ISO/IEC 14763-2

Edition 1.1 2015-09
CONSOLIDATED VERSION

INTERNATIONAL STANDARD

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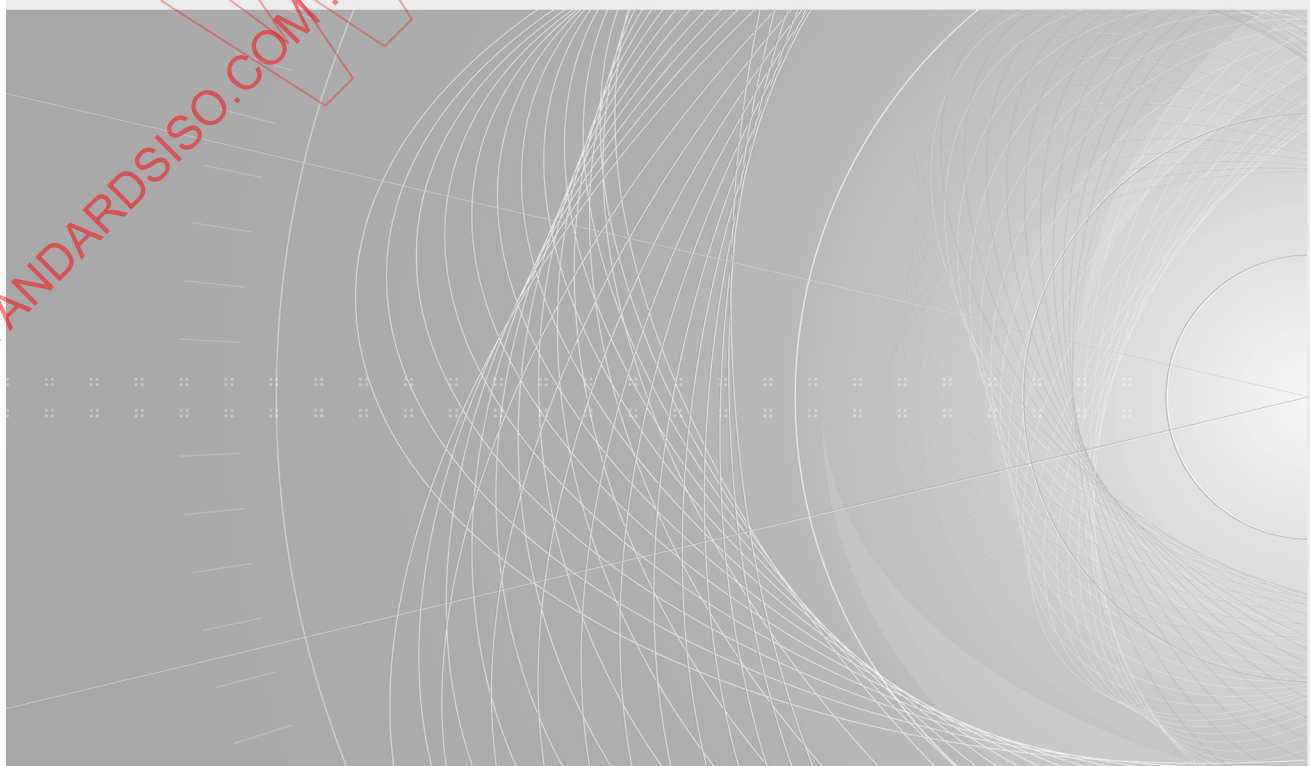
Information technology – Implementation and operation of customer premises cabling –
Part 2: Planning and installation



ISO/IEC 14763-2:2012-02+AMD1:2015:09 CSV(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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Part 2: Planning and installation

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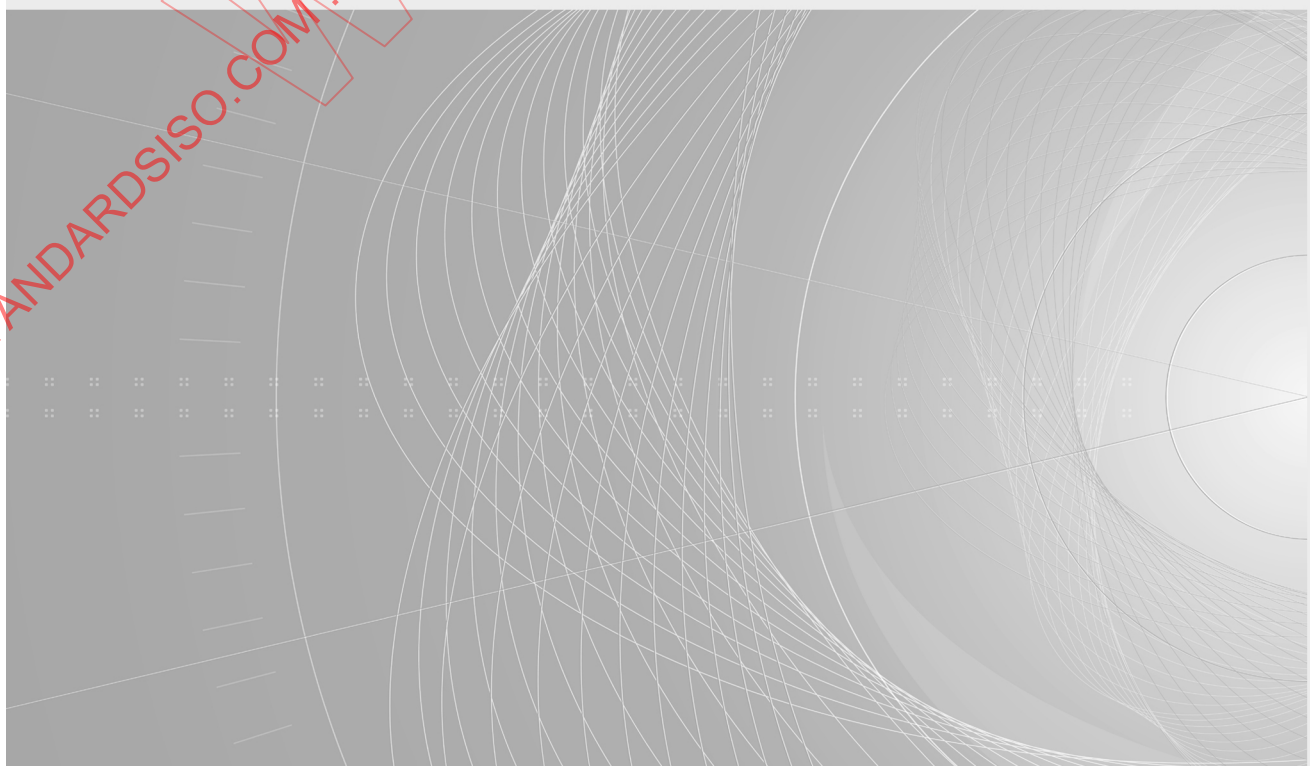

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CONTENTS

INFORMATION TECHNOLOGY – IMPLEMENTATION AND OPERATION OF CUSTOMER PREMISES CABLING –

Part 2: Planning and installation

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

ISO/IEC 14763-2 edition 1.1 contains the first edition (2012-02) and its amendment 1 (2015-09).

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard ISO/IEC 14763-2 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

This edition includes the following significant technical changes with respect to the previous edition:

In addition to the supersession of parts of earlier standards and the incorporation of other standards, this standard provides much greater detail in all aspects of planning and installation with respect to ISO/IEC TR 14763-2 and provides clearly differentiated and directed requirements and recommendations.

The list of all currently available parts of the ISO/IEC 14763 series, under the general title *Information technology – Implementation and operation of customer premises cabling*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The importance of services delivered by information technology cabling infrastructure is similar to that of utilities such as heating, lighting and electricity supplies. As with those utilities, interruptions to service can have a serious impact. Poor quality of service due to lack of planning, use of inappropriate components, incorrect installation, poor administration or inadequate support can threaten an organisation's effectiveness.

There are four phases in the successful implementation of information technology cabling

a) design,

b) specification – the detailed requirement for the cabling, including the planning of its accommodation and associated building services addressing safety and specific environments (e.g. electromagnetic) together with the quality assurance requirements to be applied,

c) installation – in accordance with the requirements of the specification,

d) operation – the management of connectivity and the maintenance of transmission performance during the life of the cabling.

This International Standard supports the specification, implementation and operation of generic information technology cabling designed in accordance with the standards and associated documents developed by ISO/IEC JTC 1/SC 25 and addresses the following topics

- specification depending on the application, environment, building infrastructure and facilities, etc.,
- quality assurance,
- installation planning (including pathways and spaces) depending on the application, environment, building infrastructure and facilities, etc,
- installation practice (including pathways and spaces),
- documentation and administration,
- testing,
- inspection,
- operation,
- maintenance and maintainability (based on any impact from planning and installation),
- repair and repairability (based on any impact from planning and installation).

It does not cover those aspects of installation associated with the transmission of signals in free space between transmitters, receivers or their associated antenna systems (e.g. wireless, radio, microwave or satellite).

The following normative Annexes support specific aspects of planning and installation

- Annex A: Optical fibre polarity,
- Annex B: Common infrastructures within multi-tenant premises.

The requirements and recommendations of the main body of this standard are premises-independent. The following normative Annexes include requirements for generic cabling in accordance with specific standards

- Annex C: Cabling in accordance with ISO/IEC 11801,
- Annex D: Cabling in accordance with ISO/IEC 15018,
- Annex E: Cabling in accordance with ISO/IEC 24764,

- Annex F: Cabling in accordance with ISO/IEC 24702,
- Annex G: Cabling in accordance with ISO/IEC TR 24704.

This standard sets out the responsibilities of information technology cabling installers and premises owners, and is intended to be referenced in relevant contracts. The owners may delegate selected responsibilities to designers, specifiers, operators and maintainers of installed information technology cabling.

This standard is also relevant to

- architects, building designers and builders,
- main contractors,
- designers, suppliers, installers, inspectors (auditors), building managers, maintainers and owners of information technology cabling,
- public network providers and local service providers,
- end users.

This International Standard is one of a number of documents prepared in support of international standards and technical reports for cabling design produced by ISO/IEC JTC 1/SC 25. Figure 1 shows the inter-relationship between these standards and technical reports.

Users of this standard should be familiar with the applicable cabling design standard.

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

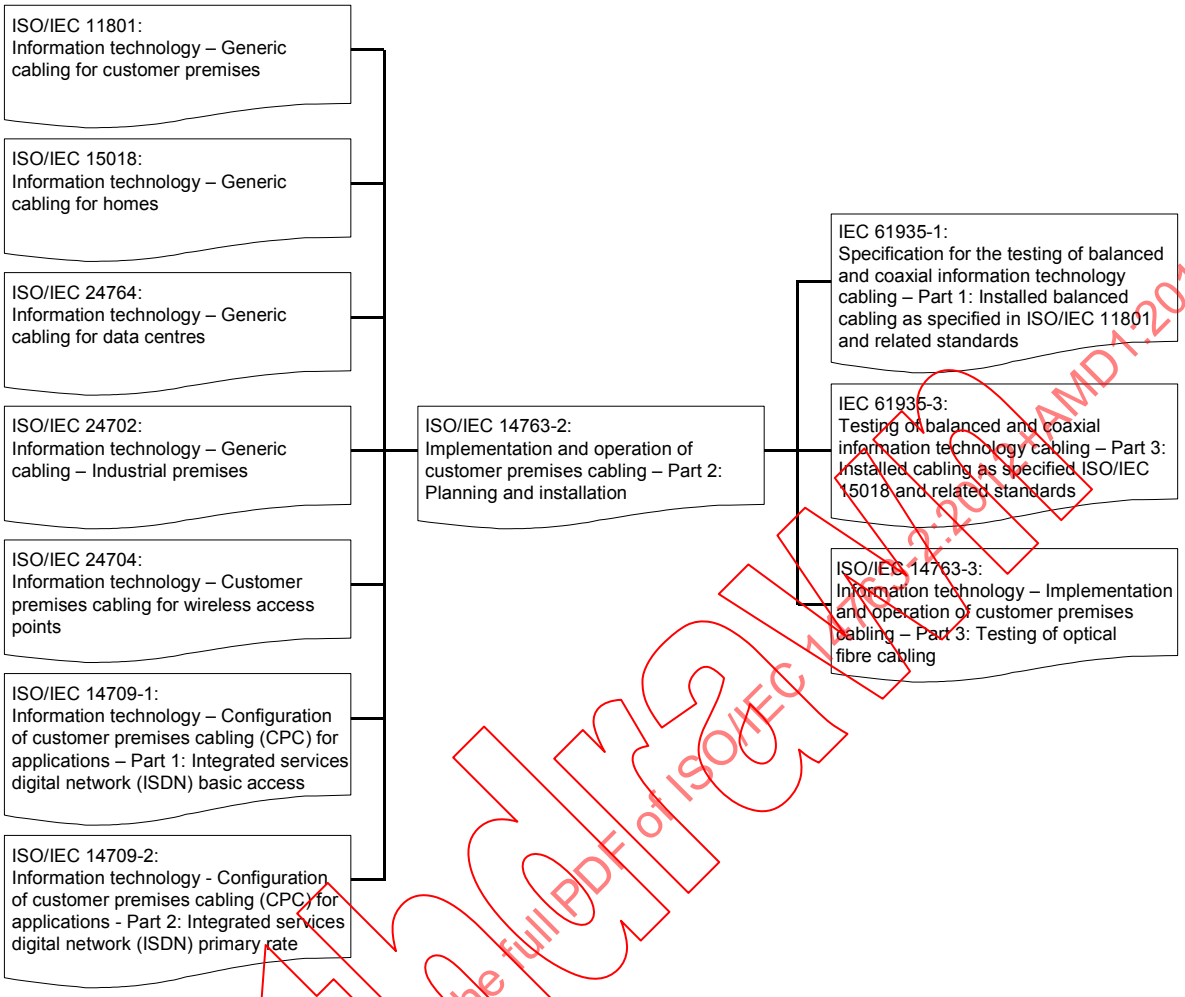


Figure 1 – Schematic relationship between ISO/IEC 14763-2 and other relevant standards

INFORMATION TECHNOLOGY – IMPLEMENTATION AND OPERATION OF CUSTOMER PREMISES CABLING –

Part 2: Planning and installation

1 Scope

This part of ISO/IEC 14763 specifies requirements for the planning, installation and operation of cabling and cabling infrastructures (including cabling, pathways, spaces, earthing and bonding) in support of generic cabling standards and associated documents.

The following aspects are addressed

- specification of the installation,
- quality assurance,
- installation planning,
- installation practice,
- documentation,
- administration,
- testing,
- inspection,
- operation,
- maintenance,
- repair.

The requirements of Clauses 5 to 14 of this standard are premises-independent and may be amended by the requirements of premises-specific Annexes.

This part of ISO/IEC 14763 excludes

- specific requirements applicable to other cabling systems (e.g. mains power cabling); however, it takes account of the effects other cabling systems may have on the installation of information technology cabling (and vice versa) and gives general advice,
- those aspects of installation associated with the transmission of signals in free space between transmitters, receivers or their associated antenna systems (e.g. wireless, radio, microwave or satellite).

This standard is applicable to certain hazardous environments but does not exclude additional requirements which are applicable in particular circumstances (e.g. electricity supply and electrified railways).

Safety (electrical safety and protection, optical power, fire, etc.) and electromagnetic compatibility (EMC) requirements are outside the scope of this international standard and are covered by other standards and regulations. However, information given in this international standard may be of assistance in meeting these standards and regulations.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60364-5-52, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Chapter 52: Wiring systems*

IEC 60794-2, *Optical fibre cables – Part 2: Indoor cables – Sectional specification*

IEC 61082-1, *Preparation of documents used in electrotechnology – Part 1: Rules*

IEC 61084 (all parts), *Cable trunking and ducting systems for electrical installations*

IEC 61156-5 (all parts), *Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring*

IEC 61156-6 (all parts), *Multicore and symmetrical pair/quad cables for digital communications – Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring*

IEC 61386 (all parts), *Conduit systems for cable management*

IEC 61537, *Cable management – Cable tray systems and cable ladder systems*

IEC 61784-5 (all parts), *Industrial communication networks – Profiles*

IEC 61918:2010, *Industrial communication networks – Installation of communication networks in industrial premises*

IEC 61935-1, *Specification for the testing of balanced and coaxial information technology cabling – Part 1: Installed balanced cabling as specified in ISO/IEC 11801 and related standards*

IEC 61935-3, *Testing of balanced and coaxial information technology cabling – Part 3: Installed cabling as specified in ISO/IEC 15018*

IEC 61969-1, *Mechanical structures for electronic equipment – Outdoor enclosures – Part 1: Design guidelines*

IEC 61969-2, *Mechanical structures for electronic equipment – Outdoor enclosures – Part 2: Sectional specification – Coordination dimensions for cases and cabinets*

IEC 62305-4, *Protection against lightning – Electrical and electronic systems within structures*

ISO/IEC 11801:2002, *Information technology – Generic cabling for customer premises*
Amendment 1 (2008)
Amendment 2 (2010)

ISO/IEC 14709-1, *Information technology – Configuration of Customer Premises Cabling (CPC) for applications – Part 1: Integrated Services Digital Network (ISDN) basic access*

ISO/IEC 14709-2, *Information technology – Configuration of Customer Premises Cabling (CPC) for applications – Part 2: Integrated services Digital Network (ISDN) primary rate*

ISO/IEC 14763-3, *Information technology – Implementation and operation of customer premises cabling – Part 3: Testing of optical fibre cabling*

ISO/IEC 15018:2004, *Information technology – Generic cabling for homes*
Amendment 1 (2009)

ISO/IEC 20000-1, *Information technology – Service management – Part 1: Service management system requirements*

ISO/IEC 24702:2006, *Information technology – Generic cabling – Industrial premises*
Amendment 1 (2009)

ISO/IEC TR 24704:2004, *Information technology – Customer premises cabling for wireless access points*

ISO/IEC 24764:2010, *Information technology – Generic cabling systems for data centres*

ISO/IEC TR 29106, *Information technology – Generic cabling – Introduction to the MICE environmental classification*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document the following definitions apply in addition to those of the applicable referenced cabling design standard.

3.1.1
acceptance test (of installed cabling)
contractual test to confirm that the installed cabling satisfies specific aspects of its specification

[IEC 60050-151:2001, 151-16-23 modified]

3.1.2
anchoring guy wire
tensioned cable designed to add support to structures

3.1.3
balun
device for transforming an unbalanced voltage to a balanced voltage or vice-versa

3.1.4
bonding network
BN
set of interconnected conductive structures that provides electromagnetic protection for electronic systems and personnel at frequencies from direct current (DC) to low radio frequency (RF)

3.1.5
(cable) bundle
multiple cables maintained in close proximity, generally by fasteners (e.g. cable ties)

3.1.6
building entrance facility
facility that provides all necessary mechanical and electrical services for the entry of telecommunications cables into a building and which may allow for transition from external to internal cable

3.1.7
cabinet
enclosed construction intended for housing closures and other information technology components and equipment

3.1.8
cable management system
system used for the support and/or containment, retention, protection of all types of cables, information and communication lines, electrical power distribution conductors and their associated accessories

NOTE Includes ducts and tubes housing, or intended to house, blown information technology cables and/or cable elements.

3.1.9
cabling component
any product associated with the cabling installation including cables, connecting hardware, closures, cabinets, frames, racks and pathway systems together with components used to provide earth connections for the cabling installation

3.1.10
catenary wire
dedicated wire used in aerial applications to which information technology cables are attached

3.1.11
closure
fixture or fitting of either open or closed construction intended to contain connecting hardware

3.1.12
civil works
activities required to prepare pathways and pathway systems, particularly external to buildings, prior to the installation of cabling

3.1.13
common bonding network
CBN
principal means for effective bonding and earthing inside a building with information technology equipment

NOTE It is the set of metallic components that are intentionally or incidentally interconnected to form the principal bonding network in a building. These components include: structural steel or reinforcing rods, metallic plumbing, alternating current (AC) power conduit, protective conductors, cable racks and bonding conductors. The CBN is connected to the earthing network.

3.1.14
earth electrode
conductive part, which may be embedded in the soil or in a specific conductive medium, e.g. concrete or coke, in electric contact with the Earth

[IEC 60050-826:2004, 826-13-05; IEC 60050-195:1998, 195-02-01]

3.1.15
earthing conductor
conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode or an earth-electrode network

[IEC 60050-826:2004, 826-13-12; IEC 60050-195:1998, 195-02-03 modified]

3.1.16
electrostatic discharge
ESD
transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

[IEC 60050-161:1990,161-01-22]

3.1.17
electromagnetic disturbance
any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

NOTE An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

[IEC 60050-161:1990, 161-01-05]

3.1.18
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

[IEC 60050-826:2004, 826-13-19; IEC 60050-195:1998, 195-01-10]

3.1.19
frame (rack)
open construction intended for housing closures and other information technology equipment

3.1.20
functional earthing conductor
conductors that are only used for functional earthing (not protection)

3.1.21
hand hole
point of access to a pathway that is too small for a person to enter to perform work but that allows the routing of cables during the cable installation process such that bending and pulling requirements are met (an example of a hand-hole within a building is called a draw-box)

3.1.22
high-voltage
voltage over 1 000 V r.m.s. or 1 500 V DC

3.1.23
home entrance
space at the boundary of a home that may house the interface(s) between the home networks and external networks provided to the home and that demarcate the administration and maintenance of the two networks

3.1.24
identifier
unique item of information to distinguish a specific component of the cabling installation

3.1.25
impedance matching device
device designed to match the impedance of transmission equipment to that of the installed cabling

3.1.26
information technology (telecommunications)
branch of technology concerned with the transmission, emission and reception of signs, signals, writing, images and sounds; that is, information of any nature by cable, radio, optical or other electromagnetic systems

3.1.27
information technology equipment
active or passive equipment necessary to deliver a specific application (e.g. hubs, switches, routers, adapters)

3.1.28
installer
person installing cabling components – no design functions are assumed

3.1.29
isolated bonding network
IBN
bonding network that has a single point of connection to either the common bonding network or another isolated bonding network

NOTE All isolated bonding networks considered here will have a connection to earth through the single point of connection.

3.1.30
junction box
space within a home that enables cables to be routed between pathway systems

3.1.31
label
means of clearly marking a specific component of the information technology infrastructure with its identifier and (optionally) other information

3.1.32
local distribution space
space within a home that houses the area connection point of ISO/IEC 15018

3.1.33
main earthing terminal
terminal or busbar that is part of the earthing arrangement of an installation and enabling the electric connection of a number of conductors for earthing purposes

3.1.34
maintenance hole (telecommunications)
vault/chamber located in the ground or earth as part of an underground conduit system and used to facilitate placing, connectorization, and maintenance of cables as well as the placing of associated equipment, in which it is expected that a person will enter to perform work

3.1.35
meshed bonding network
bonding network in which all associated equipment cabinets, frames and racks are bonded together as well as at multiple points to the CBN

NOTE Consequently, the meshed BN augments the CBN.

3.1.36
met by design
requirement which may be met by calculation and selection of appropriate materials and installation techniques, where either there is no test method specified that allows verification or there is no requirement for verification by testing

3.1.37
metallic information technology cable (cabling)
cables (cabling) utilising metallic conductors for signal transmission

3.1.38
minimum bend radius (installation)
minimum radius as defined by the cable manufacturer, supplier or relevant product standard to which a cable or cable element is allowed to be subjected during installation

3.1.39
minimum bend radius (operating static)
minimum radius as defined by the cable manufacturer, supplier or relevant product standard to which a cable or cable element is allowed to be subjected following installation and fixed in its final operating position

3.1.40
minimum bend radius (operating dynamic)
minimum radius as defined by the cable manufacturer, supplier or relevant product standard to which a cable or cable element is allowed to be subjected under conditions where the cable or cable element is subject to movement during operation

3.1.41
non-deformed mains power supply
mains power supply that excludes the effects of non-linear loads which generate harmonic currents (fluorescent lamps, switch mode power supply devices, etc.)

3.1.42
parallel earthing conductor
PEC
earthing conductor that is parallel to the mains power cable or information technology cable

3.1.43
pathway (cable route, cable way)
defined route for cables between termination points

3.1.44
pathway system
cable management system or other area or volume defined by markings or fittings used to protect and/or support the cabling in order that its desired performance is maintained

3.1.45
PEN conductor
conductor combining the functions of both a protective earthing conductor and a neutral conductor

[IEC 60050-826:2004, 826-13-25; IEC 60050-195:1998, 195-02-12]

3.1.46
premises owner
owner of the premises within which cabling is to be installed and who may delegate the responsibilities specified in this standard to appointed representatives such as designers, specifiers, operators and maintainers of the resulting cabling infrastructures

3.1.47
primary distribution space
space within a home that houses the home distributor (primary home distributor) of ISO/IEC 15018 and associated equipment

3.1.48
protective (earth) conductor
PE
conductor provided for purposes of safety, for example protection against electric shock

[IEC 60050-826:2004, 826-13-22; IEC 60050-195:1998, 195-02-09]

3.1.49
rack
see frame

3.1.50
rack unit
44,45 mm (1.75 inches) of vertical mounting space in an IEC 60297 series standard cabinet or rack

3.1.51
record
collection of information about, or related to, a specific element of the information technology infrastructure

3.1.52
referenced cabling design document
relevant international standard or technical report for cabling design

Refer to ISO/IEC JTC 1/SC 25 and Figure 1 for a list of relevant standards.

3.1.53
secondary distribution space
space within a home that houses a secondary home distributor of ISO/IEC 15018

3.1.54
segregation
physical separation and/or isolation for the purposes of safety, protection of damage to equipment or the prevention of electromagnetic noise from mains power cabling interfering with circuits operating on telecommunications cabling

3.1.55
service loop
excess length of cable or cable element(s)

3.1.56
surge protective device
device intended to protect the electrical apparatus from high transient over-voltages and to limit the duration and frequently the amplitude of the follow-on current

NOTE The device contains at least one non-linear component.

3.1.57
space
specified volume (e.g. room, maintenance hole or part thereof) housing closures and/or other information technology equipment

3.1.58
Stage 1
a possible contractual boundary following the installation of cable but prior to its termination at which testing may be appropriate (certain systems allow the installation of pre-terminated cables which may be subject to Stage 1 testing)

3.1.59
Stage 2
a possible contractual boundary following the completion of cabling installation at which testing may be appropriate

3.1.60
telecommunications
see “information technology”

NOTE The term telecommunications has no legal meaning when used in this standard.

3.1.61
termination point
connection, free connector or fixed connector (as appropriate) fitted to an installed cable and housed within a closure

3.1.62
wall section
fixed-size section of a wall used to mount telecommunications equipment or termination hardware

3.1.63
work order
collection of information which documents the changes requested and the operations to be carried out on the information technology infrastructure

3.1.64
automated infrastructure management system
AIM system
integrated hardware and software which automatically detects the insertion or removal of cords and documents the cabling infrastructure including connected equipment enabling management of the infrastructure and data exchange with other systems

3.1.65
discoverable equipment
equipment with a network address

Note 1 to entry: Discoverable equipment could be treated as non-discoverable equipment per end user choice.

3.2 Abbreviations

For the purposes of this document the following abbreviations apply.

AC	alternating current
AIM	automated infrastructure management
BEF	building entrance facility
BN	bonding network
CATV	community antenna television
CAD	computer aided design
CBN	common bonding network
CER	common equipment room
CSA	cross-sectional area
CTR	common telecommunications room
DC	direct current
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMS	energy management systems
ENI	external network interface
EQP	equipment
ESD	electrostatic discharge
IBN	isolated bonding network
HV	high-voltage
HVAC	heating, ventilation and air conditioning
IDC	Insulation displacement connection
ISDN	integrated services digital network
LV	low-voltage
MAC	move, add, change
MESH-BN	mesh bonding network
MET	main earthing terminal
NVP	nominal velocity of propagation
PE	protective (earth) conductor
PEC	parallel earthing conductor
PEN	conductor combining the functions of both a protective conductor and a neutral conductor
SPD	surge protective device
U	rack unit

3.3 Conventions

Annexes B to G adopt a non-sequential Clause numbering structure in order to clarify and directly reference the Clauses in the main body that are affected by the text of each Annex.

4 Conformance

For planning and installation of cabling and cabling infrastructures to conform to this International Standard

a) the requirements of the applicable generic cabling design standards shall be applied,

b) the specification of the installation shall meet the requirements of Clause 5,

c) the quality planning of the installation shall meet the requirements of Clause 6,

d) the planning of the installation shall meet the requirements of Clause 7,

e) the installation practices shall meet the requirements of Clause 8,

f) the documentation and administration of the installation shall meet the requirements of Clause 9,

g) the testing and inspection of the installation shall meet the requirements of Clauses 10 and 11 respectively,

h) the operation of the installation shall meet the requirements of Clause 12,

i) the maintenance and repair shall meet the requirements of Clauses 13 and 14 respectively,

j) the additional requirements of the applicable premises-specific Annex shall be met,

k) where a lightning protection system is required, it shall conform to the “integrated lightning protection system" according to IEC 62305-4,

l) other lightning protection systems, including the “isolated lightning protection system” according to IEC 62305-3 are allowed provided that specific restrictions are applied both to the implementation of the information technology cabling as agreed between the planners of the lightning protection system and the information technology cabling,

m) local regulations, including safety, shall be met.

5 Specification of installations

5.1 General

This clause in conjunction with Clause 6 describes the key aspects of installation quality assurance as shown in Figure 2.

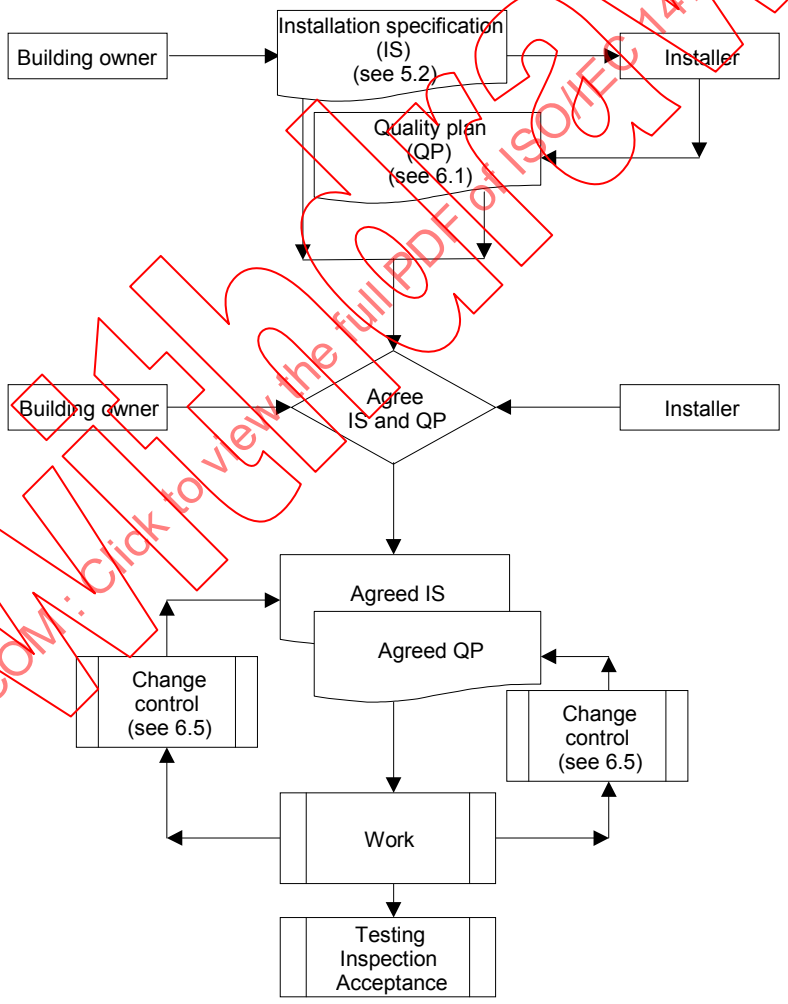


Figure 2 – Quality assurance schematic

5.2 Installation specification

5.2.1 Requirements

5.2.1.1 General

An installation specification shall be produced by, or on behalf of, the premises owner, in accordance with the requirements of this clause. The installation specification shall be agreed with the installer prior to the commencement of the installation.

The installation specification shall comprise

- the technical specification (see 5.3),
- the scope of work (see 5.4),
- quality assurance (see 5.5).

5.2.1.2 Other infrastructures

The installation specification shall detail how the following has been taken into account

- other building services such as mains power distribution and earthing systems,
- building management systems including security, access control, etc.,
- circuits for smoke/fire detection and associated controls,
- heating, ventilation and air conditioning (HVAC) infrastructures,
- industrial machinery (e.g. automation islands as described in Annex F),
- piping systems (water supply and waste, fire suppression, compressed air, machine lubricating oil, hydraulic fluids, dry material and high temperature exhaust ports),
- other relevant infrastructures.

The installation specification shall explicitly state where any of the above do not apply.

5.2.1.3 Legislation, regulations and statements of compliance

Applicable legislation, regulations and statements of compliance shall be detailed including

- building regulations relating to the installation,
- specific site regulations,
- safe working practices,
- external service protection,
- contractors' authorization,
- accreditation of installer personnel.

The installation specification shall explicitly state where any of the above do not apply.

5.2.1.4 Site contacts

The installation specification shall detail the site contacts with responsibilities for

- operational requirements,
- site information (including access and applicable restrictions, knowledge of relevant hazardous areas),
- technical requirements,
- documentation of existing cabling, if relevant,

- compatibility of existing information technology cabling components,
- items to be issued to the information technology cabling installer by, or on behalf of, the premises owner,
- storage of materials,
- removal, disposal and/or recycling of excess and waste material,
- occupational health and safety,
- installation of cabling by a third party,
- main contractor and/or sub-contractors,
- transfer of responsibility and/or property.

5.2.2 Recommendations

The installation specification should reflect predictable expansion to the cabling system, whether from the need to support additional users or increases in quantity or type of applications, with reference to

- pathways and pathway systems,
- cabinets, frames and racks,
- termination points,
- the mains power supply system.

The quantity and location of termination points should reflect the predicted requirements over the intended life of information technology cabling.

The installation specification should contain the elements of the information technology strategy that include details of

- the application(s) to be supported by the installed cabling highlighting, where relevant, current and future requirements,
- external service provision and its interface(s) to the information technology cabling (see Clause 7),
- resilience planning,
- security requirements/access restrictions.

5.3 Technical specification

5.3.1 General

5.3.1.1 Requirements

The technical specification shall contain details of, and the performance requirements for, the cabling and associated components. The technical specification forms the basis of assessment of the performance of installed cabling together with all cabling components and installation techniques used.

The technical specification shall cover both new installations and extensions of existing installations.

The technical specification shall detail the location of, and requirements for, any relevant external network interfaces (ENIs) (see Clause 7).

The technical specification shall define the

- level of administration system to be applied to the cabling infrastructure (see Clause 9,

- range of documentation to be supplied by the installer including any requirements to link records to each other and to other building services records,
- format of the documentation (see Clause 9),
- labelling to be undertaken by the installer (see Clause 9),
- specification of labels (as a minimum, meeting the requirements of Clause 7),
- requirements for acceptance testing (see Clause 10),
- requirements for inspection (see Clause 11),
- requirements for the treatment of parts of the installation that do not comply with the requirements for inspection and acceptance testing,
- the format of test result and inspection documentation (see Clauses 10 and 11) which shall contain the pass/fail results of the acceptance tests, where required, and any actions taken to repair or correct installation failures.

5.3.1.2 Recommendations

The technical specification should detail the requirements for the

- physical and operational lifetime of the cabling installation,
- provision of facilities necessary to support the installation of additional termination points over the intended operational life of the installed cabling.

5.3.2 Safety requirements

The technical specification shall

- identify and classify any hazards within the pathways and at termination points,

  NOTE The hazard classification of areas containing, or intended to contain, optical fibre information technology equipment and optical fibre information technology cabling is described in IEC 60825-2 and is used to define appropriate installation and labelling practices.

- detail the boundaries of areas containing hazards, or potentially hazardous areas.

5.3.3 Security requirements

The technical specification shall detail measures required to prevent unauthorised access to pathways, pathway systems, closures, cabinets, frames, racks and cords.

5.3.4 Performance and configuration – Requirements

The technical specification shall detail the required transmission performance of the cabling to be installed

- when subject to the defined operational environment (see 5.3.5),
- in conjunction with existing cabling.

The environmental compatibility shall be achieved by selection of appropriate components and/or by mitigation techniques that modify the environment to which the component is subjected including

- isolation from the defined environment (by means of protection/segregation),
- separation from the defined environment.

The technical specification shall detail any mitigation products or techniques necessary to allow the components selected to be installed and operate as specified when subjected to the defined environmental conditions.

The technical specification shall detail the

- pin-pair assignment for balanced cable elements at interfaces to the installed cabling,

NOTE 1 Annex A provides information about possible connections between the wires and the pins of information technology outlets within generic cabling systems in accordance with the referenced cabling design document. The same set of pin-pair combination should be used throughout the whole cabling installation.

- positioning of optical fibres at interfaces to the installed cabling.

NOTE 2 Annex A contains requirements and recommendations for the maintenance of polarity within cabling terminated with connecting hardware housing multiple optical fibres.

The technical specification shall contain the requirements for

- the pathways, pathways systems, cabinets, frames, racks, closures, cables, termination points and cords (see Clause 7),
- the functional earthing and equipotential bonding of cabling components and accessories.

5.3.5 Environmental conditions

5.3.5.1 Requirements

The technical specification shall detail the intended installation and operational environmental conditions.

The MICE classification system described in ISO/IEC TR 29106 shall be used where the intended installation and operational environmental conditions lie within the boundaries defined by $M_3I_3C_3E_3$. In addition, the following environmental conditions shall be taken into account:

- biological attack (e.g. mould or fungal growth);
- physical damage (accidental or malicious) including damage caused by animals;
- presence, or potential presence, of hazards (such as contaminating, toxic or explosive materials);
- the movement of air (e.g. caused by fans, heating and ventilation systems);
- meteorological effects (e.g. wind);
- impact of natural events e.g. lightning strike, earthquake.

NOTE A number of standards exist for the classification of environments relevant to information technology components and equipment. Reference should be made to the IEC 60721 series of standards.

5.3.5.2 Recommendations

The technical specification should include a risk assessment including abnormal environmental conditions (temperature changes, flooding) which should result in a risk management plan that may have an effect on the requirements for component performance or mitigation.

5.4 Scope of work

5.4.1 Pre-installation

5.4.1.1 Requirements

The scope of work shall detail requirements for

- any building work required on each pathway,
- pathway preparation and the installation of pathway systems,

- accommodation of the terminating devices for external (outdoor) and internal (indoor) cables at building entrance facilities,
- the quantities of cabling components and installation accessories,
- the protective earthing, functional earthing and equipotential bonding of pathway systems,
- additional surveys to be undertaken to supplement information in the scope of work.

The scope of work shall define

- the responsibilities for the identification, design and completion of the works involved,
- the responsibilities for obtaining all necessary clearances and permits,
- requirements for site-specific safety inductions and training requirement,
- the location of storage facilities for cabling components and installation accessories,
- a system for the disposal of waste components and/or installation materials.

5.4.1.2 Recommendations

The scope of work should contain

- site plans that are marked up to show the works required,
- details of the facilities (such as telephone and accommodation) to be used by the installer,
- details of the processes operating on the premises, for the duration of the installation, for the delivery of, storage of, access to and removal of, materials.

5.4.2 Installation

5.4.2.1 Requirements

The scope of work shall detail locations of

- spaces,
- pathways,
- cabinets, frames and racks,
- closures,
- termination points,
- relevant earthing points.

The scope of work shall detail requirements for

- warning signs and equipment to ensure safe working,
- the pathway systems to be used in each pathway,
- the cables to be installed in each pathway,
- jointing and/or termination at each termination point,
- the protective earthing, functional earthing and equipotential bonding of cabling components,
- marking and labelling the cabling components,
- the quantity and type(s) of inspection and testing to be applied to the cabling installation.

The scope of work shall define an installation programme detailing key dates including

- requirements for progress meetings,
- attendance at contract inspection points,

- final installation date,
- the date that the installation documentation is to be supplied,
- the date that the installation is to be brought into service,
- hand-over date(s).

The scope of work shall detail

- items to be provided by information technology cabling installer,
- items to be issued to the information technology cabling installer by, or on behalf of the premises owner,
- other works with potential to affect the programme,
- access limitations together with restrictions on personnel movement, vetting and clearance levels,
- the responsibilities for the identification, design and completion of the works involved,
- the responsibilities for obtaining all necessary clearances and permits,
- applicable fire precautions and escape routes,
- site access and security arrangements.

5.4.2.2 Recommendations

The scope of work should contain

- site plans that are marked up to show the works required,
- details of the facilities (such as telephone and accommodation) to be used by the installer,
- details of a system of materials control.

During the development of the scope of work, testing should be considered:

- where application-specific cabling is to be used to support a more demanding application;
- where extending or modifying an undocumented installation.

5.4.3 Post-installation

5.4.3.1 Requirements

The scope of work shall detail requirements for reinstatement and shall define

- the responsibilities for the identification, design and completion of the works involved,
- the responsibilities for obtaining all necessary clearances and permits (where not covered by those obtained in 5.4.2.1),
- a maintenance and control procedure for the final cabling documentation.

5.4.3.2 Recommendations

The scope of work should detail requirements for

- operational training including safety,
- maintenance training for the premises owner and/or the designated cabling maintainer,
- fault analysis training,
- repair and maintenance contracts,
- spares, e.g. cable, cords, closures, connecting hardware, tools, test equipment and test leads.

5.5 Quality assurance

The installation specification shall

- contain a list of the items to be addressed in the quality plan applicable to the installation as defined by, or on behalf of, the premises owner,
- identify the responsibilities for any additional tasks necessary to allow agreement of the quality plan (see Clause 6).

NOTE For installations of cabling in accordance with ISO/IEC 15018 in single homes, quality plans are not required but may be requested.

6 Quality planning

6.1 Quality plan

A quality plan addressing the requirement of the installation specification shall be produced by, or on behalf of, the installer in accordance with the requirements of this standard. The quality plan shall be agreed with the premises owner prior to the commencement of the installation.

NOTE For installations of cabling in accordance with ISO/IEC 15018 in single homes, quality plans are not required but may be requested.

The quality plan shall clearly state the measures and procedures to be adopted to demonstrate compliance with

- the requirements of this standard,
- the requirements of the referenced cabling design document,
- the installation specification.

The quality plan shall detail the procedures

a) for the transfer of responsibilities between the installer, premises owner and, where relevant, other contractors,

b) for the acceptance of cabling components and the cabling installation (including verification of physical, mechanical, optical and/or electrical specifications based on the manufacturers' or suppliers' specifications and relevant standards),

NOTE Cabling components to be installed may be supplied by the installer or by, or on behalf of, the premises owner.

c) to be adopted to assess compatibility between cabling components to be used during the installation,

d) to be adopted to assess compatibility with any existing installed cabling,

e) to address the impact of potential component incompatibilities,

f) to ensure the selection of appropriate cords to extend the fixed portion of the cabling to create channels.

Where, at any point during the installation process, inspection and/or testing of cabling components or installed cabling is specified in the installation specification, or by local regulations, the quality plan shall detail the

- inspection and test equipment,
- the calibration status of the inspection and test equipment,
- sampling plans (see 6.2),
- measurement procedures (see Clause 10),

- treatment of results which are non-compliant or marginal (i.e. within the specified measurement accuracy of the test system), see 6.2.

The quality plan shall detail the competency of personnel to undertake the installation in accordance with the installation specification.

Where sampling plans are applied, the quality plan shall detail the procedures (for example, extension of sampling procedures) to be adopted if sample testing identifies results which are non-compliant or marginal (i.e. within the specified measurement accuracy of the test system), see 6.2.

6.2 Sampling

6.2.1 Balanced cabling

6.2.1.1 General

Table 1 shows three groups of balanced cabling transmission parameters (basic verification, internal transmission and alien (exogenous) crosstalk) using the parameters that define the Classes of links and channels within the referenced cabling design standards. This subclause specifies requirements and recommendations for the testing of these parameter groups. The test procedures and equipment for balanced cabling links and channels are specified in Clause 10.

Requirements are defined for other transmission parameters but are considered to be met by design.

Table 1 – Installed balanced cabling test parameters

Parameter group	Transmission parameter
Basic verification	Wire-map
	Continuity (d.c.) – Signal conductors – Screen conductors (if present) [a] – Short circuits – Open circuits
Internal transmission	Return loss
	Insertion loss
	Pair-to-pair NEXT
	PS NEXT
	Pair-to-pair ACR-N
	PS ACR-N
	Pair-to-pair ACR-F
	PS ACR-F
	Direct current (d.c.) loop resistance
	Propagation delay
	Delay skew
Alien (exogenous) crosstalk	PS ANEXT
	PS $ANEXT_{avg}$
	PS AACR-F
	PS $AACR\text{-}F_{avg}$

[a] It shall be ensured that continuity be provided by the cabling components and

not by alternative connections such as protective earth conductors.
NOTE Link or channel length may also be of interest, but is not a pass/fail criterion.

It is recommended that installation specifications require the acceptance testing of permanent links since permanent link requirements incorporate an adequate margin to support the expected variability of the cords used to create channels.

NOTE A conformant channel containing a permanent link does not ensure that other channels created from that permanent link will themselves be conformant to channel requirements.

6.2.1.2 Permanent link testing

Independent of the requirements of the installation specification, basic verification parameters of Table 1 shall be tested using a sample level of 100 %.

Where the installation specification requires acceptance testing of internal transmission parameters of Table 1 against the permanent link requirements of Classes D, E, E_A, F or F_A the sample level applied should be 100 %.

Where the installation specification requires acceptance testing of alien (exogenous) transmission parameters of Table 1 against the permanent link requirements of Classes E_A, F or F_A the minimum sample level applied should be in accordance with 6.2.1.4.

6.2.1.3 Channel testing

In all cases, independent of the requirements of the installation specification, basic verification parameters should be tested using a sample level of 100 %.

Channel tests may be used to determine performance where the installation specification requires

a) one or more cords to be added to each end of a permanent link of a given Class to create a channel of the same or lower Class,

b) permanent links of a given Class to be interconnected and one or more cords are added to each end to create a channel of a lower Class,

c) any cords attached to a permanent link of a given Class (or within a channel of a given Class) to be changed,

d) cabling implementations for which there are no permanent link limits (where standards do not contain requirements or where the installation specification contains channel requirements different from those specified in the referenced cabling design standards),

e) lengths and configurations of cabling that lie outside the reference implementations of the referenced cabling design standards.

In cases a), b), and c), where the installation specification requires acceptance testing of internal transmission parameters of Table 1 against the permanent link requirements of Classes D, E, E_A, F or F_A the sample level applied should be 100 %. A lower sample level may be applied to channel testing provided that the associated risk of undiagnosed faults is recognised in the Quality Plan.

In cases d) and e), where the installation specification requires acceptance testing of internal transmission parameters of Table 1 against the requirements of channel Classes D, E, E_A, F or F_A the sample level applied should be 100 %.

Where the installation specification requires acceptance testing of alien (exogenous) transmission parameters of Table 1 against the requirements of a specific channel Class the minimum sample level applied should be in accordance with 6.2.1.4.

6.2.1.4 Alien (exogenous) crosstalk testing

Where the installation specification requires acceptance testing of alien (exogenous) crosstalk transmission parameters of Table 1 of installed permanent links or channels against the requirements of permanent link or channel Classes E_A or F_A of ISO/IEC 11801, the minimum sample of disturbed permanent links or channels to be tested should be in accordance with Table 2.

