANSI T1.404)

* Since publication of the ANSI/TIA-942 standard, the ANSI/TIA-568-C.2 and ANSI/TIA-568-C.3 standards supersede the referenced ANSI/TIA-568-B.2 and ANSI/TIA-568-B.3 standards.

** Although not part of the current ANSI/TIA-942 Standard, best practices for data centres would include recommending Cat 6A twisted-pair cabling ANSI/TIA-568-C.1 and ANSI/TIA-568-C.2.

Redundancy

Data centres that are equipped with diverse telecommunications facilities may be able to continue their function under catastrophic conditions that would otherwise interrupt the data centre's telecommunications service. This standard includes four tiers relating to various levels of availability of the data centre facility infrastructure. The tiers are related to research conducted by the Uptime Institute, which defines four tiers of performance as shown in the following table.

Providing redundant cross-connect areas and pathways that are physically separated can increase the reliability of the communications infrastructure. It is common for data centres to have multiple access providers that supply 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.

Tier Clarification

	Tier I: Basic	Tier II: Redundant Components	Tier III: Concurrently Maintainable	Tier IV: Fault Tolerant
Number of Delivery paths	**Only 1**	**Only 1**	**1 Active, 1 Passive**	**2 Active**
Redundant Components	N	N+1	N+1	2 (N+1) S+S
Support Space to Raised Floor Ratio	20%	30%	80-90%	100%
Initial Watts/ft.	20-30	40-50	40-60	50-80
Ultimate Watts/ft.	20-30	40-50	100-150	150+
Raised Floor Height	12 in.	18 in.	30-36 in.	30-36 in.
Floor Loading Pounds/ft.	85	100	150	150+
Utility Voltage	208, 480	208, 480	12-15 kV	12-15 kV
Months to Implement	3	3-6	15-20	15-20
Year First Deployed	1965	1970	1985	1995
Construction $/ft. Raised Floor	$450	$600	$900	$1,100+
Annual IT Downtime Due to Site	28.8 hrs.	22.0 hrs.	1.6 hrs.	0.4 hrs.
Site Availability	99.671%	99.749%	99.982%	99.995%

Table 38 – Uptime Institute tier references

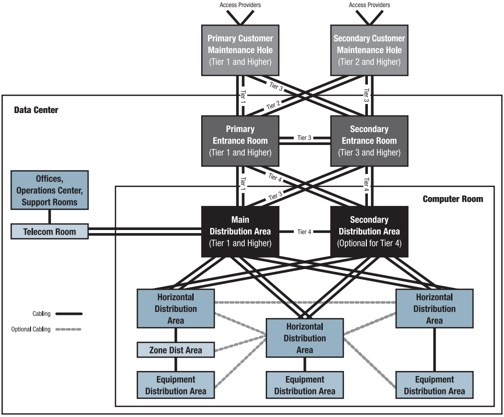
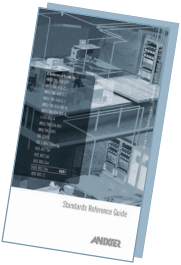


Figure 24 – Telecommunications infrastructure redundancy

Note: The TIA-942 standard is currently in the process of being updated. Please check with the TIA for the most recent updates.

The Anixter U.S. Standards Reference Guide



The Anixter U.S. Standards Reference Guide is an invaluable industry tool to help you stay informed of recent standard developments for structured cabling systems. The guide includes an up-to-date summary of the ANSI/TIA, ISO, and IEEE standards featuring standards ANSI/TIA-568-C.0, ANSI/TIA-568-C.1, ANSI/TIA-568-C.2, ANSI/TIA-568-C.3, ANSI/TIA-569-B, ANSI/TIA-606-A, J-STD-607-A, ANSI/TIA/EIA-942, ANSI/TIA/1005, ISO 11801, ISO 11801 Class E_A, IEEE 802.3af, IEEE 802.3at, IEEE 802.3an, IEEE 802.3ba and IEEE 802.11.

To request a copy, contact your local Anixter representative, or visit anixter.com/literature.