Table 2 – Minimum sample sizes for alien (exogenous) crosstalk testing

Total no. of links/channels N	Sample size
3 to 150	3 or 0,1 × N (whichever is the greater)
151 to 3,200	33 [a]
3 201 to 35 000	126 [a]
35 001 to 150 000	201 [a]
150 001 to 500 000	315 [a]
[a] Equivalent to acceptance quality level (AQL) of 0,4 %, normal inspection, general inspection level I as defined in ISO 2859 series for populations of up to 500 000 links.	

The sample quantity shall be subject to the selection criteria as specified in IEC 61935-1.

IEC 61935-1 contains an option to reduce the quantity of tests provided that evidence exists to indicate that measured performance exhibits adequate margin against the specified limit.

6.2.2 Optical fibre cabling

6.2.2.1 General

Table 3 shows two groups of optical fibre cabling transmission parameters (basic verification and transmission) using the parameters that define the Classes of links and channels within the referenced cabling design standards. This subclause specifies requirements and recommendations for the testing of these parameter groups. The test procedures and equipment for optical fibre cabling links and channels are specified in Clause 10.

Table 3 – Installed optical fibre cabling test parameters

Parameter group	Transmission parameter
Basic verification	Polarity
Transmission	Attenuation
	Length (propagation delay)

6.2.2.2 Permanent link testing

Where the permanent link contains non-fixed cabling (e.g. CP cord in ISO/IEC 11801 and LDP cord in ISO/IEC 24764) any result is only applicable to the specific configuration under test.

Independent of the requirements of the installation specification, basic verification parameters of Table 3 shall be tested using a sample level of 100 %.

Where the installation specification requires acceptance testing of transmission parameters of Table 3 against the requirements of a specific permanent link Class and

- where testing of optical fibre cabling attenuation is undertaken with equipment that also automatically tests verification parameters, a sample level of 100 % should be used,
- where testing of propagation delay/length is undertaken with equipment that also automatically tests verification parameters, a sample level of 100 % should be used,
- provided that polarity has been confirmed, testing of length/propagation delay may be restricted to a sample level within a given cable containing a number of permanent links or within a number of cables running in common pathways.

6.2.2.3 Channel testing

Channel tests may be used to determine performance where the installation specification requires

a) one or more cords to be added to each end of a permanent link of a given Class to create a channel of the same or longer Class,

b) permanent links of a given Class to be interconnected and one or more cords are added to each end to create a channel of a longer Class,

c) any cords attached to a permanent link of a given Class (or within a channel of a given Class) to be changed,

d) cabling implementations for which there are no permanent link limits (where standards do not contain requirements or where the installation specification contains channel requirements different to those specified in the referenced cabling design standards).

Where channel tests are undertaken, the actual cords used to create the channel shall be used and installed in the as-built configuration. In all cases, the sampling recommendations of 6.2.2 apply.

6.3 Treatment of marginal results

6.3.1 Balanced cabling

6.3.1.1 General

IEC 61935-1 requires that test results of individual parameters be marked with an asterisk if the difference between the measured result and the test limit is less than the specified measurement accuracy.

The measurement accuracy is generally dependent on the field tester test limit, the nature of the test adapters, and actual link properties and is dependent on the frequency at which the minimum test margin occurs.

6.3.1.2 Requirements

The quality plan shall include guidelines on how marginal test results are handled.

As examples, the quality plan may state that

- marginal pass results shall be accepted but marginal fail results shall not be accepted,
- marginal results shall not be accepted,

NOTE This implies that the performance of the installed cabling has sufficient margin to accommodate the measurement accuracy of the tester to be used and that the tester measurement accuracy to be used is known.

- marginal results shall be accepted: meaning that the fail limit is less stringent, as compared to the required limit, by the uncertainty of the field tester.

To minimize marginal test results, the quality plan shall specify the properties of the field tester that is used for testing. Field test equipment with better accuracy than the minimum specified in IEC 61935-1 for a given cabling performance and frequency range should be used.

6.3.2 Optical fibre cabling

ISO/IEC 14763-3 does not require that test results of individual parameters be marked with an asterisk if the difference between the measured result and the test limit is less than the specified measurement accuracy.

6.4 Treatment of non-compliant results

The quality plan shall detail the procedures to be applied where it has been impossible to obtain a compliant result. Examples of such procedures include labelling the cabling appropriately and highlighting its status and the impact of the non-compliance in the installation documentation.

6.5 Change control

All modifications, changes and variations to the installation specification and quality plan should be clearly documented to enable traceability.

7 Installation planning

7.1 General

This clause details requirements and recommendations for planning of installations. It covers

- pathways and spaces,
- functional elements of the referenced cabling design standards,
- segregation from mains power cabling,
- support for installation practices (e.g. bend radius, pulling load).

Cabling for all relevant telecommunication services shall be considered when the installation is planned including

- voice,
- data,
- video,
- fire, security and access control systems,
- other building signalling systems (e.g. HVAC, EMS),
- machine control.

7.2 Safety

7.2.1 General

The specification of safety requirements is beyond the scope of this International Standard. It is referred to those safety standards and regulations applicable at the location of the installation.

7.2.2 Mains power cabling

The proper implementation of the requirements of this standard assume that electrical installations, bonding networks and protective measures against overlvoltages are undertaken in accordance with the local regulations, as appropriate.

NOTE The IEC 60364 series may contain appropriate information.

In addition, installation and mitigation guidelines for electrical installations (including earthing) to ensure electromagnetic compatibility may be found in IEC TR 61000-5-2.

7.2.3 Optical fibre cabling

The hazard classification of areas containing optical fibre information technology equipment and optical fibre information technology cabling shall be undertaken in accordance with IEC 60825-2 to define appropriate installation and labelling practices.

7.3 Environment

The MICE concept according to ISO/IEC TR 29106 shall be used to describe the environment where the cabling or parts of the cabling will be located.

Product and/or supporting systems shall be selected, where appropriate, to provide sufficient protection from the environment to enable the cabling to meet the required transmission performance.

7.4 Points of electrical contact

The long term stability of electrical connections including earth connections and connections between sections, or parts of pathway systems depends on the galvanic coupling of the materials used. Where risk of galvanic corrosion exists relevant specialists shall be consulted and any measures taken shall be documented for future use.

7.5 External service provision

7.5.1 Requirements

Information shall be obtained from, and agreement reached with, the external service provider(s) with respect to

a) the precise physical location of the ENI(s),
b) the quantity and capacity of the components that provide the ENI(s),
c) the identification and numbering of individual circuits at each ENI,
d) any additional options required,
e) the responsibility of the technical and operational maintenance of the boundary of the external service provision,
f) the liaison arrangements for the external service provider(s) and the premises owner or an appointed representative,
g) the procedures to be followed by the premises owner or an appointed representative in reporting and reacting to faults in the external service provision,
h) arrangements for access to the premises,
i) technical requirements for equipment supplied by the external service provider(s).

7.5.2 Recommendations

External service provider(s) should be advised of the foreseeable service requirements.

7.6 Pathways and pathway systems

7.6.1 General

7.6.1.1 Pathway system types

Examples of pathway systems that may be used are shown in Table 4.

NOTE If a pathway system, cable management system or a compartment of a cable management system is selected to support a specific cabling technology, it may not be suitable for the subsequent installation of other cabling technologies.

Table 4 – Examples of pathway systems

Pathway systems	Features
Cable trunking systems	Enclosed containment systems – consisting of a base and access cover, providing an enclosure for cables or insulated conductors and possible electrical and or communications accessories. Single or multiple compartment forms. Available in metallic or non-metallic form.
Cable tray systems	Open containment systems, consisting of a base and side members, intended to house cables and to provide support for the contained cable when used in horizontal pathways. Cable tray systems are mainly used in floor/ceiling spaces or in restricted access areas (e.g. above suspended ceiling, basements, plant rooms, telecommunications spaces etc.). Available in metallic or non-metallic form.
Wire mesh cable tray system (basket)	A form of cable tray system where the cable tray consists of a mesh of wires. Typically available in metallic form.
Cable ladder systems	Open containment systems, consisting of side members, fixed to each other by means of rungs, intended to house cables and to provide support for the contained cable when used in horizontal pathways. Cable ladder systems are mainly used in horizontal and vertical pathways. Available in metallic and non-metallic form.
Conduit systems	Enclosed containment systems of circular cross-section, providing an enclosure for cables or insulated conductors. Available in metallic or non-metallic form.
Cable ducting systems	Enclosed containment systems of non-circular cross-section, providing an enclosure for cables or insulated conductors and possibly electrical and or communication accessories. Available in metallic or non-metallic form.
Interval support	Open support system installed with appropriate spacing. Designed to support small to medium number of cables and normally used above suspended ceiling or below raised floors. Available in a range of forms (e.g. hooks and fasteners) and materials (metallic or non-metallic).
Designated routes	Pathways defined by markings or some other designation, normally used in floor spaces or within hollow walls or other building structures.
Catenary	A suspended strength member to which single or multiple cables may be attached to span an open space. Available in metallic or non-metallic form. In some cases the cable is designed as a catenary cable and contains an integral catenary strength member.

7.6.1.2 Pathway systems – Requirements

Access to pathways and pathway systems containing the cabling infrastructures serving multiple premises (enterprises, tenants, etc.) shall be restricted as specified in Annex B.

Elements of other supply systems such as water, heating, HVAC or sprinklers shall not be used as pathways or support for pathway systems due to the potential environmental impact and the risk that cable support will disappear by change to the supporting system.

The inside of the pathway systems shall

- have smooth surfaces and be free of burrs, sharp edges or projections that can damage cable insulation,
- be free of localised pressure points that may degrade the transmission performance of the installed system.

Abrasive supports (e.g. threaded rod) installed within the cable fill area shall have that portion within the pathway system protected with a smooth, non-scratching covering so that cable can be pulled without physical damage.

Cable management systems of the types listed below shall comply with the relevant international standards

- conduit systems: IEC 61386 series,
- cable trunking systems and cable ducting systems: IEC 61084 series,
- cable tray systems and cable ladder systems: IEC 61537.

Where pathway systems take the form of non-enclosed cable management systems to which cables are to be attached or supported by (e.g. dedicated/catenary wires or designated routes) then the cross-sectional area shall be considered to be the minimum available area surrounding the pathway system.

Segregation between mains power cabling and metallic telecommunications cabling shall be in accordance with 7.9.

Where separation between different cabling systems is required, it shall be maintained by physical separation to prevent accidental change during installation or extensions to the installation.

7.6.1.3 Recommendations

7.6.1.3.1 Pathway and pathway system selection

It is recommended that the planning of pathways and the selection of pathway systems is undertaken using a structured approach and addressing each cabling sub-system in turn. For example, for cabling in accordance with ISO/IEC 11801

a) the campus backbone cabling sub-system,
   1) between building entrance facilities (BEFs),
   2) between BEFs and distributors,
b) the building backbone cabling sub-systems,
c) the horizontal cabling sub-systems.

Pathway systems should be selected to ensure that water or other contaminant liquids cannot collect. The use of hidden pathways (such as within plastered wall surfaces) is not recommended but, if used, cabling should have either vertical or horizontal orientation.

7.6.1.3.2 Pathway and pathway system capacity planning

It is recommended to plan the pathway systems for the maximum predicted deployment of cabling. This can be achieved either by deploying sufficient pathway systems at the time of installation or by planning and reserving space for sufficient additional pathway systems.

The planning of pathway systems should provide adequate capacity to allow subsequent installation of an additional 40 % of telecommunications cables whilst maintaining minimum bend radii and segregation from mains power cabling (see 7.8).

7.6.2 Inside buildings

7.6.2.1 Requirements

7.6.2.1.1 Pathway systems

Pathway systems shall be installed to provide adequate protection to the installed cabling where cabling can be damaged or have its transmission properties adversely affected.

The use of hidden pathways within plastered wall surfaces requires the use of appropriately specified cables.

In fixed installations where impact to the installed cabling can occur (specifically including all cabling within 50 mm above floor level) protection shall be afforded by one or more of the following

- the mechanical characteristics of the pathway system,
- the location selected,
- the provision of additional local or general mechanical protection.

The selection of pathway systems shall enable the installation of fire barriers, if required.

Appropriate space shall be allocated to hand holes and the storage of cable loops (service loops) in accordance with manufacturer's instructions (see 7.6.2.1.2 in relation to minimum bend radius).

7.6.2.1.2 Minimum bend radii

The pathway system shall ensure that cable is able to be installed and, where appropriate, fixed in accordance with the applicable minimum bend radius (installation, operating – static and operating – dynamic) by using identifiable techniques. These requirements apply in three dimensions. Examples of such techniques are pre-fabricated curved corners and radius limiters as shown in Figure 3.

The techniques employed shall

- be designed to maintain the relevant minimum bend radius of the cable(s) to be installed; where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with dedicated/catenary wires attached), the largest minimum bend radius shall apply,
- not introduce deformation of the cable sheath,
- not apply compressive loads exceeding that specified for the cable.

Minimum bend radius is determined by manufacturers instructions. If instructions do not exist the following shall apply

- the minimum bend radius for balanced cables containing up to 4-pairs shall be 50 mm,
- the minimum bend radius for optical fibre cables in accordance with IEC 60794-2-21 and containing up to four optical fibres shall be 50 mm,
- the minimum bend radius for other optical fibre cables shall be 10 times the cable diameter and shall not be less than 30 mm,
- the minimum bend radius for coaxial cables shall be 10 times the cable diameter,

- the minimum bend radius for other metallic telecommunications cables shall be 8 times the cable diameter.

NOTE 1 Pathway systems that do not allow such an approach may restrict the type and use of cables installed in the pathways and cable management systems selected.

NOTE 2 Specific cable constructions, e.g. armoured cables, may require greater bend radii than those specified above.

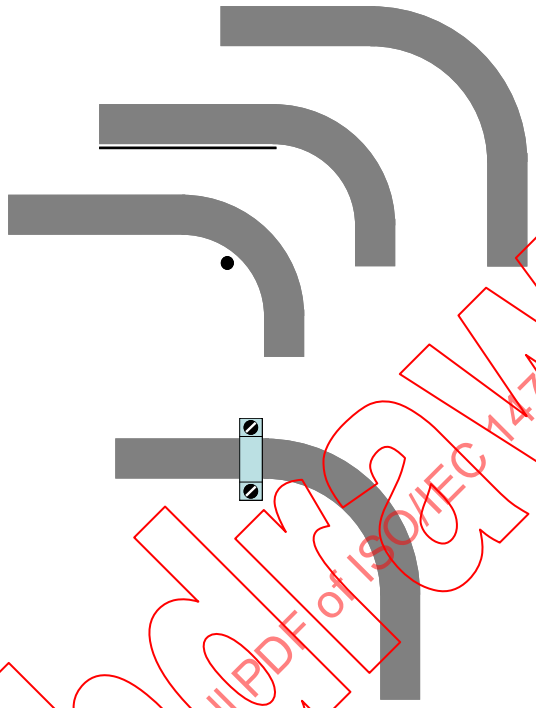


Figure 3a – Examples of non-conformant bend limiting techniques

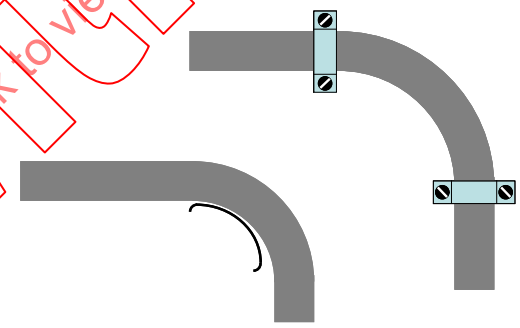


Figure 3b – Examples of conformant bend limiting techniques

Figure 3 – Example of conformant and non-conformant bend radius management

7.6.2.1.3 Maximum stacking height

The maximum stacking height in pathway systems is determined by manufacturers' instructions. If instructions do not exist the following shall apply

- for continuous pathway systems (e.g. cable trays), the stacking height shall not exceed 150 mm,

- for non-continuous pathway systems (e.g. wire mesh cable tray, cable ladder) and interval support pathway systems (e.g. hooks) the maximum stacking height shall be calculated according to Table 5.

Table 5 – Stacking height for non-continuous and interval support pathway systems

Distance between support distance l in mm	**Formula**	**Maximum stacking height** height h in mm
0	$h = 150/(-l*0{,}000\ 7+1)$	150
100		140
150		136
250		128
500		111
750		98
1 000		88
1 500		73

7.6.2.1.4 Conduit

Where conduits are installed without bends, the maximum distance between pulling points shall be 100 m unless appropriately specified cables and/or installation techniques are to be used.

Where a conduit contains bends

- the conduit shall not be subject to cumulative changes in direction of more than 180° between pulling points,
- the conduit shall not contain more than two bends of up to 90° each between pulling points (e.g. outlets, telecommunications rooms, or pull boxes),
- the maximum distance between pulling points shall be 15 m.

Bends within conduits shall be accessible and able to act as pulling points unless no additional cables are to be installed within the conduit, following the initial installation of cable, unless

- cables are to be removed before any additional installation takes place,
- the conduit contains sub-ducts to allow additional cables to be installed.

The inside radius of a bend in conduit shall be at least 6 times the internal conduit diameter. Bends in the conduit shall not contain any kinks or other discontinuities that may have a detrimental effect on the cable sheath during cable pulling operations.

Conduits should be considered as “full” when the cross-sectional area of the planned/installed cables reaches 40 % of the conduit cross-sectional area.

7.6.2.1.5 Non-continuous support for cables

The maximum distance allowed between supporting elements of the pathway system is 1 500 mm.

7.6.2.2 Recommendations

7.6.2.2.1 Pathway system capacity planning

Where bundles of cables are to be used, they should not contain more than 24 cables to reduce risk of stress and compression at bends.

7.6.2.2.2 Cable protection

The use of curved corners (pre-fabricated or manufactured on site) should be considered to maintain cable bend radii and avoid over-filling around bends (see Figure 4).

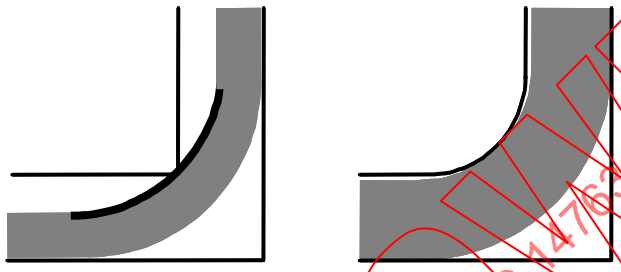


Figure 4 – Example of use of curved corners in pathway systems

7.6.2.2.3 Conduit

Where conduits are installed without bends, the maximum distance between pulling points should be 50 m unless appropriately specified cables and/or installation techniques are to be used.

Conduits (or ductings) protruding through a floor should be terminated at least 50 mm above the finished floor surface.

NOTE This protrusion aids in preventing poured concrete from entering the pathway during construction and protects cabling and fire-stop materials from water and other liquid spills.

7.6.3 Outside buildings

7.6.3.1 General

In installations outside buildings, such as those shown in the example of Figure 5, it is commonly required to consider other factors (visible and hidden) which might have an environmental impact on the information technology cabling. These include

- high voltage underground cables or overhead lines (electromagnetic impact),
- steam pipes (temperature impact),
- flooding (ingress impact),
- chemical contamination (liquid, gas),
- roads or railroad tracks (mechanical impact).

Where possible, the installation of information technology cabling in such areas affected by these factors should be avoided. However, where national or local regulations allow, mitigation may be applied by selecting appropriate components, pathways, and/or spaces.

Pathways between buildings may use a variety of underground and aerial pathway systems and may use spaces and structures (e.g. hand holes, maintenance holes and

telecommunications cabinets) that are constructed to assist cabling installation and to house closures.

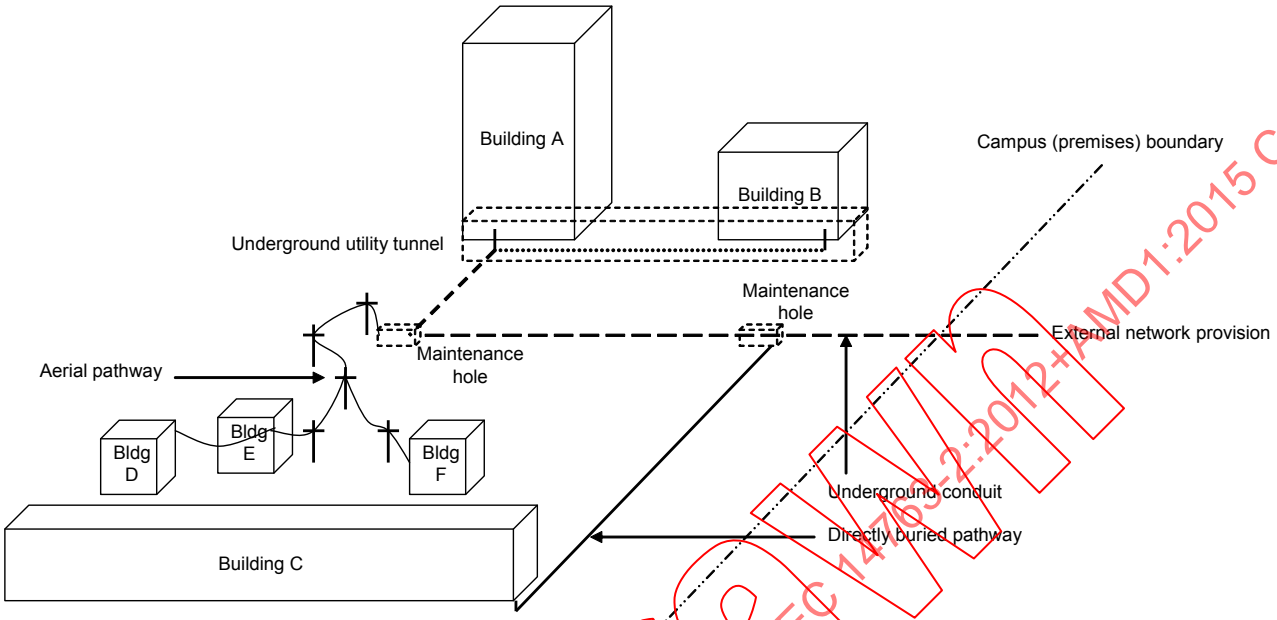


Figure 5 – Example of cabling installations outside buildings

Table 6 – Design and planning of pathways outside buildings

Dedicated underground pathways		**Dedicated aerial pathways**	
Pathway	Clearances from other utilities	Poles	Type
	Separations from other utilities		Length
	Depth of burial		Depth of burial
	Road crossings		Guying
	Rail crossings		Braces (stays)
Method of excavation	Buried		Attachment
	Casing	Spans	Pole-to-pole span
	Trenching		Pole-to-building span
	Boring (pipe pushing)		Slack
	Ploughing		Lashing
Landscape restoration	Backfill		Cable sag
		Pathway	Clearance
			Separation
			Riser protection
			Earthing
		Catenary wire	Type of strand
			Strand tension

Underground pathways and spaces may be

- dedicated to the installation of information technology cables (e.g. direct-buried cable, buried conduit, maintenance holes, hand-holes); Table 6 gives a non-exhaustive list of design and planning issues,
- shared spaces such as a utility tunnel providing other services (e.g. electricity, steam, water).

NOTE Information technology cabling pathways within utility tunnels may consist of indoor pathway systems in accordance with 7.6.1 and 7.6.2.

Aerial pathways and spaces may comprise

- poles, catenary wire, anchoring guy wires and closures; Table 6 gives a non-exhaustive list of design and planning issues,
- self-supporting cables, which may include a catenary wire; Table 6 gives a non-exhaustive list of design and planning issues,
- conduit or other pathway systems following the pathway of other utilities.

7.6.3.2 Requirements

7.6.3.2.1 Pathway planning

The plan for routing of pathways shall take into account

- existing buildings and structures,
- anticipated placement of new buildings or structures on the campus,
- requirements, where appropriate, for redundancy of both pathways and cabling,
- requirements, where appropriate, for external service provision between the campus boundary and BEFs,
- risk assessment of accidental or intentional damage to the installation.

In areas accessible to the public, information technology cables shall be mechanically protected from 0,3 m below the surface to a height of at least 3 m.

7.6.3.2.2 Underground pathways

Where pathway systems are used the location of, and distance between, access points shall take into account

- the maximum tensile load of the cable,
- the installation method,
- requirements for future expansion of the cabling to service additional buildings,
- need for access.

The following shall be documented

- the installation method,
- the location of access points.

Depths of lay are dependent upon the actual and potential use of land crossed by the pathway and shall comply with national or local regulations. Requirements for marker tapes shall comply with national or local regulations.

It shall be assumed that underground pathway systems will become at least partially water filled due to leaking and condensation.

Utility tunnels are normally dry but can have a varying environment, cables placed in tunnels shall have the appropriate properties for the environment.

7.6.3.2.3 Aerial pathways

The route of the cable shall be designed and built in such a way that damage or unsafe situations caused by overloading the construction are avoided. At the crossing of two or more routes, different cables shall not touch each other in any circumstances.

Special consideration shall be given to overhead routes that run parallel to or cross railways, tramways, trolley bus cables, cable railways, cable ways, ski and chair lifts, motor ways, roads and navigable rivers and waterways, etc. The minimum height of cables shall comply with national or local regulations during installation, maintenance and operation.

The stresses on the cables and poles depend on the span length and the sag. The climatic conditions that can have a major effect on tensions in poles, aerial cables and sag are heat, cold, wind and snow/ice load on cables and poles. Reference shall be made to the national regulations for routes affected by such conditions and the appropriate construction methods utilized.

Precautions shall be taken to avoid contact with parts of power cables and equipment.

Unless allowed by national or local regulations, information technology cables shall be installed lower than power cables.

7.6.3.2.4 Minimum bend radii

The pathway system shall ensure that cable can be installed and, where appropriate, fixed in accordance with the applicable minimum bend radius (installation, operating static and operating dynamic) by using identifiable techniques. These requirements apply in three dimensions. Examples of such techniques are pre-fabricated curved corners and radius limiters as shown in Figure 3. The techniques employed shall

- be designed to maintain the relevant minimum radius of the cable(s) to be installed, where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- not introduce deformation of the cable sheath,
- not apply compressive loads exceeding that specified for the cable.

Minimum bend radius is determined by manufacturers instructions. If instructions do not exist the minimum bend radius shall be 20 times the cable diameter.

NOTE 1 Pathway systems that do not allow such an approach may restrict the type and use of cables installed in the pathways and cable management systems selected.

NOTE 2 Specific cable constructions, e.g. armoured cables, may require greater bend radii than those specified above.

7.6.3.3 Recommendations

7.6.3.3.1 General

Information technology cables should be mechanically protected from 0,5 m below the surface to a height of at least 3 m.

Separation between information technology and mains power cables should be at least 1 m throughout pathways and within spaces.

Where the IT cable contains metallic cable elements, surge protection should be applied at all building entrances.

7.6.3.3.2 Underground pathways

During any given installation phase, additional pathway systems should be installed to enable the subsequent installation of additional cables to minimize the number of future excavations that are both disruptive and costly.

The following examples are included as guidance

- direct burial: while the trench is open, install additional spare ducts,
- conduit without sub-conduits,
  - conduits should be 100 mm minimum diameter,
  - conduits should be considered as “full” when the cross-sectional area of the planned/installed cables reaches 40 % of the conduit cross-sectional area,
  - a minimum of one empty conduit should be installed during each installation phase,
  - where there is a known number of installation phases, the number of conduits to be installed should be calculated as the number of planned phases x the initial number of filled ducts,
- conduit with sub-conduits,
  - an alternative is to apply multi-conduit/sub-conduit constructions that provide the required capacity (this approach reduces the available cross-sectional area within the overall conduit and requires additional cable installation resources but provides significantly more flexibility).

NOTE 1 The most flexible installation would therefore comprise a number of 100 mm single ducts (for the largest cables and multi-cable phases) and a larger number of smaller ducts.

NOTE 2 Additional conduits may be required to support management of services/technologies.

7.6.3.3.3 Aerial pathways

Aerial crossing of roads and railways should be planned using the shortest route across the roads and railway respectively.

The use of stays or struts to reinforce the stability of two poles adjacent to the road or railway is recommended.

Aerial crossing of electrified railways is not recommended.

7.7 Spaces

7.7.1 Requirements

7.7.1.1 General

Spaces shall not be located

- in emergency escape ways (where they obstruct),
- in areas that are subject to risk of flooding.

Dimensions of spaces allocated to entrance facilities and distributors shall take into account the initial volume and future expansion of information technology cabling and associated equipment.

Spaces shall be located to provide appropriate levels of security (restricted access) to the cabling and equipment to be contained within them. Access to spaces containing the cabling infrastructures serving multiple premises (enterprises, tenants, etc.) shall be restricted as specified in Annex B.

Signage shall be in accordance with the security plan for the premises.

7.7.1.2 Spaces and structures outside buildings

Access to pathways between buildings is provided by spaces and structures that typically comprise maintenance holes, hand-holes and telecommunication cabinets. Maintenance holes are preferred over hand holes as they provide greater flexibility for extension and expansion of the installed cabling infrastructure (e.g. additional pathways).

The spaces and structures are frequently located in unrestricted access areas and are subject to considerable physical risk. Spaces and structures shall be designed to survive the estimated risk and shall be constructed and installed in accordance with the required design.

All openings to spaces and structures shall maintain the environmental performance of the space or structure.

Cable entrances to spaces and structures shall

- be provided with the necessary cable support to prevent kinking at the point of entry,
- provide strain relief for the cable if not already done by separate fixtures.

Material used to construct spaces and structures shall be specified to resist deterioration when exposed to sunlight.

Maintenance holes shall be

- designed to maintain the relevant minimum radius of the cable(s) to be installed, where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- large enough to contain closures and “feed in” if required,
- contain adequate fittings to support closures, if required.

Routing of cables through maintenance holes shall enable the installation to comply with the requirements of 8.9.4.

Telecommunications cabinets shall be in accordance with the design guidelines of IEC 61969-1 and IEC 61969-2.

Where the spaces and structures are intended to contain active equipment

- the temperature and humidity shall be maintained to allow continuous operation of the active equipment,
- adequate mains power shall be provided.

The loading limits of the locations of telecommunications spaces and structures shall not be exceeded during construction and operation.

The loading limits of any mounting hardware within telecommunications spaces and structures shall not be exceeded during construction and operation.

7.7.1.3 Entrance facilities

Provision shall be made to allow the sealing of pathway systems entering buildings to prevent ingress of water.

Information technology cables that do not comply with the minimum recommended performance requirements of IEC 60332-1-2 shall either be

- terminated inside the building, within 2 m (unless an alternative distance is specified by local regulations) of the point of internal penetration of the external fire barrier (e.g. floor/ceiling/wall)

  or

- any length exceeding 2 m (unless an alternative distance if specified by local regulations) is installed within trunking or conduit that is considered as a fire barrier in accordance with local fire regulations.

  NOTE This also applies where the cable has to pass through a space between two external fire barriers within a building.

7.7.1.4 Rooms intended to contain distributors

Rooms intended to contain distributors shall be provided with access 0,9 m (min) wide and 2 m (min) high.

Rooms in which cables are routed to cabinets, frames, or racks using underfloor pathways shall be provided with raised floor with a underfloor depth of not less than 0,2 m.

NOTE The height of rooms in which cables are routed using high-level or ceiling-mounted pathway systems restricts the height of cabinets, frames, and racks that may be installed (see 7.8.1.4).

While access is required to cabinets, frames, and racks, lighting shall provide a minimum of 500 lx in the horizontal plane and 200 lx in the vertical plane, measured 1 m above the finished floor in front (and at the rear, if applicable) of the cabinets, frames and racks.

Where the rooms are intended to contain active equipment in addition to the distributors

- the temperature and humidity shall be maintained to allow continuous operation of the active equipment,
- adequate mains power shall be provided.

The location of the distributors within the room and any relevant mounting shall be capable of supporting the loads applied during the construction and operation of the distributors and associated equipment. It shall be verified that proposed loading does not exceed the loading limit of the supporting structure.

7.7.1.5 Enclosures containing distributors

Where the enclosure is intended to contain active equipment in addition to the distributor

- the temperature and humidity shall be maintained to allow continuous operation of that active equipment,
- adequate mains power shall be provided.

The location of the enclosure and any relevant mounting shall be capable of supporting the loads applied during the construction and operation of the distributor and associated equipment. It shall be verified that proposed loading does not exceed the loading limit of the supporting structure.

7.7.2 Recommendations

7.7.2.1 General

Spaces should be located centrally in the area they serve.

Positive air pressure systems (including appropriate filters) should be used to prevent ingress of dust and other contamination to the space.

Any water and drain pipes that pass through the space should be located away from and not directly above cabling or equipment.

The provision of mains, or other, power should be adequate to support the operation of the information technology equipment intended to be housed within the space.

7.7.2.2 Spaces and structures outside buildings

Maintenance holes are preferred over hand holes as they provide greater flexibility for extension and expansion of the installed cabling infrastructure, e.g. additional pathways.

Telecommunications cabinets should be provided with

- adequate physical protection (e.g. by appropriate ruggedisation or location),
- adequate security (e.g. locks).

7.7.2.3 Rooms intended to contain distributors

Floors, walls and ceiling should be selected and treated to minimise the generation of dust.

Consideration should be given to application of floor covering comprised of anti-static material.

Rooms in which cables are routed to cabinets, frames, or racks using underfloor pathways should be provided with raised floor with an underfloor depth of not less than 0,3 m.

Ceiling height should be 3 m minimum to allow the installation of

- widest range of cabinets, frames and rack heights,
- high-level or ceiling-mounted pathway systems.

To provide additional space for equipment installation and maintenance, the room dimensions should be 3 m × 3 m minimum.

To provide additional space for equipment installation and maintenance, the minimum room dimensions for distributors containing up to 500 outlets should be 3,2 m (length) × 3 m (width) (see Figure 6a).

For distributors containing more than 500 outlets, the minimum room size should be increased by 1,6 m along the line of cabinets for each additional group of up to 500 outlets to accommodate the additional space for connecting hardware, cord management and active equipment (see Figure 6b).

NOTE These recommendations are based on the use of 800 mm × 800 mm cabinets that allow for sufficient cord management for fully utilized cabinets or open racks with vertical cable management for sufficient cord management for fully utilized racks, this will also accommodate access from both front and back of the cabinets or rack to install additional cabling and equipment (see 7.8.2.3).

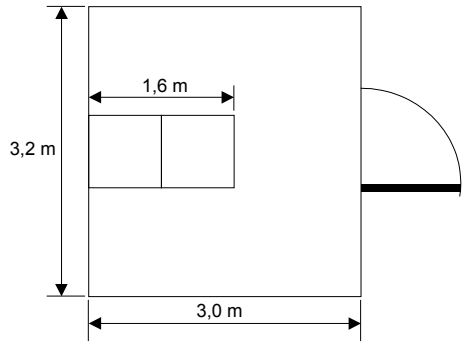


Figure 6a – Minimum room dimensions to support distributors containing up to 500 outlets

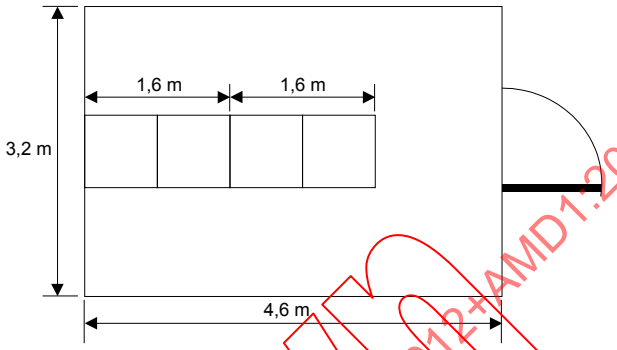


Figure 6b – Minimum room dimensions to support distributors containing between 501 and 1 000 outlets

Figure 6 – Dimensions of rooms intended to contain distributors

Building elements (e.g. doors, floors, lifts) that provide access to rooms intended to contain distributors should accommodate the probable weights and sizes of equipment to be brought to the rooms.

NOTE Equipment is often pre-assembled off site and delivered as complete cabinet/frame/rack units.

7.8 Functional elements

7.8.1 Requirements

7.8.1.1 General

Functional elements shall be located where it is possible to undertake subsequent measurements, repair, expansion or extension of the installed cabling with minimal disruption and in safety.

Where information technology cabling and mains power cabling are contained within a closure, access to mains power cabling shall be restricted according to local regulations.

NOTE If mains power cabling and information technology cabling are installed without physical barrier between the two systems, work on either cabling system may be limited to persons with appropriate qualifications designated by national or local regulation.

Information concerning functional elements shall be included in the administration system in accordance with Clause 9.

7.8.1.2 Termination points

Termination points for information technology cables shall be located and oriented in such a way as to prevent ingress of moisture or other contaminants and to reduce the risk of damage to the cables connected to them. Connecting hardware selected for information technology cabling shall not be interchangeable with the sockets or plugs used for mains power distribution.

Where termination points are presented at outlets (i.e. not within distributors)

- user-accessible outlets shall be located in fully accessible, permanent locations such as building columns, and permanent walls,
- restricted-access outlets may be installed in other places (e.g. above suspended ceilings or under raised floors),
- outlets shall be placed or protected to prevent accidental damage due to frequently moving objects such as vacuum cleaners, rolling tables and hospital beds,
- outlets shall be placed or protected to allow normal maintenance/cleaning (e.g. fluids from cleaning) of the surrounding area.

7.8.1.3 Distributors within rooms

The location of the distributor within the room shall allow for the installation of additional cabling without major disruption.

7.8.1.4 Cabinets, frames and racks

Cabinets, frames and racks (or the closures within them) shall provide the necessary levels of physical and environmental protection for the information technology cabling and equipment installed. Cabinets, frames and racks shall achieve the necessary protection by their location, design features or a combination of both. Where necessary, environment control shall be provided within the space and/or cabinets.

The location of cabinets, frames and racks shall

- be consistent with the space, floor loading and other services required for information technology equipment,
- allow the installation of the necessary cabling together with the delivery and removal of larger items of apparatus,
- provide a minimum clearance of 0,9 m on all faces where access is required.

The height of cabinets, frames and racks shall not exceed 2,4 m and shall not exceed 75 % of the room height in rooms in which cables are routed using high-level or ceiling-mounted pathway systems.

The design and dimensions of the cabinets, frames and racks, together with clearances shall ensure that

- it is possible to install the initial quantity of cables in accordance with the minimum bend radii (installation and operating). Where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- additional cables can be subsequently installed in accordance with the minimum bend radii (installation and operating). Where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- facilities for the management of cables and cords are provided that enable horizontal and vertical management of all cords and jumpers to the maximum planned fill,
- fittings are provided for the functional and protective earthing of information technology equipment and cabling,
- adequate ventilation is provided for anticipated information technology equipment,
- cable segregation requirements of 7.9 are met.

7.8.2 Recommendations

7.8.2.1 Distributors within rooms

Distributors should be located in dedicated rooms.

Distributors should be located in accordance with the maximum lengths specified within the reference implementations of the referenced cabling design standards.

7.8.2.2 Distributors within enclosures

Distributors should be located in accordance with the maximum lengths specified within the reference implementations of the referenced cabling design standards.

7.8.2.3 Cabinets, frames and racks

Where both information technology cabling and mains power cabling are contained within a closure they should be in separate parts of the closures or under separate covers.

The location of cabinets, frames and racks should provide a minimum clearance of 1,2 m on all faces where access is required.

The vertical cable management, horizontal cable management, slack storage, and location of access floor openings should be designed to ensure that the bend radius requirements of the installed cables are met.

The height of floor-standing cabinets, frames and racks should not exceed 2,1 m and connection points within them should be located at least 0,15 m above the finished floor.

7.9 Segregation of information technology cabling and mains power cabling

7.9.1 General

This subclause specifies segregation requirements and recommendations for unscreened and screened cables in accordance with the IEC 61156 series (together with other balanced and unbalanced, including coaxial, cables) with respect to electromagnetic interference from mains power supply cabling. Where appropriate, the requirements and recommendations are specific to particular cable specifications.

The segregation requirements of 7.9.2 assume that

- the electromagnetic environment complies with the levels defined in the IEC 61000-6 series of standards for conducted and radiated disturbances (e.g. mains power cabling),
- the mains power supply is non-deformed but has high frequency content consistent with the switching and operation of connected equipment in accordance with the IEC 61000-6 series of standards,

NOTE 1 “Deformed” mains power supplies are outside the scope of this standard and may require additional engineering practices.

- the information technology cabling supports any applications listed in the referenced cabling design standards.

The segregation requirements of 7.9.2 are those required with regard to electromagnetic interference (EMI). Local regulations for safety may contain different segregation requirements. In these circumstances safety has highest priority but the more stringent requirement shall take precedence.

NOTE 2 Mains power cabling outside buildings may carry high voltages and currents which render above assumptions invalid and separation distances of many metres may be required.

The premises-specific clauses of this standard may contain modified segregation requirements. Where manufacturers' instructions require more stringent installation practices, these shall be followed.

When cabling is installed in an electromagnetic environment exceeding the levels of IEC 61000-6 the separations may need to be increased.

Specific items of electrical equipment and the power supply cabling associated with them may require additional practices resulting in segregation requirements in excess of those of 7.9.2. Examples of such items include certain types of lamps and equipment including that used in arc welding, frequency induction heating and hospitals together with radio, TV and radar transmission systems. Table 7 provides minimum recommended separation distances between metallic information technology and certain items of electrical equipment and the power supply cabling associated with them (without taking into consideration the screening effectiveness of cables or cable management systems). In all cases, analysis should be performed based on products supplier's information, where available, to determine the required segregation. Where supplier's information regarding the sources of interference does not exist, analysis should be performed regarding possible disturbances. e.g. frequency range, harmonics, transients, bursts, transmitted power, etc. Where there is a conflict between the outcome of such analysis and the requirements resulting from the analysis of 7.9.2, the most stringent requirements shall apply.

Table 7 – Separation recommendations between metallic information technology cabling and specific EMI sources

Source of disturbance	Minimum separation mm
Fluorescent lamps	130
Neon lamps	130
Mercury vapour lamps	130
High-intensity discharge lamps	130
Arc welders	800
Frequency induction heating	1 000

The environmental compatibility shall be achieved by selection of appropriate components and/or by mitigation techniques that modify the environment including,

- isolation from the defined environment (by means of protection/segregation),
- separation from the defined environment.

7.9.2 Requirements

7.9.2.1 General requirements

The requirements for separation between information technology cables and mains power cables depends upon

- the electromagnetic immunity of the information technology cable measured as
  - coupling attenuation for screened balanced cables,
  - tranverse conversion loss (TCL) for unscreened balanced cables,
  - screening attenuation for unbalanced (coaxial) and twin axial cables,

- the construction of the mains power cable,
- the quantity of, and type of electrical circuit provided by, the mains power cables,
- the presence of dividers between the information technology cables and mains power cables.

The minimum separation requirement “A” is calculated by multiplying the minimum separation “S” obtained from Table 9 by the power cabling factor “P” from Table 10. The value of “S” obtained from Table 9 depends upon the classification of the information technology cable of Table 8 as shown in Figure 7. A flow-chart approach to this calculation is shown in Figure 8.

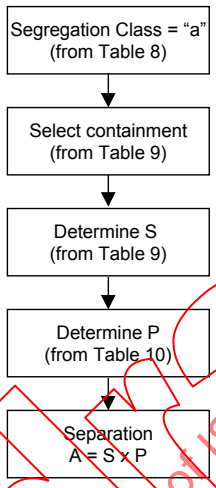


Figure 7 – Process of determining cable separation

The separation requirements for segregation Class “a” in Table 9 shall be applied if

- the mix of applications or the cabling to be installed is unrestricted,
- the type of cabling to be installed is unrestricted.

If the cable performance with regard to the relevant parameters is unknown then it shall be assumed to meet the requirements of segregation Class ”a”.

The separation requirements for segregation Class “b” in Table 9 represent the minimum requirements of this standard, where the cabling to be installed is in accordance with, and is intended to support the applications listed in, the referenced cabling design standards. Reduced separations based upon segregation Classes “c” or “d” of Table 9 may restrict the type and use of cables installed in the pathways and cable management systems selected.

Future expansion of both the mains power and information technology cabling shall be taken into account when determining the separation requirement and the selection of pathways and cable management systems to be used to provide the required separation.

Local regulations may require a barrier or greater separation than calculated using this approach.

The free space separation of Table 9 also applies

- to telecommunications cables and main power cables installed in the same containment,
- any containment that does not meet the minimum screening performance levels applicable to the open containment of Table 9.

Table 8 – Classification of information technology cables

Information technology cable			
Screened	**Unscreened**	**Coaxial/twinaxial**	
Coupling attenuation at (30 to 100) MHz dB	**TCL** at (30 to 100) MHz dB	**Screening attenuation** at (30 to 100) MHz dB	**Segregation Class**
≥80 (see Note 1)	≥70 − 10 × lg *f*	≥85 (see Note 5)	d
≥55 (see Note 2)	≥60 − 10 × lg *f*	≥55	c
≥40 (see Note 3)	≥50 − 10 × lg *f* (see Note 4)	≥40	b
<40	<50 − 10 × lg *f*	<40	a

NOTE 1 Category 5, 6, 6_A, 7 and 7_A cables meeting the Type Ia coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “d”.

NOTE 2 Category 5, 6, 6_A, 7 and 7_A cables meeting the Type II coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “c”.

NOTE 3 Category 5, 6, 6_A, 7 and 7_A cables meeting the Type III coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “b”.

NOTE 4 Category 5, 6, 6_A, 7 and 7_A cables meeting the Level 2 TCL requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “b”. These cables may deliver performance of segregation Class “c” or “d” provided that the relevant requirements are also met.

NOTE 5 Cables in accordance with IEC 61196-7 (ISO/IEC 15018, Category BCT-C) meet segregation Class “d”.

Table 9 – Minimum separation S

Segregation Class (from Table 8)	**Free space separation (i.e. without electromagnetic barrier)** mm	**Containment applied to information technology or mains power cabling**		
		Open metallic containment (NOTE 1) mm	**Perforated metallic containment** [a] (NOTE 2) mm	**Solid metallic containment** (NOTE 3) mm
d	10	8	5	0
c	50	38	25	0
b	100	75	50	0
a	300	225	150	0

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

NOTE 1 Screening performance (DC to 100 MHz) equivalent to welded mesh steel wire mesh cable tray of mesh size 50 mm × 100 mm (excluding cable ladders). This screening performance is also achieved with a steel cable tray of less than 1,0 mm wall thickness and/or more than 20 % equally distributed perforated area.

NOTE 2 Screening performance (DC to 100 MHz) equivalent to a steel cable tray of at least 1,0 mm wall thickness and no more than 20 % equally distributed perforated area. This screening performance is also achieved with screened power cables that do not meet the performance defined in Note 3.

NOTE 3 Screening performance (DC to 100 MHz) equivalent to a steel conduit of 1,5 mm wall thickness. Specified separation is in addition to that provided by any divider/barrier.