Anixter Standards Reference Guide

Telecommunications Infrastructure for Industrial Premises

Anixter's Standards Reference Guide for Telecommunications Infrastructure for Industrial Premises is an invaluable tool to help you plan and install telecommunications cabling infrastructure within and between industrial buildings. The ANSI/TIA-1005 standard address the potential exposure to hostile environments in the industrial space. In addition to the special cabling system requirements for industrial operations, including 2-pair cabling systems, the standard provides definitions for areas in the industrial space including automation islands, outlets and cables.

To request a copy, contact your local Anixter representative, or visit anixter.com/literature

ISO 11801 Class E_A Standard

The requirements for ISO Class E_A are more demanding compared to the TIA Augmented Category 6 requirements. Anixter's Infrastructure Solutions Lab tests to the more stringent ISO standards.

ISO Compared to TIA		
Characteristics 500 MHz (dB)	**ISO Class E_A**	**TIA Augmented Category 6**
PSNEXT Loss	24.8 dB	23.2 dB
NEXT Loss	27.9 dB	26.1 dB
PSANEXT Loss	49.5 dB	49.5 dB
Return Loss	6.0 dB	6.0 dB
Insertion Loss	49.3 dB	49.3 dB
Referred to by IEEE	Yes	No

Table 39 – ISO Class E_A and TIA Augmented Category 6 performance comparison

TIA Category 6 versus Augmented Category 6 versus ISO Class E_A				
	TIA Category 5e	**TIA Category 6**	**TIA Augmented 6**	**ISO Class E_A**
Recognised by IEEE 802.3an	No	Yes	Yes	Yes
55 Metre Distance Support	No	Yes	Yes	Yes
100 Metre Distance Support	No	No	Yes	Yes
Extrapolated Test Limits for NEXT and PSNEXT to 500 MHz	No	No	No	Yes

Table 40 – ISO and TIA 10GBASE-T media types

Table 40 summarises the various UTP cabling options and their respective 10 Gigabit performance attributes as defined by the latest draft standards. Category 5e is not recognised as a viable cabling media to support 10 Gigabit transmission regardless of its installed cabling distance. Category 6 cabling will only support 10 Gigabit at a maximum installed distance of 55 metres.

Today, the only options for operating 10 Gigabit at 100 metres using RJ45 connectivity are the TIA Augmented Category 6 and ISO Class E_A standards. ISO's Class E_A system has superior NEXT and PSNEXT performance values when compared with the current TIA Augmented Category 6 standard.

ANSI/TIA-568-C.2 Augmented Category 6 or ISO 11801 Class E_A Cables

10 Gigabit Ethernet Channel Applications			
Application	**10GBASE Fibre (802.3ae)**	**10GBASE-T**	**10GBASE-CX4 (802.3ak)**
Data Centre (Server Clustering)	Yes	Yes	Yes (<15 m)
Horizontal (In Building)	No	Yes	No
Vertical (Risers)	Yes	No	No
Campus/Metro	Yes	No	No

Table 41 – 10 Gigabit Ethernet applications and recommended protocols

In Table 41, the recommended application road maps for 10 Gigabit Ethernet cabling and protocol types have been provided. The choice of which media to use will revolve around three variables:

- Circuit distances
- Cost
- Active equipment interfaces (connectors)

10GBASE fibre will maintain traditional applications in backbones and risers and also in the data centre for server clustering.

10GBASE-T copper will remain in the traditional areas of application (in horizontal building cabling but also in the data centre between servers and clusters).

10GBASE-CX4 defines a multiconductor copper solution primarily designed to connect servers and switches over short distances.

IEEE 802.3af Power over Ethernet (PoE) Standard

The IEEE 802.3af specification calls for power source equipment (PSE) that operates at 48 volts of direct current. This guarantees 12.95 watts of power over unshielded twisted-pair cable to data terminal equipment (DTE) 100 metres away (the maximum distance supported by Ethernet). That's enough power to support IP phones, WLAN access points and many other DTE devices. Two PSE types are supported including Ethernet switches equipped with power supply modules called endspan devices and a special patch panel called a midspan device that sits between a legacy switch and powered equipment, injecting power to each connection.