Table 10 – Power cabling factor P

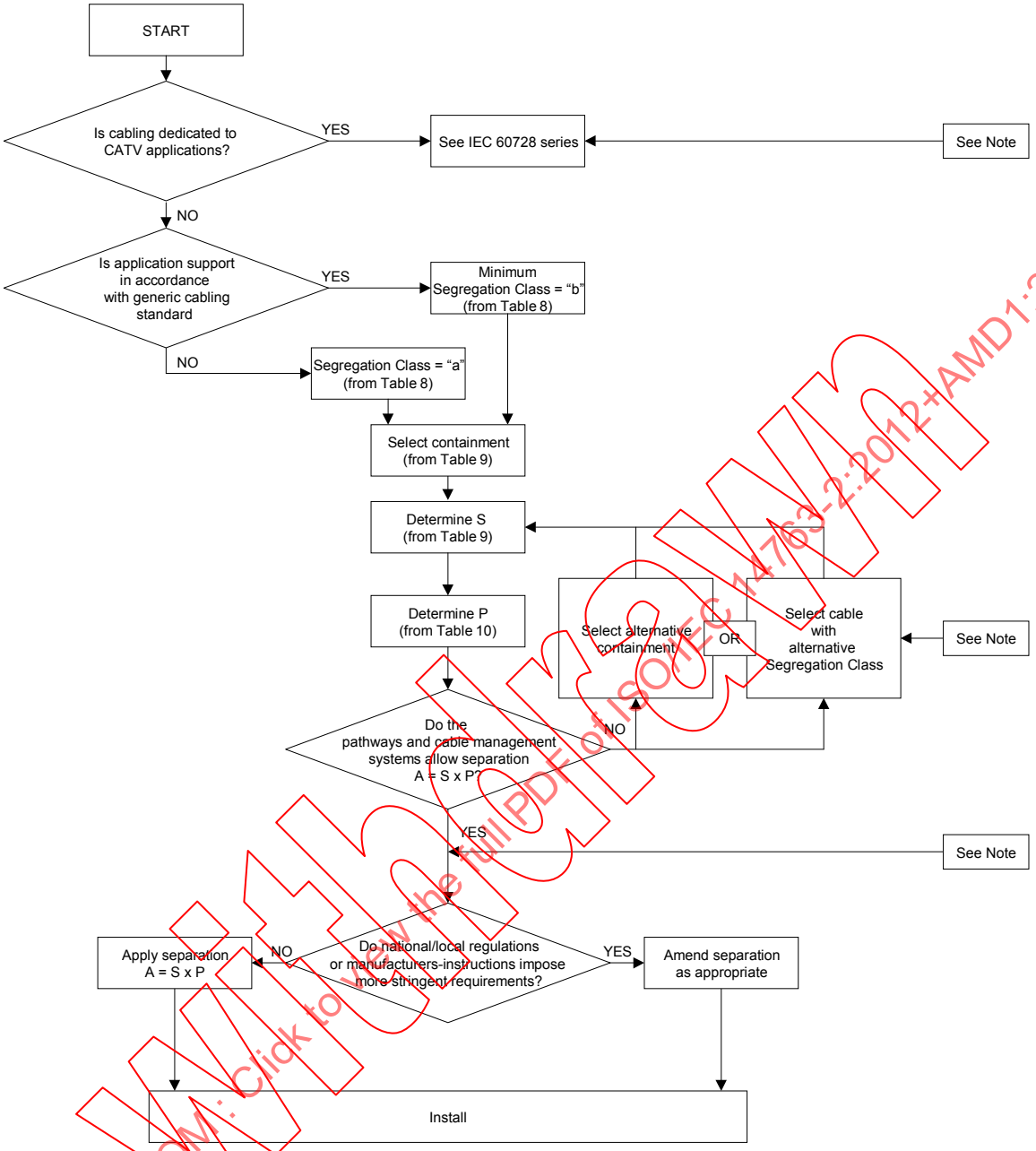
Electrical circuit type (see [a,b,c])	Quantity of circuits	Power cabling factor "P" (see [d])
20 A 230 V 1-phase	1 to 3	0,2
	4 to 6	0,4
	7 to 9	0,6
	10 to 12	0,8
	13 to 15	1,0
	16 to 30	2
	31 to 45	3
	46 to 60	4
	61 to 75	5
	>75	6

[a] The power cabling factor shall be used as a multiplier for the calculation of distance A from Table 9.

[b] 3-phase cables shall be treated as 3 off 1-phase cables.

[c] More than 20 A shall be treated as multiples of 20 A.

[d] Lower voltage AC or DC power supply cables shall be treated based upon the their current ratings, i.e. a 100 A 50 V DC cable = 5 off 20 A cables (P = 0,4).



NOTE Unless the cabling to be installed is intended to support the applications listed in the relevant generic cabling design standard: i.e. the mix of applications or the type of cabling to be installed is unrestricted, the separation requirements for Segregation Class "a" in Table 9 are applied.

Figure 8 – Flowchart for cable separation calculation

The applicable minimum separation requirement "*A*" is the minimum separation between the information technology cables and mains power cables that is allowed at any point between their respective fixing points or that is created by other restraints (physical or contractual) including barriers or dividers.

For information technology cables and mains power cables within a single pathway system, or in parallel pathway systems, without dividers

a) A is the minimum separation between the information technology cables and mains power cables including all allowances for cable movement between their fixing points (see Figure 9a),

b) where no fixing or restraint is present, A is assumed to be 0 mm (see Figure 9b).

For information technology cables and mains power cables within a single pathway system, or in parallel pathway systems, with dividers

c) for cables installed in adjacent compartments of a pathway system or another pathway that incorporates a divider, the required separation A shall be provided by the divider (see Figure 10a), unless additional cable fixing or restraint is present (see a above),

d) for cables installed in non-adjacent compartments of a pathway system or another pathway that incorporates more than one divider, required separation A shall be provided by the distance between the dividers (see Figure 10b), unless additional cable fixing or restraint is present (see a) above).

The minimum separation requirement applies in three dimensions. However, where Information technology cables and mains power cables are required to cross and required minimum separation cannot be maintained then the angle of their crossing shall be maintained at 90 ° on either side of the crossing for a distance no less than the applicable minimum separation requirement.

Where mains power cables (other than single core cables operating at voltages exceeding AC 600 V) pass through a fire barrier it is possible to reduce the separation requirements of this subclause provided that

- the total distance over which the reduction in the separation occurs is not greater than the thickness of the fire segregation barrier plus 0,5 m on either side,
- the information technology cables and mains power cables are enclosed in separate trunking or conduit,
- local regulations concerning fire barriers are complied with,
- IEC 60364-5-52 is taken into account.

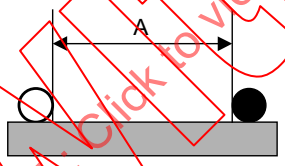


Figure 9a – Separation with restrain

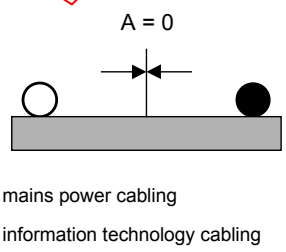


Figure 9b – Separation without restraint

Figure 9 – Separation of mains power and information technology cables without dividers

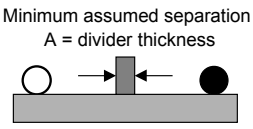


Figure 10a – Separation with single divider

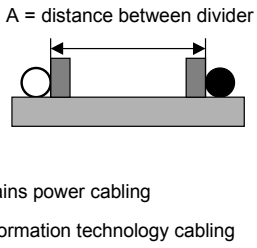


Figure 10b – Separation with multiple dividers

Figure 10 – Separation of mains power and information technology cables with dividers

7.9.2.2 Conditions for zero segregation

No segregation is required between information technology cabling and mains power cabling (other than that required by national or local regulation) provided that all the following conditions are met

- the environmental classification for the information technology cabling complies with E_1 of ISO/IEC TR 29106,
- the power conductors
- form single phase circuits,
- provide a total power of 10 kVA (maximum),

  NOTE 1 In regions using 110/120 V this corresponds to a maximum current of 80 A and in regions using 230 V this corresponds to a maximum current 32 A.

- comprising a circuit are maintained in close proximity (e.g. within an overall sheath or twisted, taped or bundled together),
- and either
- the information technology cables meet the requirements of segregation Classes “b”, “c” or “d” of Table 8

  or

- in circumstances where the cabling is application(s)-specific, then the application(s) support(s) a zero segregation relaxation.

This allowance should be not applied in spaces allocated to distributors in accordance with the referenced design standards or equivalent concentrations of transmission equipment.

In all other cases the requirements of 7.9.2.1 apply.

NOTE 2 The selection of this segregation approach and the planning of the pathway may render it unsuitable if modifications are subsequently made to the resulting electromagnetic environmental classification.

7.9.3 Recommendations

Telecommunications cabinets, frames and racks should be separated from electrical equipment, e.g. high-voltage/low-voltage (HV/LV) transformers.

7.10 Cabling – Requirements

7.10.1 General

The installation of the cabling shall be in accordance with Clause 8.

Mixing of unscreened and screened components within a channel shall only be implemented in accordance with supplier’s instructions.

Connecting hardware shall be arranged and mounted in closures in accordance with connecting hardware supplier’s instructions.

The earthing of extraneous metallic elements (e.g. armouring, strain relief members of optical fibre cables) that are part of the cable construction shall be in accordance with local and/or national regulations and the procedures used shall be documented.

7.10.2 Unscreened cabling

The cabling shall be terminated in accordance with 8.10.2.

7.10.3 Screened cabling

The cabling shall be terminated in accordance with 8.10.3.

The screen shall be continuous at and between connectors providing the connection to the application-specific equipment via a cabling channel.

7.10.4 Optical fibre cabling

Optical fibre provides electrical isolation between buildings. Extraneous metal in optical fibre cables shall be treated as detailed in 8.9.2.1.

8 Installation practices

8.1 General

Installations shall be carried out in accordance with the installation specification (see Clause 5), quality planing (see Clause 6) and the relevant planning carried out in accordance with Clause 7. The client shall be advised of all deviations and actions required.

The installation method used shall be compatible with the products used.

All installation locations shall be selected to allow for any anticipated additional installations and necessary equipment to be delivered and installed during the anticipated lifetime of the installation.

8.2 Safety

8.2.1 General

The specification of safety requirements is beyond the scope of this International Standard. Local regulations, including safety, shall be met.

8.2.2 Mains power cabling

The proper implementation of the requirements of this standard assume that electrical installations, bonding networks and protective measures against overlvoltages are undertaken in accordance with the local regulations, as appropriate.

NOTE The IEC 60364 series may contain appropriate information.

8.2.3 Functional bonding

The bonding networks within premises served by metallic cabling shall be undertaken in accordance with local regulations, as appropriate.

NOTE The IEC 60364 series may contain appropriate information.

8.2.4 Optical fibre cabling

Installations shall be carried out in accordance with IEC 60825-2 as applicable according to the relevant hazard classification of each installation location including

- exposure of optical fibre ends to the skin and eyes,
- the quantity of optical fibre waste,
- the collection and disposal of waste fragments,

- the viewing of connector end faces, prepared optical fibres or fractured optical fibres.

8.2.5 Guards and signs

All necessary guards, protective structures and warning signs shall be used to protect both the cabling components and all personnel during installation.

Relevant local regulations for safe working practices shall be complied with.

8.2.6 Enclosed spaces

It is possible for explosive, asphyxiating or toxic gases to build up in ducts, draw pits, maintenance holes or other closed chambers. Before entering any such areas, they shall be well ventilated and the atmosphere shall be tested to detect any potentially hazardous gases. Where a gas hazard is detected, the installer shall inform the nominated site contact and appropriate action shall be agreed and performed.

8.2.7 Maintenance holes

Frames and covers of maintenance holes shall be correctly seated and shall not present a safety hazard.

8.2.8 Closures

Before installing information technology cabling within closures containing mains power cabling, compliance with local regulations shall be ensured.

8.3 Environment

8.3.1 Storage

8.3.1.1 Requirements

The environmental conditions under which cabling components, inspection and test equipment are stored shall be compatible with the manufacturers'/suppliers' specifications.

Where protective caps, or equivalent, have been used to protect components, they shall not be removed until necessary and shall be replaced or renewed as necessary until the installation is completed.

8.3.1.2 Recommendations

The ends of stored cable should be sealed.

8.3.2 Installation – Requirements

The installer shall ensure that the environment local to the cabling is in accordance with the installation specification (see 5.3.5) and is compatible with the cabling components to be installed.

8.4 Component inspection and testing – Requirements

Cabling components shall be inspected for damage as soon as possible following delivery and before installation. Documentation supplied with the components shall be checked for compliance with the procurement specification and shall be retained.

If required by the quality plan, detailed component inspection and/or acceptance testing shall be undertaken as soon as practicable. Any packaging and/or seals removed to allow

inspection and/or testing shall be replaced to provide the required environmental and physical protection to the components.

8.5 Pathways

8.5.1 Requirements

It shall be confirmed that the pathways in accordance with the installation specification and the installation schedule are accessible and available.

It shall be confirmed that the proposed locations of cable deployment systems (e.g. boxes, reels, drums) and associated installation equipment in accordance with the installation schedule are accessible and available. The client shall be advised of all necessary deviations or actions required.

The accessibility and availability of proposed locations of cable service loops shall be confirmed.

The installer shall ensure that

- the pathway systems selected are able to support the mass of the cables to be installed,
- the fixings and supporting structures for the pathway systems are suitable to support the combined mass of the pathway system and the cables to be installed.

The installer shall ensure that

- all necessary installation accessories are available,
- the required identifiable techniques (see 7.6.2.1.2) are installed to allow cable to be installed and, where appropriate, fixed in accordance with the applicable minimum bend radius.

8.5.2 Inside buildings – Requirements

Where it is necessary to remove materials to access pathways (e.g. ceiling tiles, floor covers or duct covers) only the minimum shall be removed and these shall be replaced and/or reinstated as soon as practicable and in accordance with local regulations (site conditions).

In fixed installations where impact to the installed cabling can occur (specifically including all cabling within 50 mm above floor level) protection shall be afforded by one or more of the following

- the mechanical characteristics of the pathway system,
- the location selected,
- the provision of additional local or general mechanical protection.

Fire barriers and gas seals shall be opened only when necessary and reinstated as soon as practicable and in accordance with local regulations.

8.5.3 Outside buildings

8.5.3.1 Requirements

8.5.3.1.1 Overhead

Supporting structures shall be suitably treated to prevent decay.

8.5.3.1.2 Underground

Sections shall be jointed to inhibit ingress of gases, water and foreign materials.

8.5.3.2 Recommendations

8.5.3.2.1 Overhead

Attachment of catenary wires to buildings should be

- permitted only when it is clear that the load on the fixing point will not exceed its design strength and the structure of the building is capable of sustaining the load with a safety factor,
- avoided in earthquake zones.

8.5.3.2.2 Underground

All underground cable management systems should be made of a non-porous material. (see 7.6.3.3.2).

8.6 Spaces

8.6.1 Requirements

The installer shall ensure that the spaces within which the cabling and equipment are to be installed are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.7.1.1. The client shall be advised of all deviations and actions required.

8.6.2 Entrance facilities

The installer shall ensure that the facilities exist to allow the treatment of cables in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.7.1.3.

8.6.3 Rooms and enclosures intended to contain distributors

The installer shall ensure that the spaces intended to contain distributors are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.7.1.4 and 7.7.1.5.

8.6.4 Cabinets, frames and racks

The installer shall ensure that cabinets, frames and racks are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.8.1.4.

8.6.5 Closures

The installer shall ensure that closures are in accordance with the installation specification (see Clause 5).

8.6.6 Outlets

The installer shall ensure that outlets are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.8.1.2.

8.7 Pathway system installation

8.7.1 General

8.7.1.1 Requirements

Pathway systems shall be installed

- in accordance with instructions provided by the manufacturer(s)/supplier(s) of the cable management systems,
- to achieve the planned electromagnetic performance in relation to the installed cabling,
- to allow installation of cable without damage to the cable,
- without sharp edges or corners that could damage the cabling installed within or upon them,
- to enable the creation of fire barriers in accordance with local regulations,
- taking into account relevant external/environmental influences – in particular
- cable management systems shall be installed to ensure that water or other contaminant liquids cannot collect,
- where required, sections of cable management systems shall be jointed to prevent ingress of gases, liquids, etc.

Pathway systems shall be left clean and free from obstruction with all separators and bridging pieces in place before the cabling installation commences.

Until the installation work is finished the pathway system shall be protected from contamination (e.g. dust, water and construction parts).

Pulling wheels or other temporary structures (to assist cabling installation) shall be fitted where necessary.

8.7.1.2 Recommendations

Where applicable, pathway systems should be installed to allow removal of the cable without damage to any remaining cables.

8.7.2 Inside buildings

8.7.2.1 Requirements

Pathway systems shall be sealed at the point of entry to buildings to prevent ingress of water.

8.7.2.2 Recommendations

Cable management systems should be installed in such a way that the transfer of acoustic noise is minimized.

8.7.3 Outside buildings

8.7.3.1 Requirements

Existing catenary wires shall be checked for satisfactory function and, where necessary, catenary wires shall be replaced.

8.7.3.2 Recommendations

Marking tapes should be laid above underground pathway systems.

8.8 Closure installation

Closures shall be fixed or mounted in position using the recommended fittings and labelled and identified according to the installation specification (see 9.2).

Closures containing optical fibre terminations or joints shall be labelled in accordance with IEC 60825-2 as appropriate to the hazard classification of the location (see 5.3.3 and 7.2.3). Optical fibre adaptors shall be fixed or fitted with suitable protective caps to prevent the ingress of foreign material.

8.9 Cable installation

8.9.1 Cable installation within pathway systems

8.9.2 General

8.9.2.1 Requirements

Installation of cables shall be in accordance with the instructions supplied by the manufacturers/suppliers of the cables and the pathway systems.

Cabling components shall be conditioned at the recommended environmental condition before installation.

Cables shall not be exposed to humidity levels or temperatures outside the limits detailed in the manufacturers'/suppliers' specifications; this includes localised effects such as those from hot air blowers, gas burners and sprinklers.

The installation process shall not degrade the intended environmental performance of the pathway/cable management system. Where there is an identified risk of ingress of water or contaminants to a cable during installation, the cable ends shall be sealed.

Metallic information technology cabling and mains power cabling shall be segregated in accordance with the requirements of 7.9.

When installing cables appropriate techniques shall be applied to

a) eliminate cable stress caused by
– tension in suspended cable runs,
– tightly cinched cable bundles,
b) ensure that minimum bend radii are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,
c) ensure that the tensile load applied to the cables and cable bundles are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,

NOTE Unless otherwise stated in the suppliers/manufacturers specification, the maximum tensile load applied to a bundle is that specified for a single cable.

d) protect cables from damage during installation (e.g. stepping on cables or hanging bundles with insufficient support),
e) prevent pressure marks (e.g. through improper fastening or crossovers) on the cable sheath or the cable elements,
f) prevent optical fibre within cables experiencing direct stress following installation (where long vertical runs are proposed optical fibre cables may need to deviate from the vertical by the inclusion of short horizontal runs or loops at intervals as recommended by the manufacturer),

g) avoid joints other than those in accordance with the installation specification.

Labels, or equivalent, shall be applied to cable elements where they are not otherwise identified (see 9.2).

Precautions shall be taken during the installation of draw ropes, where used, to prevent the draw ropes becoming entangled with cables.

Where cable is to be installed in shared pathways precautions shall be taken to avoid damage to existing cables or structures within those routes.

The earthing of extraneous metallic elements (e.g. armouring, strain relief members of optical fibre cables) that are part of the information technology cable construction shall be in accordance with local regulations. The procedures used shall be documented.

8.9.2.2 Recommendations

Labels, or equivalent, should be applied to the ends of cables where multiple cables are installed to a closure and where they are not otherwise identified (see 9.2).

8.9.3 Inside buildings

8.9.3.1 Requirements

Following cable installation, pathway systems shall be sealed at the point of entry to buildings to prevent ingress of water.

Information technology cables that do not comply with the minimum recommended performance requirements of IEC 60332-1-2 shall be installed according to the instructions of the planner (see 7.7.1.3).

Measures shall be taken to prevent any liquids and/or gels present within the information technology cable from leaking in pathways.

The position of information technology cables and the location of closures in cable management systems shall be in accordance with the instructions provided by the manufacturers/suppliers of the cable management systems (subject to meeting the segregation requirements of 7.9). When installing cables into cable management systems they shall be secured as specified in the installation specification.

The final placement of cables and cable bundles shall take into account the risk of damage due to external influences.

8.9.3.2 Recommendations

The size of cable bundles should be restricted to a maximum of 24 4-pair balanced cables.

8.9.4 Cable installation in maintenance holes

The following practices shall be applied

- cables shall be installed in lowest conduits first,
- cables shall not be inter-twined,
- support shall be provided to cables to prevent them lying on the floor,
- no excess cable lengths (other than specifically designated in the installation specification) shall remain,

- sufficient floor area shall be maintained to allow work to be undertaken.

Following the installation of cables within maintenance holes

- floors shall be free of debris,
- sump covers shall be removed,
- maintenance hole frames shall be secured,
- access key-holes shall be checked for wear and appropriate action taken,
- maintenance hole covers shall be seated correctly.

8.9.5 Cable installation within closures – Requirements

Cables entering closures shall use appropriate openings, glands and/or fittings to

a) maintain the environmental performance of the closure,
b) provide the necessary cable support and ensure minimum bend radii are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,
c) provide strain relief for the cable if not already provided by separate fixtures within the closure.

Measures shall be taken to prevent any liquids and/or gels present within the information technology cable from leaking in closures.

A sufficient length of cable shall be provided at each closure to enable

- subsequent access to the closure for terminating, jointing and repairing of the cable (this can also be achieved by the use of service loops in appropriate places),
- cable tests to be undertaken, where required by the quality plan, prior to terminating or jointing of the cable.

Any cabling not contained within a cable management system shall be protected from physical damage by use of appropriate measures. Where the cable elements comprise primary coated optical fibre, sleeves shall be applied to protect the optical fibre from damage within the closure.

Within closures, each cable element shall be uniquely identifiable using one or more of the following methods

- colour coding,
- labelling,
- physical position or routing.

If required by the quality plan, installed cable tests shall be undertaken as soon as practicable following cable installation.

8.10 Jointing and terminating of cables

8.10.1 Requirements

Cables shall be jointed or terminated in accordance with the instructions provided by the manufacturer/supplier of the connecting hardware. If special tools are required for jointing or terminating, then only those recommended by the connecting hardware manufacturer shall be used.

Measures shall be taken to prevent any liquids and/or gels present within the information technology cable from leaking at any termination point.

During and after the jointing and terminating process, the minimum bend radii of cable elements shall be as specified by the cable manufacturer, supplier or in accordance with the relevant product standard.

Following jointing or terminating, the cable elements shall be arranged within the closure in a manner that allows access to individual connectors, joints and cable elements with minimal disruption to neighbouring components during subsequent repair, expansion or extension of the installed cabling.

Cable elements not terminated within connecting hardware shall be treated as detailed in the installation specification.

The presentation of cable elements within joints, terminating connecting hardware and closures shall be in accordance with the installation specification.

8.10.2 Balanced cabling

Balanced cables shall be terminated in accordance with the connecting hardware manufacturer's instructions to maintain the intended performance of connecting hardware.

Where no connecting hardware manufacturer's instructions exist, the connecting hardware used for balanced cabling shall be installed to provide minimal signal impairment by preserving wire pair twists and conductor separation as closely as possible to the point of mechanical termination (by not changing the original twist). In addition, only a minimum of the cable sheath shall be removed.

Care shall be taken to ensure that the removal of the cable sheath does not damage the internal cable construction.

8.10.3 Screened balanced cabling

Cable screens shall be terminated at each termination point. Balanced cabling screens shall be terminated in accordance with the connecting hardware manufacturer's instructions to maintain the intended performance of the cable screen termination to the connecting hardware.

Where instructions for termination of cables are not available from the manufacturer/supplier of the connecting hardware, the conductive surface of the cable screen shall be terminated to conductive surface of the connector screen.

8.10.4 Optical fibre cabling

Joints (fusion or mechanical splices) and their strain relief mechanisms shall be fixed and supported within the optical fibre management system of the closure.

If required by the quality plan, optical fibre connector end faces shall be inspected in accordance with ISO/IEC 14763-3.

Identification (by labelling or other means) of optical fibres within closures shall be such that the polarisation of optical fibre connections of more than one optical fibre is known and consistent throughout the installation in accordance with Annex A.

8.11 Cords and jumpers

See Clause 12 for requirements for cord and jumpers installed during the installation process.

8.12 Surge protective devices

Where installed, the earth connection of surge protection devices shall be functionally bonded to both the equipment earth connection and that of the main earthing terminal.

8.13 Acceptance

8.13.1 Inspection

If required by the quality plan, acceptance inspection shall be undertaken as soon as practicable following the

- final assembly of the closure into the desired location,
- labelling in accordance with the installation specification.

8.13.2 Testing

If required by the quality plan, acceptance testing shall be undertaken as soon as practicable following the

- final assembly of the closure into the desired location,
- labelling in accordance with the installation specification.

The testing process shall verify the accuracy of the labelling applied.

9 Documentation and administration

9.1 Symbols and preparation of documents

9.1.1 Requirements

Symbols used in specific documentation shall be compiled (including their description) and shall be provided either on each drawing or on a separate sheet. Symbols used for cabling administration shall be different from those used for the documentation of other building services (such as heating, ventilation and air conditioning).

9.1.2 Recommendations

Documentation of the cabling administration should be based upon the principles of IEC 61082-1.

Symbols to be used for records should be in accordance with the IEC 60617 series.

9.2 Administration

9.2.1 General

This standard addresses the administration of telecommunications infrastructure by

a) specifying elements of information that make up records for each component,
b) specifying the type of database or system to manage the records,
c) assigning identifiers to components of the infrastructure,
d) specifying how components shall be labelled,
e) specifying reports presenting information on groups of records,
f) specifying graphical and symbolic requirements.

The administration system specified by this standard enables management of the following components

a) telecommunications cables,
b) telecommunications terminations, joints and closures containing them,
c) telecommunications pathways and pathway systems,
d) telecommunications spaces including cabinets, frames and racks,
e) telecommunications bonds to earthing networks.

The administration system enables the components of the cabling system to be identified in terms of their type, location, usage and other criteria.

9.2.2 Administration system

9.2.2.1 General

An administration system shall be specified to enable effective operation, maintenance and repair of the cabling infrastructure. All information produced for or by the administration system shall be dated. Change control shall be exercised and records shall be retained for a specified minimum period. Service management shall conform to ISO/IEC 20000-1.

The minimum requirements of an administration system (see 9.2.2.4) are defined based upon the installation complexity level (see 9.2.2.2 and operational complexity level (see 9.2.2.3) of the infrastructure.

9.2.2.2 Installation complexity

The installation complexity level is based upon the type of premises and quantity of cable elements in the fixed cables comprising the installation and should be determined by reference to Table 11. The levels shown are based upon implementations of generic cabling in accordance with the referenced cabling design documents. Other implementations of fixed cabling may require other levels to be applied.

Where areas may have multiple functions (e.g. homes that can be converted to office premises) the more demanding level should apply.

Table 11 – Level of installation complexity

No. of fixed cable elements [a]	2 to 200	201 to 20 000	>20 000
Office	Level 2	Level 2	Level 3
Industrial	Level 3	Level 3	Level 3
Homes	Level 1	Level 1	Level 1
Multi-tenant residential premises	Level 2	Level 2	Level 3
Data centres	Level 2	Level 2	Level 3

[a] This is the number of fixed cables multiplied by the number of cable elements per cable. It is the total for all cables (coaxial, balanced pair and optical fibre).

9.2.2.3 Operational complexity

The operational complexity level is based upon the type of premises and quantity of administered ports and should be determined by reference to Table 12. The number of administered ports is defined as the number of user-accessible equipment interfaces including those on the connected equipment.

Table 12 – Level of operational complexity

No. of administered ports	2 to 100	101 to 5 000	>5 000
Office	Level 1	Level 2	Level 3
Industrial	Level 1	Level 2	Level 3
Homes	Level 1	Level 1	Level 1
Multi-tenant residential premises	Level 1	Level 2	Level 3
Data centres	Level 2	Level 3	Level 3

9.2.2.4 Administration system

9.2.2.4.1 Requirements

The administration system shall meet the requirements of

- Table 13 based upon the installation complexity Level determined from Table 11
- Table 14 based upon the operational complexity Level of Table 12.

Table 13 – Minimum requirements of administration systems

	Administration system		
IDENTIFIERS			
Infrastructure complexity Level	1	2	3
Bonds – functional earth	-	-	Yes
Cabinets/frames	Yes	Yes	Yes
Cables	Yes	Yes	Yes
Closures	-	Yes	Yes
Pathways	-	-	Yes
Spaces	-	Yes	Yes
Termination points including joints	Yes	Yes	Yes
LABELS (fixed to the item or are part of the item)			
Infrastructure complexity Level	1	2	3
Bonds – functional earth (see Note 1)	-	-	-
Cabinets/frames	Yes	Yes	Yes
Cables (see Note 2)	-		Yes
Closures (unless indicated by visible termination point labelling)	-	Yes	Yes
Pathways	-	-	Yes
Spaces (at entrances)	-	Yes	Yes
Termination points including joints (see Note 3)	Yes	Yes	Yes
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Infrastructure complexity Level	1	2	3
Fixed cabling (see Note 4)	Manual	Manual	Electronic

NOTE 1 National or local regulation may require labels to identify their function.

NOTE 2 Labels at both ends.

NOTE 3 Indicating the treatment of cable elements at the joint.

NOTE 4 Manual records include paper-based systems. Electronic records include spreadsheets, databases, etc.

The additional features provided by "Enhanced" administration systems in Table 14 may be required by local regulations regarding security of information technology service delivery.

The administration level shall be specified in the technical specification (see 5.3).

Table 14 – Minimum requirements of operational administration systems

	Administration system			
IDENTIFIERS				
Operational complexity Level	1	2	3	Enhanced
Cords/jumpers	-	-	Yes	Yes
LABELS (fixed to the item or are part of the item)				
Operational complexity Level	1	2	3	Enhanced
Cords/jumpers (see Note 1)	-	-	Yes	Yes
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it				
Operational complexity level	1	2	3	Enhanced
Cord connections (see Notes 2 and 3)	None	Manual	Electronic	Automated
Service delivery (see Note ~~2~~ 3)	~~None~~	None	None	Automated

NOTE 1 Labels or other means to identify both ends of a cord

NOTE 2 Manual records include paper-based systems. Electronic records include spreadsheets, databases, etc.

NOTE 3 Automated records include the data from automated infrastructure management (AIM) systems that detect connection/disconnection~~/reconnection~~ of cords and~~/or services provided over the cabling~~ the presence of discoverable equipment connected to the network. Requirements and recommendations for specifying and operating AIM systems are provided in Annex H.

~~Cable management software with automation should have the capability of documenting the infrastructure elements as described in this standard. The system should be capable of automatically monitoring patch connections between cross-connects with automated management, and of generating alerts and updating documentation when any of these patch connections are changed.~~

~~Such systems may have additional functions including the discovery and documentation of the configuration of transmission and terminal equipment.~~

9.2.2.4.2 Recommendations

Additional labelling should be considered in locations where separation of cabling components during maintenance or repair could result in identification problems during their re-instatement.

9.2.3 Identifiers – Requirements

The elements of the telecommunications infrastructure that are required, by the specified administration level, to be subject to an identifier scheme shall each have an identifier that

- is unique within the administration system,
- explicitly defines the element to which it refers (e.g. closure, cable, outlet etc).

The identifier scheme shall conform to the requirements of ISO/IEC TR 14763-2-1 unless the installation specification requires an alternative scheme that also meets the above requirements.

The identifier serves as the key to finding the record of additional information related to that element.

9.2.4 Component labelling

9.2.4.1 Requirements

Label(s) shall provide a direct link to the identifier within the record within the administration system.

Labels shall be durably affixed. Labels shall be resistant to the environmental conditions at the point of installation (such as moisture, heat, or ultraviolet light), and shall have a design life equal to or greater than that of the labelled component.

Non-machine readable labels shall

- feature permanent and readable text (by use of appropriate size, colour, and contrast),
- be printed, machine-generated or manufactured as part of the component.

Machine readable labels shall

- use permanent media,
- be printed, machine-generated or manufactured as part of the component,
- be located so that each machine readable label can be read uniquely.

Labels shall be located where they can be read without risk of “material” degradation of the transmission performance of the cabling. Additional labels may be applied for convenience of cabling maintenance.

Table 15 contains requirements for labelling the infrastructure elements that are required, by the specified administration level, to be labelled.

Table 15 – Labelling requirements

Element	Requirements for labelling	Specific requirements for labels
Telecommunications spaces	• at the exterior of all entrances either on or adjacent to the doors.	• containing space identifier.
Cabinets, frames, racks	• at the top of the front surface with its identifier; • at the top of the rear surface of the cabinet, rack, or frame if the rear of the cabinet, rack or frame is not in direct contact with a wall.	• containing cabinets/frame/rack identifier.
Cabinet,frame, rack row	• at both ends of a row.	• containing row identifier.
Patch panels and blocks	• on an exterior surface	• containing patch panel or block identifier.

Cables	• on both ends, conspicuously displayed just prior to the cable being routed into the termination device; • on each side of any intermediate termination points – such as splices, consolidation points, and local distribution points.	• containing cable identifier.
TOs in accordance with ISO/IEC 11801	• on the exterior surface of the TO closure.	• containing TO identifier.
Protective earthing bonds	• in accordance with local and national regulations • unless otherwise specified by local and national regulations: • on both ends of the bonding conductor conspicuously displayed just prior to each cable being routed into the termination.	
Functional earthing bonds	• on both ends of the bonding conductor conspicuously displayed just prior to each cable being routed into the termination.	

9.2.4.2 Recommendations

9.2.4.2.1 Labelling

Table 16 contains recommendations, in addition to the requirements detailed in Table 15 for labelling the infrastructure elements.

Table 16 – Labelling recommendations (additional)

Element	Recommendations for labelling	Specific recommendations for labels
Telecommunications spaces	at the interior of all entrances either on or adjacent to the doors.	containing space identifier.
Cabinets, frames, racks	on the bottom front and rear surfaces, as the labels at the top may not be visible – particularly on “two post” racks and frames.	
Patch panels and blocks		provided that space is available; with the identifier of the ports/termination points; with the identifier of any distributors to which the cables are routed; with the identifier for the remote ports.
Pathways	at both ends	with their identifiers.
Main earthing terminals and local common bonding network access		with their identifiers.
Cords and jumpers (Figure 11 provides an example of cord and jumper labelling)	two labels on each end to identify the equipment, patch panels, or blocks at both ends of the cable; a third label at each end indicating additional information regarding function of the connection that may be useful when tracing a connection that is routed through multiple patch panels and would be the same on both ends of the cord.	the label closest to each connector should identify the equipment or patch panel to which that cord is attached. the next label toward the far end of the cord identifies the equipment, patch panel, or block at the other end of the cord. the third label may include server name, business partner name, remote office name, circuit number, or name of equipment at each end of the channel.

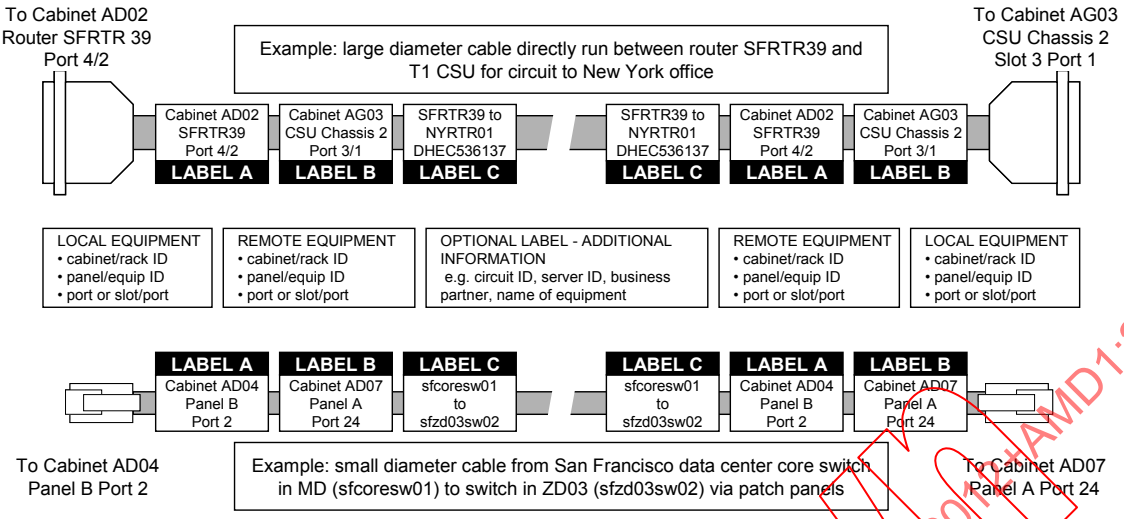


Figure 11 – Examples of cord and jumper labelling

9.2.4.2.2 Colour coding

Colour coding of labels, cables, cords, and termination fields may be used to differentiate between different levels of the cabling system topology, to differentiate between different distributors, or to differentiate between services. To be of most value, such colour-coding should be consistent throughout the system.

9.2.5 Records

9.2.5.1 General

Each component that is uniquely identified in the cabling administration system shall have its own record(s). Records shall be updated whenever changes are made to cabling infrastructure.

Change control shall be exercised and records shall be retained for a specified minimum period.

9.2.5.2 Requirements

Records for each infrastructure element shall include the items listed as “requirements” in Table 17, Table 18, Table 19 and Table 20.

9.2.5.3 Recommendations

Records for each infrastructure element should include the items listed as “recommended” in Table 17, Table 18, Table 19 and Table 20.

9.2.5.4 Optional

Records for each infrastructure element may include, amongst others, the items listed as “optional” in Table 17, Table 18, Table 19 and Table 20.

9.2.5.5 Other recommended documentation

The following additional documentation should be maintained

- floor plans of buildings and campus showing telecommunications spaces and pathways,

- floor plans of telecommunications spaces,
- elevations of cabinets, racks, frames, and walls on which telecommunications hardware is mounted,
- design drawings of building common bonding networks,
- results of link and channel measurements,
- telecommunications cabling system bid documents and change orders,
- telecommunications cabling system warranties,
- work orders.

Table 17 – Infrastructure records for spaces, cabinets, racks, frames and closures

Element	Requirements	Recommendations	Optional
Telecommunication spaces	• space identifier; • location (for example, room number); • type or function of space; • key or access card identification; • contact person; • hours of access; • date of last record update.	• linkage to floor plan drawing indicating location of space in building – for example, active link to drawing or file name of drawing; • linkage to floor plan of telecommunications space – for example, active link to drawing or file name of drawing; • available and utilized power; • cooling capacity.	• cabinets, frames, racks and wall segments located in the space; • telephone number of telephones located in the space; • identifier of local common bonding network access; • location of local common bonding network access; • equipment located in the space.
Cabinet, rack, frame, and wall segment	• cabinet, rack, frame, or wall segment identifier; • identifier of space where cabinet, rack, frame, or wall segment is located; • date of last record update.	• total rack mounting space in rack units; • used rack mounting space in rack units; • available rack mounting space in rack units; • dimensions of space on wall segment for mounting of telecommunications hardware; • used space on wall segment; • available space on wall segment; • manufacturer and part number; • location of earthing or identifier of bonding conductor.	• linkage to cabinet, rack, frame, or wall elevation drawing – for example, active link to drawing or file name of drawing; • equipment located in cabinet, rack, frame, or wall segment; • manufacturers and part numbers of cable management hardware installed on rack, frame, cabinet, or wall segment.

Patch panel and block records	• patch panel or block identifier; • identifier of cabinet, rack, frame, or wall where patch panel or block is located; • location of patch panel or block in cabinet, rack, frame, or wall; • performance category of patch panel or block; • type of ports or connectors; • number of ports or connectors; • unterminated ports or connectors; • ports or connectors with failures; • date of last record update.	• manufacturer and part number of patch panel or block; • location of earthing or identifier of bonding conductor.	• manufacturer of fixed connectors or optical fibre connector adapters (if different from patch panel manufacturer); • size of patch panel or block.

Table 18 – Infrastructure records for cables and termination points

Element	Requirements	Recommendations	Optional
Cables	• cable identifier; • cable performance category; • type of terminations or connectors on each end of the cable; • number of terminations or connections (e.g. optical fibres, optical fibre pairs, copper pairs, or 4-pair ports; • identifiers of patch panels, telecommunications outlets, equipment outlets, and terminations on each end of the cable (for example, patch panels or telecommunications outlet and ports); • unterminated conductors or optical fibres; • conductors or optical fibres with failures; • date of last record update.	• cable length; • identifier of spaces or cabinets, frames, racks or walls at each end of the cable (not required as termination identifier should identify the location of the terminations); • manufacturer and part number; • identifiers of pathways in which the cable is installed.	• cable sheath colour; • location of earthing or identifier of bonding conductor; • treatment of shields/screens; • cable test data.
Termination points (including patch panel ports, telecommunications outlets, equipment outlets, or termination points on blocks)	• termination point, port, telecommunications outlet, or equipment outlet identifier; • patch panel or block; • type of ports/connectors; • performance category; • identifier of cable terminated on termination point; • strand, pair, or port of cable terminated on termination point;	• name of patch cord or jumper connected to termination point; • name and port of device connected to termination point; • manufacturer and part number.	• port colour or icon.

	• identifier of termination point at the other end of the cable terminated on the port; • status – for example: • bad (failure); • no cable (no cable terminated on port or connector); • open (no patch cord or jumper); • connected (patch cord or jumper connected to termination point); • date of last record update.		

Table 19 – Infrastructure records

Element	Requirements	Recommendations	Optional
Cords and jumpers		• cord, or jumper identifier; • cord or jumper performance category; • type of termination or connector on each end; • identifiers of termination point at each end of the cord, or jumper (for example, patch panel and port, block and port, telecom outlet and port, device and port); • carrier, local access provider, and circuit identifiers for wide area circuits; • date of last record update.	• manufacturer and part number; • length; • cable sheath colour
Active devices		• identifier of the device; • identifier of room, rack, cabinet, frame, or wall; • location in room, rack, cabinet, frame, or wall; • manufacturer and model number; • type or function of device; • number of slots; • type of module or card in each slot; • number and type of ports in each module or card; • name of owner, user, department, or company; • serial number; • date of last record update.	• connector types for each port; • contact information for device owner, user, department, or company; • power requirements; • assigned power receptacles; • serial numbers (as appropriate); • IP address and hostname (if applicable); • location of earthing or identifier of bonding conductor.
Earthing bonds		• identifier of earthing bond; • identifier of components connected at ends of bonding conductor; • identifier of bonding conductors that tap bonding conductor; • size of bonding conductor; • type and location of each termination and tap; • date of last record update.	• manufacturer and part number of bonding conductor; • length; • cable sheath colour.

Table 20 – Infrastructure records for pathways and premises

Element	Requirements	Recommendations	Optional
Pathways		• identifier of the pathway; • identifier of the spaces at either end of the pathway; • location and routing of pathway; • linkage to floor plan drawing indicating location of pathway building – for example, active link to drawing or file name of drawing; • type of pathway including type of material (metal, plastic, etc.); • dimensions of pathway; • branching points; • cables installed in pathway; • date of last record update.	• manufacturer and part number; • location of earthing or identifier of bonding conductor.
Buildings		• identifier of building used in cabling administration system; • address; • list of all telecommunications spaces; • contact information for access; • access hours.	•
Site or campus		• identifier of site or campus used in cabling administration system; • name of campus or site commonly used within the organization; • address; • linkage to campus or site plan drawing providing locations of buildings and routing of pathways between buildings – for example, active link to drawing or file name of drawing; • contact information for local administrator of infrastructure; • list of buildings at the site or campus; • location of main cross-connect, if applicable; • access hours.	•

9.2.6 Cable administration system

9.2.6.1 General

The minimum requirements for the management of records are defined in Tables 13 and 14.

A computer-based administration system may use a database of records to maintain up-to-date information relating to the cabling. It enables the user to keep control of moves, additions and changes to the cabling and to generate reports on the state of the cabling system.

Records regarding components of cabling, pathways and spaces may be linked to each other using their identifiers and may make reference to further premises records on power, heating, air conditioning systems, lighting, etc.

Figure 12 gives an overview of database records and examples of possible linkages.

Linkages support the retrieval of information about the telecommunications infrastructure from administration records. Each required record type defines a primary indexing identifier to facilitate linkage between infrastructure identifiers and records.

The basic administration database information flow is illustrated by Figure 13.

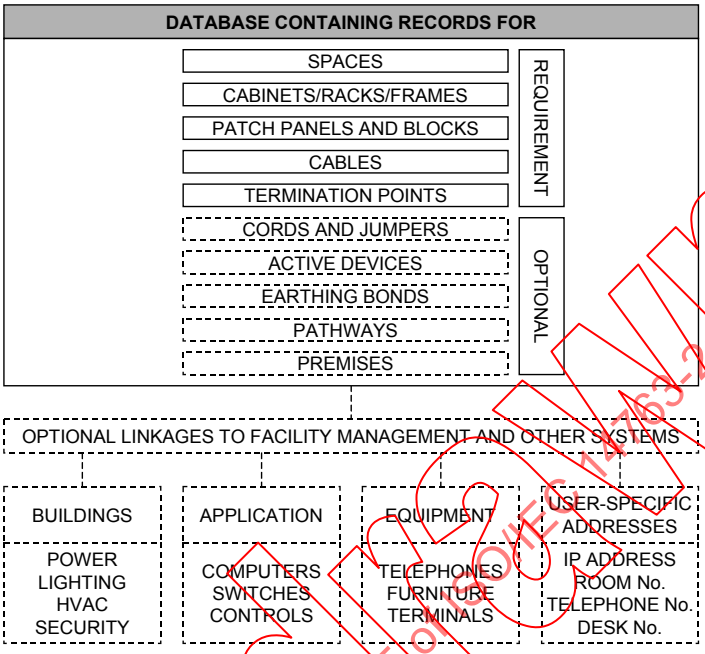


Figure 12 – Cable administration database and possible linkages

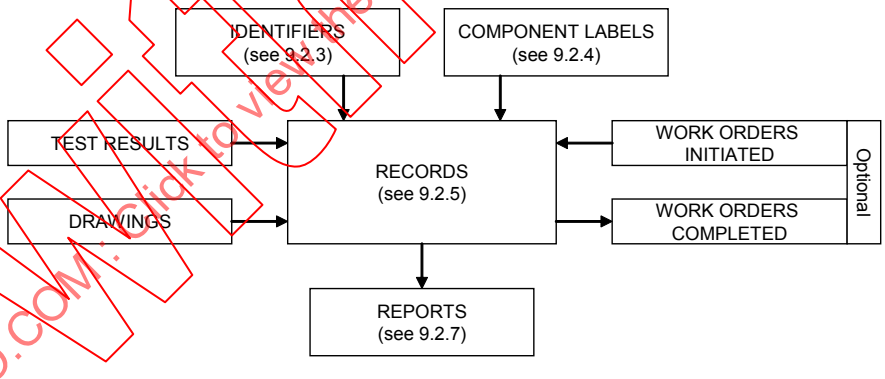


Figure 13 – Basic cabling administration

9.2.6.2 Requirements

When administration is performed with special-purpose cable management software, linkages shall be provided between each appearance of an infrastructure identifier in a record and any record for which that identifier is the primary indexing identifier.

9.2.6.3 Recommendations

The records of the administration system should meet the recommendations of

- Table 21 based upon the installation complexity Level determined from Table 11,
- Table 22 based upon the operational complexity Level of Table 12.

Table 21 – Recommendations of installation administration systems

	Administration system		
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Infrastructure complexity Level	1	2	3
Fixed cabling (see Note)	Manual	Electronic	Electronic
NOTE Manual records include paper-based systems. Electronic records include spreadsheets, databases, etc.			

Table 22 – Recommendations of operational administration systems

	Administration system		
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Operational complexity level	1	2	3
Cord connections (see Note)	None	Electronic	Automated
Service delivery (see Note)	None	None	Automated
NOTE Manual records include paper-based systems. Electronic records include spreadsheets, databases etc. Automated records include the data from AIM systems that detect connection/disconnection~~/reconnection~~ of cords and~~/or services provided over the cabling~~ the presence of discoverable equipment connected to the network. Requirements and recommendations for specifying and operating AIM systems are provided in Annex H. ~~Cable management software with automation should have the capability of documenting the infrastructure elements as described in this standard. The system should be capable of automatically monitoring patch connections between cross-connects with automated management, and of generating alerts and updating documentation when any of these patch connections are changed. Such systems may have additional functions including the discovery and documentation of the configuration of transmission and terminal equipment.~~			

It is recommended that the principles of administration outlined in this standard be implemented using a computer based administration system. The complexity of the administration system may be related to the size of the telecommunications infrastructure. For a small system, a customised commercial database or spreadsheet programme may be adequate. For a large organisation, the cabling administration system may require a sophisticated database, an efficient data retrieval program and additional features. For example, the computer administration package may input drawings directly from CAD programs or may output reports to external packages or e-mail work orders and automatically update records on completion of work and may also serve as a cabling design tool.

When administration is performed using spreadsheets or paper-based systems, records should be designed and organised to facilitate information retrieval based on primary indexing identifiers. This provides functionality similar to software linkages. Indexes relating record locations to primary identifiers may also be beneficial.

Drawings should be available showing all identified elements of infrastructure. Refer to 9.1 for further information.

Optional or user-defined record types should also define a primary indexing identifier. Linkages to additional records in which the identifier appears are also desirable.

9.2.7 Reports

9.2.7.1 Requirements

Reports are the means by which information about a telecommunications infrastructure is communicated.

Administration systems using special purpose cable management software shall make available to the telecommunications infrastructure operator reports listing all records containing a selected identifier and all information in those records, any desired subset of those records and the recorded information, or any desired union of such information.

9.2.7.2 Recommendations

Paper-based or spreadsheet-based administration systems may require additional record-keeping to provide adequate reporting capabilities. For example, a drawing or graphical representation of the infrastructure would allow the operator to easily locate all telecommunications outlets in a given work area, even if they are connected to links originating from multiple telecommunications spaces.

Reports are generated from information in the data base. Reports may take the form of lists, tables, diagram, forms, etc. Reports may be used for status determination, trouble shooting and may help for planning purposes.

10 Testing

10.1 General

10.1.1 Links and permanent links

As shown in Figure 14 and according to the design standards supported by this standard, a permanent link comprises either

- a single length of fixed cable terminated at both ends or
- a separately defined link comprising a single length of fixed cable (e.g. CP link of ISO/IEC 11801, LDP link of ISO/IEC 24764) connected to a non-fixed cable (e.g. CP cable of ISO/IEC 11801, LDP cable of ISO/IEC 24764).

Tests applied to links are generally used to verify the initial performance of the link.

Where a permanent link contains a non-fixed cable any test result is only applicable to the specific configuration under test.

Although each end of a link features a test interface, definitions of link performance include the connection at these points.

The accuracy of the test system is defined at its reference plane. The reference plane of a link is within the test cord cable next to, and including, the test cord connector which mates to the interface of the link under test. The reference planes for links are defined according to Figure 15.

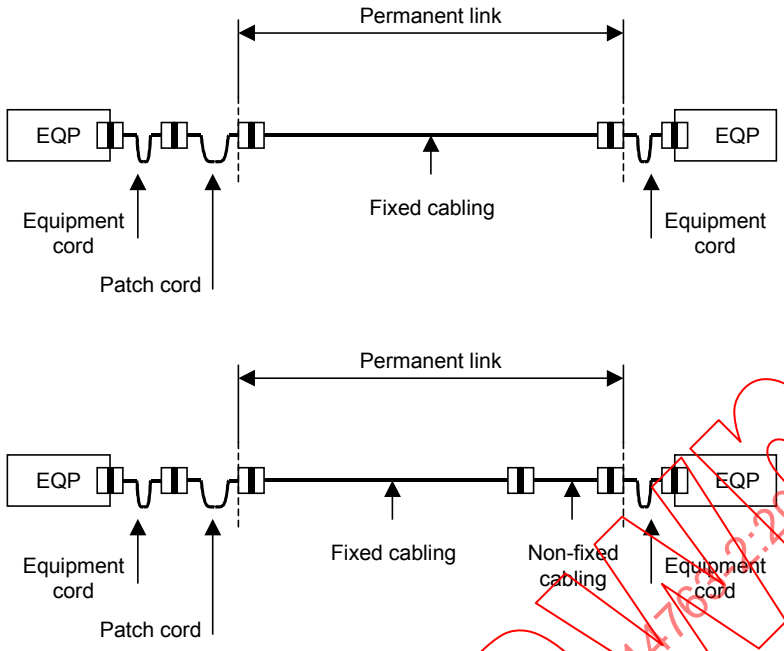


Figure 14 – Examples of cabling permanent links

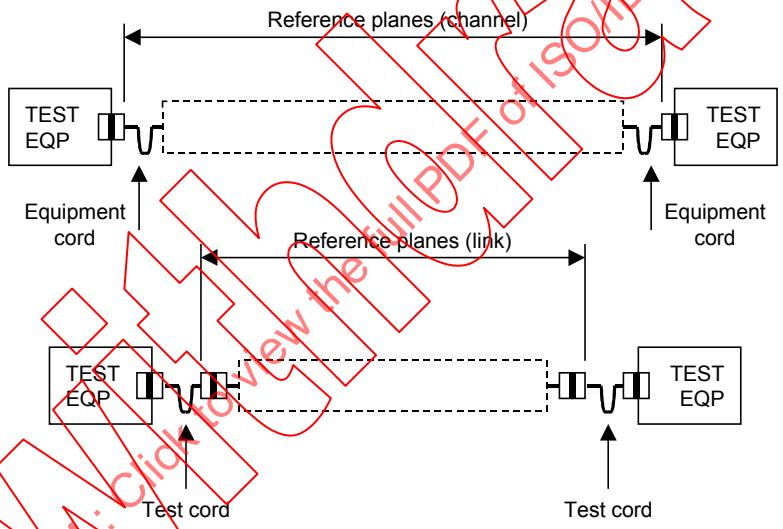


Figure 15 – Reference planes for link and channels (point-to-point)

10.1.2 Channels

A channel contains one or more permanent links interconnected by jumpers and cords (see Figure 3 of ISO/IEC 11801:2002). Although the equipment cords are terminated at both ends, definitions of channel performance exclude the connection at the transmission/terminal equipment.

The approach adopted by the installation specification defines the characteristics (length, transmission performance, etc.) of cords to be attached to permanent links and that are necessary to provide the required channel performance.

Testing of channels is not generally applied where such cords are attached to a permanent link of a given Class to provide a channel of the same Class.

However, channel tests for balanced cabling may be used to determine performance where required by the installation specification, see 6.2.1.3.

Tests may also be applied to channels for application trouble-shooting.

Where channel tests are carried out, the actual cords used to create the channel shall be used and installed in the as-built configuration.

Although each end of a channel features a test interface, definitions of channel performance exclude the connection at these points.

The accuracy of the test system is defined at its reference plane. The reference plane of a channel is within the equipment cable next to, but excluding, the equipment cord connector into the test equipment. The reference planes for channels are defined according to Figure 16.

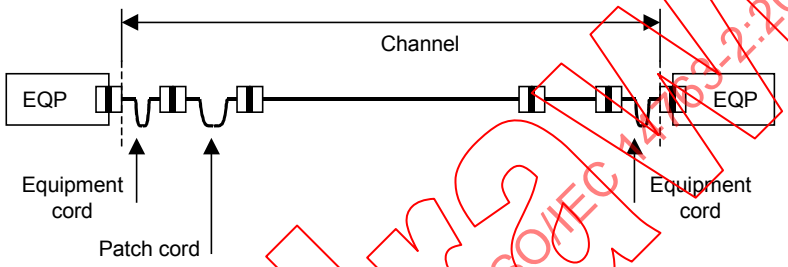


Figure 16 – Example of a cabling channel

10.1.3 Cabling interface adaptors

The design of test equipment and/or the requirements of a test procedure may necessitate the use of cabling interface adaptors (e.g. test cords or fixtures).

A maximum operational lifetime shall be defined for the cabling interface adaptors.

This may be expressed as a time period or a maximum number of mating cycles to the test equipment and/or cabling under test. Alternatively, if the test equipment offers a “self-test” process, including artefacts, to assess the condition of the adapters, such processes shall be applied.

Where no information exists as to the maximum operational lifetime of a particular cabling interface adaptor, it shall be replaced with products known to meet the required performance.

For optical fibre cabling, temporary index matching materials (gels and/or fluids) in mated connectors under test shall not be used.

10.1.4 Calibration

The test operator shall have evidence, in the form of a valid calibration certificate or equivalent, to support the use of the test equipment at the time the tests are carrieed out.

The test operator shall ensure that the test system has been normalised in accordance with the appropriate testing standard or test equipment manufacturers instructions prior to the test being undertaken. This requirement may be part of the specified test procedure.

10.1.5 Equipment protection

Transmission and terminal equipment shall be removed from the interfaces to the cabling under test.

10.1.6 Measurement conditions

Measurements shall either

a) be made under environmental conditions which are representative of the intended operational environment, or

b) have correction factors applied to the measured results in accordance with manufacturers specifications to reflect the intended operating environment, or

c) be clearly documented as being carried out in unrepresentative conditions.

The ambient temperature shall be recorded in the test result documentation.

10.2 Test procedures for balanced cabling

10.2.1 General

Where testing is required by the installation specification and detailed in the quality plan then

- for links and channels of Classes D, E, E_A, F or F_A
  - the test procedures are specified in IEC 61935-1,
  - testing should be carried out using equipment in accordance with IEC 61935-1,
  - testing of individual parameters within the parameter groups of Table 1 should not be applied;
- for links and channels of other Classes
  - it is only necessary to test individual parameters within the internal transmission group,
  - test procedures and equipment other than those in accordance with IEC 61935-1 may be used.

10.2.2 Measurement of length-related parameters

The nominal velocity of propagation (NVP) of the cable shall be determined and input, as necessary, to test equipment before testing is carried out.

10.2.3 Treatment of marginal test results

The treatment of marginal results shall be as detailed in the quality plan (see 6.3.1.2).

10.2.4 Treatment of unacceptable test results

Where results are obtained that do not meet the requirements of the installation specification, the following steps may be considered

- re-verification of the normalisation of the test system,
- repetition of the measurement using a test system with an improved measurement accuracy.

Where the test result continues to be unacceptable, the appropriate corrective actions and re-testing of repaired links or channels (and any other cabling affected by the repair activity) shall be carried out and documented in accordance with the procedures defined in the quality plan.

10.2.5 Test result format

Test results shall be given in the native format of the tester manufacturer including reader software. Alternatively, results shall be delivered in a standardised document format as agreed between the installer and premises owner such as .pdf, .odf or .xml but no adulteration of the test result is allowed.

10.2.6 Test result documentation

10.2.6.1 Equipment in accordance with IEC 61935-1

The documentation for each parameter shall include

a) test equipment,
   1) type and manufacturer,
   2) serial number and calibration status,
   3) level and software version,
b) details of the cabling interface adaptors (type, reference numbers and manufacturer),
c) details of the cabling under test,
d) the date of the test (the time of the test may also be recorded),
e) relevant environmental conditions,
f) the test operator.

10.2.6.2 Other equipment

In addition to the items in 10.2.6.1 the documentation for each parameter shall include

a) details of the parameter,
b) details of the test system,
c) the measured result,
d) the required result.

10.3 Test procedures for optical fibre cabling

10.3.1 General

The performance Classes of links and channels within the referenced cabling design standards contain requirements for some or all of the parameters in Table 3 against which installed cabling may be tested.

Where testing of optical fibre cabling links and channels is required by the installation specification and detailed in the quality plan, it shall be carried out in accordance with ISO/IEC 14763-3.

Permanent link testing in accordance with ISO/IEC 14763-3 does not reflect the reference planes of Figure 14. ISO/IEC 14763-3 contains information on the appropriate modifications to the test limits which reflect this difference.

Channel testing in accordance with ISO/IEC 14763-3 adopts the reference planes of Figure 16. However, the test limits are modified due to the use of reference connections on the test cords. The test results obtained cannot be directly compared with the requirements of application support such as those in Annex F of ISO/IEC 11801:2002. ISO/IEC 14763-3 contains information on the appropriate modifications to the test limits which reflect this difference.

10.3.2 Treatment of unacceptable test results

Where results are obtained that do not meet the requirements of the installation specification then the following steps may be applied

- re-verification of the normalisation of the test system,
- repetition of the measurement using a test system with an improved measurement accuracy.

Where the test result continues to be unacceptable, the appropriate corrective actions and re-testing of repaired links or channels (and any other cabling affected by the repair activity) shall be carried out in accordance with and documented by the procedures defined in the quality plan.

10.3.3 Test result documentation

The documentation for each parameter shall include

a) details of the parameter
   1) details of the test system,
   2) test equipment,
   3) type and manufacturer,
   4) serial number and calibration status,
   5) level and software version,
b) details of the cabling interface adaptors (type, reference numbers and manufacturer),
c) the stated uncertainty of measurement (measurement accuracy),
d) details of the cabling under test,
e) reference measurement numbers,
f) the date of the test (the time of the test may also be recorded),
g) relevant environmental conditions,
h) the test operator,
i) the measured result,
j) the required result.

11 Inspection

11.1 General

This clause defines levels of inspection that may be referenced from the installation specification of Clause 5. The inspection may be implemented by the installer (and would be indicated in the quality planning of Clause 6) or by a third-party operating independently and subject to a separate contract; or, according to 6.2, shall be applied in accordance with local regulations.

Inspection combines visual and physical inspection with some type of testing. Where the testing is that included within the quality plan and implemented by the installer, the sampling requirements of 6.2 apply.

Where the testing of the inspection is separate from that carried out by the installer of the quality plan and is implemented by the third-party, the inspector shall apply a sampling scheme that provides the required assurance.

11.2 Inspection Level 1

Level 1 inspection provides confirmation that the installation has been completed and that basic connectivity is assured.

Level 1 combines visual/physical inspection with limited testing to confirm that

- the documentation supplied meets the requirements of the installation specification,
- the documentation correctly reflects the as-built installation,
- the as-built installation is in accordance with the physical requirements (e.g. location of outlets, labelling, fittings, etc.) of the installation specification,
- basic verification parameters of Table 1 and Table 3 are met. For balanced and coaxial cabling, this is referred to as “verification” testing in IEC 61935-1 and IEC 61935-3,
- the labelling of the installation is in accordance with the installation specification.

11.3 Inspection Level 2

Level 2 inspection provides confirmation that the installation has been completed in accordance with this standard and provides additional confidence that specific applications are supported. Inspection at this level may allow the production of contractual documentation on this basis.

Level 2 combines the visual/physical inspection of Level 1 with additional inspection and testing processes to confirm that

- installation practices are in accordance with Clause 8,
- the cabling components of the installation are in accordance with the installation specification,
- where the installation specification identifies the applications to be supported, the cabling performance meets the transmission requirements of those applications. For balanced and coaxial cabling, this is referred to as “qualification” testing in IEC 61935-1 and IEC 61935-3.

11.4 Inspection Level 3

Level 3 inspection provides the highest level of confidence that the transmission requirements of the selected cabling design standard are met. Inspection at this level may allow the production of contractual documentation on this basis.

Level 3 combines the processes of Level 1 with additional inspection and testing processes to confirm that

- installation practices are in accordance with Clause 8,
- the cabling components of the installation are in accordance with the installation specification,
- for balanced cabling, internal transmission and alien (exogenous) parameters of Table 1 are in accordance with the requirements of the installation specification for the relevant transmission Classes (channel or link) of the cabling design standard – this is referred to as “certification” testing in IEC 61935-1,
- for optical fibre cabling, internal transmission parameters of Table 3 are in accordance with the requirements of the installation specification for the relevant transmission classes (channel or link) of the cabling design standard.

11.5 Inspection documentation – Requirements

Information relating to the inspection: date of inspection, inspector, and remedial action taken in the event of failed inspection will be clearly indicated in the inspection document.

Inspection documents are considered as records within the documentation system of Clause 9.

Unless otherwise defined in the installation specification, results provided in electronic format shall be delivered in a standardised document format such as .pdf, .odf or .xml.

12 Operation

12.1 Standard operating procedure

12.1.1 Requirements

The records relating to the infrastructure shall be retained, as appropriate, as physical or electronic record (using either a specifically design operations management application or a general purpose word processing or spreadsheet application).

Physical records shall be kept in a protected and accessible location.

Events (e.g. changes to connectivity or fault indications) shall be recorded with date, time and location.

12.1.2 Recommendations

Records of events should also contain information regarding key parameters (e.g. temperature, humidity, main voltage, bit error rate).

12.2 Cords and jumpers

The cords and jumpers used shall be in accordance with the installation specification.

The cords or jumpers selected shall be

- as short as possible and consistent with their intended route within the facilities provided for horizontal and vertical management,
- subject to any restriction specified within the referenced design standards.

When installing cords and jumpers appropriate techniques shall be applied to

- eliminate cable stress caused by tightly cinched cable bundles,
- ensure that minimum bend radii are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,
- ensure that the tensile load applied to the cord and jumpers are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,
- prevent pressure marks (e.g. through improper fastening or crossovers) on the cable sheath or the cable elements.

Cords and jumpers shall be secured in such a way that mechanical damage is avoided during operation and subsequent access. Any spare length shall be coiled in such a way as to minimise the effects of twisting (e.g. figure-of-8).

12.3 Optical fibre adaptors

Unmated optical fibre adaptors within closures shall be fixed or fitted with suitable protective caps to prevent the ingress of foreign material.

13 Maintenance

13.1 Approaches to maintenance

13.1.1 General

There are several maintenance approaches including

- preventative maintenance: scheduled maintenance on the basis of either time or cycle count (e.g. flexing, disconnection/reconnection),
- condition-based maintenance: applies continuous monitoring of vital network statistics and setting trigger thresholds. When a threshold is exceeded, the maintenance planning and execution begins. The effectiveness of a condition-based program relies on accurately defined thresholds which may only come with experience,
- "run-to-failure" maintenance: essentially is a maintain-by-repair policy (i.e. an absence of maintenance) and may be justifiable on the basis of redundancy or cost of breakdown.

The comparative costs of the different approaches not only differ in scale but they present their costs at different times during the maintenance cycle.

For example, the cost of preventative and condition-based maintenance plans may be amortized across a period in time. By comparison, "run-to-failure" maintenance approaches defers the cost until repair is required and, in addition, any redundancy is an upfront cost.

13.1.2 Requirements

The selection of the most appropriate maintenance approach shall be performed following a risk analysis taking into account the information provided in 13.1.1.

NOTE Clause F.13 provides further details for industrial premises which may be useful in other type of premises.

A maintenance contract shall be agreed upon that specifies the operations that shall be performed (i.e. the schedule, routines, tests and checks to be applied). Consideration shall be given to the inclusion of maintenance activity to

- ensure that the installation is still electromagnetically compatible with its environment,
- check of supply voltages and/or earth control,
- the periodic maintenance of connection points in harsh environments,
- the periodic maintenance of equipotential bonds and connections to surge protection devices.

13.2 Maintenance procedures

13.2.1 Requirements

Maintenance operations shall be performed according to the contract.

Consideration shall be given to cleanliness, temperature and humidity of spaces together with periodic inspection or remote surveillance of hidden areas (e.g. under raised floors).

Records shall be updated with any actions resulting from the maintenance process.

Unused cords shall be removed and, where appropriate, stored for future use, unless removal represents a risk to the operation of adjacent cabling.

13.2.2 Recommendations

All maintenance and repair operations performed near active equipment should consider the risk of electro-static discharge and adopt preventive measures.

In spaces containing distributors, cleaning should only be undertaken by personnel having completed suitable training.

Cables which have been designated as no longer necessary should be removed unless removal represents a risk to the operation of adjacent cabling.

NOTE Local regulations may require removal of such cables.

Structures supporting pathway systems should be checked periodically so that degradation and damage can be detected and corrected if required.

14 Repair

The fault detection and repair process shall be documented describing

- the process to be used to identify the nature and location of the fault,
- the safety procedures to be applied (e.g. for optical fibre cabling, see IEC 60825-2),
- the process of elimination to determine the faulty cabling component(s) or equipment,
- the action required where repair is not possible (e.g. marking of components, circuits).

The documented process shall be followed where faults occur and repair is attempted.

Records shall be updated with any actions resulting from the repair process.

Annex A
(normative)

Optical fibre polarity maintenance: connecting hardware for multiple optical fibres

A.1 General

Optical fibre cables typically contain optical fibres with coloured buffers or coatings for identification purposes. A colour scheme for cables containing up to twelve optical fibres is described in IEC 60794-2 and shown in Table A.1. Other conventions exist for the colour-based identification of optical fibres. The requirements and recommendations of this Annex are applicable independently of the actual colour scheme adopted.

Table A.1 – Optical fibre colour code scheme of IEC 60794-2

Optical fibre number	Colour
01	Blue
02	Yellow
03	Red
04	White
05	Green
06	Violet
07	Orange
08	Slate/Grey
09	Aqua/Cyan
10	Black
11	Brown
12	Rose

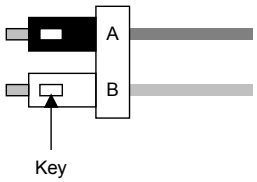
NOTE The figures in this Annex show connectors labelled with position numbers. This is done for reference purposes only; it is not a requirement of this Annex that connectors be labelled with a position number.

Where cables do not contain coloured optical fibres then the requirements of this Annex shall be applied via the optical identification system present in the cable being used.

A.2 Duplex connecting hardware interfaces

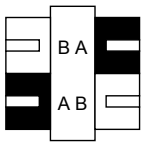
A.2.1 Duplex plugs, adapters and cords

A duplex connector plug and a duplex adapter are shown in Figure A.1 and Figure A.2. When looking at the duplex connector plug head-on (into the optical fibres) with the raised keys on top, the left position is A and the right position is B, as shown in Figure A.1. The raised keys on the plug, and the keyways in the adapter, allow the plug to be inserted into the adapter in only one orientation, so that plug A inserts into adapter position A and plug B into adapter position B.



NOTE Shading is for clarity of the illustration only.

Figure A.1 – Duplex connecting hardware plug



NOTE Shading is for the clarity of the illustration only.

Figure A.2 – Duplex connecting adapter

The adapter provides a crossover between two mated plugs because the keyways on the front and back halves of the adapter are oriented in the same direction (for example, on top) as shown in Figure A.2. When looking into the front of the adapter, this construction causes the right position (labelled A) to mate to the left position (labelled B) as viewed when looking into the back of the adapter. Thus position A on one plug mates to position B on the other plug, and vice versa, which provides the crossover in the adapter. The letters A and B are generally marked on the plug and on the adapter for identification.

A-to-B patch cords shall be built as shown in Figure A.3.

Figure A.3 – Duplex patch cord

Figure A.4 illustrates how duplex patch cords provide a crossover, since the optical fibres are attached to opposite plug positions from one end to the other. To illustrate this more clearly, the same crossover patch cord is shown in three different orientations. In all three views, each of the two optical fibres is attached to plug position A on one end and position B on the other end. Note the positions of the keyways on the connectors.

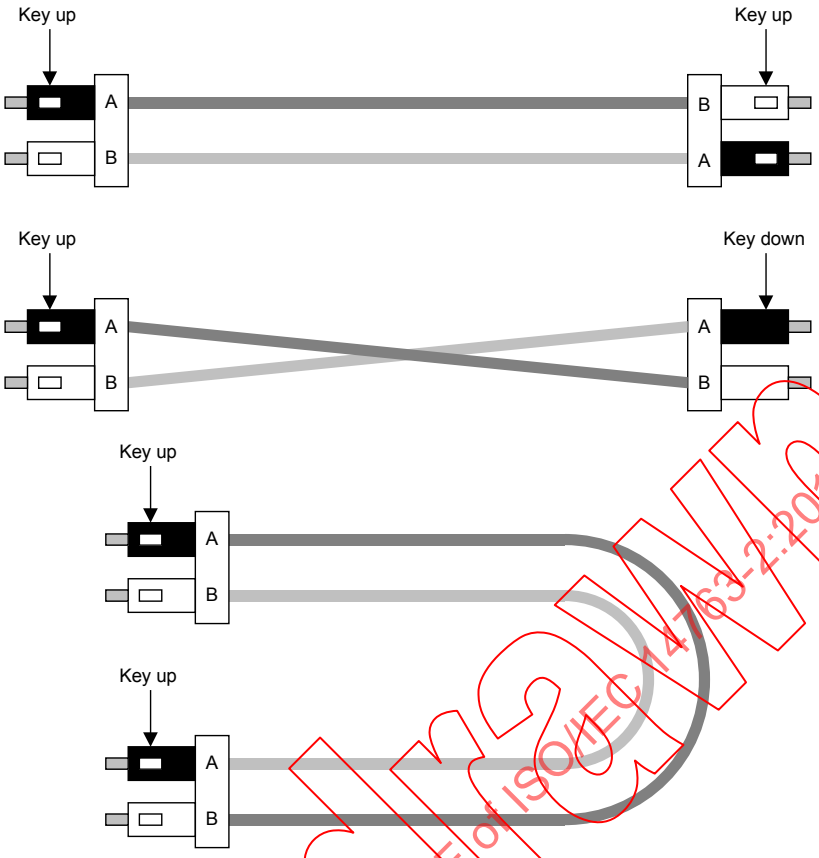


Figure A.4 – Views of crossover patch cords

A.2.2 Polarity of installed cabling segments

Permanent cable segments shall be installed with a crossover in each optical fibre pair such that each optical fibre of a pair is plugged into an adapter position A on one end and an adapter position B on the other end.

There are two methods available to achieve proper polarity when terminating cables at patch panels. The first method is preferred, as it provides more straightforward administration for applications that operate on other than two optical fibres, such as surveillance video on one optical fibre, or high-resolution component video that operates on three fibres (for R, G, B signals). This method is referred to as symmetrical positioning and it maintains the same order of the fibres at both ends of the cable. The alternate method, called reverse-pair positioning, is used when the adapter orientation in patch panels is fixed.

Following either of these methods ensures that each optical fibre will be plugged into position A on one end and position B on the other end, thus providing the required crossover. Figure A.5 illustrates the symmetrical positioning method and Figure A.6 illustrates the reverse-pair positioning method.

A.2.3 Symmetrical positioning method

In the symmetrical positioning method, adapters are inserted in the patch panel at one end of the cable with the opposite orientation of the adapters at the other end of the cable. At one end of the cable, adapters are installed such that adapter position A corresponds to odd numbered panel positions (A-B, A-B order), and on the other end of the cable, adapters are installed in the opposite orientation, such that adapter position B corresponds to odd numbered panel positions (B-A, B-A order).

Optical fibres are plugged into the adapters with the same number (or colour code) sequence on both ends of the cable (that is, 1 (blue), 2 (yellow), 3 (red), 4 (white), etc.) so that the optical fibre number (or colour code) sequence is symmetrical with respect to the panel positions.

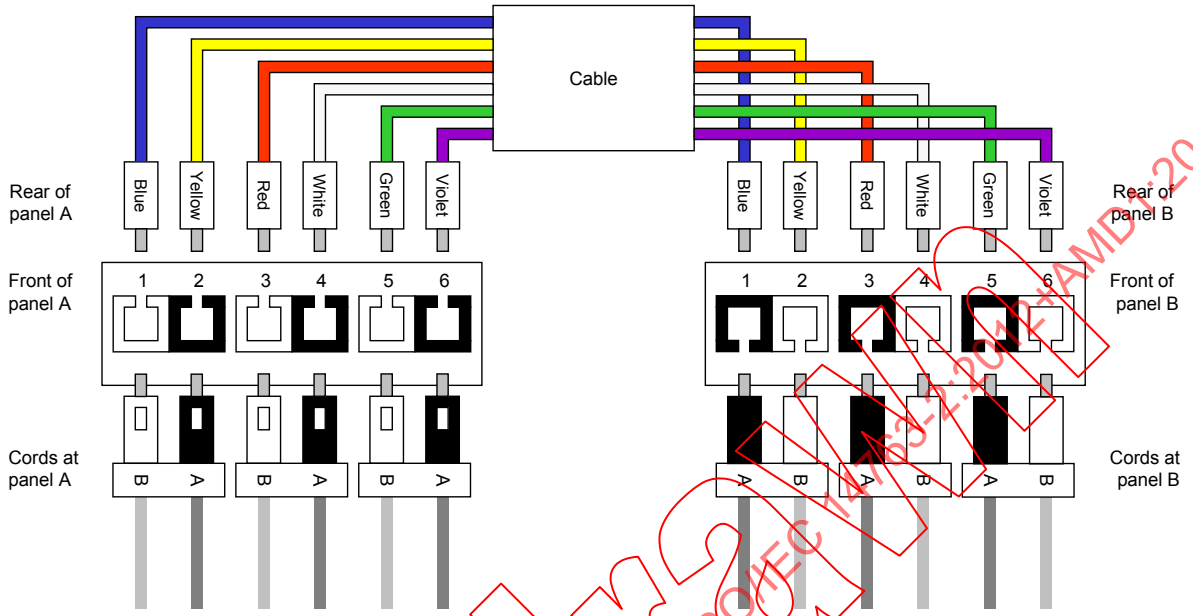


Figure A.5 – Optical fibre sequences and adapter orientation in patch panel for the symmetrical position method

A.2.4 Reverse-pair positioning method

In the reverse-pair positioning method, adapters are inserted (or are pre-installed) in the patch panel at one end of the cable with the same orientation of the adapters at the other end of the cable. They may be installed either in A-B, A-B order or B-A, B-A order

Optical fibres are plugged into the adapters with normal number (or colour code) sequence on one end of the cable (that is, 1 (blue), 2 (yellow), 3 (red), 4 (white), etc.), and with pair-reversed ordering on the other end (that is, 2 (yellow), 1 (blue), 4 (white), 3 (red), etc).

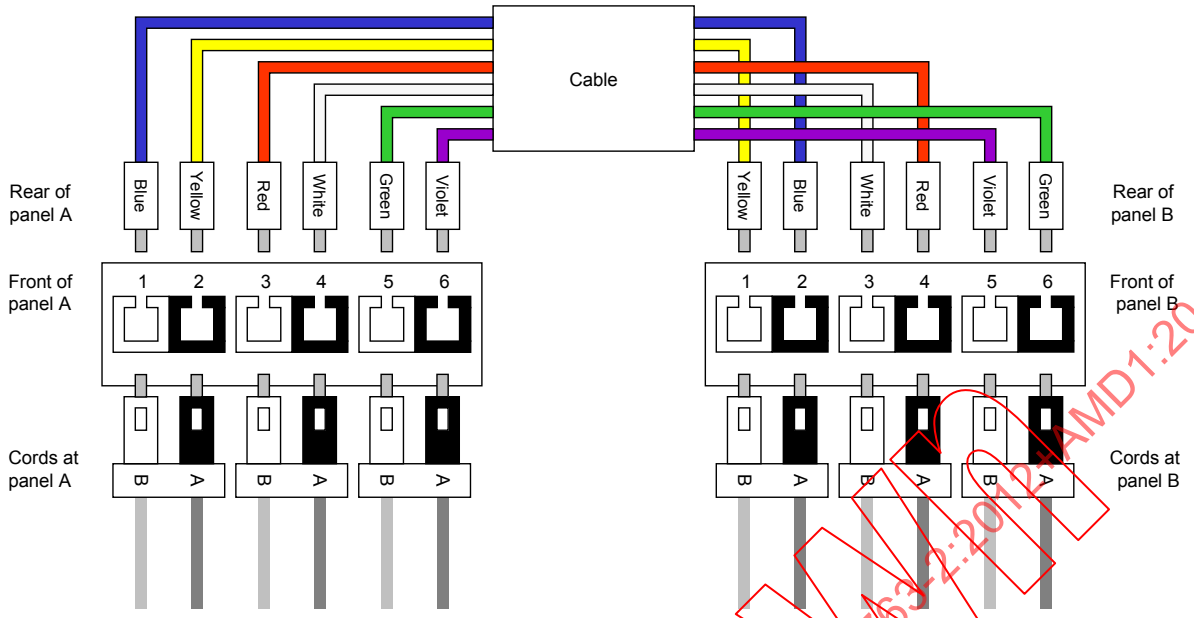


Figure A.6 – Optical fibre sequences and adapter orientation in patch panel for the reverse-pair position method

A.3 Array connecting hardware interfaces

A.3.1 General

Array connecting hardware enables the installation of pre-terminated cables containing multiple optical fibres. The optical fibres within the cables may be presented at panels in a number of ways including the use of

- transition assemblies for the creation of duplex optical fibre channels,
- array interfaces for onward connection to transmission equipment that uses array connecting hardware for applications that require parallel optics.

An implementation of the type described in A.3.2 and A.3.3 is recommended to provide the required control of optical fibre polarity through array interfaces, transition assemblies and attached cords.

Where the array connection is created using a combination of pinned and unpinned connectors, the pinned connector is typically located where the risk of damage is least (e.g. inside panels, transition assemblies and transceivers) whereas the connector that is frequently removed and handled is unpinned.

This convention leads to the following recommendations

- patch cords (from transceiver to panel) should be unpinned on both ends,
- transition assemblies (mounted behind the panel) should be pinned,
- cables from panel to panel should be unpinned on both ends.

NOTE Flat-polished array connectors do not optically mate with angle-polished array connectors.

A.3.2 Array connecting hardware components

A.3.2.1 General

A.3.2.2 describes an approach for the termination of cables and patch cords. A.3.2.2 describes an approach for the configuration of array connection adaptors. A.3.2.4 describes an approach for the implementation of duplex transition assemblies.

The use of these components as described in A.3.3 ensures the maintenance of the correct optical fibre polarity using the minimum number of component configurations.

Alternative approaches to those described in A.3.2.2 to A.3.2.4 may be applied but will require implementations other than those of A.3.3 in order to maintain the correct optical fibre polarity. In addition, a greater number of component configurations may be required e.g. different designs of transition assembly or patch cord at each end.

A.3.2.2 Cables and array connector patch cords

As shown in Figure A.7, array connector cables have a sequential number assigned to each optical fibre which are then inserted into the array connectors as follows

a) within the array connector, the optical fibres are fixed within the array connector in consecutive number (1, 2, 3, 4…12) from left to right as viewed looking at the end-face of the connector with the connector key up,

b) on the other end of the cable, the optical fibres are fixed within the array connector in reverse consecutive number (12, 11, 10, 9…1) from left to right as viewed looking at the end-face of the connector with the connector key up.

NOTE The cable shown is unpinned on both ends, following the gender convention described in A.3.1. In some instances (such as when supporting parallel signals as shown in Figure A.11) it will be necessary to use a combination of unpinned and pinned array connectors on cables and patch cords.

Figure A.7 – Array connector cable or patch cord (key-up to key-up)

A.3.2.3 Array adapters

Array adapters shall be built in such a way that they mate two array connectors with the connector keys aligned (i.e. key-up to key-up) as depicted in Figure A.8.

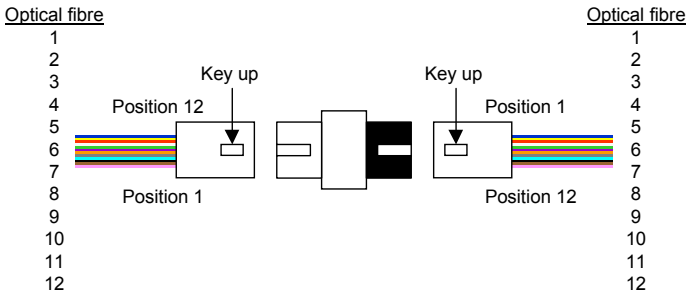


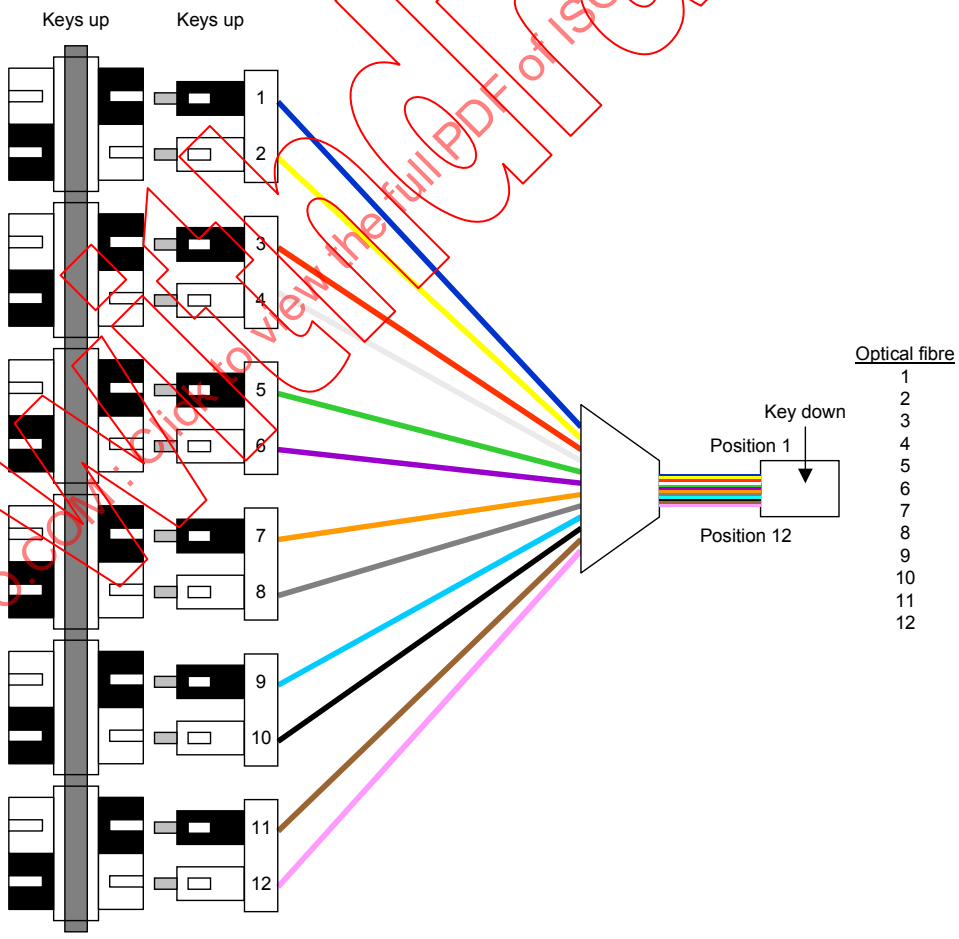
Figure A.8 – Array adapter with aligned keyways

A.3.2.4 Transition assemblies for duplex cabling

As shown in Figure A.9, transition assemblies have a sequential number assigned to each optical fibre which are then inserted into the connectors as follows

a) within the array connector the optical fibres are fixed in consecutive numbers (1, 2, 3, 4…12) from right to left as viewed looking at the end-face of the connector with the connector key down,

b) in the duplex connecting hardware the optical fibres are fixed in consecutive numbering (1, 2..3, 4..5, 6…11, 12) from left to right as viewed looking through the adapters with keys up.



NOTE For ease of illustration, this transition assembly is shown with duplex adapters, although they are not necessarily part of the assembly.

Figure A.9 – Transition assembly

A.3.3 Array connectivity methods

A.3.3.1 Duplex channels

Implementation of the array connectivity method for duplex signals is shown Figure A.10.

When connecting multiple duplex optical transceiver ports, the backbone (composed of one or many array connector cables mated with array adapters) is connected on each end to a transition assembly. The transition assemblies are mounted in two orientations such that their duplex adapter key orientation on one end of the backbone is rotated 180° relative to their adapter key orientation on the other end of the backbone. For example, one transition assembly is installed with keys up and the other with keys down. If the 180-degree rotation of one of the transition assemblies is not feasible, a port mapping labelling scheme shall be implemented. Duplex patch cords as specified in A.2.1 are used to connect ports on the transition assembly to their respective duplex transceiver ports.

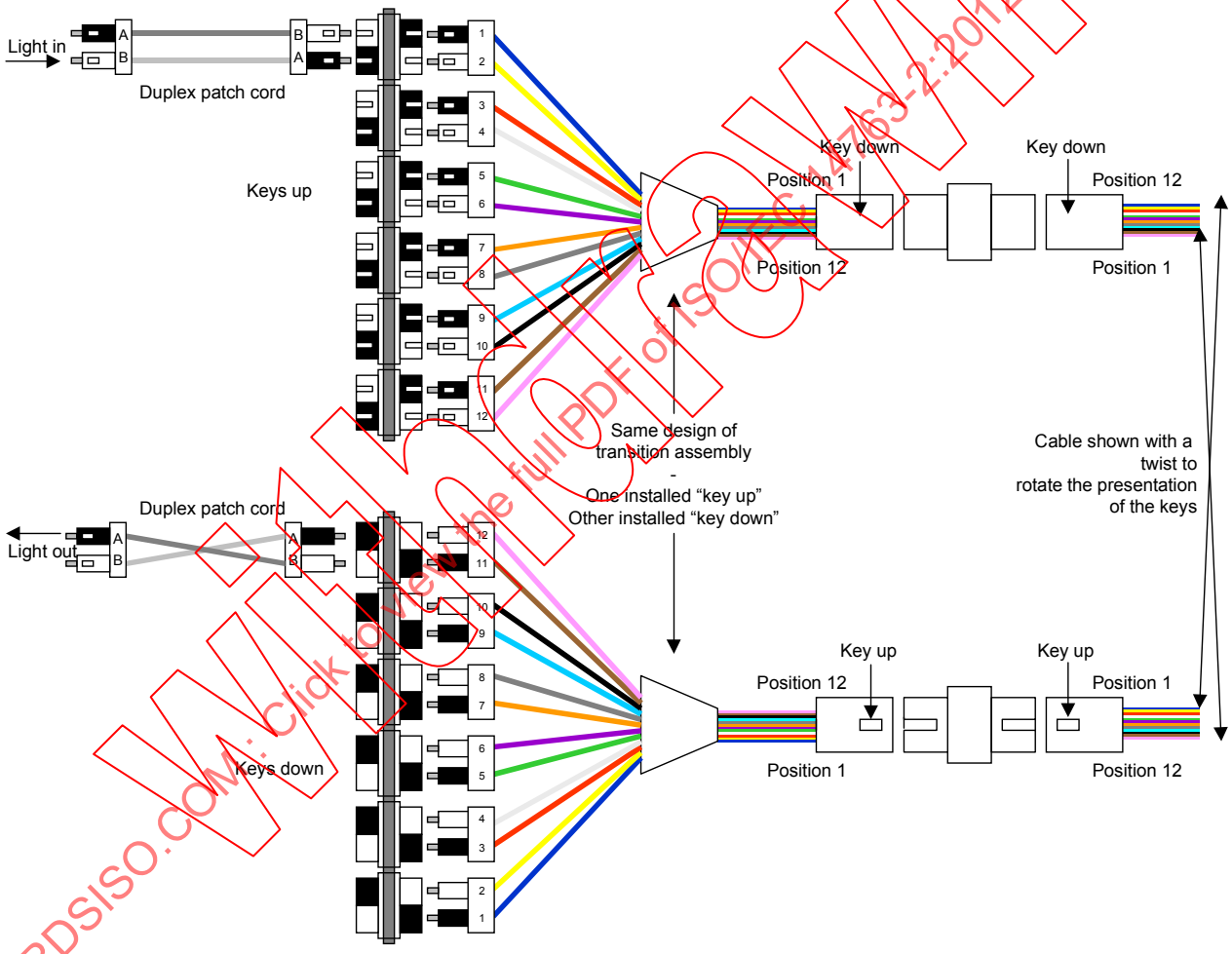
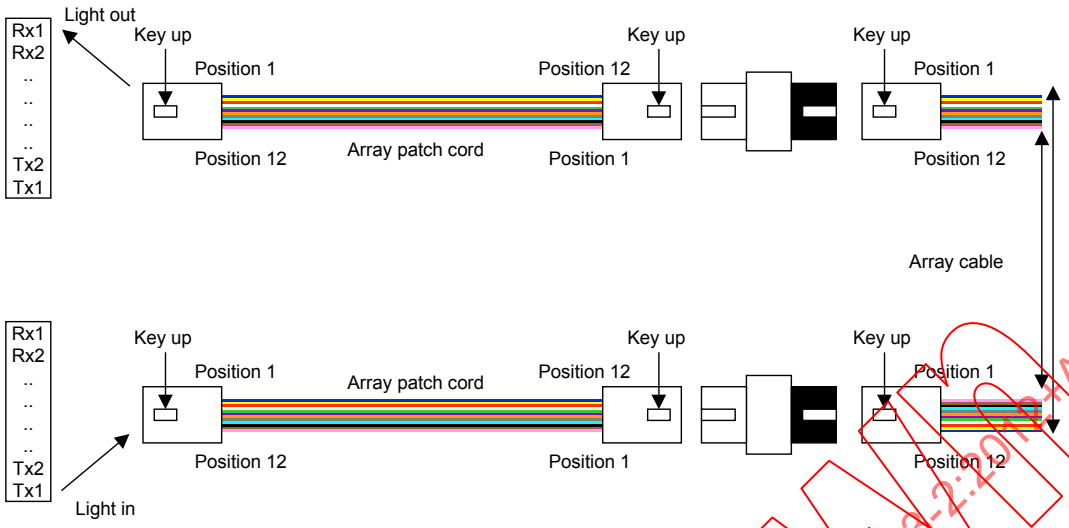


Figure A.10 – Connectivity method for duplex signals

A.3.3.2 Parallel optics channels

Implementation of the connectivity method for parallel signals is shown in Figure A.11. When connecting parallel signals, the array backbone (composed of one or many array connector cables mated in array adapters) is connected on each end to a patch panel. Array patch cords are then used to connect the patch panel ports to their respective parallel transceiver ports.



NOTE This connectivity method will also work with other types of array transmitter and receiver devices.

Figure A.11 – Connectivity method for parallel optics channels

Annex B
(normative)

Common infrastructures within multi-tenant premises

B.1 General

This Annex supplements or modifies the corresponding clauses in the main body of the text as they apply to the planning and installation of information technology cabling in common spaces within multi-tenant premises (e.g. multi-tenant residential buildings, multi-tenant office buildings, multi-enterprise campus).

When a particular subclause of the main body of the text is not mentioned in this Annex, that subclause applies as far as is reasonable. When this Annex states “addition”, “modification” or “replacement”, the relevant text in the main body of the text is to be adapted accordingly.

For ease of reference

- Clause B.7 addresses amendments of, or additions to, the requirements and recommendations of Clause 7.

The design and planning of such infrastructures should be prepared at an early stage of the building design or refurbishment and should be integrated with the design and planning of electrical power, earthing and bonding systems, water, gas, heating and HVAC distribution systems.

Telecommunications pathways and spaces in multi-tenant premises are challenged by the character of their use. Once the premises have been built and as soon as the first group of tenants move in, the tenants' telecommunications needs may immediately impose modifications. Furthermore, over a span of years, as tenants move in and out of the premises, evolving tenant needs will continue to make adaptations necessary to comply with all the demands of its tenants.

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

Figure B.1 illustrates a representative model for the various functional elements that comprise multi-tenant pathways and spaces for a building. This is not intended to be an all-inclusive representation. It depicts the relationship between the elements and how they are configured to create a total system.

Elements of common spaces within multi-tenant premises include, but are not limited to

- entrance rooms,
- access provider spaces,
- service provider spaces,
- common equipment rooms (CERs) – similar in nature to a space housing a BD, but serving more than one tenant),
- common telecommunications rooms (CTRs) – similar in nature to a space housing a FD, but serving more than one tenant).

Table B.1 provides a summary of the telecommunications spaces.