IEEE 802.3at Power over Ethernet + (Plus) Standard

The IEEE 802.3at Power over Ethernet Plus amendment to the IEEE 802.3af standard offers improved power-management features and increases the amount of power to end devices. The new amendment will usher in new possibilities of powering devices through standard Class D, E, E_A, F and F_A cabling. It will allow many more devices, such as access control and video surveillance, to receive power over a twisted-pair cabling infrastructure. The standard defines the technology for powering a wide range of devices up to 25 watts over existing Class D /Category 5e and above cables. The 802.3at standard states that 30 watts at a minimum are allocated at the port, so 24.6 watts are ensured at the end-device connector 100 metres away. It also allows for gigabit pass-through. PoE Plus represents a considerable upgrade over the existing PoE standard.

IEEE 802.3an, Physical Layer and Management Parameters for 10 Gbps Operation Type 10GBASE-T

Describes the physical layer (PHY) for 10 Gigabit Ethernet transmission over twisted-pair copper cable.

IEEE 802.3an Standard		
Standard	**Media**	**Distance**
ISO Class F (Individual Shields)	S/FTP	100 m
ISO Class E_A	UTP	100 m
TIA Augmented Category 6	UTP	100 m
Shielded Category 6 (Overall Shield)	F/UTP, ScTP, STP	100 m
TIA Standard Category 6/ISO Class E	UTP	$<$55 m

Table 42 – Maximum 10GBASE-T cabling distances

ANSI/TIA-568-C.2 (Augmented Category 6) and ISO 11801 (Class E_A) cable specifications are based on IEEE cabling models. 100 metres over UTP is only guaranteed when using Augmented Category 6 or ISO Class E_A compliant cabling systems.

IEEE 802.3ba Media Access Control Parameters, Physical Layers and Management Parameters for 40 Gbps and 100 Gbps Operation

The 802.3ba amendment to the IEEE 802.3-2008 standard defines Media Access Control (MAC) parameters, physical layer specifications and management parameters for the transfer of 802.3 frames at 40 Gbps and 100 Gbps. The updated amendment will facilitate the migration of 10 Gigabit Ethernet from the network core to the network edge by providing 40 Gbps and 100 Gbps data rates for backbone and backhaul applications to effectively remove the bandwidth bottleneck that exists in many corporate networks today.

The following media types and distances are approved as part of the 802.3ba amendment:

40 Gigabit Ethernet		
Protocol	**Media**	**Distance**
40GBASE-CR4	Twinax	10 m
40GBASE-SR4	OM3 MMF	100 m
40GBASE-SR4	OM4 MMF	150 m
40GBASE-LR4	SMF	10 km

100 Gigabit Ethernet		
Protocol	**Media**	**Distance**
100GBASE-CR10	Twinax	10 m
100GBASE-SR10	OM3 MMF	100 m
100GBASE-SR10	OM4 MMF	150 m
100GBASE-LR4	SMF	10 km
100GBASE-ER4	SMF	40 km

Table 43 – 40 Gbps and 100 Gbps approved media types and distances

IEEE 802.11 Wireless Standard

IEEE 802.11, the Wi-Fi standard, denotes a set of wireless LAN/WLAN standards developed by working group 11 of the IEEE LAN/MAN standards committee (IEEE 802). The term 802.11x is also used to denote this set of standards and is not to be mistaken for any one of its elements. There is no single 802.11x standard.

802.11 details a wireless interface between devices to manage packet traffic (to avoid collisions, etc.). Some common specifications and their distinctive attributes include the following:

802.11a – Operates in the 5 GHz frequency range (5.125 to 5.85 GHz) with a maximum 54 Mbps signalling rate. The 5 GHz frequency band isn't as crowded as the 2.4 GHz frequency because it offers significantly more radio channels than the 802.11b and is used by fewer applications. It has a shorter range than 802.11g, is actually newer than 802.11b and is not compatible with 802.11b.

802.11b – Operates in the 2.4 GHz Industrial, Scientific and Medical (ISM) band (2.4 to 2.4835 GHz) and provides signalling rates of up to 11 Mbps. This is a commonly used frequency. Microwave ovens, cordless phones, medical and scientific equipment, as well as Bluetooth® devices, all work within the 2.4 GHz ISM band.

802.11e – Ratified by the IEEE in late September 2005, the 802.11e quality-of-service specification is designed to guarantee the quality of voice and video traffic. It will be particularly important for companies interested in using Wi-Fi phones.

802.11g – Similar to 802.11b, this standard supports signalling rates of up to 54 Mbps. It also operates in the heavily used 2.4 GHz ISM band but uses a different radio technology to boost overall throughput. Compatible with older 802.11b.