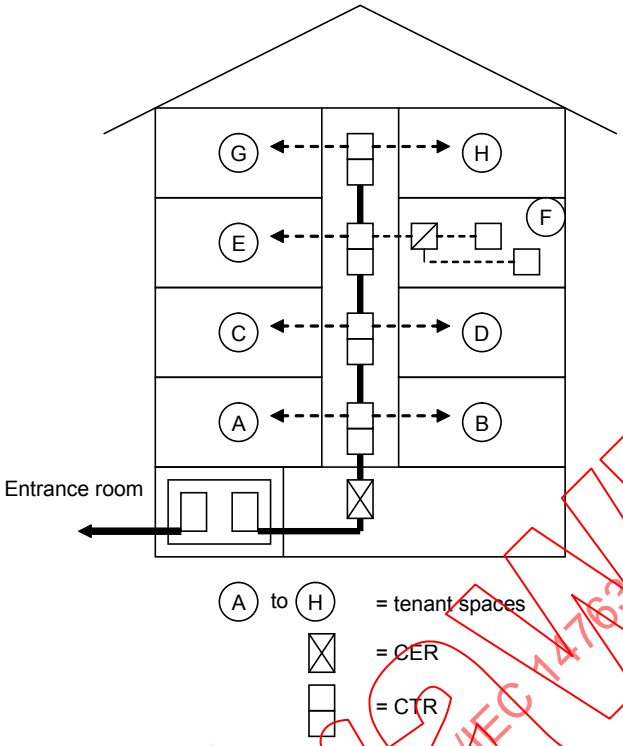


Figure B.1 – Example of common pathways and spaces in a multi-tenant building

Table B.1 – Summary of common spaces used to service a multi-tenant building

Space name	Recommended dimensions minimum	Sample functions/equipment	Primary/secondary responsible organisation
Entrance room	3 m × 3 m	Entrance, protection, transition for access provider cables	Building owner or agent
Access provider space	1,5 m × 2 m	Location of access provider transmission and support equipment	External service provider/ Building owner or agent
External service provider space	1,5 m × 2 m	Location of external service provider transmission and support equipment	External service provider/ Building owner or agent
CER	3 m × 4 m	• Cable infrastructure pathway • Infrastructure demarcation points • Paging • Fire/smoke detection and alarm • Security • Access • Surveillance systems • Building automation and control, including energy monitoring, lighting control and environmental control • Area of rescues assistance equipment	Building owner or agent

B.7 Installation planning

B.7.6 Pathways and pathway systems

B.7.6.1 Common pathways and spaces bypass (diverse cable routing)

Common pathways and spaces bypass occurs when the tenant's requirements exceed the common use pathways or spaces of the premises. A tenant who wants to keep their cabling physically separate from the common pathways and spaces used by other tenants in the premises would be a typical example of such a bypass. Unfortunately, such a bypass results in a capacity reduction in the common pathways and spaces of the premises. Note that common pathways and spaces bypass may be implemented using the specifications within the main body of this standard.

B.7.6.2 Requirements

B.7.6.2.1 Access and security

Access to pathways within the premises boundary that contain cables for tenants shall be limited to personnel authorised by the building owner/agent.

Methods of restricting access to pathways include the use of mechanical locks (using keys or special tools) or electronic access control on

- doors to rooms containing pathways,
- maintenance holes and hand holes,
- lids attached to pathways,
- barriers,
- trunking systems with access covers that can only be opened or removed with a tool.

Techniques may be employed that make evidence of attempted intrusion visible (e.g. location of pathways).

Methods of preventing access to pathways include the use of specific products such as

- conduit or duct,
- pathways embedded in walls or other building structures,
- permanently installed barriers.

Techniques may be employed that make evidence of intrusion visible (e.g. seals).

B.7.6.2.2 External network entrance pathways

External network entrance pathways may be inside the building (between the BEF and the relevant distributor of the referenced design standards) or outside the building (between the building boundary and the BEF as shown in Figure B.2). External network entrance pathways shall be specified to support the initial and forecast telecommunications needs including the total building area served and the connectivity requirements of the tenants (for both cabled and wireless infrastructures).

The forecasted telecommunications needs shall be agreed upon between the building owner and the designer.

To protect cables from environmental damage and isolate cables from pedestrian traffic, they shall be placed inside a conduit or in a cable tray, or be otherwise secured from physical damage.

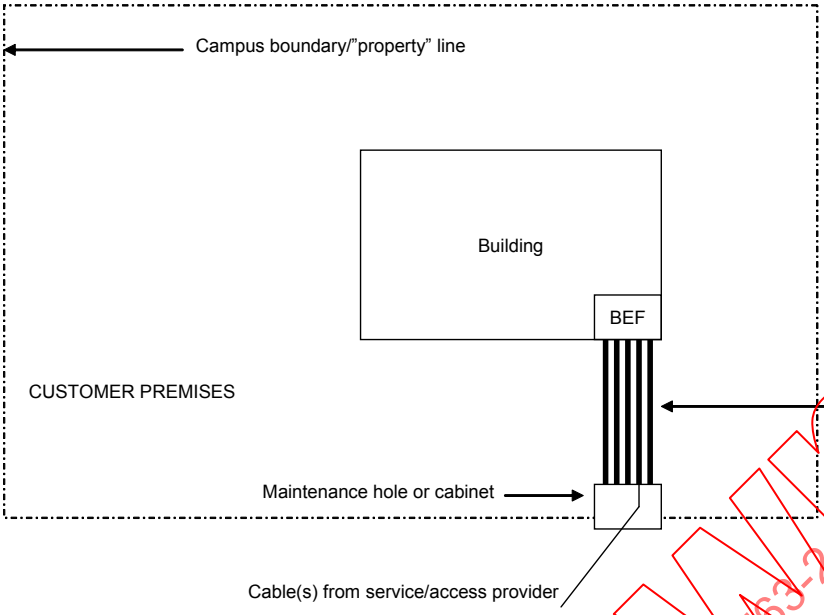


Figure B.2 – Example of a campus entrance facility

B.7.6.2.3 Common pathways within the premises

Adequate pathways shall be provided between

- access provider spaces and the CER(s),
- access provider spaces to service provider spaces,
- external service provider spaces and the CER(s).

Adequate pathways shall also be provided between

- CER(s) and any CTRs,
- CER(s) and any equipment rooms (e.g., where bypass is contemplated).

B.7.6.3 Recommendations

B.7.6.3.1 Campus pathways

The dimensions of pathways for multi-tenant premises in a campus environment should take into account any needs for multiple access providers and external service providers together with the impact of bypass connection, intra-tenant connectivity and pathway demands associated with cable infrastructures shared by multiple tenants.

B.7.6.3.2 External network entrance pathways

Accommodation should be made for multiple entrance pathways and associated facilities to support multiple external service providers.

B.7.6.3.3 Common pathways within the premises

The quantity and dimensions of CTR penetrations should take into consideration the following requirements

- cable infrastructures shared by multiple tenants,
- intra-building connectivity requirements,
- inter-building connectivity requirements,

- access providers and external service providers' bypass needs.

In the event that cable infrastructures shared by multiple tenants do not meet specific tenant needs, sufficient pathway capacity should be reserved to accommodate bypass of shared infrastructures.

Where pathways pass through spaces accessible by the public or by other tenants of the building, cabling should be installed in enclosed trunking, conduit, or other secure pathway systems.

Any maintenance holes, hand holes and closures within the pathways in unsecured areas should be equipped with locks.

Pathways less than 3 m above the finished floor should be installed in secure pathway systems (such as those listed in B.7.6.2.1) or apply alternative means to prevent accidental and/or intentional damage to the installed cabling.

B.7.8 Spaces

B.7.8.1 Requirements

B.7.8.1.1 Entrance room

Consideration shall be given to facility, occupants' and users' telecommunications connectivity needs. If access to both cabled and wireless services is required, then the entrance facilities may require adjustment in size, quantity and location.

Access to the entrance room shall be controlled by the primary or secondary responsible organization (see Table B.1).

B.7.8.1.2 Access provider and external service provider spaces

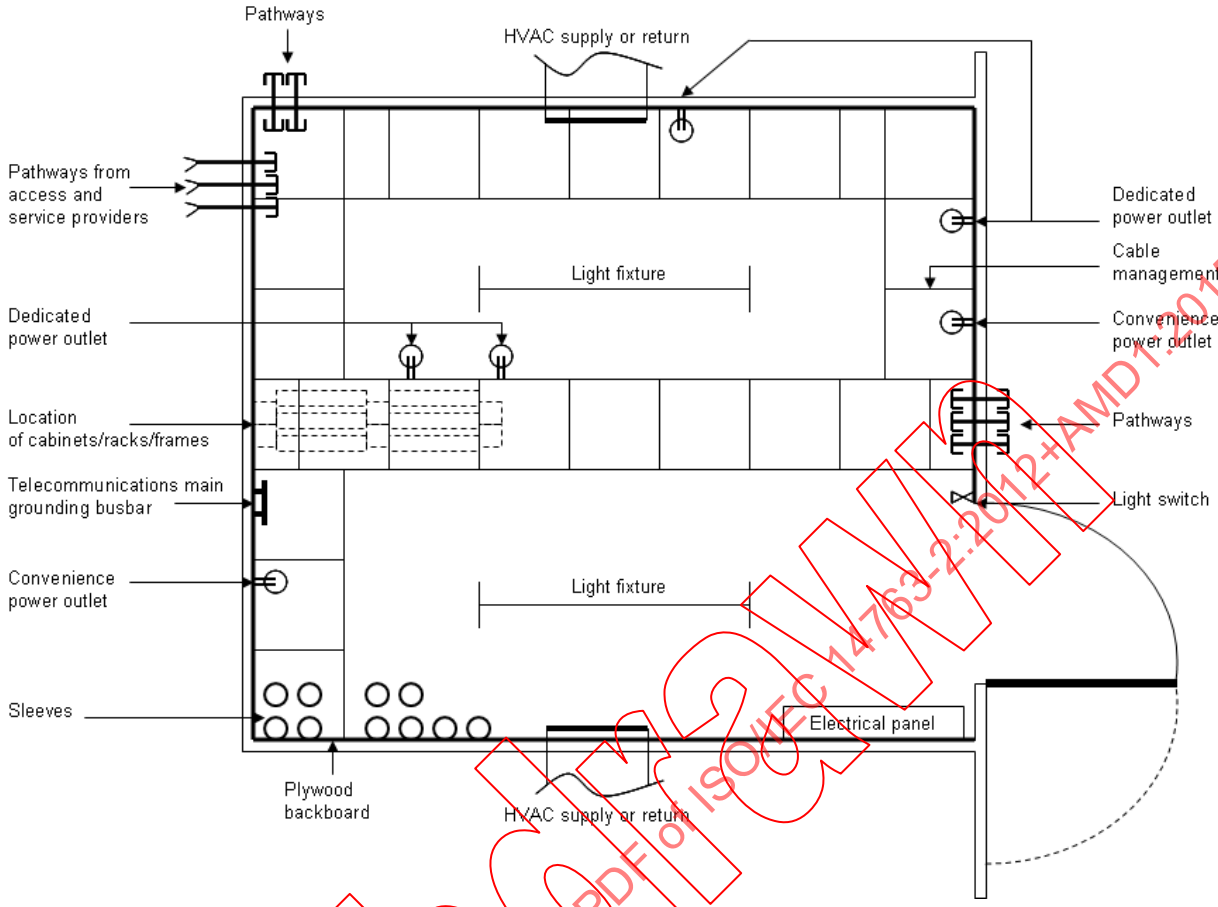
Access to the access provider spaces and external service provider spaces shall be controlled by the primary or secondary responsible organization (see Table B.1). Common approaches include lockable cabinets and caged spaces.

Access provider spaces and service provider spaces shall be configured so that each can be accessed through common-use corridors.

Access provider and external service provider spaces shall be located away from sources of electromagnetic interferences. Examples of such noise sources include electrical power supply transformers, motors and generators, x-ray equipment, radio or radar transmitter and induction sealing devices.

B.7.8.1.3 CERs

Figure B.3 shows the typical content of a CER.



NOTE Some of the icons in the figure do not conform to IEC 60617.

Figure B.3 – Example 1: Common equipment room

The CER shall be located as close as practicable to the location where the vertical backbone pathways rise throughout the building to the CTR(s), thereby reducing the length of the associated pathways.

Access to the CER shall be controlled by the primary or secondary responsible organization. Tenants premises equipment shall not be located in a CER.

The room width shall not be less than 2,5 m internal dimension.

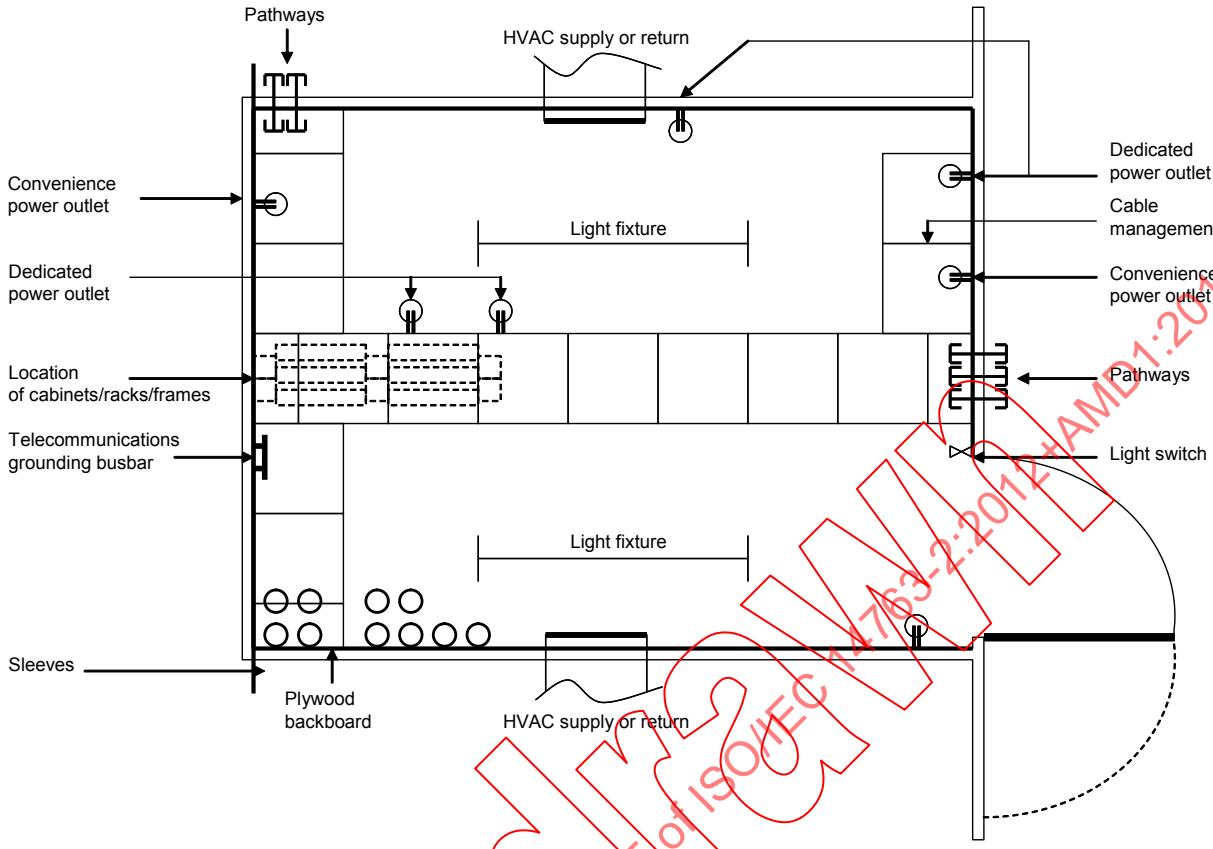
B.7.8.1.4 CTRs

Figure B.4 and Figure B.5 show typical contents of a CTR.

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

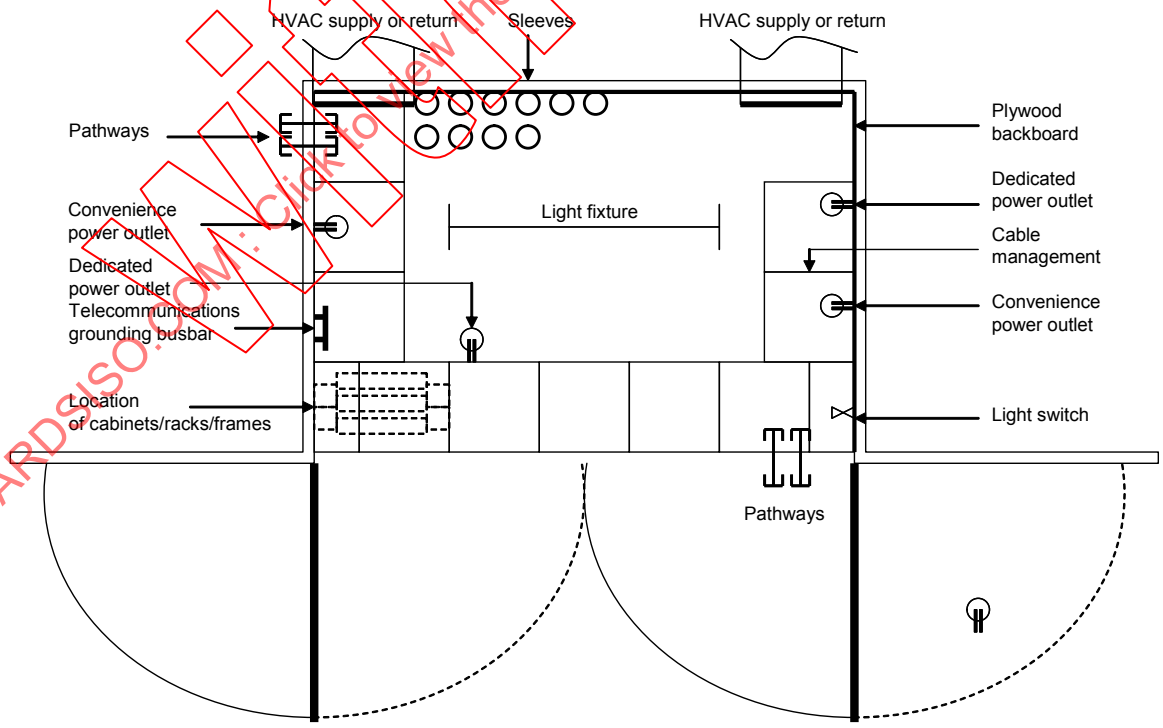
Access to the CTR shall be controlled by the primary or secondary responsible organization.

Tenants' customer premises equipment shall not be located in a CTR.



NOTE Some of the icons in the figure do not conform to IEC 60617.

Figure B.4 – Example 1: Common telecommunications room



NOTE Some of the icons in the figure do not conform to IEC 60617.

Figure B.5 – Example 2: Common telecommunications room

B.7.8.2 Recommendations

B.7.8.2.1 Access provider and external service provider spaces

Access provider spaces and external service provider spaces should be in close proximity to a CER. The access provider and external service provider spaces should be selected so that the area may be expanded.

Wireless access provider spaces should be located as close as practical to the wireless transmission/reception devices to which they are connected.

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

B.7.8.2.2 CERs

A CER should contain only those facilities that serve multiple tenants in a building. It may be appropriate to employ more than one CER in a building.

Efficiencies can be gained through establishment of space to support functions of access providers, service providers and CER in one contiguous space. The CER location should be selected so that the room may be expanded.

Buildings with gross area of 50 000 m^2 or less should allocate 12 m^2 of floor space for the CER, and preference should be given to efficient use of any available wall space. Buildings with gross area greater than 50 000 m^2 should adjust the CER area upward in increments of 1 m^2 for every increase of 10 000 m^2 in gross building area and rack mounted equipment should then be considered. The room width shall not be less than 2,5 m internal dimension.

B.7.8.2.3 CTRs

A CTR should contain only those facilities that serve multiple tenants in a building.

A typical CTR should be sized at 6 m^2.

When the area served exceeds 2 000 m^2 consideration should be given to providing more than one CTR.

Annex C
(normative)

Cabling in accordance with ISO/IEC 11801

C.1 General

This Annex supplements or modifies the corresponding clauses in the main body of the text as they apply to the planning and installation of information technology cabling in office premises in accordance with ISO/IEC 11801.

When a particular subclause of the main body of the text is not mentioned in this Annex, that subclause applies as far as is reasonable. When this Annex states "addition", "modification" or "replacement", the relevant text in the main body of the text is to be adapted accordingly.

For ease of reference

- Clause C.5 addresses amendments of, or additions to, the requirements and recommendations of Clause 5,
- Clause C.7 addresses amendments of, or additions to, the requirements and recommendations of Clause 7,
- Clause C.8 addresses amendments of, or additions to, the requirements and recommendations of Clause 8,
- Clause C.9 addresses amendments of, or additions to, the requirements and recommendations of Clause 9,
- Clause C.11 addresses amendments of, or additions to, the requirements and recommendations of Clause 11.

For the purposes of this Annex the single term "equipment room" is applied to the space(s) containing distributors in accordance with ISO/IEC 11801 together with the associated telecommunications equipment. This modifies the definition of "equipment room" in ISO/IEC 11801 by including "telecommunications rooms".

The design and planning of such infrastructures should be undertaken at an early stage of the building design or refurbishment and should be integrated with the design and planning of electrical power, earthing and bonding systems, water, gas, heating and HVAC distribution systems.

C.5 Specification of installations

C.5.2 Installation specification

C.5.2.2 Recommendations

C.5.2.2.1 Application considerations

Consideration should be given to providing multiple BDs, FDs and cabling pathways between distributors and TOs to provide redundancy. Figure C.1 shows one of many possible examples of the connection of functional elements within the structured framework to provide such protection against failure in one or more parts of the cabling infrastructure.

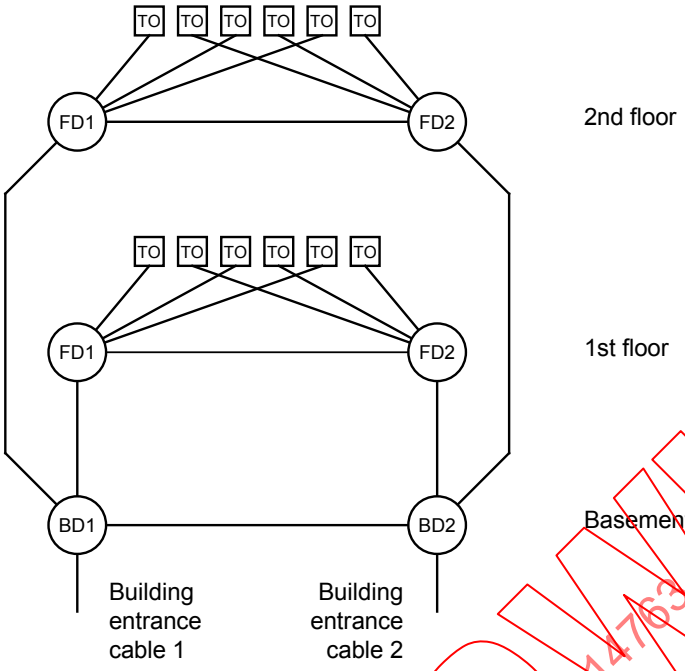


Figure C.1 – Connection of functional elements providing redundancy

Additionally, redundancy may be provided by utilizing multiple cables between distributors, with cables following different routes.

C.5.2.2.2 External service provision

Each external service provider should enter the premises via at least two pathways (see C.7.6.2.1.3).

C.5.3 Technical specification

C.5.3.4 Performance and configuration

C.5.3.4.2 Recommendations

Consideration should be given to maximum application distance restrictions for balanced and optical fibre channels when planning pathways and location of distributors.

C.7 Installation planning

C.7.6 Pathways and pathway systems

C.7.6.1 Requirements

C.7.6.1.2 Pathway systems

C.7.6.1.2.1 Pathway system co-ordination

If the pathway systems are to be supported from the ceiling, the weight of fully loaded pathway systems shall be evaluated and co-ordinated with the structural engineer (the ceiling shall have a minimum hanging capacity of 1,2 kPa).

If the pathway systems are to be supported by access floor systems (e.g. within equipment rooms), the weight of fully loaded pathway systems shall be evaluated and co-ordinated with the access floor system designer.

C.7.6.2 Recommendations

C.7.6.2.1 Pathways

C.7.6.2.1.1 Pathway co-ordination

Co-ordination of cabling pathway and space design in conjunction with architects and other engineers is critical.

Within equipment rooms, the location of aisles separating rows of cabinets, frames or racks should be co-ordinated with lighting and fire protection plans

- lighting should be placed above aisles and not above cabinets, frames, racks and overhead pathways,
- pathways should not be located where they interfere with proper operation of fire suppression systems such as water distribution from sprinkler heads.

Pathways should not block airflow to or from air conditioning equipment.

Pathways should not restrict access to components of other infrastructures that require periodic maintenance (e.g. valves, electrical receptacles and smoke detectors). Under-floor pathways should not be located above such equipment unless there is an uncovered (accessible) row of tiles adjacent to these pathways.

C.7.6.2.1.2 Security

Any maintenance holes, hand holes and closures within the pathways in unsecured areas should be equipped with locks.

C.7.6.2.1.3 Building entrance pathways

A minimum of two entrance pathways should be provided both of which should be

- located underground (aerial entrance pathways are not recommended because of their vulnerability due to physical exposure),
- physically separated, between the boundary of the premises and the point of entry into the building, by at least 20 m to ensure that a single incident will not cause damage to both entrance pathways.

C.7.6.2.2 Pathway systems

C.7.6.2.2.1 Pathway system co-ordination

If pathway systems are to be suspended from the ceiling, the ceiling should have a hanging capacity of 2,4 kPa (min).

C.7.6.2.2.2 Pathway system capacity planning

During initial planning, pathway systems should be considered full when the cross-sectional area of the cables is 40 % of the cross-sectional area of the pathway system so as to leave adequate space for future cabling.

During operation, open pathway systems (cable tray, wire mesh cable tray, cable ladder, etc.) should be considered full when the cross-sectional area of cables is 50 % of the cross sectional area of the pathway system.

C.7.6.2.2.3 Pathway systems associated with building entrance pathways

The number of pathway systems required within each of the building entrance pathways depends on the number of external service providers and the number and type of cables that the external service providers will install.

The entrance pathway systems should have adequate capacity to handle growth and additional external service providers.

C.7.6.2.2.4 Pathway systems under access floors

There should be adequate space between the top of open cable management systems (e.g. cable tray, wire mesh cable tray, etc.) and the access floor tiles to allow the cables to enter/exit the pathway systems without risk of damage and in accordance with the applicable minimum bend radius (installation, operating-static and operating-dynamic).

Where cable management systems are vertically stacked and run in parallel to provide additional capacity

- access to lower layers should be provided by either using narrower cable management systems for upper layers (as shown in Figure E.2) or by providing uncovered (accessible) row of adjacent tiles (as shown in Figure E.3),
- at least 300 mm vertical separation should be provided between each layer to provide adequate access to lower layers for addition and removal of cables.

C.7.6.2.2.5 Overhead pathway systems

Overhead cable pathways may alleviate the need for access floors that do not employ floor-standing systems that are cabled from below. Overhead cable management systems may be stacked to provide additional capacity.

Cable management systems should be suspended from the ceiling where increased operational flexibility is required to

- support the use of cabinets, frames and racks of various heights
- add and/or remove cabinets, frames and racks.

Cable management systems may be attached to the tops of cabinets, frames and racks where they are of uniform height.

C.7.7 Spaces

C.7.7.1 Requirements

C.7.7.1.1 General

Where risk of water ingress exists, a means of evacuating water from the space shall be provided (e.g. a floor drain).

C.7.7.1.2 Equipment rooms

Equipment rooms shall be provided with doors that

- are 1 m (min) wide and 2,13 m (min) high,
- do not have a doorsill,
- are fitted with a lock,

- have either no centre post or a removable centre post to facilitate access for large equipment.

Equipment rooms shall provide 2,6 m (min) unobstructed height between the finished floor and any overhead objects such as sprinklers, lighting fixtures, or cameras.

NOTE Cooling requirements or the use of overhead pathway systems or cabinets, frame and racks taller than 2,13 m may necessitate increased unobstructed height requirements.

Floor loading capacity in the equipment room shall be sufficient to bear both the distributed and concentrated load of the installed equipment with associated cabling and media.

The minimum distributed floor loading capacity shall be 7,2 kPa.

Floors, walls and ceiling shall be selected and treated (e.g. sealed, painted, constructed) to minimise the generation of dust.

C.7.7.1.3 Access floors

The area of the access floor tile opening shall be twice the cross-sectional area of the cables to be installed when the cabinets or frames are at full capacity. If the floor tile cut uses grommets or brushes, the size of the opening may need to be increased to accommodate the support mechanisms for the grommets and brushes.

C.7.7.2 Recommendations

C.7.7.2.1 Equipment rooms

The space allocated to equipment rooms intended to contain distributors should be 2 m × 3 m minimum.

The space allocated to equipment rooms should not be restricted by building components (e.g. lifts, core, outside walls, or other fixed building walls) that limit expansion.

Equipment rooms should not have exterior windows to minimise heat load and increase security.

The minimum distributed floor loading capacity should be 12 kPa.

C.7.7.2.2 Access floors

Access floor tile openings should

- be no larger than required and should use gaskets, brushes, or other method to minimize loss of under-floor pressure,
- have edging or grommets along all cut edges that does not interfere with placement of frames and cabinets,
- the edging or grommets should not be placed where cabinets, frames or racks are intended to be in contact with the surface of the access floor.

Access floor tile openings for cabinets should be placed under the cabinets, where cabinets are intended to be placed or at other location where the opening will not create a tripping hazard.

Access floor tile openings for frames should be placed either under the vertical cable managers between the frames or under the frame (at the opening between the bottom angles). Generally, placing the opening under the vertical cable managers is preferable as it allows equipment to be located at the bottom of the frame.

C.7.8 Functional elements

C.7.8.1 Requirements

C.7.8.1.1 Cabinets, frames and racks containing distributors only

Distributors should be located in cabinets, frames or racks.

C.7.8.1.2 Cabinets, frames and racks containing, or intended to contain, active equipment

Cables, cord and cable management fittings shall allow the required airflow into and out of equipment as specified by the equipment manufacturer/supplier.

C.7.8.2 Recommendations

C.7.8.2.1 Cabinets, frames and racks containing distributors only

When placed on an access floor, cabinets, frames and racks should be arranged so that they permit at least one and preferably two tiles in the front and rear of the cabinets and frames to be lifted.

Cabinets should be aligned with either the front or rear edge along the edge of the floor tile.

Frames should be placed in such a way that the rods that secure the frames to the concrete slab will not penetrate an access floor stringer.

The capacity of the vertical cable management within cabinets, frames and racks should be twice the cross-sectional area of the cables to be installed when the cabinets or frames are at full capacity.

C.7.8.2.2 Cabinets, frames and racks containing, or intended to contain, active equipment

In addition to the recommendations of C.7.8.2.1, cabinets should provide adequate ventilation for equipment – if no active cooling mechanisms are provided by the cabinet, the front and rear doors should have at least 66 % open space.

If placement of cabinets in accordance with C.7.8.2.1 creates unequal aisle sizes, the front aisle should be the larger one to provide more working space for installation of equipment and a greater area for providing cool air to cabinets.

C.7.9 Cabling pathway power segregation

In equipment rooms containing aisles, separate aisles should be used for information technology and mains power cabling.

Where it is not possible to allocate separate aisles to information technology cabling and mains power both horizontal and vertical segregation should be provided by

- using different rows of tiles in the aisles for power and information technology cabling, with the power and information technology cables as far apart from each other as is practicable,
- installing the information technology cabling in pathways as far above the power cables as is practicable.

Lighting should be located in aisles between overhead cable pathways rather than adjacent to or directly above overhead cable pathways.

C.11 Inspection

C.11.1 Requirements

The Level 2 Inspection defined in Clause 11 is a minimum requirement.

Annex D
(normative)

Cabling in accordance with ISO/IEC 15018

D.1 General

This Annex supplements or modifies the corresponding clauses in the main body of the text as they apply to the planning and installation of information technology cabling in homes in accordance with ISO/IEC 15018.

When a particular subclause of the main body of the text is not mentioned in this Annex, that subclause applies as far as is reasonable. When this Annex states "addition", "modification" or "replacement", the relevant text in the main body of the text is to be adapted accordingly.

For ease of reference

- Clause D.7 addresses amendments of, or additions to, the requirements and recommendations of Clause 7,
- Clause D.11 addresses amendments of, or additions to, the requirements and recommendations of Clause 11.

D.7 Installation planning

D.7.5 External service provision

All external networks shall enter the home via a common home entrance (see D.7.7.1.1).

D.7.6 Pathways and pathway systems

D.7.6.1 Requirements

D.7.6.1.1 Pathways

The infrastructure for home cabling shall be implemented according to the following principles

- pathways may be planned within or through the building fabric (e.g. inside or through walls), in voids (e.g. above ceilings, under floors) or on building surfaces (e.g. walls),
  - when pathway systems or suitable specified cables are to be routed within the building fabric, their orientation shall be in accordance with national or local regulations,
- any openings created within the building fabric by the planning of the selected pathways and pathway systems shall
  - be treated to maintain the mechanical strength, fire protection, thermal insulation and sound insulation of the premises,
  - allow the installation of the pathways systems of equivalent cross-sectional areas to those specified in D.7.6.1.2,
- the planning of cabling infrastructure shall take into account the other distribution systems in homes (e.g. water, gas, heating, cooling, drain, etc.),
  - information technology cables shall be separated from "hot pipes" (e.g. heating, hot water) by at least 0,1 m unless heat insulating materials are used to protect the cables or the pipes.

D.7.6.1.2 Pathway systems

D.7.6.1.2.1 Home entrance to primary distribution space

There shall be a minimum of three pathway systems for services to be provided using different types of media.

Where conduits are used to provide a pathway within or through the building fabric, the conduits shall have a minimum internal diameter of 38 mm.

Other pathway systems within or through the building fabric shall have equivalent minimum cross-sectional areas.

D.7.6.1.2.2 Primary distribution space to secondary distribution space

The requirements for pathway systems between the primary distribution space and secondary distribution space(s) cannot be defined unless locations have been specified for the secondary distribution space(s).

Where conduits are used to provide a pathway within or through the building fabric, the conduits shall have a minimum internal diameter of 38 mm.

Other pathway systems within or through the building fabric shall have equivalent minimum cross-sectional areas.

D.7.6.1.2.3 Primary/secondary distribution space into the home

The requirements for pathway systems from the distribution spaces into the home cannot be defined unless locations have been specified for the telecommunications outlets, broadcast outlets and area connection points in accordance with ISO/IEC 15018.

The following requirements apply to pathway systems between the primary/secondary distribution spaces, local distribution space(s) and equipment connection spaces.

Where conduits are used to provide a pathway within or through the building fabric, the conduits shall have a minimum internal diameter of 20 mm.

Other pathway systems within or through the building fabric shall have equivalent minimum cross-sectional areas.

D.7.6.2 Recommendations

D.7.6.2.2 Pathway systems

D.7.6.2.2.1 Primary/secondary distribution space into the home

The location of telecommunications outlets and broadcast outlets should be in close proximity to mains power outlets.

D.7.7 Spaces

D.7.7.1 Requirements

D.7.7.1.1 Home entrance

The decision whether a room or open area is provided to accommodate the home entrance shall be based on security, quantity and type of protectors, number of services and dimensions of their interfaces, availability of space and physical location within the building.

The dimensions of the home entrance shall take into account predicted requirements for additional external service provision (including the accommodation necessary for associated equipment, where known).

If network interface devices and telecommunications equipment are required in the entrance facility, additional space will be needed.

In some situations the space associated with primary home distributor may be integrated into the home entrance space.

Lightning and over-voltage protection, if fitted, shall be sited within the entrance facility.

D.7.7.1.2 Primary home distribution

The primary distribution space shall be placed with due consideration to

- the pathways to the home entrance and into the home,
- any applicable restrictions of transmission distances between the home entrance facilities and the primary distribution space,
- access for changes.

NOTE This may be close to the barycentre of the home.

The location and physical volume allocated to the primary distribution space(s) shall be foreseen at an early stage in the design of the home and shall

- provide sufficient space for the applicable segregation requirements between mains power and information technology cabling,
- provide sufficient space for access control (space for management equipment),
- be in accordance with Table D.1.

Table D.1 – Minimum requirements for dimensions of primary distribution spaces

Floor area of home F m^2	Height mm	Width mm	Depth mm
$F < 50$	700	450	150
$50 \leq F < 150$	550	550	150
$150 \leq F < 200$	700	550	150
$200 \leq F < 250$	900	550	150
$250 \leq F \leq 300$	1 100	550	150
$F > 300$	(see Notes 1 and 2)		

NOTE 1 For areas greater than 300 m^2, the required dimensions may be calculated based upon the area required, e.g for 600 m^2 the total area required is $2 \times (1\,100 \times 550)$ m^2 which may be provided as 2 200 mm × 550 mm or 1 500 mm × 800 mm.

NOTE 2 Where a 800 mm wide space is used, the depth should also be increased to 800 mm to accommodate cabinets that are able to house a wider range of equipment that would be associated with the distributor.

The planning of dimensions and locations of closures in distribution spaces shall ensure that

- separation between mains power and information technology cables is in accordance with the requirements of 7.9,

- separate access is provided for mains power and information technology cables,
- cables are accessible,
- patch panels are accessible for the end-user.

D.7.7.1.3 Secondary home distribution

The location and physical volume allocated to the secondary distribution space(s) shall be foreseen at an early stage in the design of the home and shall

- provide sufficient space for the applicable segregation requirements between mains power and information technology cabling,
- provide sufficient space for access control (space for management equipment),
- be in accordance with Table D.2.

Table D.2 – Requirements for dimensions of secondary distribution spaces

Area served by secondary distribution space S m^2	**Height** (minimum) mm	**Width** (minimum) mm	**Depth** (minimum) mm
$S < 50$	700	450	150
$50 \leq S < 150$	550	550	150

The planning of dimensions and locations of closures in distribution spaces shall ensure that

- separation between mains power and information technology cables is in accordance with the requirements of 7.9,
- separate access is provided for mains power and information technology cables,
- cables are accessible,
- patch panels are accessible for the end-user.

D.7.7.1.4 Local distribution

Local distribution spaces shall be located to house area connection points as required by the quantity and configuration of COs according to ISO/IEC 15018.

It is envisaged that this will be in restricted access area (above ceilings or below floor) or be a surface mounted/flush mounted closure in accordance with local building practices.

D.7.7.1.5 Junction box

Junction boxes shall be located as required to

- allow the interconnection of cable management systems using conduit to simplify the installation of pathway systems while maintaining the applicable cabling topology,
- ease the installation of cables with respect to maximum pulling strength.

Where junction boxes are planned to be installed within the building fabric a flush mounted closure in accordance with local building practices shall be used.

As a minimum, junction boxes shall be installed

- every 10 m of a straight path,
- at least one per room.

The minimum dimensions of the space allocated to a junction box shall be based on the required number of incoming/outgoing conduits to be interconnected and shall be in accordance with Table D.3.

Table D.3 – Minimum dimensions of spaces allocated to junction boxes

Junction box dimensions $L \times W \times D$ mm	Number of conduits/side face		
	32 mm internal diameter conduit	25 mm internal diameter conduit	20 mm internal diameter conduit
100 × 100 × 50	2	3	4
100 × 100 × 70	3	7	10
150 × 100 × 70	5	10	15
200 × 150 × 70	6	12	18
300 × 200 × 70	9	18	27
400 × 200 × 70	12	36	54
500 × 200 × 70	25	39	58

D.7.7.2 Recommendations

D.7.7.2.1 Primary home distribution

Spaces should be located where noise or vibrations from active equipment (e.g. fans, hard disks) is not spread. Primary distribution space(s) should not be placed in conjunction with heat sources (e.g. boilers, etc.).

The location and physical volume allocated to the primary distribution space(s) should be in accordance with Table D.4.

Table D.4 – Recommendations for dimensions of primary distribution spaces

Floor area of home F m^2	Height (minimum) mm	Width (minimum) mm	Depth (minimum) mm
$F < 75$	550	550	150
$75 \leq F < 100$	800	550	150
$100 \leq F < 150$	1000	550	150
$150 \leq F < 200$	1200	550	150
$200 \leq F < 250$	1400	550	150
$250 \leq F \leq 300$	1600	550	150
$F > 300$	(see Notes 1 and 2)		

NOTE 1 For areas greater than 300 m^2, the required dimensions may be calculated based upon the area required, e.g for 600 m^2 the total area required is $2 \times (1\,600 \times 550)$ m^2 which may be provided as 2 200 mm × 800 mm.

NOTE 2 where a 800 mm wide space is used, the depth should also be increased to 800 mm to accommodate cabinets that are able to house a wider range of equipment that would be associated with the distributor.

D.7.7.2.2 Secondary home distribution

Spaces should be located where noise or vibrations from active equipment (e.g. fans, hard disks) is not spread. Primary distribution space(s) should not be placed in conjunction with heat sources (e.g. boilers, etc.).

The location and physical volume allocated to the secondary distribution space(s) should be in accordance with Table D.5.

Table D.5 – Recommendations for dimensions of secondary distribution spaces

Area served by secondary distribution space S m^2	**Height** (minimum) mm	**Width** (minimum) mm	**Depth** (minimum) mm
$S < 75$	550	550	150
$75 \leq S < 100$	800	550	150
$100 \leq F < 150$	1 100	550	150

D.11 Inspection

D.11.1 Requirements

The Level 1 inspection defined in Clause 11 is a minimum requirement.

D.11.2 Recommendations

The Level 2 inspection defined in Clause 11 is recommended.

Annex E
(normative)

Cabling in accordance with ISO/IEC 24764

E.1 General

This Annex supplements or modifies the corresponding clauses in the main body of the text as they apply to the planning and installation of information technology cabling in data centres in accordance with ISO/IEC 24764.

When a particular subclause of the main body of the text is not mentioned in this Annex, that subclause applies as far as is reasonable. When this Annex states "addition", "modification" or "replacement", the relevant text in the main body of the text is to be adapted accordingly.

For ease of reference

- Clause E.5 addresses amendments of, or additions to, the requirements and recommendations of Clause 5,
- Clause E.7 addresses amendments of, or additions to, the requirements and recommendations of Clause 7,
- Clause E.8 addresses amendments of, or additions to, the requirements and recommendations of Clause 8,
- Clause E.9 addresses amendments of, or additions to, the requirements and recommendations of Clause 9,
- Clause E.11 addresses amendments of, or additions to, the requirements and recommendations of Clause 11.

The design and planning of such infrastructures should be carried out at an early stage of the building design or refurbishment and should be integrated with the design and planning of electrical power, earthing and bonding systems, water, gas, HVAC distribution systems together with relevant aspects of safety engineering.

For the purposes of this Annex the term equipment room is applied to the space(s) containing the functional elements of the information technology cabling infrastructure in accordance with ISO/IEC 24764 together with the associated telecommunications equipment.

E.5 Specification of installations

E.5.2 Installation specification

E.5.2.2 Recommendations

E.5.2.2.1 Application considerations

Consideration should be given to providing multiple ENIs, MDs, and ZDs and cabling pathways between distributors to provide redundancy in the data centre. Figure E.1 shows one of many possible examples of the connection of functional elements within the structured framework to provide such protection against failure in one or more parts of the cabling infrastructure.

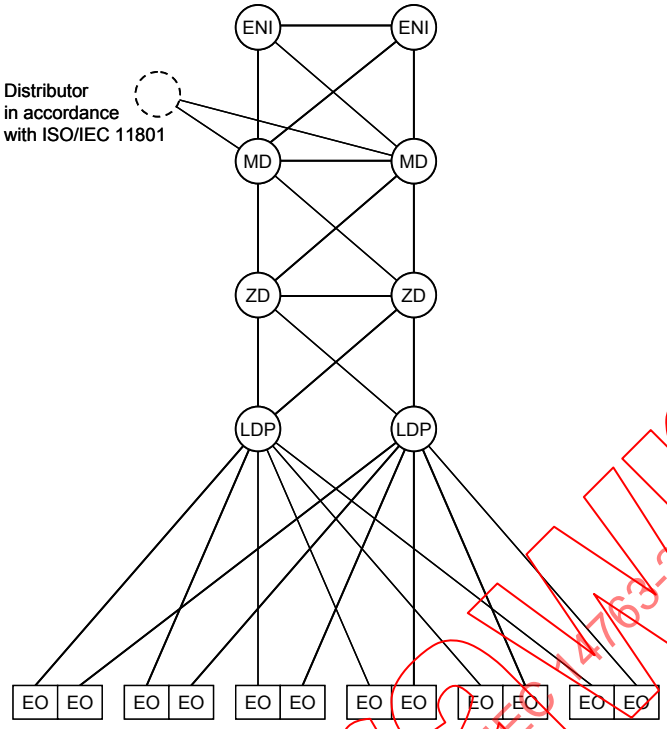


Figure E.1 – Connection of functional elements providing redundancy

Additionally, redundancy may be provided by utilizing multiple cables between distributors, with cables following different routes.

E.5.2.2.2 External service provision

Each external service provider should enter the premises via at least two pathways (see E.7.6.2.1.4).

E.5.3 Technical specification

E.5.3.4 Performance and configuration

E.5.3.4.2 Recommendation

Consideration should be given to maximum application distance restrictions for balanced and optical fibre channels when planning pathways and location of distributors.

E.7 Installation planning

E.7.3 Environment

In order to support the operation of the widest range of information technology equipment in data centre equipment rooms, the temperature and humidity in the equipment room's cold aisles and at the air intake of operating equipment shall meet the requirements specified in Table E.1.

Table E.1 – Environmental requirements for data centres

Environmental parameter	Requirement
Temperature	(18 to 27) ^{0}C dry bulb [a]
Maximum rate of temperature change	5 ^{0} C/h
Maximum relative humidity (RH)	60 %
Maximum dew point [b]	15 ^{0}C
Minimum dew point [c] (lower moisture limit)	5,5 ^{0}C

[a]	Derate maximum dry-bulb temperature 1 ^{0}C / 300 m above 1 800 m
[b]	Dew point is the temperature to which air shall be cooled (assuming constant air pressure and moisture content) to reach a relative humidity of 100 % (i.e. saturation)
[c]	Dewpoint of 5,5 ^{0}C – corresponds to 44 % RH at 18 ^{0}C and 25 % RH at 27 ^{0}C. The lower moisture limit is used to control electrostatic discharge (ESD) and uses dewpoint because ESD is a function of absolute humidity rather than relatively humidity.

E.7.6 Pathways and pathway systems

E.7.6.1 Requirements

E.7.6.1.2 Pathway systems

If the pathway systems are to be supported from the ceiling, the weight of fully loaded pathway systems shall be evaluated and co-ordinated with the structural engineer (the ceiling shall have a minimum hanging capacity of 1,2 kPa).

If the pathway systems are to be supported by access floor systems, the weight of fully loaded pathway systems shall be evaluated and co-ordinated with the access floor system designer.

E.7.6.2 Recommendations

E.7.6.2.1 Pathways

E.7.6.2.1.1 Pathway co-ordination

Co-ordination of cabling pathway and space design in conjunction with architects and other engineers is critical for data centre projects.

Within data centre equipment rooms, the location of aisles separating rows of cabinets, frames or racks should be co-ordinated with lighting and fire protection plans

- lighting should be placed above aisles and not above cabinets, frames, racks and overhead pathways,
- pathways should not be located where they interfere with proper operation of fire suppression systems, such as water distribution from sprinkler heads.

Pathways should not block airflow to or from air conditioning equipment.

Pathways should not restrict access to other data centre systems that require periodic maintenance, e.g. valves, electrical receptacles, and smoke detectors. Under-floor pathways should not be located above such equipment unless there is an uncovered (accessible) row of tiles adjacent to these pathways.

E.7.6.2.1.2 Security

See Annex B for common pathways and spaces in data centres providing services to multiple enterprises.

Any maintenance holes, hand holes and closures within the pathways in unsecured areas should be equipped with locks.

E.7.6.2.1.3 Pathway capacity planning

Sizing of pathways should consider quantities of cables when the data centre is fully occupied and all expansion areas are built. Particular attention is required for adequate capacity of pathways at intersections, ENIs, MDs, and ZDs.

E.7.6.2.1.4 Building entrance pathways

A minimum of two entrance pathways should be provided both of which should be

- located underground (aerial entrance pathways are not recommended because of their vulnerability due to physical exposure),
- physically separated, between the boundary of the premises and the point of entry into the building, by at least 20 m to ensure that a single incident will not cause damage to both entrance pathways.

E.7.6.2.2.5 Equipment room pathways

Where under-floor pathways are to be used in equipment rooms containing designated hot and cold aisles (see E.7.8.2.2), the pathways for information technology cables should be located under the access floor in the hot aisles (to avoid blocking air flow through perforated tiles).

See E.7.9 for additional requirements and recommendations regarding separation between information technology and mains power cabling.

E.7.6.2.3 Pathway systems

E.7.6.2.3.1 Pathway system co-ordination

If pathway systems are to be suspended from the ceiling, the ceiling should have a hanging capacity of 2,4 kPa (min).

E.7.6.2.3.2 Pathway system capacity planning

During initial planning of the data centre, pathway systems should be considered full when the cross-sectional area of the cables is 40 % of the cross-sectional area of the pathway system so as to leave adequate space for future cabling.

During operation of the data centre, open pathway systems (cable tray, wire mesh cable tray, cable ladder, etc.) should be considered full when the cross-sectional area of cables is 50 % of the cross sectional area of the pathway system.

Within equipment rooms, separate pathway systems should be installed to segregate permanently installed cabling and less permanent cables such as equipment cords and patch cords.

The size and quantity of all pathway systems should take into account the volume of cables to be contained when the data centre is at maximum planned utilization.

E.7.6.2.3.3 Pathway systems associated with building entrance pathways

The number of pathway systems required within each of the building entrance pathways depends on the number of external service providers and the number and type of cables that the external service providers will install.

The entrance pathway systems should have adequate capacity to handle growth and additional external service providers.

E.7.6.2.3.4 Pathway systems under access floors

There should be adequate space between the top of open cable management systems (e.g. cable tray, wire mesh cable tray, etc.) and the access floor tiles to allow the cables to enter/exit the pathway systems without risk of damage and in accordance with the applicable minimum bend radius (installation, operating-static and operating-dynamic).

Where cable management systems are vertically stacked and run in parallel to provide additional capacity

- access to lower layers should be provided by either using narrower cable management systems for upper layers (as shown in Figure E.2) or by providing an uncovered (accessible) row of adjacent tiles (as shown in Figure E.3).
- at least 300 mm vertical separation should be provided between each layer to provide adequate access to lower layers for addition and removal of cables.

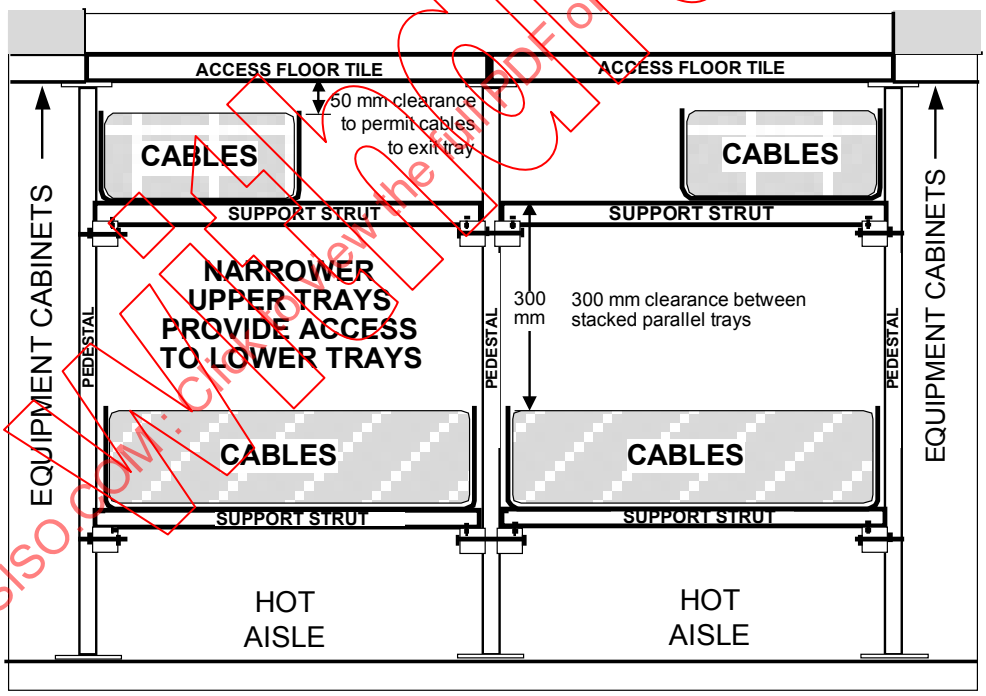


Figure E.2 – Example of layered cable trays with smaller width upper trays

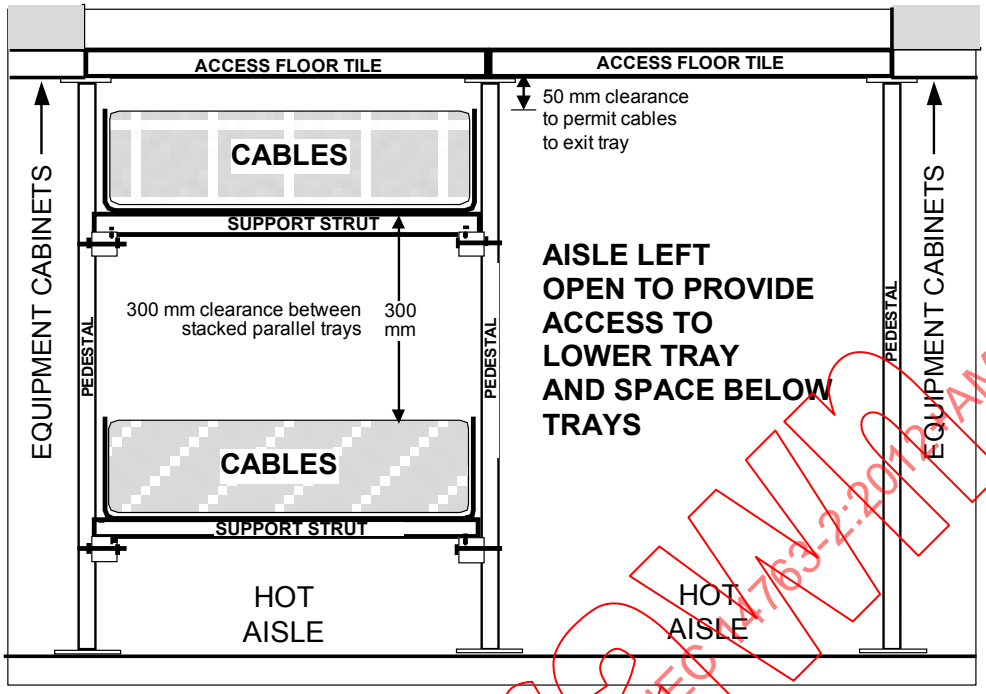


Figure E.3 – Example of uncovered (accessible) row of floor tiles to provide access to lower tray

E.7.6.2.3.4 Overhead pathway systems

Overhead cable pathways may alleviate the need for access floors in data centres.

Overhead cable pathways may be used to supplement the floor-standing systems that are also cabled from below.

Overhead cable pathways may be used in data centres that have access floor systems to minimize airflow obstructions and turbulence caused by under-floor cabling and associated pathway systems.

Overhead cable management systems may be stacked to provide additional capacity.

Cable management systems should be suspended from the ceiling where increased operational flexibility is required to

- support the use of cabinets, frames and racks of various heights,
- add and/or remove cabinets, frames and racks.

Cable management systems may be attached to the tops of cabinets, frames and racks where they are of uniform height.

E.7.7 Spaces

E.7.7.1 Requirements

E.7.7.1.1 General

Where risk of water ingress exists, a means of evacuating water from the space shall be provided (e.g. a floor drain).

E.7.7.1.2 Equipment rooms

Equipment rooms shall be provided with doors that

- are 1 m (min) wide and 2,13 m (min) high,
- do not have a doorsill,
- are fitted with a lock,
- have either no centre post or a removable centre post to facilitate access for large equipment.

Equipment rooms shall provide 2,6 m (min) unobstructed height between the finished floor and any overhead objects such as sprinklers, lighting fixtures, or cameras.

NOTE Cooling requirements or the use of overhead pathway systems or cabinets, frame and racks taller than 2,13 m may necessitate increased unobstructed height requirements.

Consideration should also be given to the floor loadings generated through the transit of equipment and associated infrastructure.

The minimum distributed floor loading capacity shall be 7,2 kPa.

Floors, walls and ceiling shall be selected and treated (e.g. sealed, painted, constructed) to minimise the generation of dust.

E.7.7.1.3 Access floors

The area of the access floor tile opening shall be twice the cross-sectional area of the cables to be installed when the cabinets or frames are at full capacity. If the floor tile cut uses grommets or brushes, the size of the opening may need to be increased to accommodate the support mechanisms for the grommets and brushes.

E.7.7.2 Recommendations

E.7.7.2.1 Equipment rooms

The space allocated to equipment rooms should not be restricted by building components (e.g. lifts, core, outside walls, or other fixed building walls) that limit expansion.

Equipment rooms should not have exterior windows to minimise heat load and increase security.

The minimum distributed floor loading capacity should be 12 kPa.

E.7.7.2.2 Rooms intended to contain distributors

To provide additional space for equipment installation and maintenance, the minimum room dimensions for distributors containing up to 500 outlets should be 3,2 m (length) × 3,4 m (width) (see Figure 6a).

For distributors containing more than 500 outlets, the minimum room size should be increased by 2,0 m along the line of cabinets for each additional group of up to 500 outlets to accommodate the additional space for connecting hardware, cord management and active equipment (see Figure 6b).

NOTE These recommendations are based on the use of 1 000 mm × 1 000 mm cabinets that allow for sufficient cord management for fully utilized cabinets or open racks with vertical cable management for sufficient cord management for fully utilized racks, this will also accommodate access from both front and back of the cabinets or rack to install additional cabling and equipment (see 7.8.2.3).

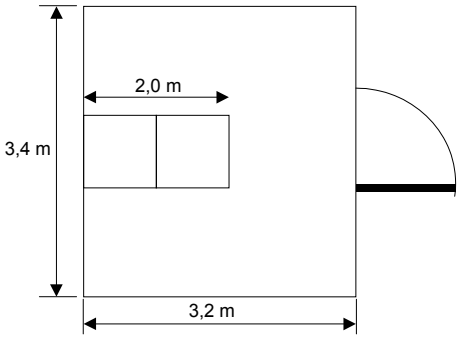


Figure E.4a – Minimum room dimensions to support distributors containing up to 500 outlets

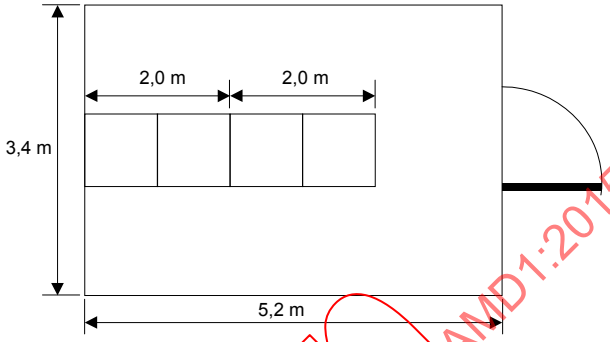


Figure E.4b – Minimum room dimensions to support distributors containing between 501 and 1 000 outlets

Figure E.4 – Dimensions of rooms intended to contain distributors

E.7.7.2.3 Access floors

Access floor tile openings should

- be no larger than required and should use gaskets, brushes, or other method to minimize loss of under-floor pressure,
- have edgings or grommets along all cut edges that do not interfere with the placement of frames and cabinets (see E.7.8),
- the edgings or grommets should not be placed where cabinets, frames or racks are intended to be in contact with the surface of the access floor.

Access floor tile openings for cabinets should be placed under the cabinets, where cabinets are intended to be placed (see E.7.8) or in other locations where the opening will not create a tripping hazard.

Access floor tile openings for frames should be placed either under the vertical cable managers between the frames or under the frame (at the opening between the bottom angles). Generally, placing the opening under the vertical cable managers is preferable as it allows equipment to be located at the bottom of the frame.

E.7.8 Functional elements

E.7.8.1 Requirements

E.7.8.1.1 Cabinets, frames and racks containing, or intended to contain, active equipment

Cables, cord and cable management fittings shall allow the required airflow into and out of equipment as specified by the equipment manufacturer/supplier.

E.7.8.2 Recommendations

E.7.8.2.1 Cabinets, frames and racks containing distributors only

Distributors may be located in dedicated areas outside equipment rooms.

Distributors in data centres should be located in cabinets, frames or racks.

When placed on an access floor, cabinets, frames and racks should be arranged so that they permit at least one and preferably two tiles in the front and rear of the cabinets and frames to be lifted.

Cabinets should be aligned with either the front or rear edge along the edge of the floor tile.

Frames should be placed such that the rods that secure the frames to the concrete slab will not penetrate an access floor stringer.

The capacity of the vertical cable management within cabinets, frames and racks should be twice the cross-sectional area of the cables to be installed when the cabinets or frames are at full capacity.

E.7.8.2.2 Cabinets, frames and racks containing, or intended to contain, active equipment

The following recommendations are additional to those of E.7.8.2.1.

For maximum cooling efficiency, cabinets, frames and racks should be arranged in rows with their fronts facing each other as shown in Figure E.5 to create an alternating pattern of hot aisles (behind the cabinets, frames or racks) and cold aisles (in front of the cabinets, frames or racks).

NOTE It is assumed that equipment is installed with the cold air intake at the front of the cabinet, frame of rack, and the hot air exhaust at the back.

To avoid mixing of hot and cold air

- blank panels should be installed in unused cabinet, frame and rack positions,
- cabinets, frames and racks should only be located within equipment rows,
- there should be no empty cabinet, frame or rack positions within an equipment row (i.e. place empty cabinets or racks fully filled with blank panels instead of leaving an empty cabinet/rack position).

To prevent the overflow of cold or hot air above the cabinets, frames or racks, it is necessary to coordinate the need and position of the ventilation with the HVAC engineering. It may be required to install fixtures and/or fittings (e.g. curtains or dividers above cabinets, frames or racks to maintain the separation of cold and hot air.

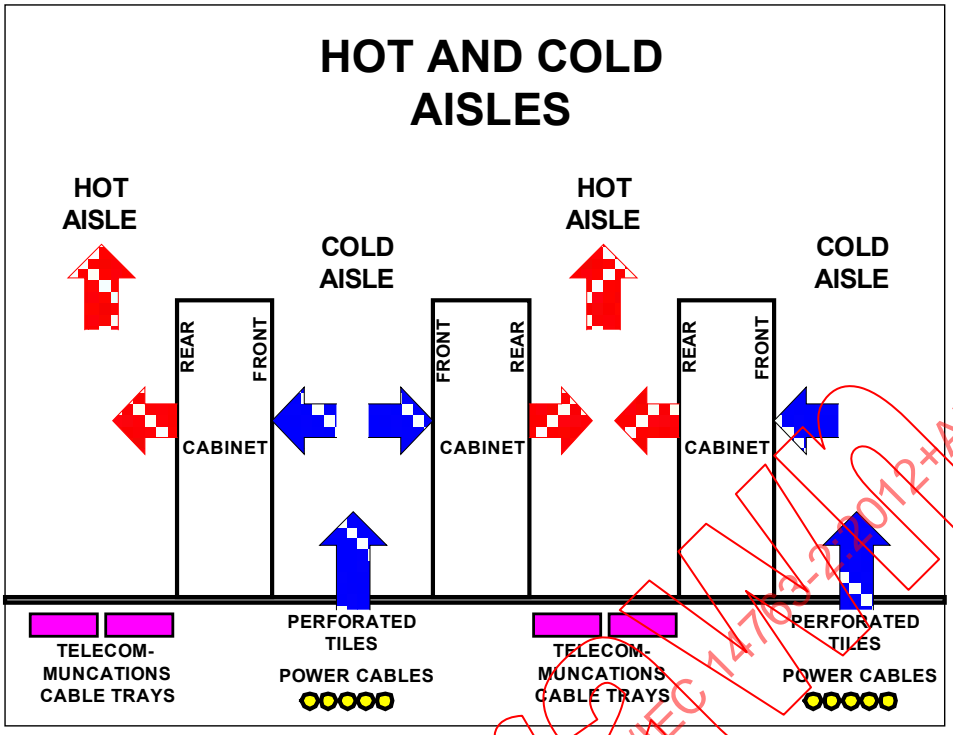


Figure E.5 – Example of "hot" aisles, "cold" aisles and cable pathway locations

The distance between cabinets, frames and racks across a cold aisle should not be less than 1,2 m.

The distance between the rear of cabinets, frames and racks across a hot aisle should not be less than 1,2 m.

If placement of cabinets in accordance with E.7.8.2.1 creates unequal aisle sizes, the front aisle should be the larger one to provide more working space for installation of equipment and a greater area to supply cool air to cabinets.

Cabinets should provide adequate ventilation for equipment. If no active cooling mechanisms are provided by the cabinet, the front and rear doors should at least have 66 % open space.

The capacity of the vertical cable management within cabinets, frames and racks should be twice the cross-sectional area of the cables to be installed when the cabinets or frames are at full capacity.

Penetrations into cabinets and in vertical wire managers from external locations should be restricted both when occupied and when unoccupied by cabling. Electrostatic free brush strips or cable socks should be utilised on all cable entrance points or floor penetrations.

E.7.9 Segregation of information technology cabling and mains power cabling

E.7.9.2 Recommendations

In equipment rooms containing aisles, separate aisles should be used for information technology cabling and mains power cabling.

If under-floor pathways are utilised within equipment rooms containing designated hot and cold aisles (see E.7.8.2.2) then

- pathways for information technology cables should be located under the access floor in the hot aisles (see E.7.6.2.2.5),
- pathways for mains power cables should be located under the access floor in the cold aisles.

Where it is not possible to allocate separate aisles to information technology cabling and mains power both horizontal and vertical segregation should be provided by

- using different rows of tiles in the aisles for power and information technology cabling, with the power and information technology cables as far apart from each other as is practicable,
- installing the information technology cabling in pathways as far above the power cables as is practicable.

Lighting should be located in aisles between overhead cable pathways rather than adjacent to or directly above overhead cable pathways.

E.7.11 Equipotential bonding

E.7.11.1 Requirements

Where a MESH-BN (see E.7.11.2) is implemented

- the minimum density of the MESH-BN shall be a grid that is on 6 m centres or one that corresponds to the computer room cold- or hot-aisles and the aisles running perpendicular to the cold- and hot-aisles,
- the elements used to create the MESH-BN shall have electrical performance equal to, or better than, 16 mm^2 copper conductors,

  NOTE 1 Elements meeting the above requirements/recommendations having greater surface areas (e.g. stranded or flat conductors) have, in general, improved higher frequency performance.

- connections between elements shall be made using techniques that comply with national/local regulations for bonds within protective earthing systems (examples of such techniques include exothermic welding, brazing, appropriate compression connectors or clamps),

  NOTE 2 If exothermic welds are performed in a room with active electronics, a low emission exothermic weld should be used.

- the bonding conductors shall not be in contact with metallic surfaces or other conductors that are not part of the telecommunications earthing system,
- cable sheath identifiers (e.g. colours or labels) shall be in accordance with national/local regulations.

Connections to the MESH-BN shall meet the following requirements

- shall have the shortest practicable dedicated connection to MESH-BN (shorter than grid size),
- telecommunications earthing busbars external to the mesh shall be connected to the MESH-BN using a bonding conductor of cross-sectional area of at least 50 mm^2,
- each floor-standing cabinet and rack containing equipment with an external earthing connection point shall be connected to the MESH-BN using a bonding conductor of cross-sectional area of at least 16 mm^2,
- each wall-standing cabinet and rack containing equipment with an external earthing connection point shall be connected to the MESH-BN using a bonding conductor of cross-sectional area of at least 10 mm^2,

- the electrical supply ground serving the area shall be connected to the MESH-BN using a bonding conductor that is sized per local codes and per manufacturers' recommendations (or cross-sectional area of at least 35 mm^2 if no such specifications are available),
- conductive access floors shall be connected to the MESH-BN using manufacturers'/suppliers' instructions. If these conditions do not exist, no less than every sixth pedestal in each direction shall be connected to the MESH-BN. The bonding conductor used shall have a cross-sectional area of at least 16 mm^2,
- all other equipment and metallic structures shall be connected to the MESH-BN using a bonding conductor in accordance with the national/local regulations,
- where bonding conductors are placed in a ferrous metallic conduit and the conduit is more than 1 m in length, the conductors shall be bonded to each end of the conduit using an earthing bushing or a bonding conductor of a cross-sectional area of at least 16 mm^2,
- bonding conductors shall not be routed where they create a tripping hazard or impair access to equipment,
- bonding conductors shall not be attached with staples or any other method that could damage the conductors.

E.7.11.2 Recommendations

Each computer room or equipment room should have a mesh-bonding network (MESH-BN) that comprises a conductor grid that covers the entire equipment room space.

Where a MESH-BN is implemented

- the minimum density of the MESH-BN should be a grid that is on 3 m centres,
- the elements used to create the MESH-BN should have electrical performance equal to, or better than, 50 mm^2 (ffs) copper conductors,

  NOTE Elements meeting the above requirements/recommendations having greater surface areas (e.g. stranded or flat conductors) have, in general, improved higher frequency performance.

Connections to the MESH-BN should be in accordance with the following recommendations

- multiple connections should be implemented between all items listed in E.7.11.1 and the MESH-BN,
- each cabinet and rack should be connected to the MESH-BN using a bonding conductor of at least 4 mm diameter,
- conductive pathway systems should be connected in accordance with the national/local regulations – they may be bonded in series,
- bonding conductors should be secured at no greater than 1 m intervals,
- bonding conductors should not be placed in ferrous metallic conduit.

E.9 Documentation and administration

E.9.2 Recommendations

The identifier scheme for cabinets, frames and racks should use a grid co-ordinate system based on the access floor grid or, where no access floor exists, a grid created by aisles and cabinets, frames and racks.

E.11 Inspection

E.11.1 Requirements

The Level 2 inspection defined in Clause 11 is a minimum requirement.

E.11.2 Recommendations

The Level 3 inspection defined in Clause 11 is recommended.

Annex F
(normative)

Cabling in accordance with ISO/IEC 24702

F.1 General

This Annex supplements or modifies the corresponding clauses in the main body of the text as they apply to the planning and installation of information technology cabling in industrial premises in accordance with ISO/IEC 24702.

When a particular clause of the main body of the text is not mentioned in this Annex, that clause applies as far as is reasonable. When this Annex states “addition”, “modification” or “replacement”, the relevant text in the main body of the text is to be adapted accordingly.

There are two distinct supersets of applications in the industrial areas

- information communication technologies (ICT): providing services including voice, data, video, building security, building control,
- process monitoring, control and automation (PMCA): providing services for machine control.

The cabling supporting the two application supersets may share the same infrastructure. However, local regulations may define segregation requirements.

Special considerations are required to guarantee network availability for PMCA applications. This has an impact on the network planning and installation of components. For example, extra precautions may be needed to protect the cabling components from non-intentional or intentional damage that are not normally considered in other situations.

IEC 61918 specifies general requirements for the installation of cabling in support of PMCA applications. For networks that provide communications within automation islands, IEC 61918 contains references to the IEC 61784-5 series. These standards specify communications profiles and provide installation guidance for industrial control networks; primarily those that use Ethernet cabling as a media. When the intent of the network is to provide connectivity to one of these networks in the automation island or to provide services to the automation island, these standards should prevail. These standards shall be considered when machine control is using parts of the infrastructure and may apply to the entire network. In addition, security of the network may need to be considered. However, security is beyond the scope of this standard.

This Annex provides additional guidance and gives references to other existing standards that may be used in addition to the clauses of this standard. Only those clauses where additions and/or modifications are required are detailed here.

It is assumed that the main part of this standard applies unless otherwise modified by adding or replacing text. When additional text is needed that is not part of another standard, the text is added without introduction.

References to other standards containing requirements for components and installations, including IEC 61918 are identified by the word “addition: standard and clause, subclause”. When the entire clause, subclause of this standard is being replaced, the word “replacement:” is used, followed by the replacement text. Where there are discrepancies between this standard and other referenced standards, the differences shall be reconciled by determining

the requirements of the specific application(s). If in doubt, the more stringent requirement of the ISO/IEC 14763-2 and IEC 61918 shall be applied.

F.5 Specification of installations

The requirements of Clause 5 apply augmented by the requirements and recommendations of 4.1.3 of IEC 61918.

F.6 Quality planning

The requirements of Clause 6 apply augmented by the requirements and recommendations of Clause 6 of IEC 61918.

F.7 Installation planning

The requirements of Clause 4 of IEC 61918 apply in place of Clause 7 of this standard.

F.8 Installation practices

The requirements of Clause 8 apply augmented by the requirements and recommendations of Clause 5 of IEC 61918.

F.9 Documentation and administration

The requirements of Clause 7 of IEC 61918 apply in place of Clause 9 of this standard.

Identifiers for industrial premises are provided in IEC 81346-1, IEC 81346-2, IEC 61666, and IEC 62491.

F.10 Testing

The requirements of Clause 10 apply augmented by the requirements and recommendations of Clause 6 of IEC 61918.

F.11 Inspection

The Level 3 requirements of Clause 11 apply augmented by the requirements and recommendations of Clause 6 of IEC 61918.

F.13 Maintenance

The requirements of 8.2 of IEC 61918 apply in place of Clause 13 of this standard.

The determination of the type of maintenance approach to be adopted for a given industrial infrastructure shall take into account the applicable risk elements shown in Table F.1.

Table F.1 – Risk elements for consideration in determining an appropriate maintenance approach

Maintenance program	Relative costs associated with each maintenance program				
	Component	Materials loss	Troubleshooting labour	Lost production	Program cost
Preventative based	Low	Low	Moderate (spread over time)	Low	Moderate to high
Condition based	Moderate	Low	Moderate (spread over time)	Low	Low
Run to failure	Potentially high	Potentially high	High due to potential overtime	High	Potentially high

F.14 Repair

The requirements of 8.3 and 8.4 of IEC 61918 apply in place of Clause 14 of this standard.

Annex G
(normative)

Cabling in accordance with ISO/IEC TR 24704

ISO/IEC TR 24704 was originally written in support of ISO/IEC 11801. However, the intent of ISO/IEC TR 24704 is applicable to all the other referenced design standards, i.e. ISO/IEC 15018, ISO/IEC 24702 and ISO/IEC 24764.

For this reason the requirements and recommendations of the relevant premises-specific Annex of this standard shall be applied to any implementation of ISO/IEC TR 24704.

Annex H
(normative)

Automated infrastructure management (AIM) systems

H.1 Overview

Clause 9 refers to “enhanced” administration systems which automatically record both cord connections and discoverable equipment using the data produced by AIM systems. AIM systems should be considered when it is important to provide a common framework within which

d) planners are able to specify their detailed requirements,

e) operational efficiency and accuracy of the management information provided can be improved.

To support these objectives, this annex defines the core functions required for such systems (see H.3.1) and also describes other auxiliary features that AIM systems may incorporate (see H.3.2).

H.2 Specifying AIM systems

The AIM system shall meet the requirements defined in H.3.1 and may include additional features as required by H.3.2, noting the usage and operational requirements of Clause H.4 and recommendations of Clause H.5 respectively.

H.3 Functions

H.3.1 Core functions of AIM systems

H.3.1.1 System requirements

NOTE The following requirements are subject to revision within ISO/IEC 18598[1].

An AIM system shall be able to

a) automatically detect connectivity between AIM-enabled panel ports (i.e. ports able to automatically detect the insertion or removal of a cord and process that event as part of an automated infrastructure management system),

b) automatically detect connectivity between AIM-enabled panel ports and other equipment (with AIM-enabled ports) or document and/or infer connectivity between AIM-enabled panel ports and other equipment (without AIM-enabled ports),

c) monitor the connections and disconnections of a) and b).

H.3.1.2 Functional requirements

Once configured, an AIM system shall be able to

a) accommodate the chosen identification scheme (see Clause 9.2) for the items to be documented within the AIM software,

b) record the connections between elements within the cabling infrastructure,

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1 Under consideration.

c) automatically detect, document and monitor the presence of discoverable equipment connected to the network and

   1) the configuration of managed network distribution equipment (i.e. discoverable electronic equipment that provides connectivity and supports data exchange between end-devices and which uses communications protocols such as the Simple Network Management Protocol (SNMP) to exchange management information),

   2) the network-related information of end devices,

d) automatically update records when any monitored connections are modified,

e) manually document asset information for equipment without a network address,

f) document the physical location of the electronic equipment that provides connectivity and supports data exchange between end-devices and which is connected to the network,

g) document and/or infer connectivity between non-AIM enabled ports and other equipment,

h) document the presence and physical location of AIM hardware.

i) identify and track the physical location of end devices connected to the network,

j) maintain a history of events relating to items a) to i);

k) enable the display of mapped items documented within the AIM software to a physical location on building plans and layouts.

H.3.1.3 Management and usage of information within AIM software

An AIM system shall be able to

a) enable a user to define the circumstances in which an event generates an alert,

b) enable a user to view graphical representation of connectivity (circuit trace) and other relational information for the items documented within the AIM software,

c) provide recommendations on the cabling connectivity tasks required within work orders for service provision,

d) enable a user to manage work orders related to items documented within the AIM software

   1) create,

   2) assign or re-assign,

   3) schedule or re- schedule,

   4) enact,

   5) track (status),

   6) close,

e) maintain a work order history,

f) provide means for retrieval of electronic work orders in spaces accommodating AIM hardware,

g) provide a means to automatically detect the accuracy of implementation of connect/disconnect work order tasks between AIM-enabled ports,

h) provide a means to alert in case of an incorrect implementation,

i) automatically update the task status following correct implementation,

j) generate reports (both automatically and on-demand) related to items documented within the AIM software.

H.3.1.4 Integrity of information within AIM software

Integrity of information shall be maintained in the event of disruption of the AIM system or its components.

H.3.2 Auxiliary functions of AIM systems

Other features of AIM systems should be considered during the specification of an AIM system (see ISO/IEC 18598[2]).

H.4 Operational requirements

AIM systems shall be implemented and maintained with an appropriate level of operational discipline, including an auditing regimen to ensure ongoing accuracy.

H.5 Usage recommendations

Subclause 9.2.6.3 (Table 22) recommends the use of automated records within Class 3 administration systems.

In addition to this basic recommendation, this annex recommends the consideration of AIM systems

a) within Class 2 administration systems where there is an identified or predicted shortage of staff with the expertise to administer telecommunications cabling,

b) for the administration of remote sites of any Class of administration system.

2 Under consideration.

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IEC 61196-7,— *Coaxial communication cables – Part 7: Sectional specification for cables for BCT cabling in accordance with ISO/IEC 15018 (EN 50173-4) – Indoor drop cables for systems operating at 5 MHz to 3 000 MHz*[3]

IEC 61666, *Industrial systems, installations and equipment and industrial products – Identification of terminals within a system*

IEC 62305-3, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

IEC 62491, *Industrial systems, installations and equipment and industrial products – Labelling of cables and cores*

IEC 81346-1, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

IEC 81346-2, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 2: Classification of objects and codes for classes*.

ISO/IEC 18598, *Information technology – Automated infrastructure management (AIM) systems – Requirements, data exchange and applications*[4]

ISO 2859 (all parts), *Sampling procedures for inspection by attributes*

3 To be published.

4 Under consideration.

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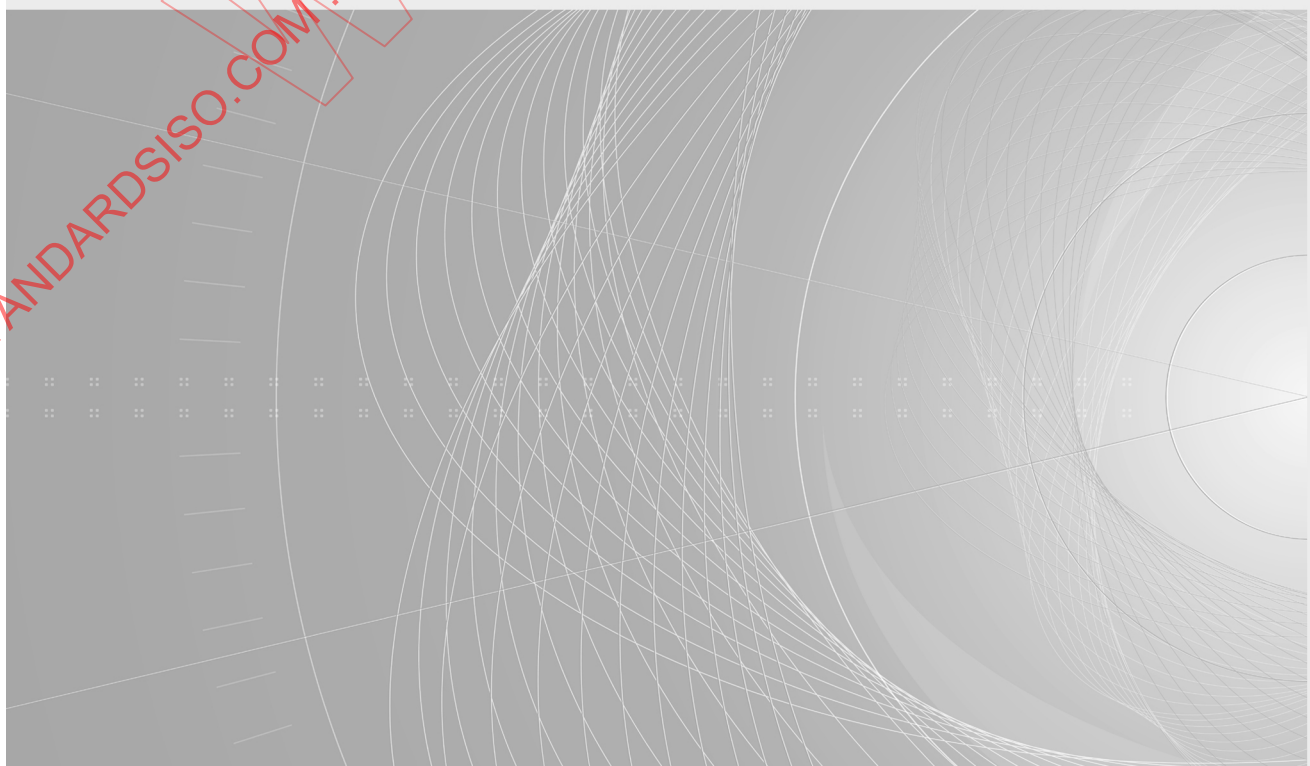
FINAL VERSION

Information technology – Implementation and operation of customer premises cabling –
Part 2: Planning and installation



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INFORMATION TECHNOLOGY – IMPLEMENTATION AND OPERATION OF CUSTOMER PREMISES CABLING –

Part 2: Planning and installation

FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

ISO/IEC 14763-2 edition 1.1 contains the first edition (2012-02) and its amendment 1 (2015-09).

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard ISO/IEC 14763-2 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

This edition includes the following significant technical changes with respect to the previous edition:

In addition to the supersession of parts of earlier standards and the incorporation of other standards, this standard provides much greater detail in all aspects of planning and installation with respect to ISO/IEC TR 14763-2 and provides clearly differentiated and directed requirements and recommendations.

The list of all currently available parts of the ISO/IEC 14763 series, under the general title *Information technology – Implementation and operation of customer premises cabling*, can be found on the IEC web site.

This International Standard has been approved by vote of the member bodies, and the voting results may be obtained from the address given on the second title page.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

The importance of services delivered by information technology cabling infrastructure is similar to that of utilities such as heating, lighting and electricity supplies. As with those utilities, interruptions to service can have a serious impact. Poor quality of service due to lack of planning, use of inappropriate components, incorrect installation, poor administration or inadequate support can threaten an organisation's effectiveness.

There are four phases in the successful implementation of information technology cabling

a) design,

b) specification – the detailed requirement for the cabling, including the planning of its accommodation and associated building services addressing safety and specific environments (e.g. electromagnetic) together with the quality assurance requirements to be applied,

c) installation – in accordance with the requirements of the specification,

d) operation – the management of connectivity and the maintenance of transmission performance during the life of the cabling.

This International Standard supports the specification, implementation and operation of generic information technology cabling designed in accordance with the standards and associated documents developed by ISO/IEC JTC 1/SC 25 and addresses the following topics

- specification depending on the application, environment, building infrastructure and facilities, etc.,
- quality assurance,
- installation planning (including pathways and spaces) depending on the application, environment, building infrastructure and facilities, etc,
- installation practice (including pathways and spaces),
- documentation and administration,
- testing,
- inspection,
- operation,
- maintenance and maintainability (based on any impact from planning and installation),
- repair and repairability (based on any impact from planning and installation).

It does not cover those aspects of installation associated with the transmission of signals in free space between transmitters, receivers or their associated antenna systems (e.g. wireless, radio, microwave or satellite).

The following normative Annexes support specific aspects of planning and installation

- Annex A: Optical fibre polarity,
- Annex B: Common infrastructures within multi-tenant premises.

The requirements and recommendations of the main body of this standard are premises-independent. The following normative Annexes include requirements for generic cabling in accordance with specific standards

- Annex C: Cabling in accordance with ISO/IEC 11801,
- Annex D: Cabling in accordance with ISO/IEC 15018,
- Annex E: Cabling in accordance with ISO/IEC 24764,

- Annex F: Cabling in accordance with ISO/IEC 24702,
- Annex G: Cabling in accordance with ISO/IEC TR 24704.

This standard sets out the responsibilities of information technology cabling installers and premises owners, and is intended to be referenced in relevant contracts. The owners may delegate selected responsibilities to designers, specifiers, operators and maintainers of installed information technology cabling.

This standard is also relevant to

- architects, building designers and builders,
- main contractors,
- designers, suppliers, installers, inspectors (auditors), building managers, maintainers and owners of information technology cabling,
- public network providers and local service providers,
- end users.

This International Standard is one of a number of documents prepared in support of international standards and technical reports for cabling design produced by ISO/IEC JTC 1/SC 25. Figure 1 shows the inter-relationship between these standards and technical reports.

Users of this standard should be familiar with the applicable cabling design standard.

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

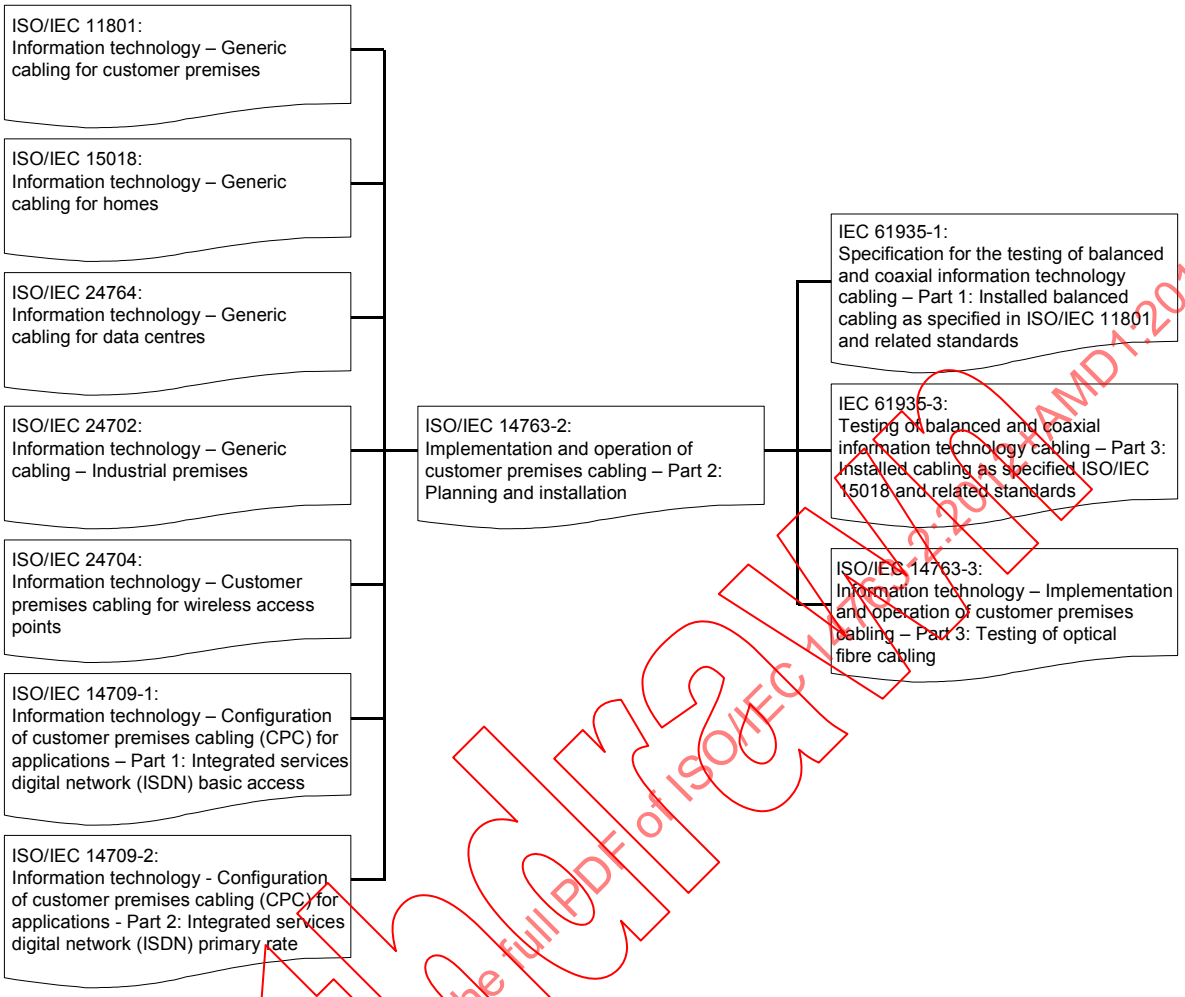


Figure 1 – Schematic relationship between ISO/IEC 14763-2 and other relevant standards

INFORMATION TECHNOLOGY – IMPLEMENTATION AND OPERATION OF CUSTOMER PREMISES CABLING –

Part 2: Planning and installation

1 Scope

This part of ISO/IEC 14763 specifies requirements for the planning, installation and operation of cabling and cabling infrastructures (including cabling, pathways, spaces, earthing and bonding) in support of generic cabling standards and associated documents.

The following aspects are addressed

- specification of the installation,
- quality assurance,
- installation planning,
- installation practice,
- documentation,
- administration,
- testing,
- inspection,
- operation,
- maintenance,
- repair.

The requirements of Clauses 5 to 14 of this standard are premises-independent and may be amended by the requirements of premises-specific Annexes.

This part of ISO/IEC 14763 excludes

- specific requirements applicable to other cabling systems (e.g. mains power cabling); however, it takes account of the effects other cabling systems may have on the installation of information technology cabling (and vice versa) and gives general advice,
- those aspects of installation associated with the transmission of signals in free space between transmitters, receivers or their associated antenna systems (e.g. wireless, radio, microwave or satellite).

This standard is applicable to certain hazardous environments but does not exclude additional requirements which are applicable in particular circumstances (e.g. electricity supply and electrified railways).

Safety (electrical safety and protection, optical power, fire, etc.) and electromagnetic compatibility (EMC) requirements are outside the scope of this international standard and are covered by other standards and regulations. However, information given in this international standard may be of assistance in meeting these standards and regulations.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60364-5-52, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Chapter 52: Wiring systems*

IEC 60794-2, *Optical fibre cables – Part 2: Indoor cables – Sectional specification*

IEC 61082-1, *Preparation of documents used in electrotechnology – Part 1: Rules*

IEC 61084 (all parts), *Cable trunking and ducting systems for electrical installations*

IEC 61156-5 (all parts), *Multicore and symmetrical pair/quad cables for digital communications – Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Horizontal floor wiring*

IEC 61156-6 (all parts), *Multicore and symmetrical pair/quad cables for digital communications – Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz – Work area wiring*

IEC 61386 (all parts), *Conduit systems for cable management*

IEC 61537, *Cable management – Cable tray systems and cable ladder systems*

IEC 61784-5 (all parts), *Industrial communication networks – Profiles*

IEC 61918:2010, *Industrial communication networks – Installation of communication networks in industrial premises*

IEC 61935-1, *Specification for the testing of balanced and coaxial information technology cabling – Part 1: Installed balanced cabling as specified in ISO/IEC 11801 and related standards*

IEC 61935-3, *Testing of balanced and coaxial information technology cabling – Part 3: Installed cabling as specified in ISO/IEC 15018*

IEC 61969-1, *Mechanical structures for electronic equipment – Outdoor enclosures – Part 1: Design guidelines*

IEC 61969-2, *Mechanical structures for electronic equipment – Outdoor enclosures – Part 2: Sectional specification – Coordination dimensions for cases and cabinets*

IEC 62305-4, *Protection against lightning – Electrical and electronic systems within structures*

ISO/IEC 11801:2002, *Information technology – Generic cabling for customer premises*
Amendment 1 (2008)
Amendment 2 (2010)

ISO/IEC 14709-1, *Information technology – Configuration of Customer Premises Cabling (CPC) for applications – Part 1: Integrated Services Digital Network (ISDN) basic access*

ISO/IEC 14709-2, *Information technology – Configuration of Customer Premises Cabling (CPC) for applications – Part 2: Integrated services Digital Network (ISDN) primary rate*

ISO/IEC 14763-3, *Information technology – Implementation and operation of customer premises cabling – Part 3: Testing of optical fibre cabling*

ISO/IEC 15018:2004, *Information technology – Generic cabling for homes*
Amendment 1 (2009)

ISO/IEC 20000-1, *Information technology – Service management – Part 1: Service management system requirements*

ISO/IEC 24702:2006, *Information technology – Generic cabling – Industrial premises*
Amendment 1 (2009)

ISO/IEC TR 24704:2004, *Information technology – Customer premises cabling for wireless access points*

ISO/IEC 24764:2010, *Information technology – Generic cabling systems for data centres*

ISO/IEC TR 29106, *Information technology – Generic cabling – Introduction to the MICE environmental classification*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document the following definitions apply in addition to those of the applicable referenced cabling design standard.

3.1.1
acceptance test (of installed cabling)
contractual test to confirm that the installed cabling satisfies specific aspects of its specification

[IEC 60050-151:2001, 151-16-23 modified]

3.1.2
anchoring guy wire
tensioned cable designed to add support to structures

3.1.3
balun
device for transforming an unbalanced voltage to a balanced voltage or vice-versa

3.1.4
bonding network
BN
set of interconnected conductive structures that provides electromagnetic protection for electronic systems and personnel at frequencies from direct current (DC) to low radio frequency (RF)

3.1.5
(cable) bundle
multiple cables maintained in close proximity, generally by fasteners (e.g. cable ties)

3.1.6
building entrance facility
facility that provides all necessary mechanical and electrical services for the entry of telecommunications cables into a building and which may allow for transition from external to internal cable

3.1.7
cabinet
enclosed construction intended for housing closures and other information technology components and equipment

3.1.8
cable management system
system used for the support and/or containment, retention, protection of all types of cables, information and communication lines, electrical power distribution conductors and their associated accessories

NOTE Includes ducts and tubes housing, or intended to house, blown information technology cables and/or cable elements.