802.11i – Also sometimes called Wi-Fi Protected Access 2 (WPA 2), 802.11i was ratified in June 2004. WPA 2 supports the 128-bit-and-above Advanced Encryption Standard, along with 802.1x authentication and key management features.

802.11k – Passed in June 2008, the 802.11k Radio Resource Management Standard will provide measurement information for access points and switches to make wireless LANs run more efficiently. It may, for example, better distribute traffic loads across access points or allow dynamic adjustments of transmission power to minimise interference.

802.11n – Ratified in September 2009, 802.11n is a set of standards for wireless local area network (WLAN) communications, developed by the IEEE LAN/MAN Standards Committee (IEEE 802) in the 5 GHz and 2.4 GHz public spectrum bands. The proposed amendment improves upon the previous 802.11 standards by adding multiple-input multiple-output (MIMO) and many other newer features.

The Anixter Infrastructure Solutions Lab

Anixter's Infrastructure Solutions Lab actively demonstrates the best practical technology solutions from best-in-class manufacturers in the area of enterprise cabling, video security and access control for our customers. Our mission for The Lab is simple—educate, demonstrate and evaluate.

- Educate customers on the latest industry standards and technologies
- Demonstrate the latest infrastructure product solutions available from our manufacturer partners
- Evaluate our network infrastructure and security solutions to ensure that our customers are selecting the right products for their specific needs

We are continually testing products in The Lab to ensure:

- Quality products are recommended and delivered to our customers
- Consistency of performance across product lines and within systems
- Interoperability of products and systems to ensure customers can integrate systems and follow the trend toward convergence.

Networking and security product testing at The Lab includes:

- Random performance testing of Anixter inventory to ensure quality of standards compliance
- Network throughput and interoperability testing
- Copper and fibre cabling compliance verification (TIA, ISO/IEC, IEEE)
- Customer proof of concept
- Power over Ethernet (PoE)
- Application testing
- 10 Gig Ethernet cabling testing
- Video over IP, video quality and bandwidth utilisation
- Power over Ethernet capability and verification
- Digital compression image quality vs. analogue technology testing
- Evaluation of analogue and IP cameras, video management software evaluation, DVR, NDVR and NVR products.

THE LAB
ANIXTER'S INFRASTRUCTURE SOLUTIONS LAB

Products. Technology. Services. Delivered Globally.

Anixter's Infrastructure Solutions Lab In Action

Challenge: Leading Pennsylvania University Explores Campuswide Rewiring Project

Anixter Infrastructure Solutions Lab Resolution: The Anixter Infrastructure Solutions Lab was called upon to help this university determine which copper cabling system would best meet its current and future information technology needs. The university had a variety of different copper cabling products installed in its network infrastructure: Category 3, Category 5 and some Category 5e. The Anixter Infrastructure Solutions Lab deployed computer applications that the university typically carried over its cabling infrastructure, including Lotus Notes, SAP and streaming video. Testing found that its current infrastructure was consistently dropping information, causing the network to operate slowly and inefficiently. This same traffic was sent over a Category 6 infrastructure with no degradation to the data. Armed with testing from the Anixter Infrastructure Solutions Lab, university IT professionals wrote cabling infrastructure specifications around a higher performing Category 6 system that better met the university's network performance needs.

Challenge: Major Railway Company Needs Video Surveillance to Monitor Switchyard

Anixter Infrastructure Solutions Lab Resolution: A railroad company wanted to use video surveillance to monitor yards as it assembled unit trains, but it had a big cabling challenge. Installing traditional cabling in the switchyard would have entailed major disruptions and expense for the customer. Instead, Anixter's Infrastructure Solutions Lab recommended a sophisticated wireless Internet video surveillance system that did not require cabling. Anixter was able to simulate the wireless Internet video surveillance solution in the Infrastructure Solutions Lab for the customer. The Infrastructure Solutions Lab also provided this customer with test results illustrating how much bandwidth the video solution would absorb on the customer's network as well as the video quality the customer could expect from the recommended system.