3.1.9
cabling component
any product associated with the cabling installation including cables, connecting hardware, closures, cabinets, frames, racks and pathway systems together with components used to provide earth connections for the cabling installation

3.1.10
catenary wire
dedicated wire used in aerial applications to which information technology cables are attached

3.1.11
closure
fixture or fitting of either open or closed construction intended to contain connecting hardware

3.1.12
civil works
activities required to prepare pathways and pathway systems, particularly external to buildings, prior to the installation of cabling

3.1.13
common bonding network
CBN
principal means for effective bonding and earthing inside a building with information technology equipment

NOTE It is the set of metallic components that are intentionally or incidentally interconnected to form the principal bonding network in a building. These components include: structural steel or reinforcing rods, metallic plumbing, alternating current (AC) power conduit, protective conductors, cable racks and bonding conductors. The CBN is connected to the earthing network.

3.1.14
earth electrode
conductive part, which may be embedded in the soil or in a specific conductive medium, e.g. concrete or coke, in electric contact with the Earth

[IEC 60050-826:2004, 826-13-05; IEC 60050-195:1998, 195-02-01]

3.1.15
earthing conductor
conductor which provides a conductive path, or part of the conductive path, between a given point in a system or in an installation or in equipment and an earth electrode or an earth-electrode network

[IEC 60050-826:2004, 826-13-12; IEC 60050-195:1998, 195-02-03 modified]

3.1.16
electrostatic discharge
ESD
transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact

[IEC 60050-161:1990,161-01-22]

3.1.17
electromagnetic disturbance
any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

NOTE An electromagnetic disturbance may be an electromagnetic noise, an unwanted signal or a change in the propagation medium itself.

[IEC 60050-161:1990, 161-01-05]

3.1.18
equipotential bonding
provision of electric connections between conductive parts, intended to achieve equipotentiality

[IEC 60050-826:2004, 826-13-19; IEC 60050-195:1998, 195-01-10]

3.1.19
frame (rack)
open construction intended for housing closures and other information technology equipment

3.1.20
functional earthing conductor
conductors that are only used for functional earthing (not protection)

3.1.21
hand hole
point of access to a pathway that is too small for a person to enter to perform work but that allows the routing of cables during the cable installation process such that bending and pulling requirements are met (an example of a hand-hole within a building is called a draw-box)

3.1.22
high-voltage
voltage over 1 000 V r.m.s. or 1 500 V DC

3.1.23
home entrance
space at the boundary of a home that may house the interface(s) between the home networks and external networks provided to the home and that demarcate the administration and maintenance of the two networks

3.1.24
identifier
unique item of information to distinguish a specific component of the cabling installation

3.1.25
impedance matching device
device designed to match the impedance of transmission equipment to that of the installed cabling

3.1.26
information technology (telecommunications)
branch of technology concerned with the transmission, emission and reception of signs, signals, writing, images and sounds; that is, information of any nature by cable, radio, optical or other electromagnetic systems

3.1.27
information technology equipment
active or passive equipment necessary to deliver a specific application (e.g. hubs, switches, routers, adapters)

3.1.28
installer
person installing cabling components – no design functions are assumed

3.1.29
isolated bonding network
IBN
bonding network that has a single point of connection to either the common bonding network or another isolated bonding network

NOTE All isolated bonding networks considered here will have a connection to earth through the single point of connection.

3.1.30
junction box
space within a home that enables cables to be routed between pathway systems

3.1.31
label
means of clearly marking a specific component of the information technology infrastructure with its identifier and (optionally) other information

3.1.32
local distribution space
space within a home that houses the area connection point of ISO/IEC 15018

3.1.33
main earthing terminal
terminal or busbar that is part of the earthing arrangement of an installation and enabling the electric connection of a number of conductors for earthing purposes

3.1.34
maintenance hole (telecommunications)
vault/chamber located in the ground or earth as part of an underground conduit system and used to facilitate placing, connectorization, and maintenance of cables as well as the placing of associated equipment, in which it is expected that a person will enter to perform work

3.1.35
meshed bonding network
bonding network in which all associated equipment cabinets, frames and racks are bonded together as well as at multiple points to the CBN

NOTE Consequently, the meshed BN augments the CBN.

3.1.36
met by design
requirement which may be met by calculation and selection of appropriate materials and installation techniques, where either there is no test method specified that allows verification or there is no requirement for verification by testing

3.1.37
metallic information technology cable (cabling)
cables (cabling) utilising metallic conductors for signal transmission

3.1.38
minimum bend radius (installation)
minimum radius as defined by the cable manufacturer, supplier or relevant product standard to which a cable or cable element is allowed to be subjected during installation

3.1.39
minimum bend radius (operating static)
minimum radius as defined by the cable manufacturer, supplier or relevant product standard to which a cable or cable element is allowed to be subjected following installation and fixed in its final operating position

3.1.40
minimum bend radius (operating dynamic)
minimum radius as defined by the cable manufacturer, supplier or relevant product standard to which a cable or cable element is allowed to be subjected under conditions where the cable or cable element is subject to movement during operation

3.1.41
non-deformed mains power supply
mains power supply that excludes the effects of non-linear loads which generate harmonic currents (fluorescent lamps, switch mode power supply devices, etc.)

3.1.42
parallel earthing conductor
PEC
earthing conductor that is parallel to the mains power cable or information technology cable

3.1.43
pathway (cable route, cable way)
defined route for cables between termination points

3.1.44
pathway system
cable management system or other area or volume defined by markings or fittings used to protect and/or support the cabling in order that its desired performance is maintained

3.1.45
PEN conductor
conductor combining the functions of both a protective earthing conductor and a neutral conductor

[IEC 60050-826:2004, 826-13-25; IEC 60050-195:1998, 195-02-12]

3.1.46
premises owner
owner of the premises within which cabling is to be installed and who may delegate the responsibilities specified in this standard to appointed representatives such as designers, specifiers, operators and maintainers of the resulting cabling infrastructures

3.1.47
primary distribution space
space within a home that houses the home distributor (primary home distributor) of ISO/IEC 15018 and associated equipment

3.1.48
protective (earth) conductor
PE
conductor provided for purposes of safety, for example protection against electric shock

[IEC 60050-826:2004, 826-13-22; IEC 60050-195:1998, 195-02-09]

3.1.49
rack
see frame

3.1.50
rack unit
44,45 mm (1.75 inches) of vertical mounting space in an IEC 60297 series standard cabinet or rack

3.1.51
record
collection of information about, or related to, a specific element of the information technology infrastructure

3.1.52
referenced cabling design document
relevant international standard or technical report for cabling design

Refer to ISO/IEC JTC 1/SC 25 and Figure 1 for a list of relevant standards.

3.1.53
secondary distribution space
space within a home that houses a secondary home distributor of ISO/IEC 15018

3.1.54
segregation
physical separation and/or isolation for the purposes of safety, protection of damage to equipment or the prevention of electromagnetic noise from mains power cabling interfering with circuits operating on telecommunications cabling

3.1.55
service loop
excess length of cable or cable element(s)

3.1.56
surge protective device
device intended to protect the electrical apparatus from high transient over-voltages and to limit the duration and frequently the amplitude of the follow-on current

NOTE The device contains at least one non-linear component.

3.1.57
space
specified volume (e.g. room, maintenance hole or part thereof) housing closures and/or other information technology equipment

3.1.58
Stage 1
a possible contractual boundary following the installation of cable but prior to its termination at which testing may be appropriate (certain systems allow the installation of pre-terminated cables which may be subject to Stage 1 testing)

3.1.59
Stage 2
a possible contractual boundary following the completion of cabling installation at which testing may be appropriate

3.1.60
telecommunications
see “information technology”

NOTE The term telecommunications has no legal meaning when used in this standard.

3.1.61
termination point
connection, free connector or fixed connector (as appropriate) fitted to an installed cable and housed within a closure

3.1.62
wall section
fixed-size section of a wall used to mount telecommunications equipment or termination hardware

3.1.63
work order
collection of information which documents the changes requested and the operations to be carried out on the information technology infrastructure

3.1.64
automated infrastructure management system
AIM system
integrated hardware and software which automatically detects the insertion or removal of cords and documents the cabling infrastructure including connected equipment enabling management of the infrastructure and data exchange with other systems

3.1.65
discoverable equipment
equipment with a network address

Note 1 to entry: Discoverable equipment could be treated as non-discoverable equipment per end user choice.

3.2 Abbreviations

For the purposes of this document the following abbreviations apply.

AC	alternating current
AIM	automated infrastructure management
BEF	building entrance facility
BN	bonding network
CATV	community antenna television
CAD	computer aided design
CBN	common bonding network
CER	common equipment room
CSA	cross-sectional area
CTR	common telecommunications room
DC	direct current
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMS	energy management systems
ENI	external network interface
EQP	equipment
ESD	electrostatic discharge
IBN	isolated bonding network
HV	high-voltage
HVAC	heating, ventilation and air conditioning
IDC	Insulation displacement connection
ISDN	integrated services digital network
LV	low-voltage
MAC	move, add, change
MESH-BN	mesh bonding network
MET	main earthing terminal
NVP	nominal velocity of propagation
PE	protective (earth) conductor
PEC	parallel earthing conductor
PEN	conductor combining the functions of both a protective conductor and a neutral conductor
SPD	surge protective device
U	rack unit

3.3 Conventions

Annexes B to G adopt a non-sequential Clause numbering structure in order to clarify and directly reference the Clauses in the main body that are affected by the text of each Annex.

4 Conformance

For planning and installation of cabling and cabling infrastructures to conform to this International Standard

a) the requirements of the applicable generic cabling design standards shall be applied,

b) the specification of the installation shall meet the requirements of Clause 5,

c) the quality planning of the installation shall meet the requirements of Clause 6,

d) the planning of the installation shall meet the requirements of Clause 7,

e) the installation practices shall meet the requirements of Clause 8,

f) the documentation and administration of the installation shall meet the requirements of Clause 9,

g) the testing and inspection of the installation shall meet the requirements of Clauses 10 and 11 respectively,

h) the operation of the installation shall meet the requirements of Clause 12,

i) the maintenance and repair shall meet the requirements of Clauses 13 and 14 respectively,

j) the additional requirements of the applicable premises-specific Annex shall be met,

k) where a lightning protection system is required, it shall conform to the “integrated lightning protection system" according to IEC 62305-4,

l) other lightning protection systems, including the “isolated lightning protection system” according to IEC 62305-3 are allowed provided that specific restrictions are applied both to the implementation of the information technology cabling as agreed between the planners of the lightning protection system and the information technology cabling,

m) local regulations, including safety, shall be met.

5 Specification of installations

5.1 General

This clause in conjunction with Clause 6 describes the key aspects of installation quality assurance as shown in Figure 2.

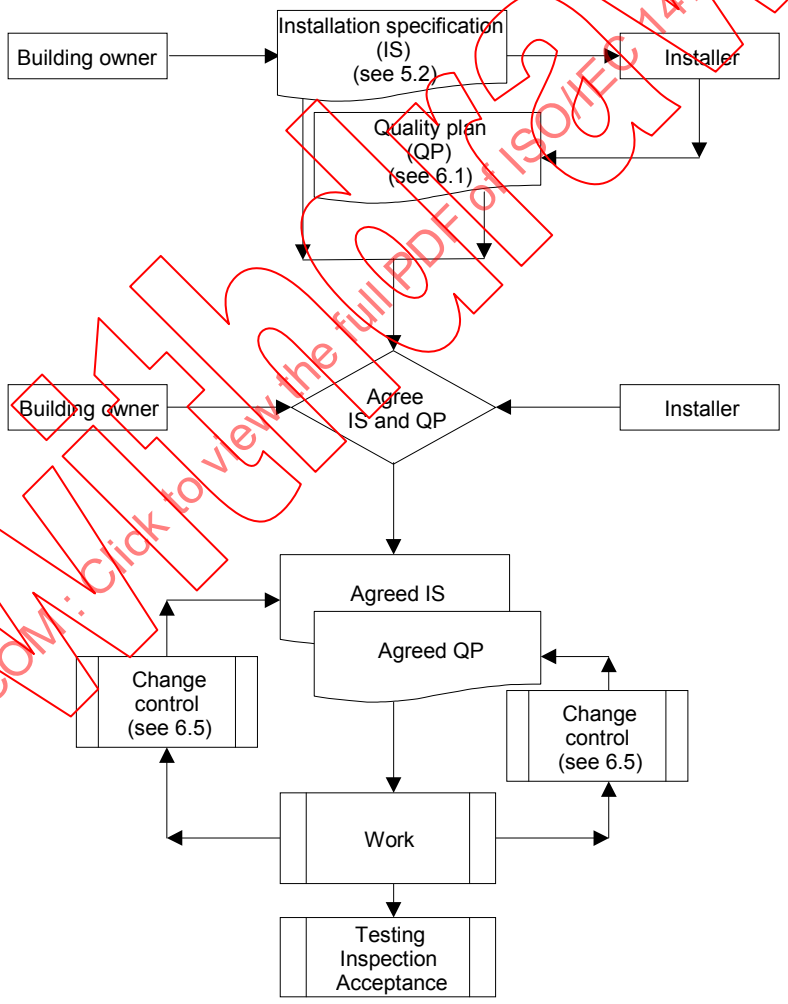


Figure 2 – Quality assurance schematic

5.2 Installation specification

5.2.1 Requirements

5.2.1.1 General

An installation specification shall be produced by, or on behalf of, the premises owner, in accordance with the requirements of this clause. The installation specification shall be agreed with the installer prior to the commencement of the installation.

The installation specification shall comprise

- the technical specification (see 5.3),
- the scope of work (see 5.4),
- quality assurance (see 5.5).

5.2.1.2 Other infrastructures

The installation specification shall detail how the following has been taken into account

- other building services such as mains power distribution and earthing systems,
- building management systems including security, access control, etc.,
- circuits for smoke/fire detection and associated controls,
- heating, ventilation and air conditioning (HVAC) infrastructures,
- industrial machinery (e.g. automation islands as described in Annex F),
- piping systems (water supply and waste, fire suppression, compressed air, machine lubricating oil, hydraulic fluids, dry material and high temperature exhaust ports),
- other relevant infrastructures.

The installation specification shall explicitly state where any of the above do not apply.

5.2.1.3 Legislation, regulations and statements of compliance

Applicable legislation, regulations and statements of compliance shall be detailed including

- building regulations relating to the installation,
- specific site regulations,
- safe working practices,
- external service protection,
- contractors' authorization,
- accreditation of installer personnel.

The installation specification shall explicitly state where any of the above do not apply.

5.2.1.4 Site contacts

The installation specification shall detail the site contacts with responsibilities for

- operational requirements,
- site information (including access and applicable restrictions, knowledge of relevant hazardous areas),
- technical requirements,
- documentation of existing cabling, if relevant,

- compatibility of existing information technology cabling components,
- items to be issued to the information technology cabling installer by, or on behalf of, the premises owner,
- storage of materials,
- removal, disposal and/or recycling of excess and waste material,
- occupational health and safety,
- installation of cabling by a third party,
- main contractor and/or sub-contractors,
- transfer of responsibility and/or property.

5.2.2 Recommendations

The installation specification should reflect predictable expansion to the cabling system, whether from the need to support additional users or increases in quantity or type of applications, with reference to

- pathways and pathway systems,
- cabinets, frames and racks,
- termination points,
- the mains power supply system.

The quantity and location of termination points should reflect the predicted requirements over the intended life of information technology cabling.

The installation specification should contain the elements of the information technology strategy that include details of

- the application(s) to be supported by the installed cabling highlighting, where relevant, current and future requirements,
- external service provision and its interface(s) to the information technology cabling (see Clause 7),
- resilience planning,
- security requirements/access restrictions.

5.3 Technical specification

5.3.1 General

5.3.1.1 Requirements

The technical specification shall contain details of, and the performance requirements for, the cabling and associated components. The technical specification forms the basis of assessment of the performance of installed cabling together with all cabling components and installation techniques used.

The technical specification shall cover both new installations and extensions of existing installations.

The technical specification shall detail the location of, and requirements for, any relevant external network interfaces (ENIs) (see Clause 7).

The technical specification shall define the

- level of administration system to be applied to the cabling infrastructure (see Clause 9,

- range of documentation to be supplied by the installer including any requirements to link records to each other and to other building services records,
- format of the documentation (see Clause 9),
- labelling to be undertaken by the installer (see Clause 9),
- specification of labels (as a minimum, meeting the requirements of Clause 7),
- requirements for acceptance testing (see Clause 10),
- requirements for inspection (see Clause 11),
- requirements for the treatment of parts of the installation that do not comply with the requirements for inspection and acceptance testing,
- the format of test result and inspection documentation (see Clauses 10 and 11) which shall contain the pass/fail results of the acceptance tests, where required, and any actions taken to repair or correct installation failures.

5.3.1.2 Recommendations

The technical specification should detail the requirements for the

- physical and operational lifetime of the cabling installation,
- provision of facilities necessary to support the installation of additional termination points over the intended operational life of the installed cabling.

5.3.2 Safety requirements

The technical specification shall

- identify and classify any hazards within the pathways and at termination points,

  NOTE The hazard classification of areas containing, or intended to contain, optical fibre information technology equipment and optical fibre information technology cabling is described in IEC 60825-2 and is used to define appropriate installation and labelling practices.

- detail the boundaries of areas containing hazards, or potentially hazardous areas.

5.3.3 Security requirements

The technical specification shall detail measures required to prevent unauthorised access to pathways, pathway systems, closures, cabinets, frames, racks and cords.

5.3.4 Performance and configuration – Requirements

The technical specification shall detail the required transmission performance of the cabling to be installed

- when subject to the defined operational environment (see 5.3.5),
- in conjunction with existing cabling.

The environmental compatibility shall be achieved by selection of appropriate components and/or by mitigation techniques that modify the environment to which the component is subjected including

- isolation from the defined environment (by means of protection/segregation),
- separation from the defined environment.

The technical specification shall detail any mitigation products or techniques necessary to allow the components selected to be installed and operate as specified when subjected to the defined environmental conditions.

The technical specification shall detail the

- pin-pair assignment for balanced cable elements at interfaces to the installed cabling,

NOTE 1 Annex A provides information about possible connections between the wires and the pins of information technology outlets within generic cabling systems in accordance with the referenced cabling design document. The same set of pin-pair combination should be used throughout the whole cabling installation.

- positioning of optical fibres at interfaces to the installed cabling.

NOTE 2 Annex A contains requirements and recommendations for the maintenance of polarity within cabling terminated with connecting hardware housing multiple optical fibres.

The technical specification shall contain the requirements for

- the pathways, pathways systems, cabinets, frames, racks, closures, cables, termination points and cords (see Clause 7),
- the functional earthing and equipotential bonding of cabling components and accessories.

5.3.5 Environmental conditions

5.3.5.1 Requirements

The technical specification shall detail the intended installation and operational environmental conditions.

The MICE classification system described in ISO/IEC TR 29106 shall be used where the intended installation and operational environmental conditions lie within the boundaries defined by $M_3I_3C_3E_3$. In addition, the following environmental conditions shall be taken into account:

- biological attack (e.g. mould or fungal growth);
- physical damage (accidental or malicious) including damage caused by animals;
- presence, or potential presence, of hazards (such as contaminating, toxic or explosive materials);
- the movement of air (e.g. caused by fans, heating and ventilation systems);
- meteorological effects (e.g. wind);
- impact of natural events e.g. lightning strike, earthquake.

NOTE A number of standards exist for the classification of environments relevant to information technology components and equipment. Reference should be made to the IEC 60721 series of standards.

5.3.5.2 Recommendations

The technical specification should include a risk assessment including abnormal environmental conditions (temperature changes, flooding) which should result in a risk management plan that may have an effect on the requirements for component performance or mitigation.

5.4 Scope of work

5.4.1 Pre-installation

5.4.1.1 Requirements

The scope of work shall detail requirements for

- any building work required on each pathway,
- pathway preparation and the installation of pathway systems,

- accommodation of the terminating devices for external (outdoor) and internal (indoor) cables at building entrance facilities,
- the quantities of cabling components and installation accessories,
- the protective earthing, functional earthing and equipotential bonding of pathway systems,
- additional surveys to be undertaken to supplement information in the scope of work.

The scope of work shall define

- the responsibilities for the identification, design and completion of the works involved,
- the responsibilities for obtaining all necessary clearances and permits,
- requirements for site-specific safety inductions and training requirement,
- the location of storage facilities for cabling components and installation accessories,
- a system for the disposal of waste components and/or installation materials.

5.4.1.2 Recommendations

The scope of work should contain

- site plans that are marked up to show the works required,
- details of the facilities (such as telephone and accommodation) to be used by the installer,
- details of the processes operating on the premises, for the duration of the installation, for the delivery of, storage of, access to and removal of, materials.

5.4.2 Installation

5.4.2.1 Requirements

The scope of work shall detail locations of

- spaces,
- pathways,
- cabinets, frames and racks,
- closures,
- termination points,
- relevant earthing points.

The scope of work shall detail requirements for

- warning signs and equipment to ensure safe working,
- the pathway systems to be used in each pathway,
- the cables to be installed in each pathway,
- jointing and/or termination at each termination point,
- the protective earthing, functional earthing and equipotential bonding of cabling components,
- marking and labelling the cabling components,
- the quantity and type(s) of inspection and testing to be applied to the cabling installation.

The scope of work shall define an installation programme detailing key dates including

- requirements for progress meetings,
- attendance at contract inspection points,

- final installation date,
- the date that the installation documentation is to be supplied,
- the date that the installation is to be brought into service,
- hand-over date(s).

The scope of work shall detail

- items to be provided by information technology cabling installer,
- items to be issued to the information technology cabling installer by, or on behalf of the premises owner,
- other works with potential to affect the programme,
- access limitations together with restrictions on personnel movement, vetting and clearance levels,
- the responsibilities for the identification, design and completion of the works involved,
- the responsibilities for obtaining all necessary clearances and permits,
- applicable fire precautions and escape routes,
- site access and security arrangements.

5.4.2.2 Recommendations

The scope of work should contain

- site plans that are marked up to show the works required,
- details of the facilities (such as telephone and accommodation) to be used by the installer,
- details of a system of materials control.

During the development of the scope of work, testing should be considered:

- where application-specific cabling is to be used to support a more demanding application;
- where extending or modifying an undocumented installation.

5.4.3 Post-installation

5.4.3.1 Requirements

The scope of work shall detail requirements for reinstatement and shall define

- the responsibilities for the identification, design and completion of the works involved,
- the responsibilities for obtaining all necessary clearances and permits (where not covered by those obtained in 5.4.2.1),
- a maintenance and control procedure for the final cabling documentation.

5.4.3.2 Recommendations

The scope of work should detail requirements for

- operational training including safety,
- maintenance training for the premises owner and/or the designated cabling maintainer,
- fault analysis training,
- repair and maintenance contracts,
- spares, e.g. cable, cords, closures, connecting hardware, tools, test equipment and test leads.

5.5 Quality assurance

The installation specification shall

- contain a list of the items to be addressed in the quality plan applicable to the installation as defined by, or on behalf of, the premises owner,
- identify the responsibilities for any additional tasks necessary to allow agreement of the quality plan (see Clause 6).

NOTE For installations of cabling in accordance with ISO/IEC 15018 in single homes, quality plans are not required but may be requested.

6 Quality planning

6.1 Quality plan

A quality plan addressing the requirement of the installation specification shall be produced by, or on behalf of, the installer in accordance with the requirements of this standard. The quality plan shall be agreed with the premises owner prior to the commencement of the installation.

NOTE For installations of cabling in accordance with ISO/IEC 15018 in single homes, quality plans are not required but may be requested.

The quality plan shall clearly state the measures and procedures to be adopted to demonstrate compliance with

- the requirements of this standard,
- the requirements of the referenced cabling design document,
- the installation specification.

The quality plan shall detail the procedures

a) for the transfer of responsibilities between the installer, premises owner and, where relevant, other contractors,

b) for the acceptance of cabling components and the cabling installation (including verification of physical, mechanical, optical and/or electrical specifications based on the manufacturers' or suppliers' specifications and relevant standards),

NOTE Cabling components to be installed may be supplied by the installer or by, or on behalf of, the premises owner.

c) to be adopted to assess compatibility between cabling components to be used during the installation,

d) to be adopted to assess compatibility with any existing installed cabling,

e) to address the impact of potential component incompatibilities,

f) to ensure the selection of appropriate cords to extend the fixed portion of the cabling to create channels.

Where, at any point during the installation process, inspection and/or testing of cabling components or installed cabling is specified in the installation specification, or by local regulations, the quality plan shall detail the

- inspection and test equipment,
- the calibration status of the inspection and test equipment,
- sampling plans (see 6.2),
- measurement procedures (see Clause 10),

- treatment of results which are non-compliant or marginal (i.e. within the specified measurement accuracy of the test system), see 6.2.

The quality plan shall detail the competency of personnel to undertake the installation in accordance with the installation specification.

Where sampling plans are applied, the quality plan shall detail the procedures (for example, extension of sampling procedures) to be adopted if sample testing identifies results which are non-compliant or marginal (i.e. within the specified measurement accuracy of the test system), see 6.2.

6.2 Sampling

6.2.1 Balanced cabling

6.2.1.1 General

Table 1 shows three groups of balanced cabling transmission parameters (basic verification, internal transmission and alien (exogenous) crosstalk) using the parameters that define the Classes of links and channels within the referenced cabling design standards. This subclause specifies requirements and recommendations for the testing of these parameter groups. The test procedures and equipment for balanced cabling links and channels are specified in Clause 10.

Requirements are defined for other transmission parameters but are considered to be met by design.

Table 1 – Installed balanced cabling test parameters

Parameter group	Transmission parameter
Basic verification	Wire-map
	Continuity (d.c.) – Signal conductors – Screen conductors (if present) [a] – Short circuits – Open circuits
Internal transmission	Return loss
	Insertion loss
	Pair-to-pair NEXT
	PS NEXT
	Pair-to-pair ACR-N
	PS ACR-N
	Pair-to-pair ACR-F
	PS ACR-F
	Direct current (d.c.) loop resistance
	Propagation delay
	Delay skew
Alien (exogenous) crosstalk	PS ANEXT
	PS $ANEXT_{avg}$
	PS AACR-F
	PS $AACR\text{-}F_{avg}$

[a] It shall be ensured that continuity be provided by the cabling components and

not by alternative connections such as protective earth conductors.
NOTE Link or channel length may also be of interest, but is not a pass/fail criterion.

It is recommended that installation specifications require the acceptance testing of permanent links since permanent link requirements incorporate an adequate margin to support the expected variability of the cords used to create channels.

NOTE A conformant channel containing a permanent link does not ensure that other channels created from that permanent link will themselves be conformant to channel requirements.

6.2.1.2 Permanent link testing

Independent of the requirements of the installation specification, basic verification parameters of Table 1 shall be tested using a sample level of 100 %.

Where the installation specification requires acceptance testing of internal transmission parameters of Table 1 against the permanent link requirements of Classes D, E, E_A, F or F_A the sample level applied should be 100 %.

Where the installation specification requires acceptance testing of alien (exogenous) transmission parameters of Table 1 against the permanent link requirements of Classes E_A, F or F_A the minimum sample level applied should be in accordance with 6.2.1.4.

6.2.1.3 Channel testing

In all cases, independent of the requirements of the installation specification, basic verification parameters should be tested using a sample level of 100 %.

Channel tests may be used to determine performance where the installation specification requires

a) one or more cords to be added to each end of a permanent link of a given Class to create a channel of the same or lower Class,

b) permanent links of a given Class to be interconnected and one or more cords are added to each end to create a channel of a lower Class,

c) any cords attached to a permanent link of a given Class (or within a channel of a given Class) to be changed,

d) cabling implementations for which there are no permanent link limits (where standards do not contain requirements or where the installation specification contains channel requirements different from those specified in the referenced cabling design standards),

e) lengths and configurations of cabling that lie outside the reference implementations of the referenced cabling design standards.

In cases a), b), and c), where the installation specification requires acceptance testing of internal transmission parameters of Table 1 against the permanent link requirements of Classes D, E, E_A, F or F_A the sample level applied should be 100 %. A lower sample level may be applied to channel testing provided that the associated risk of undiagnosed faults is recognised in the Quality Plan.

In cases d) and e), where the installation specification requires acceptance testing of internal transmission parameters of Table 1 against the requirements of channel Classes D, E, E_A, F or F_A the sample level applied should be 100 %.

Where the installation specification requires acceptance testing of alien (exogenous) transmission parameters of Table 1 against the requirements of a specific channel Class the minimum sample level applied should be in accordance with 6.2.1.4.

6.2.1.4 Alien (exogenous) crosstalk testing

Where the installation specification requires acceptance testing of alien (exogenous) crosstalk transmission parameters of Table 1 of installed permanent links or channels against the requirements of permanent link or channel Classes E_A or F_A of ISO/IEC 11801, the minimum sample of disturbed permanent links or channels to be tested should be in accordance with Table 2.

Table 2 – Minimum sample sizes for alien (exogenous) crosstalk testing

Total no. of links/channels N	Sample size
3 to 150	3 or 0,1 × N (whichever is the greater)
151 to 3,200	33 [a]
3 201 to 35 000	126 [a]
35 001 to 150 000	201 [a]
150 001 to 500 000	315 [a]
[a] Equivalent to acceptance quality level (AQL) of 0,4 %, normal inspection, general inspection level I as defined in ISO 2859 series for populations of up to 500 000 links.	

The sample quantity shall be subject to the selection criteria as specified in IEC 61935-1.

IEC 61935-1 contains an option to reduce the quantity of tests provided that evidence exists to indicate that measured performance exhibits adequate margin against the specified limit.

6.2.2 Optical fibre cabling

6.2.2.1 General

Table 3 shows two groups of optical fibre cabling transmission parameters (basic verification and transmission) using the parameters that define the Classes of links and channels within the referenced cabling design standards. This subclause specifies requirements and recommendations for the testing of these parameter groups. The test procedures and equipment for optical fibre cabling links and channels are specified in Clause 10.

Table 3 – Installed optical fibre cabling test parameters

Parameter group	Transmission parameter
Basic verification	Polarity
Transmission	Attenuation
	Length (propagation delay)

6.2.2.2 Permanent link testing

Where the permanent link contains non-fixed cabling (e.g. CP cord in ISO/IEC 11801 and LDP cord in ISO/IEC 24764) any result is only applicable to the specific configuration under test.

Independent of the requirements of the installation specification, basic verification parameters of Table 3 shall be tested using a sample level of 100 %.

Where the installation specification requires acceptance testing of transmission parameters of Table 3 against the requirements of a specific permanent link Class and

- where testing of optical fibre cabling attenuation is undertaken with equipment that also automatically tests verification parameters, a sample level of 100 % should be used,
- where testing of propagation delay/length is undertaken with equipment that also automatically tests verification parameters, a sample level of 100 % should be used,
- provided that polarity has been confirmed, testing of length/propagation delay may be restricted to a sample level within a given cable containing a number of permanent links or within a number of cables running in common pathways.

6.2.2.3 Channel testing

Channel tests may be used to determine performance where the installation specification requires

a) one or more cords to be added to each end of a permanent link of a given Class to create a channel of the same or longer Class,

b) permanent links of a given Class to be interconnected and one or more cords are added to each end to create a channel of a longer Class,

c) any cords attached to a permanent link of a given Class (or within a channel of a given Class) to be changed,

d) cabling implementations for which there are no permanent link limits (where standards do not contain requirements or where the installation specification contains channel requirements different to those specified in the referenced cabling design standards).

Where channel tests are undertaken, the actual cords used to create the channel shall be used and installed in the as-built configuration. In all cases, the sampling recommendations of 6.2.2 apply.

6.3 Treatment of marginal results

6.3.1 Balanced cabling

6.3.1.1 General

IEC 61935-1 requires that test results of individual parameters be marked with an asterisk if the difference between the measured result and the test limit is less than the specified measurement accuracy.

The measurement accuracy is generally dependent on the field tester test limit, the nature of the test adapters, and actual link properties and is dependent on the frequency at which the minimum test margin occurs.

6.3.1.2 Requirements

The quality plan shall include guidelines on how marginal test results are handled.

As examples, the quality plan may state that

- marginal pass results shall be accepted but marginal fail results shall not be accepted,
- marginal results shall not be accepted,

NOTE This implies that the performance of the installed cabling has sufficient margin to accommodate the measurement accuracy of the tester to be used and that the tester measurement accuracy to be used is known.

- marginal results shall be accepted: meaning that the fail limit is less stringent, as compared to the required limit, by the uncertainty of the field tester.

To minimize marginal test results, the quality plan shall specify the properties of the field tester that is used for testing. Field test equipment with better accuracy than the minimum specified in IEC 61935-1 for a given cabling performance and frequency range should be used.

6.3.2 Optical fibre cabling

ISO/IEC 14763-3 does not require that test results of individual parameters be marked with an asterisk if the difference between the measured result and the test limit is less than the specified measurement accuracy.

6.4 Treatment of non-compliant results

The quality plan shall detail the procedures to be applied where it has been impossible to obtain a compliant result. Examples of such procedures include labelling the cabling appropriately and highlighting its status and the impact of the non-compliance in the installation documentation.

6.5 Change control

All modifications, changes and variations to the installation specification and quality plan should be clearly documented to enable traceability.

7 Installation planning

7.1 General

This clause details requirements and recommendations for planning of installations. It covers

- pathways and spaces,
- functional elements of the referenced cabling design standards,
- segregation from mains power cabling,
- support for installation practices (e.g. bend radius, pulling load).

Cabling for all relevant telecommunication services shall be considered when the installation is planned including

- voice,
- data,
- video,
- fire, security and access control systems,
- other building signalling systems (e.g. HVAC, EMS),
- machine control.

7.2 Safety

7.2.1 General

The specification of safety requirements is beyond the scope of this International Standard. It is referred to those safety standards and regulations applicable at the location of the installation.

7.2.2 Mains power cabling

The proper implementation of the requirements of this standard assume that electrical installations, bonding networks and protective measures against overlvoltages are undertaken in accordance with the local regulations, as appropriate.

NOTE The IEC 60364 series may contain appropriate information.

In addition, installation and mitigation guidelines for electrical installations (including earthing) to ensure electromagnetic compatibility may be found in IEC TR 61000-5-2.

7.2.3 Optical fibre cabling

The hazard classification of areas containing optical fibre information technology equipment and optical fibre information technology cabling shall be undertaken in accordance with IEC 60825-2 to define appropriate installation and labelling practices.

7.3 Environment

The MICE concept according to ISO/IEC TR 29106 shall be used to describe the environment where the cabling or parts of the cabling will be located.

Product and/or supporting systems shall be selected, where appropriate, to provide sufficient protection from the environment to enable the cabling to meet the required transmission performance.

7.4 Points of electrical contact

The long term stability of electrical connections including earth connections and connections between sections, or parts of pathway systems depends on the galvanic coupling of the materials used. Where risk of galvanic corrosion exists relevant specialists shall be consulted and any measures taken shall be documented for future use.

7.5 External service provision

7.5.1 Requirements

Information shall be obtained from, and agreement reached with, the external service provider(s) with respect to

a) the precise physical location of the ENI(s),
b) the quantity and capacity of the components that provide the ENI(s),
c) the identification and numbering of individual circuits at each ENI,
d) any additional options required,
e) the responsibility of the technical and operational maintenance of the boundary of the external service provision,
f) the liaison arrangements for the external service provider(s) and the premises owner or an appointed representative,
g) the procedures to be followed by the premises owner or an appointed representative in reporting and reacting to faults in the external service provision,
h) arrangements for access to the premises,
i) technical requirements for equipment supplied by the external service provider(s).

7.5.2 Recommendations

External service provider(s) should be advised of the foreseeable service requirements.

7.6 Pathways and pathway systems

7.6.1 General

7.6.1.1 Pathway system types

Examples of pathway systems that may be used are shown in Table 4.

NOTE If a pathway system, cable management system or a compartment of a cable management system is selected to support a specific cabling technology, it may not be suitable for the subsequent installation of other cabling technologies.

Table 4 – Examples of pathway systems

Pathway systems	Features
Cable trunking systems	Enclosed containment systems – consisting of a base and access cover, providing an enclosure for cables or insulated conductors and possible electrical and or communications accessories. Single or multiple compartment forms. Available in metallic or non-metallic form.
Cable tray systems	Open containment systems, consisting of a base and side members, intended to house cables and to provide support for the contained cable when used in horizontal pathways. Cable tray systems are mainly used in floor/ceiling spaces or in restricted access areas (e.g. above suspended ceiling, basements, plant rooms, telecommunications spaces etc.). Available in metallic or non-metallic form.
Wire mesh cable tray system (basket)	A form of cable tray system where the cable tray consists of a mesh of wires. Typically available in metallic form.
Cable ladder systems	Open containment systems, consisting of side members, fixed to each other by means of rungs, intended to house cables and to provide support for the contained cable when used in horizontal pathways. Cable ladder systems are mainly used in horizontal and vertical pathways. Available in metallic and non-metallic form.
Conduit systems	Enclosed containment systems of circular cross-section, providing an enclosure for cables or insulated conductors. Available in metallic or non-metallic form.
Cable ducting systems	Enclosed containment systems of non-circular cross-section, providing an enclosure for cables or insulated conductors and possibly electrical and or communication accessories. Available in metallic or non-metallic form.
Interval support	Open support system installed with appropriate spacing. Designed to support small to medium number of cables and normally used above suspended ceiling or below raised floors. Available in a range of forms (e.g. hooks and fasteners) and materials (metallic or non-metallic).
Designated routes	Pathways defined by markings or some other designation, normally used in floor spaces or within hollow walls or other building structures.
Catenary	A suspended strength member to which single or multiple cables may be attached to span an open space. Available in metallic or non-metallic form. In some cases the cable is designed as a catenary cable and contains an integral catenary strength member.

7.6.1.2 Pathway systems – Requirements

Access to pathways and pathway systems containing the cabling infrastructures serving multiple premises (enterprises, tenants, etc.) shall be restricted as specified in Annex B.

Elements of other supply systems such as water, heating, HVAC or sprinklers shall not be used as pathways or support for pathway systems due to the potential environmental impact and the risk that cable support will disappear by change to the supporting system.

The inside of the pathway systems shall

- have smooth surfaces and be free of burrs, sharp edges or projections that can damage cable insulation,
- be free of localised pressure points that may degrade the transmission performance of the installed system.

Abrasive supports (e.g. threaded rod) installed within the cable fill area shall have that portion within the pathway system protected with a smooth, non-scratching covering so that cable can be pulled without physical damage.

Cable management systems of the types listed below shall comply with the relevant international standards

- conduit systems: IEC 61386 series,
- cable trunking systems and cable ducting systems: IEC 61084 series,
- cable tray systems and cable ladder systems: IEC 61537.

Where pathway systems take the form of non-enclosed cable management systems to which cables are to be attached or supported by (e.g. dedicated/catenary wires or designated routes) then the cross-sectional area shall be considered to be the minimum available area surrounding the pathway system.

Segregation between mains power cabling and metallic telecommunications cabling shall be in accordance with 7.9.

Where separation between different cabling systems is required, it shall be maintained by physical separation to prevent accidental change during installation or extensions to the installation.

7.6.1.3 Recommendations

7.6.1.3.1 Pathway and pathway system selection

It is recommended that the planning of pathways and the selection of pathway systems is undertaken using a structured approach and addressing each cabling sub-system in turn. For example, for cabling in accordance with ISO/IEC 11801

a) the campus backbone cabling sub-system,
   1) between building entrance facilities (BEFs),
   2) between BEFs and distributors,
b) the building backbone cabling sub-systems,
c) the horizontal cabling sub-systems.

Pathway systems should be selected to ensure that water or other contaminant liquids cannot collect. The use of hidden pathways (such as within plastered wall surfaces) is not recommended but, if used, cabling should have either vertical or horizontal orientation.

7.6.1.3.2 Pathway and pathway system capacity planning

It is recommended to plan the pathway systems for the maximum predicted deployment of cabling. This can be achieved either by deploying sufficient pathway systems at the time of installation or by planning and reserving space for sufficient additional pathway systems.

The planning of pathway systems should provide adequate capacity to allow subsequent installation of an additional 40 % of telecommunications cables whilst maintaining minimum bend radii and segregation from mains power cabling (see 7.8).

7.6.2 Inside buildings

7.6.2.1 Requirements

7.6.2.1.1 Pathway systems

Pathway systems shall be installed to provide adequate protection to the installed cabling where cabling can be damaged or have its transmission properties adversely affected.

The use of hidden pathways within plastered wall surfaces requires the use of appropriately specified cables.

In fixed installations where impact to the installed cabling can occur (specifically including all cabling within 50 mm above floor level) protection shall be afforded by one or more of the following

- the mechanical characteristics of the pathway system,
- the location selected,
- the provision of additional local or general mechanical protection.

The selection of pathway systems shall enable the installation of fire barriers, if required.

Appropriate space shall be allocated to hand holes and the storage of cable loops (service loops) in accordance with manufacturer's instructions (see 7.6.2.1.2 in relation to minimum bend radius).

7.6.2.1.2 Minimum bend radii

The pathway system shall ensure that cable is able to be installed and, where appropriate, fixed in accordance with the applicable minimum bend radius (installation, operating – static and operating – dynamic) by using identifiable techniques. These requirements apply in three dimensions. Examples of such techniques are pre-fabricated curved corners and radius limiters as shown in Figure 3.

The techniques employed shall

- be designed to maintain the relevant minimum bend radius of the cable(s) to be installed; where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with dedicated/catenary wires attached), the largest minimum bend radius shall apply,
- not introduce deformation of the cable sheath,
- not apply compressive loads exceeding that specified for the cable.

Minimum bend radius is determined by manufacturers instructions. If instructions do not exist the following shall apply

- the minimum bend radius for balanced cables containing up to 4-pairs shall be 50 mm,
- the minimum bend radius for optical fibre cables in accordance with IEC 60794-2-21 and containing up to four optical fibres shall be 50 mm,
- the minimum bend radius for other optical fibre cables shall be 10 times the cable diameter and shall not be less than 30 mm,
- the minimum bend radius for coaxial cables shall be 10 times the cable diameter,

- the minimum bend radius for other metallic telecommunications cables shall be 8 times the cable diameter.

NOTE 1 Pathway systems that do not allow such an approach may restrict the type and use of cables installed in the pathways and cable management systems selected.

NOTE 2 Specific cable constructions, e.g. armoured cables, may require greater bend radii than those specified above.

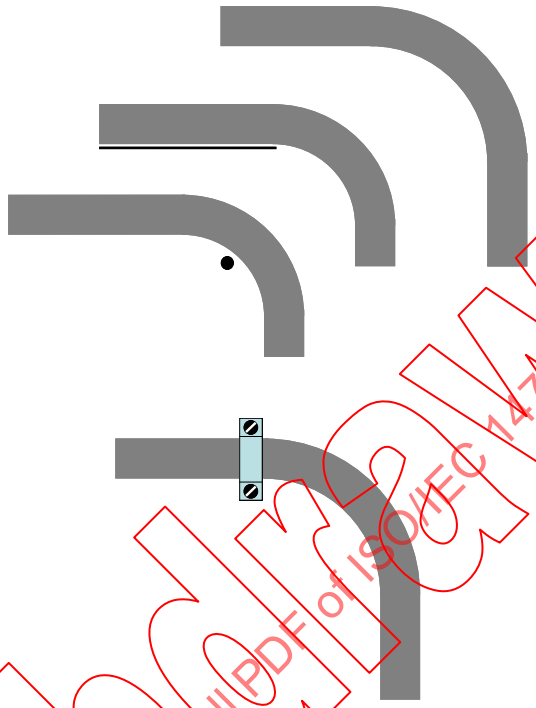


Figure 3a – Examples of non-conformant bend limiting techniques

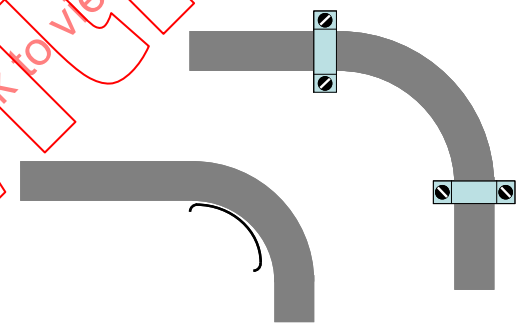


Figure 3b – Examples of conformant bend limiting techniques

Figure 3 – Example of conformant and non-conformant bend radius management

7.6.2.1.3 Maximum stacking height

The maximum stacking height in pathway systems is determined by manufacturers' instructions. If instructions do not exist the following shall apply

- for continuous pathway systems (e.g. cable trays), the stacking height shall not exceed 150 mm,

- for non-continuous pathway systems (e.g. wire mesh cable tray, cable ladder) and interval support pathway systems (e.g. hooks) the maximum stacking height shall be calculated according to Table 5.

Table 5 – Stacking height for non-continuous and interval support pathway systems

Distance between support distance l in mm	**Formula**	**Maximum stacking height** height h in mm
0	$h = 150/(-l*0{,}000\ 7+1)$	150
100		140
150		136
250		128
500		111
750		98
1 000		88
1 500		73

7.6.2.1.4 Conduit

Where conduits are installed without bends, the maximum distance between pulling points shall be 100 m unless appropriately specified cables and/or installation techniques are to be used.

Where a conduit contains bends

- the conduit shall not be subject to cumulative changes in direction of more than 180° between pulling points,
- the conduit shall not contain more than two bends of up to 90° each between pulling points (e.g. outlets, telecommunications rooms, or pull boxes),
- the maximum distance between pulling points shall be 15 m.

Bends within conduits shall be accessible and able to act as pulling points unless no additional cables are to be installed within the conduit, following the initial installation of cable, unless

- cables are to be removed before any additional installation takes place,
- the conduit contains sub-ducts to allow additional cables to be installed.

The inside radius of a bend in conduit shall be at least 6 times the internal conduit diameter. Bends in the conduit shall not contain any kinks or other discontinuities that may have a detrimental effect on the cable sheath during cable pulling operations.

Conduits should be considered as “full” when the cross-sectional area of the planned/installed cables reaches 40 % of the conduit cross-sectional area.

7.6.2.1.5 Non-continuous support for cables

The maximum distance allowed between supporting elements of the pathway system is 1 500 mm.

7.6.2.2 Recommendations

7.6.2.2.1 Pathway system capacity planning

Where bundles of cables are to be used, they should not contain more than 24 cables to reduce risk of stress and compression at bends.

7.6.2.2.2 Cable protection

The use of curved corners (pre-fabricated or manufactured on site) should be considered to maintain cable bend radii and avoid over-filling around bends (see Figure 4).

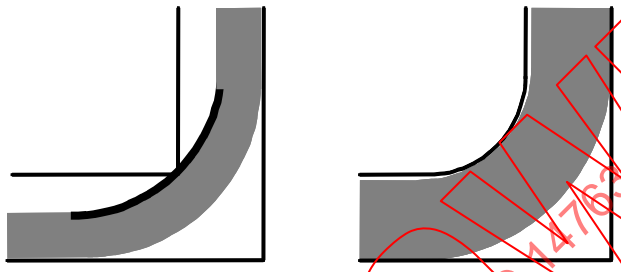


Figure 4 – Example of use of curved corners in pathway systems

7.6.2.2.3 Conduit

Where conduits are installed without bends, the maximum distance between pulling points should be 50 m unless appropriately specified cables and/or installation techniques are to be used.