Challenge: National Insurance Company with Data Centre Cabling Choice

Anixter Infrastructure Solutions Lab Resolution: The Anixter Infrastructure Solutions Lab assessed backbone cabling requirements based on the current and future bandwidth needs for this insurance provider. The Anixter Infrastructure Solutions Lab ran representative network traffic over 62.5-micron, 50-micron and laser-optimised 50-micron fibre (OM3) to ascertain which would best meet the company's needs. These tests were key in determining that the OM3 was the customer's best choice.

Anixter's 10 Gigabit Ethernet Cabling Testing

Anixter Infrastructure Solutions Lab is the only UL Certified lab to conduct rigorous, independent third-party testing of emerging 10 Gigabit cabling solutions. Anixter's 10 Gigabit cabling testing examines electrical characteristics such as insertion loss, return loss and crosstalk, but also looks at alien crosstalk (which is part of the Augmented Category 6 spec). To ensure the 10 Gigabit cabling solutions we sell meet the highest levels of performance and reliability, the Anixter Infrastructure Solutions Lab tests the toughest performance parameter, alien crosstalk, in the "worst case" scenario. Customers can rest assured that the cabling solutions Anixter sells will provide the network performance they require.

Anixter's ipAssured program

Anixter's history of technological innovation has led to the development of its ipAssured℠ program. As the company behind the development of the original specifications that became the TIA's Categories, Anixter is committed to embracing and developing new technologies and advancements. The technical experts and research capabilities at Anixter's Infrastructure Solutions Lab allow Anixter to make recommendations that help customers make sound business and technology decisions about their data and security networks.

What is Anixter ipAssured?

Developed and tested at Anixter's Infrastructure Solutions Lab, Anixter ipAssured goes beyond what the standards specify and matches infrastructure solutions to your data center and security applications based on your current and future technical and life cycle requirements.

Return on Investment

The Lab's test have shown how an Anixter ipAssured solution can improve a company's return on investment (ROI) by selecting products for the infrastructure upfront, making the initial capital investment that can save a customer thousands over the lifetime of any infrastructure.

For more information on the ipAssured program, please contact your local Anixter representative or visit anixter.com/ipassured.

Reference Documents for Further Information on Cabling Standards

ANSI/TIA-568-C.0 (2009)
Generic Telecommunications Cabling for Customer Premises

ANSI/TIA-568-C.1 (2009)
Commercial Building Telecommunications Standard

ANSI/TIA-568-C.2 (2009)
Balanced Twisted-Pair Telecommunications Cabling and Component Standard

ANSI/TIA-568-C.3 (2009)
Optical Fibre Cabling Components

ANSI/TIA-1005 (2009)
Telecommunications Infrastructure for Industrial Premises

ANSI/TIA-569-B (2004)
Commercial Building Standard for Telecommunications Pathways and Spaces

ANSI/TIA-942 (2005)
Telecommunications Infrastructure Standard for Data Centres

EN 50174 (2009)
Information Technology - Cabling Installation

EN 50310 (2006)
Application of Equipotential Bonding and Earthing in Buildings with Information Technology Equipment

EN 50173 (2007)
Information Technology-Generic Cabling Systems

IEEE 802.3af (2003)
Power over Ethernet (PoE) Standard

IEEE 802.3an (2006)
Physical Layer and Management Parameters for 10 Gbps Operation, Type 10GBASE-T

Europe and Middle East Locations

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IEEE 802.3at (2009)

Data Terminal Equipment (DTE) Power via the Media Dependant Interface (MDI) Enhancements (PoE Plus)

IEEE 802.3ba (2010)

Media Access Control Parameters, Physical Layers and Management Parameters for 40 Gbps and 100 Gbps Operation

IEEE 802.3-2008 (2008)

Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specification (also known as ANSI/IEEE Std 802.3-1998 or ISO 8802-3: 1990 (E))

IEEE 802.11

Wireless Standard

802.11n (2009)

802.11k (2008)

802.11e (2005)

802.11i (2004)

802.11a (2003)

802.11b (2003)

802.11g (2003)

ISO/IEC 24764 (2010)

Information Technology – Generic Cabling Systems for Data Centres

ISO/IEC 18010:2002 (2002)

Information technology - Pathways and spaces for customer premise cabling

ISO/IEC 11801 (2002)

Generic Cabling for Customer Premises

Obtaining Standards Documents

TIA documents may be purchased through Global Engineering Documents at www.global.ihs.com. IEEE documents may be purchased through www.ieee.org.

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