Conduits (or ductings) protruding through a floor should be terminated at least 50 mm above the finished floor surface.

NOTE This protrusion aids in preventing poured concrete from entering the pathway during construction and protects cabling and fire-stop materials from water and other liquid spills.

7.6.3 Outside buildings

7.6.3.1 General

In installations outside buildings, such as those shown in the example of Figure 5, it is commonly required to consider other factors (visible and hidden) which might have an environmental impact on the information technology cabling. These include

- high voltage underground cables or overhead lines (electromagnetic impact),
- steam pipes (temperature impact),
- flooding (ingress impact),
- chemical contamination (liquid, gas),
- roads or railroad tracks (mechanical impact).

Where possible, the installation of information technology cabling in such areas affected by these factors should be avoided. However, where national or local regulations allow, mitigation may be applied by selecting appropriate components, pathways, and/or spaces.

Pathways between buildings may use a variety of underground and aerial pathway systems and may use spaces and structures (e.g. hand holes, maintenance holes and

telecommunications cabinets) that are constructed to assist cabling installation and to house closures.

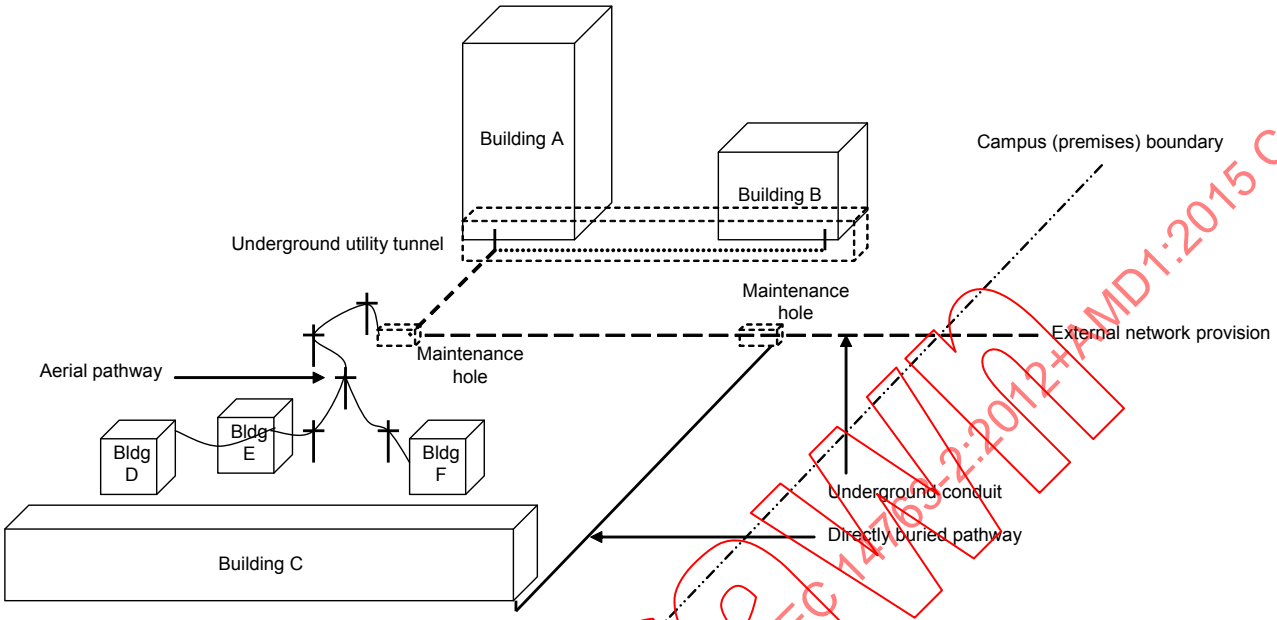


Figure 5 – Example of cabling installations outside buildings

Table 6 – Design and planning of pathways outside buildings

Dedicated underground pathways		**Dedicated aerial pathways**	
Pathway	Clearances from other utilities	Poles	Type
	Separations from other utilities		Length
	Depth of burial		Depth of burial
	Road crossings		Guying
	Rail crossings		Braces (stays)
Method of excavation	Buried		Attachment
	Casing	Spans	Pole-to-pole span
	Trenching		Pole-to-building span
	Boring (pipe pushing)		Slack
	Ploughing		Lashing
Landscape restoration	Backfill		Cable sag
		Pathway	Clearance
			Separation
			Riser protection
			Earthing
		Catenary wire	Type of strand
			Strand tension

Underground pathways and spaces may be

- dedicated to the installation of information technology cables (e.g. direct-buried cable, buried conduit, maintenance holes, hand-holes); Table 6 gives a non-exhaustive list of design and planning issues,
- shared spaces such as a utility tunnel providing other services (e.g. electricity, steam, water).

NOTE Information technology cabling pathways within utility tunnels may consist of indoor pathway systems in accordance with 7.6.1 and 7.6.2.

Aerial pathways and spaces may comprise

- poles, catenary wire, anchoring guy wires and closures; Table 6 gives a non-exhaustive list of design and planning issues,
- self-supporting cables, which may include a catenary wire; Table 6 gives a non-exhaustive list of design and planning issues,
- conduit or other pathway systems following the pathway of other utilities.

7.6.3.2 Requirements

7.6.3.2.1 Pathway planning

The plan for routing of pathways shall take into account

- existing buildings and structures,
- anticipated placement of new buildings or structures on the campus,
- requirements, where appropriate, for redundancy of both pathways and cabling,
- requirements, where appropriate, for external service provision between the campus boundary and BEFs,
- risk assessment of accidental or intentional damage to the installation.

In areas accessible to the public, information technology cables shall be mechanically protected from 0,3 m below the surface to a height of at least 3 m.

7.6.3.2.2 Underground pathways

Where pathway systems are used the location of, and distance between, access points shall take into account

- the maximum tensile load of the cable,
- the installation method,
- requirements for future expansion of the cabling to service additional buildings,
- need for access.

The following shall be documented

- the installation method,
- the location of access points.

Depths of lay are dependent upon the actual and potential use of land crossed by the pathway and shall comply with national or local regulations. Requirements for marker tapes shall comply with national or local regulations.

It shall be assumed that underground pathway systems will become at least partially water filled due to leaking and condensation.

Utility tunnels are normally dry but can have a varying environment, cables placed in tunnels shall have the appropriate properties for the environment.

7.6.3.2.3 Aerial pathways

The route of the cable shall be designed and built in such a way that damage or unsafe situations caused by overloading the construction are avoided. At the crossing of two or more routes, different cables shall not touch each other in any circumstances.

Special consideration shall be given to overhead routes that run parallel to or cross railways, tramways, trolley bus cables, cable railways, cable ways, ski and chair lifts, motor ways, roads and navigable rivers and waterways, etc. The minimum height of cables shall comply with national or local regulations during installation, maintenance and operation.

The stresses on the cables and poles depend on the span length and the sag. The climatic conditions that can have a major effect on tensions in poles, aerial cables and sag are heat, cold, wind and snow/ice load on cables and poles. Reference shall be made to the national regulations for routes affected by such conditions and the appropriate construction methods utilized.

Precautions shall be taken to avoid contact with parts of power cables and equipment.

Unless allowed by national or local regulations, information technology cables shall be installed lower than power cables.

7.6.3.2.4 Minimum bend radii

The pathway system shall ensure that cable can be installed and, where appropriate, fixed in accordance with the applicable minimum bend radius (installation, operating static and operating dynamic) by using identifiable techniques. These requirements apply in three dimensions. Examples of such techniques are pre-fabricated curved corners and radius limiters as shown in Figure 3. The techniques employed shall

- be designed to maintain the relevant minimum radius of the cable(s) to be installed, where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- not introduce deformation of the cable sheath,
- not apply compressive loads exceeding that specified for the cable.

Minimum bend radius is determined by manufacturers instructions. If instructions do not exist the minimum bend radius shall be 20 times the cable diameter.

NOTE 1 Pathway systems that do not allow such an approach may restrict the type and use of cables installed in the pathways and cable management systems selected.

NOTE 2 Specific cable constructions, e.g. armoured cables, may require greater bend radii than those specified above.

7.6.3.3 Recommendations

7.6.3.3.1 General

Information technology cables should be mechanically protected from 0,5 m below the surface to a height of at least 3 m.

Separation between information technology and mains power cables should be at least 1 m throughout pathways and within spaces.

Where the IT cable contains metallic cable elements, surge protection should be applied at all building entrances.

7.6.3.3.2 Underground pathways

During any given installation phase, additional pathway systems should be installed to enable the subsequent installation of additional cables to minimize the number of future excavations that are both disruptive and costly.

The following examples are included as guidance

- direct burial: while the trench is open, install additional spare ducts,
- conduit without sub-conduits,
  - conduits should be 100 mm minimum diameter,
  - conduits should be considered as “full” when the cross-sectional area of the planned/installed cables reaches 40 % of the conduit cross-sectional area,
  - a minimum of one empty conduit should be installed during each installation phase,
  - where there is a known number of installation phases, the number of conduits to be installed should be calculated as the number of planned phases x the initial number of filled ducts,
- conduit with sub-conduits,
  - an alternative is to apply multi-conduit/sub-conduit constructions that provide the required capacity (this approach reduces the available cross-sectional area within the overall conduit and requires additional cable installation resources but provides significantly more flexibility).

NOTE 1 The most flexible installation would therefore comprise a number of 100 mm single ducts (for the largest cables and multi-cable phases) and a larger number of smaller ducts.

NOTE 2 Additional conduits may be required to support management of services/technologies.

7.6.3.3.3 Aerial pathways

Aerial crossing of roads and railways should be planned using the shortest route across the roads and railway respectively.

The use of stays or struts to reinforce the stability of two poles adjacent to the road or railway is recommended.

Aerial crossing of electrified railways is not recommended.

7.7 Spaces

7.7.1 Requirements

7.7.1.1 General

Spaces shall not be located

- in emergency escape ways (where they obstruct),
- in areas that are subject to risk of flooding.

Dimensions of spaces allocated to entrance facilities and distributors shall take into account the initial volume and future expansion of information technology cabling and associated equipment.

Spaces shall be located to provide appropriate levels of security (restricted access) to the cabling and equipment to be contained within them. Access to spaces containing the cabling infrastructures serving multiple premises (enterprises, tenants, etc.) shall be restricted as specified in Annex B.

Signage shall be in accordance with the security plan for the premises.

7.7.1.2 Spaces and structures outside buildings

Access to pathways between buildings is provided by spaces and structures that typically comprise maintenance holes, hand-holes and telecommunication cabinets. Maintenance holes are preferred over hand holes as they provide greater flexibility for extension and expansion of the installed cabling infrastructure (e.g. additional pathways).

The spaces and structures are frequently located in unrestricted access areas and are subject to considerable physical risk. Spaces and structures shall be designed to survive the estimated risk and shall be constructed and installed in accordance with the required design.

All openings to spaces and structures shall maintain the environmental performance of the space or structure.

Cable entrances to spaces and structures shall

- be provided with the necessary cable support to prevent kinking at the point of entry,
- provide strain relief for the cable if not already done by separate fixtures.

Material used to construct spaces and structures shall be specified to resist deterioration when exposed to sunlight.

Maintenance holes shall be

- designed to maintain the relevant minimum radius of the cable(s) to be installed, where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- large enough to contain closures and “feed in” if required,
- contain adequate fittings to support closures, if required.

Routing of cables through maintenance holes shall enable the installation to comply with the requirements of 8.9.4.

Telecommunications cabinets shall be in accordance with the design guidelines of IEC 61969-1 and IEC 61969-2.

Where the spaces and structures are intended to contain active equipment

- the temperature and humidity shall be maintained to allow continuous operation of the active equipment,
- adequate mains power shall be provided.

The loading limits of the locations of telecommunications spaces and structures shall not be exceeded during construction and operation.

The loading limits of any mounting hardware within telecommunications spaces and structures shall not be exceeded during construction and operation.

7.7.1.3 Entrance facilities

Provision shall be made to allow the sealing of pathway systems entering buildings to prevent ingress of water.

Information technology cables that do not comply with the minimum recommended performance requirements of IEC 60332-1-2 shall either be

- terminated inside the building, within 2 m (unless an alternative distance is specified by local regulations) of the point of internal penetration of the external fire barrier (e.g. floor/ceiling/wall)

  or

- any length exceeding 2 m (unless an alternative distance if specified by local regulations) is installed within trunking or conduit that is considered as a fire barrier in accordance with local fire regulations.

  NOTE This also applies where the cable has to pass through a space between two external fire barriers within a building.

7.7.1.4 Rooms intended to contain distributors

Rooms intended to contain distributors shall be provided with access 0,9 m (min) wide and 2 m (min) high.

Rooms in which cables are routed to cabinets, frames, or racks using underfloor pathways shall be provided with raised floor with a underfloor depth of not less than 0,2 m.

NOTE The height of rooms in which cables are routed using high-level or ceiling-mounted pathway systems restricts the height of cabinets, frames, and racks that may be installed (see 7.8.1.4).

While access is required to cabinets, frames, and racks, lighting shall provide a minimum of 500 lx in the horizontal plane and 200 lx in the vertical plane, measured 1 m above the finished floor in front (and at the rear, if applicable) of the cabinets, frames and racks.

Where the rooms are intended to contain active equipment in addition to the distributors

- the temperature and humidity shall be maintained to allow continuous operation of the active equipment,
- adequate mains power shall be provided.

The location of the distributors within the room and any relevant mounting shall be capable of supporting the loads applied during the construction and operation of the distributors and associated equipment. It shall be verified that proposed loading does not exceed the loading limit of the supporting structure.

7.7.1.5 Enclosures containing distributors

Where the enclosure is intended to contain active equipment in addition to the distributor

- the temperature and humidity shall be maintained to allow continuous operation of that active equipment,
- adequate mains power shall be provided.

The location of the enclosure and any relevant mounting shall be capable of supporting the loads applied during the construction and operation of the distributor and associated equipment. It shall be verified that proposed loading does not exceed the loading limit of the supporting structure.

7.7.2 Recommendations

7.7.2.1 General

Spaces should be located centrally in the area they serve.

Positive air pressure systems (including appropriate filters) should be used to prevent ingress of dust and other contamination to the space.

Any water and drain pipes that pass through the space should be located away from and not directly above cabling or equipment.

The provision of mains, or other, power should be adequate to support the operation of the information technology equipment intended to be housed within the space.

7.7.2.2 Spaces and structures outside buildings

Maintenance holes are preferred over hand holes as they provide greater flexibility for extension and expansion of the installed cabling infrastructure, e.g. additional pathways.

Telecommunications cabinets should be provided with

- adequate physical protection (e.g. by appropriate ruggedisation or location),
- adequate security (e.g. locks).

7.7.2.3 Rooms intended to contain distributors

Floors, walls and ceiling should be selected and treated to minimise the generation of dust.

Consideration should be given to application of floor covering comprised of anti-static material.

Rooms in which cables are routed to cabinets, frames, or racks using underfloor pathways should be provided with raised floor with an underfloor depth of not less than 0,3 m.

Ceiling height should be 3 m minimum to allow the installation of

- widest range of cabinets, frames and rack heights,
- high-level or ceiling-mounted pathway systems.

To provide additional space for equipment installation and maintenance, the room dimensions should be 3 m × 3 m minimum.

To provide additional space for equipment installation and maintenance, the minimum room dimensions for distributors containing up to 500 outlets should be 3,2 m (length) × 3 m (width) (see Figure 6a).

For distributors containing more than 500 outlets, the minimum room size should be increased by 1,6 m along the line of cabinets for each additional group of up to 500 outlets to accommodate the additional space for connecting hardware, cord management and active equipment (see Figure 6b).

NOTE These recommendations are based on the use of 800 mm × 800 mm cabinets that allow for sufficient cord management for fully utilized cabinets or open racks with vertical cable management for sufficient cord management for fully utilized racks, this will also accommodate access from both front and back of the cabinets or rack to install additional cabling and equipment (see 7.8.2.3).

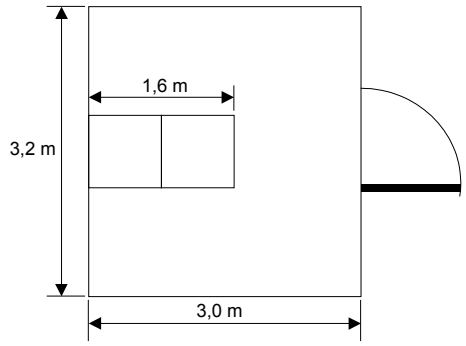


Figure 6a – Minimum room dimensions to support distributors containing up to 500 outlets

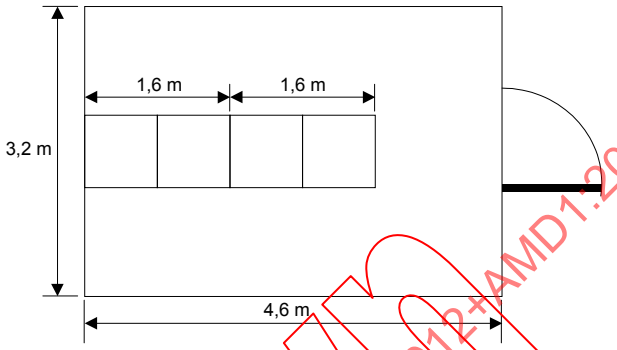


Figure 6b – Minimum room dimensions to support distributors containing between 501 and 1 000 outlets

Figure 6 – Dimensions of rooms intended to contain distributors

Building elements (e.g. doors, floors, lifts) that provide access to rooms intended to contain distributors should accommodate the probable weights and sizes of equipment to be brought to the rooms.

NOTE Equipment is often pre-assembled off site and delivered as complete cabinet/frame/rack units.

7.8 Functional elements

7.8.1 Requirements

7.8.1.1 General

Functional elements shall be located where it is possible to undertake subsequent measurements, repair, expansion or extension of the installed cabling with minimal disruption and in safety.

Where information technology cabling and mains power cabling are contained within a closure, access to mains power cabling shall be restricted according to local regulations.

NOTE If mains power cabling and information technology cabling are installed without physical barrier between the two systems, work on either cabling system may be limited to persons with appropriate qualifications designated by national or local regulation.

Information concerning functional elements shall be included in the administration system in accordance with Clause 9.

7.8.1.2 Termination points

Termination points for information technology cables shall be located and oriented in such a way as to prevent ingress of moisture or other contaminants and to reduce the risk of damage to the cables connected to them. Connecting hardware selected for information technology cabling shall not be interchangeable with the sockets or plugs used for mains power distribution.

Where termination points are presented at outlets (i.e. not within distributors)

- user-accessible outlets shall be located in fully accessible, permanent locations such as building columns, and permanent walls,
- restricted-access outlets may be installed in other places (e.g. above suspended ceilings or under raised floors),
- outlets shall be placed or protected to prevent accidental damage due to frequently moving objects such as vacuum cleaners, rolling tables and hospital beds,
- outlets shall be placed or protected to allow normal maintenance/cleaning (e.g. fluids from cleaning) of the surrounding area.

7.8.1.3 Distributors within rooms

The location of the distributor within the room shall allow for the installation of additional cabling without major disruption.

7.8.1.4 Cabinets, frames and racks

Cabinets, frames and racks (or the closures within them) shall provide the necessary levels of physical and environmental protection for the information technology cabling and equipment installed. Cabinets, frames and racks shall achieve the necessary protection by their location, design features or a combination of both. Where necessary, environment control shall be provided within the space and/or cabinets.

The location of cabinets, frames and racks shall

- be consistent with the space, floor loading and other services required for information technology equipment,
- allow the installation of the necessary cabling together with the delivery and removal of larger items of apparatus,
- provide a minimum clearance of 0,9 m on all faces where access is required.

The height of cabinets, frames and racks shall not exceed 2,4 m and shall not exceed 75 % of the room height in rooms in which cables are routed using high-level or ceiling-mounted pathway systems.

The design and dimensions of the cabinets, frames and racks, together with clearances shall ensure that

- it is possible to install the initial quantity of cables in accordance with the minimum bend radii (installation and operating). Where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- additional cables can be subsequently installed in accordance with the minimum bend radii (installation and operating). Where either multiple cable types are involved or cables have multiple bend radius specifications (e.g. so-called shotgun cables or cables with catenary cables attached), the largest minimum bend radius shall apply,
- facilities for the management of cables and cords are provided that enable horizontal and vertical management of all cords and jumpers to the maximum planned fill,
- fittings are provided for the functional and protective earthing of information technology equipment and cabling,
- adequate ventilation is provided for anticipated information technology equipment,
- cable segregation requirements of 7.9 are met.

7.8.2 Recommendations

7.8.2.1 Distributors within rooms

Distributors should be located in dedicated rooms.

Distributors should be located in accordance with the maximum lengths specified within the reference implementations of the referenced cabling design standards.

7.8.2.2 Distributors within enclosures

Distributors should be located in accordance with the maximum lengths specified within the reference implementations of the referenced cabling design standards.

7.8.2.3 Cabinets, frames and racks

Where both information technology cabling and mains power cabling are contained within a closure they should be in separate parts of the closures or under separate covers.

The location of cabinets, frames and racks should provide a minimum clearance of 1,2 m on all faces where access is required.

The vertical cable management, horizontal cable management, slack storage, and location of access floor openings should be designed to ensure that the bend radius requirements of the installed cables are met.

The height of floor-standing cabinets, frames and racks should not exceed 2,1 m and connection points within them should be located at least 0,15 m above the finished floor.

7.9 Segregation of information technology cabling and mains power cabling

7.9.1 General

This subclause specifies segregation requirements and recommendations for unscreened and screened cables in accordance with the IEC 61156 series (together with other balanced and unbalanced, including coaxial, cables) with respect to electromagnetic interference from mains power supply cabling. Where appropriate, the requirements and recommendations are specific to particular cable specifications.

The segregation requirements of 7.9.2 assume that

- the electromagnetic environment complies with the levels defined in the IEC 61000-6 series of standards for conducted and radiated disturbances (e.g. mains power cabling),
- the mains power supply is non-deformed but has high frequency content consistent with the switching and operation of connected equipment in accordance with the IEC 61000-6 series of standards,

NOTE 1 “Deformed” mains power supplies are outside the scope of this standard and may require additional engineering practices.

- the information technology cabling supports any applications listed in the referenced cabling design standards.

The segregation requirements of 7.9.2 are those required with regard to electromagnetic interference (EMI). Local regulations for safety may contain different segregation requirements. In these circumstances safety has highest priority but the more stringent requirement shall take precedence.

NOTE 2 Mains power cabling outside buildings may carry high voltages and currents which render above assumptions invalid and separation distances of many metres may be required.

The premises-specific clauses of this standard may contain modified segregation requirements. Where manufacturers' instructions require more stringent installation practices, these shall be followed.

When cabling is installed in an electromagnetic environment exceeding the levels of IEC 61000-6 the separations may need to be increased.

Specific items of electrical equipment and the power supply cabling associated with them may require additional practices resulting in segregation requirements in excess of those of 7.9.2. Examples of such items include certain types of lamps and equipment including that used in arc welding, frequency induction heating and hospitals together with radio, TV and radar transmission systems. Table 7 provides minimum recommended separation distances between metallic information technology and certain items of electrical equipment and the power supply cabling associated with them (without taking into consideration the screening effectiveness of cables or cable management systems). In all cases, analysis should be performed based on products supplier's information, where available, to determine the required segregation. Where supplier's information regarding the sources of interference does not exist, analysis should be performed regarding possible disturbances. e.g. frequency range, harmonics, transients, bursts, transmitted power, etc. Where there is a conflict between the outcome of such analysis and the requirements resulting from the analysis of 7.9.2, the most stringent requirements shall apply.

Table 7 – Separation recommendations between metallic information technology cabling and specific EMI sources

Source of disturbance	Minimum separation mm
Fluorescent lamps	130
Neon lamps	130
Mercury vapour lamps	130
High-intensity discharge lamps	130
Arc welders	800
Frequency induction heating	1 000

The environmental compatibility shall be achieved by selection of appropriate components and/or by mitigation techniques that modify the environment including,

- isolation from the defined environment (by means of protection/segregation),
- separation from the defined environment.

7.9.2 Requirements

7.9.2.1 General requirements

The requirements for separation between information technology cables and mains power cables depends upon

- the electromagnetic immunity of the information technology cable measured as
  - coupling attenuation for screened balanced cables,
  - tranverse conversion loss (TCL) for unscreened balanced cables,
  - screening attenuation for unbalanced (coaxial) and twin axial cables,

- the construction of the mains power cable,
- the quantity of, and type of electrical circuit provided by, the mains power cables,
- the presence of dividers between the information technology cables and mains power cables.

The minimum separation requirement “A” is calculated by multiplying the minimum separation “S” obtained from Table 9 by the power cabling factor “P” from Table 10. The value of “S” obtained from Table 9 depends upon the classification of the information technology cable of Table 8 as shown in Figure 7. A flow-chart approach to this calculation is shown in Figure 8.

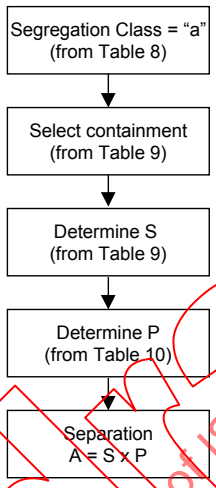


Figure 7 – Process of determining cable separation

The separation requirements for segregation Class “a” in Table 9 shall be applied if

- the mix of applications or the cabling to be installed is unrestricted,
- the type of cabling to be installed is unrestricted.

If the cable performance with regard to the relevant parameters is unknown then it shall be assumed to meet the requirements of segregation Class ”a”.

The separation requirements for segregation Class “b” in Table 9 represent the minimum requirements of this standard, where the cabling to be installed is in accordance with, and is intended to support the applications listed in, the referenced cabling design standards. Reduced separations based upon segregation Classes “c” or “d” of Table 9 may restrict the type and use of cables installed in the pathways and cable management systems selected.

Future expansion of both the mains power and information technology cabling shall be taken into account when determining the separation requirement and the selection of pathways and cable management systems to be used to provide the required separation.

Local regulations may require a barrier or greater separation than calculated using this approach.

The free space separation of Table 9 also applies

- to telecommunications cables and main power cables installed in the same containment,
- any containment that does not meet the minimum screening performance levels applicable to the open containment of Table 9.

Table 8 – Classification of information technology cables

Information technology cable			
Screened	**Unscreened**	**Coaxial/twinaxial**	
Coupling attenuation at (30 to 100) MHz dB	**TCL** at (30 to 100) MHz dB	**Screening attenuation** at (30 to 100) MHz dB	**Segregation Class**
≥80 (see Note 1)	≥70 − 10 × lg *f*	≥85 (see Note 5)	d
≥55 (see Note 2)	≥60 − 10 × lg *f*	≥55	c
≥40 (see Note 3)	≥50 − 10 × lg *f* (see Note 4)	≥40	b
<40	<50 − 10 × lg *f*	<40	a

NOTE 1 Category 5, 6, 6_A, 7 and 7_A cables meeting the Type Ia coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “d”.

NOTE 2 Category 5, 6, 6_A, 7 and 7_A cables meeting the Type II coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “c”.

NOTE 3 Category 5, 6, 6_A, 7 and 7_A cables meeting the Type III coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “b”.

NOTE 4 Category 5, 6, 6_A, 7 and 7_A cables meeting the Level 2 TCL requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class “b”. These cables may deliver performance of segregation Class “c” or “d” provided that the relevant requirements are also met.

NOTE 5 Cables in accordance with IEC 61196-7 (ISO/IEC 15018, Category BCT-C) meet segregation Class “d”.

Table 9 – Minimum separation S

Segregation Class (from Table 8)	**Free space separation (i.e. without electromagnetic barrier)** mm	**Containment applied to information technology or mains power cabling**		
		Open metallic containment (NOTE 1) mm	**Perforated metallic containment** [a] (NOTE 2) mm	**Solid metallic containment** (NOTE 3) mm
d	10	8	5	0
c	50	38	25	0
b	100	75	50	0
a	300	225	150	0

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

NOTE 1 Screening performance (DC to 100 MHz) equivalent to welded mesh steel wire mesh cable tray of mesh size 50 mm × 100 mm (excluding cable ladders). This screening performance is also achieved with a steel cable tray of less than 1,0 mm wall thickness and/or more than 20 % equally distributed perforated area.

NOTE 2 Screening performance (DC to 100 MHz) equivalent to a steel cable tray of at least 1,0 mm wall thickness and no more than 20 % equally distributed perforated area. This screening performance is also achieved with screened power cables that do not meet the performance defined in Note 3.

NOTE 3 Screening performance (DC to 100 MHz) equivalent to a steel conduit of 1,5 mm wall thickness. Specified separation is in addition to that provided by any divider/barrier.

Table 10 – Power cabling factor P

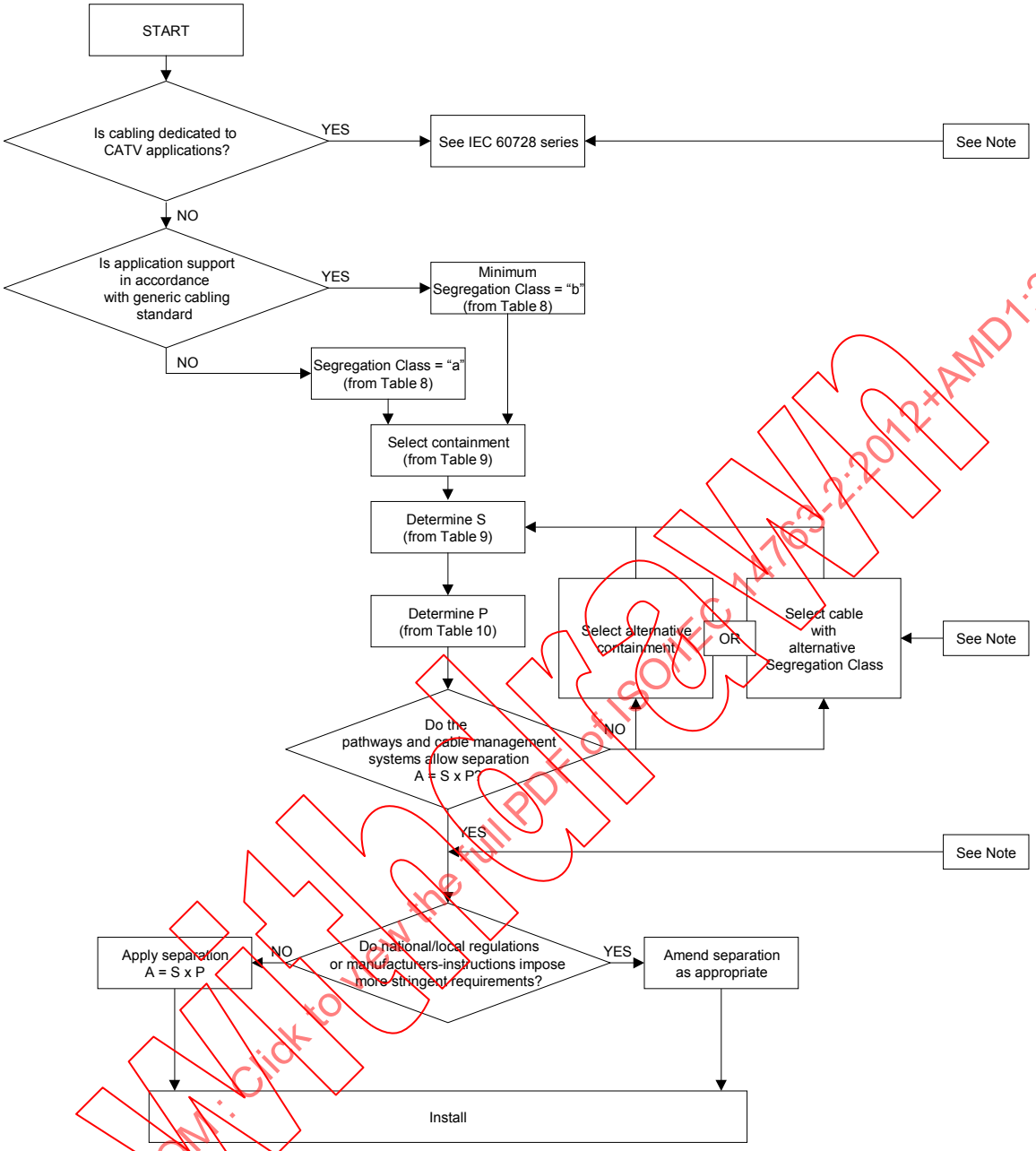
Electrical circuit type (see [a,b,c])	Quantity of circuits	Power cabling factor "P" (see [d])
20 A 230 V 1-phase	1 to 3	0,2
	4 to 6	0,4
	7 to 9	0,6
	10 to 12	0,8
	13 to 15	1,0
	16 to 30	2
	31 to 45	3
	46 to 60	4
	61 to 75	5
	>75	6

[a] The power cabling factor shall be used as a multiplier for the calculation of distance A from Table 9.

[b] 3-phase cables shall be treated as 3 off 1-phase cables.

[c] More than 20 A shall be treated as multiples of 20 A.

[d] Lower voltage AC or DC power supply cables shall be treated based upon the their current ratings, i.e. a 100 A 50 V DC cable = 5 off 20 A cables (P = 0,4).



NOTE Unless the cabling to be installed is intended to support the applications listed in the relevant generic cabling design standard: i.e. the mix of applications or the type of cabling to be installed is unrestricted, the separation requirements for Segregation Class "a" in Table 9 are applied.

Figure 8 – Flowchart for cable separation calculation

The applicable minimum separation requirement "*A*" is the minimum separation between the information technology cables and mains power cables that is allowed at any point between their respective fixing points or that is created by other restraints (physical or contractual) including barriers or dividers.

For information technology cables and mains power cables within a single pathway system, or in parallel pathway systems, without dividers

a) A is the minimum separation between the information technology cables and mains power cables including all allowances for cable movement between their fixing points (see Figure 9a),

b) where no fixing or restraint is present, A is assumed to be 0 mm (see Figure 9b).

For information technology cables and mains power cables within a single pathway system, or in parallel pathway systems, with dividers

c) for cables installed in adjacent compartments of a pathway system or another pathway that incorporates a divider, the required separation A shall be provided by the divider (see Figure 10a), unless additional cable fixing or restraint is present (see a above),

d) for cables installed in non-adjacent compartments of a pathway system or another pathway that incorporates more than one divider, required separation A shall be provided by the distance between the dividers (see Figure 10b), unless additional cable fixing or restraint is present (see a) above).

The minimum separation requirement applies in three dimensions. However, where Information technology cables and mains power cables are required to cross and required minimum separation cannot be maintained then the angle of their crossing shall be maintained at 90 ° on either side of the crossing for a distance no less than the applicable minimum separation requirement.

Where mains power cables (other than single core cables operating at voltages exceeding AC 600 V) pass through a fire barrier it is possible to reduce the separation requirements of this subclause provided that

- the total distance over which the reduction in the separation occurs is not greater than the thickness of the fire segregation barrier plus 0,5 m on either side,
- the information technology cables and mains power cables are enclosed in separate trunking or conduit,
- local regulations concerning fire barriers are complied with,
- IEC 60364-5-52 is taken into account.

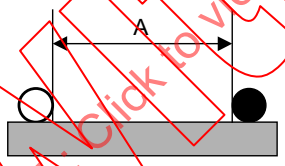


Figure 9a – Separation with restrain

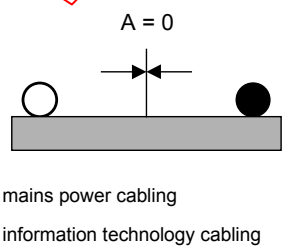


Figure 9b – Separation without restraint

Figure 9 – Separation of mains power and information technology cables without dividers

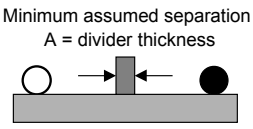


Figure 10a – Separation with single divider

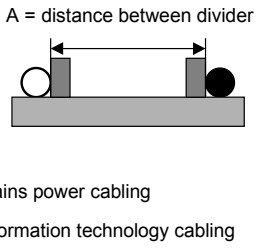


Figure 10b – Separation with multiple dividers

Figure 10 – Separation of mains power and information technology cables with dividers

7.9.2.2 Conditions for zero segregation

No segregation is required between information technology cabling and mains power cabling (other than that required by national or local regulation) provided that all the following conditions are met

- the environmental classification for the information technology cabling complies with E_1 of ISO/IEC TR 29106,
- the power conductors
- form single phase circuits,
- provide a total power of 10 kVA (maximum),

  NOTE 1 In regions using 110/120 V this corresponds to a maximum current of 80 A and in regions using 230 V this corresponds to a maximum current 32 A.

- comprising a circuit are maintained in close proximity (e.g. within an overall sheath or twisted, taped or bundled together),
- and either
- the information technology cables meet the requirements of segregation Classes “b”, “c” or “d” of Table 8

  or

- in circumstances where the cabling is application(s)-specific, then the application(s) support(s) a zero segregation relaxation.

This allowance should be not applied in spaces allocated to distributors in accordance with the referenced design standards or equivalent concentrations of transmission equipment.

In all other cases the requirements of 7.9.2.1 apply.

NOTE 2 The selection of this segregation approach and the planning of the pathway may render it unsuitable if modifications are subsequently made to the resulting electromagnetic environmental classification.

7.9.3 Recommendations

Telecommunications cabinets, frames and racks should be separated from electrical equipment, e.g. high-voltage/low-voltage (HV/LV) transformers.

7.10 Cabling – Requirements

7.10.1 General

The installation of the cabling shall be in accordance with Clause 8.

Mixing of unscreened and screened components within a channel shall only be implemented in accordance with supplier’s instructions.

Connecting hardware shall be arranged and mounted in closures in accordance with connecting hardware supplier’s instructions.

The earthing of extraneous metallic elements (e.g. armouring, strain relief members of optical fibre cables) that are part of the cable construction shall be in accordance with local and/or national regulations and the procedures used shall be documented.

7.10.2 Unscreened cabling

The cabling shall be terminated in accordance with 8.10.2.

7.10.3 Screened cabling

The cabling shall be terminated in accordance with 8.10.3.

The screen shall be continuous at and between connectors providing the connection to the application-specific equipment via a cabling channel.

7.10.4 Optical fibre cabling

Optical fibre provides electrical isolation between buildings. Extraneous metal in optical fibre cables shall be treated as detailed in 8.9.2.1.

8 Installation practices

8.1 General

Installations shall be carried out in accordance with the installation specification (see Clause 5), quality planing (see Clause 6) and the relevant planning carried out in accordance with Clause 7. The client shall be advised of all deviations and actions required.

The installation method used shall be compatible with the products used.

All installation locations shall be selected to allow for any anticipated additional installations and necessary equipment to be delivered and installed during the anticipated lifetime of the installation.

8.2 Safety

8.2.1 General

The specification of safety requirements is beyond the scope of this International Standard. Local regulations, including safety, shall be met.

8.2.2 Mains power cabling

The proper implementation of the requirements of this standard assume that electrical installations, bonding networks and protective measures against overlvoltages are undertaken in accordance with the local regulations, as appropriate.

NOTE The IEC 60364 series may contain appropriate information.

8.2.3 Functional bonding

The bonding networks within premises served by metallic cabling shall be undertaken in accordance with local regulations, as appropriate.

NOTE The IEC 60364 series may contain appropriate information.

8.2.4 Optical fibre cabling

Installations shall be carried out in accordance with IEC 60825-2 as applicable according to the relevant hazard classification of each installation location including

- exposure of optical fibre ends to the skin and eyes,
- the quantity of optical fibre waste,
- the collection and disposal of waste fragments,

- the viewing of connector end faces, prepared optical fibres or fractured optical fibres.

8.2.5 Guards and signs

All necessary guards, protective structures and warning signs shall be used to protect both the cabling components and all personnel during installation.

Relevant local regulations for safe working practices shall be complied with.

8.2.6 Enclosed spaces

It is possible for explosive, asphyxiating or toxic gases to build up in ducts, draw pits, maintenance holes or other closed chambers. Before entering any such areas, they shall be well ventilated and the atmosphere shall be tested to detect any potentially hazardous gases. Where a gas hazard is detected, the installer shall inform the nominated site contact and appropriate action shall be agreed and performed.

8.2.7 Maintenance holes

Frames and covers of maintenance holes shall be correctly seated and shall not present a safety hazard.

8.2.8 Closures

Before installing information technology cabling within closures containing mains power cabling, compliance with local regulations shall be ensured.

8.3 Environment

8.3.1 Storage

8.3.1.1 Requirements

The environmental conditions under which cabling components, inspection and test equipment are stored shall be compatible with the manufacturers'/suppliers' specifications.

Where protective caps, or equivalent, have been used to protect components, they shall not be removed until necessary and shall be replaced or renewed as necessary until the installation is completed.

8.3.1.2 Recommendations

The ends of stored cable should be sealed.

8.3.2 Installation – Requirements

The installer shall ensure that the environment local to the cabling is in accordance with the installation specification (see 5.3.5) and is compatible with the cabling components to be installed.

8.4 Component inspection and testing – Requirements

Cabling components shall be inspected for damage as soon as possible following delivery and before installation. Documentation supplied with the components shall be checked for compliance with the procurement specification and shall be retained.

If required by the quality plan, detailed component inspection and/or acceptance testing shall be undertaken as soon as practicable. Any packaging and/or seals removed to allow

inspection and/or testing shall be replaced to provide the required environmental and physical protection to the components.

8.5 Pathways

8.5.1 Requirements

It shall be confirmed that the pathways in accordance with the installation specification and the installation schedule are accessible and available.

It shall be confirmed that the proposed locations of cable deployment systems (e.g. boxes, reels, drums) and associated installation equipment in accordance with the installation schedule are accessible and available. The client shall be advised of all necessary deviations or actions required.

The accessibility and availability of proposed locations of cable service loops shall be confirmed.

The installer shall ensure that

- the pathway systems selected are able to support the mass of the cables to be installed,
- the fixings and supporting structures for the pathway systems are suitable to support the combined mass of the pathway system and the cables to be installed.

The installer shall ensure that

- all necessary installation accessories are available,
- the required identifiable techniques (see 7.6.2.1.2) are installed to allow cable to be installed and, where appropriate, fixed in accordance with the applicable minimum bend radius.

8.5.2 Inside buildings – Requirements

Where it is necessary to remove materials to access pathways (e.g. ceiling tiles, floor covers or duct covers) only the minimum shall be removed and these shall be replaced and/or reinstated as soon as practicable and in accordance with local regulations (site conditions).

In fixed installations where impact to the installed cabling can occur (specifically including all cabling within 50 mm above floor level) protection shall be afforded by one or more of the following

- the mechanical characteristics of the pathway system,
- the location selected,
- the provision of additional local or general mechanical protection.

Fire barriers and gas seals shall be opened only when necessary and reinstated as soon as practicable and in accordance with local regulations.

8.5.3 Outside buildings

8.5.3.1 Requirements

8.5.3.1.1 Overhead

Supporting structures shall be suitably treated to prevent decay.

8.5.3.1.2 Underground

Sections shall be jointed to inhibit ingress of gases, water and foreign materials.

8.5.3.2 Recommendations

8.5.3.2.1 Overhead

Attachment of catenary wires to buildings should be

- permitted only when it is clear that the load on the fixing point will not exceed its design strength and the structure of the building is capable of sustaining the load with a safety factor,
- avoided in earthquake zones.

8.5.3.2.2 Underground

All underground cable management systems should be made of a non-porous material. (see 7.6.3.3.2).

8.6 Spaces

8.6.1 Requirements

The installer shall ensure that the spaces within which the cabling and equipment are to be installed are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.7.1.1. The client shall be advised of all deviations and actions required.

8.6.2 Entrance facilities

The installer shall ensure that the facilities exist to allow the treatment of cables in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.7.1.3.

8.6.3 Rooms and enclosures intended to contain distributors

The installer shall ensure that the spaces intended to contain distributors are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.7.1.4 and 7.7.1.5.

8.6.4 Cabinets, frames and racks

The installer shall ensure that cabinets, frames and racks are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.8.1.4.

8.6.5 Closures

The installer shall ensure that closures are in accordance with the installation specification (see Clause 5).

8.6.6 Outlets

The installer shall ensure that outlets are in accordance with the installation specification (see Clause 5) and also meet the requirements of 7.8.1.2.

8.7 Pathway system installation

8.7.1 General

8.7.1.1 Requirements

Pathway systems shall be installed

- in accordance with instructions provided by the manufacturer(s)/supplier(s) of the cable management systems,
- to achieve the planned electromagnetic performance in relation to the installed cabling,
- to allow installation of cable without damage to the cable,
- without sharp edges or corners that could damage the cabling installed within or upon them,
- to enable the creation of fire barriers in accordance with local regulations,
- taking into account relevant external/environmental influences – in particular
- cable management systems shall be installed to ensure that water or other contaminant liquids cannot collect,
- where required, sections of cable management systems shall be jointed to prevent ingress of gases, liquids, etc.

Pathway systems shall be left clean and free from obstruction with all separators and bridging pieces in place before the cabling installation commences.

Until the installation work is finished the pathway system shall be protected from contamination (e.g. dust, water and construction parts).

Pulling wheels or other temporary structures (to assist cabling installation) shall be fitted where necessary.

8.7.1.2 Recommendations

Where applicable, pathway systems should be installed to allow removal of the cable without damage to any remaining cables.

8.7.2 Inside buildings

8.7.2.1 Requirements

Pathway systems shall be sealed at the point of entry to buildings to prevent ingress of water.

8.7.2.2 Recommendations

Cable management systems should be installed in such a way that the transfer of acoustic noise is minimized.

8.7.3 Outside buildings

8.7.3.1 Requirements

Existing catenary wires shall be checked for satisfactory function and, where necessary, catenary wires shall be replaced.

8.7.3.2 Recommendations

Marking tapes should be laid above underground pathway systems.

8.8 Closure installation

Closures shall be fixed or mounted in position using the recommended fittings and labelled and identified according to the installation specification (see 9.2).

Closures containing optical fibre terminations or joints shall be labelled in accordance with IEC 60825-2 as appropriate to the hazard classification of the location (see 5.3.3 and 7.2.3). Optical fibre adaptors shall be fixed or fitted with suitable protective caps to prevent the ingress of foreign material.

8.9 Cable installation

8.9.1 Cable installation within pathway systems

8.9.2 General

8.9.2.1 Requirements

Installation of cables shall be in accordance with the instructions supplied by the manufacturers/suppliers of the cables and the pathway systems.

Cabling components shall be conditioned at the recommended environmental condition before installation.

Cables shall not be exposed to humidity levels or temperatures outside the limits detailed in the manufacturers'/suppliers' specifications; this includes localised effects such as those from hot air blowers, gas burners and sprinklers.

The installation process shall not degrade the intended environmental performance of the pathway/cable management system. Where there is an identified risk of ingress of water or contaminants to a cable during installation, the cable ends shall be sealed.

Metallic information technology cabling and mains power cabling shall be segregated in accordance with the requirements of 7.9.

When installing cables appropriate techniques shall be applied to

a) eliminate cable stress caused by
– tension in suspended cable runs,
– tightly cinched cable bundles,
b) ensure that minimum bend radii are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,
c) ensure that the tensile load applied to the cables and cable bundles are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,

NOTE Unless otherwise stated in the suppliers/manufacturers specification, the maximum tensile load applied to a bundle is that specified for a single cable.

d) protect cables from damage during installation (e.g. stepping on cables or hanging bundles with insufficient support),
e) prevent pressure marks (e.g. through improper fastening or crossovers) on the cable sheath or the cable elements,
f) prevent optical fibre within cables experiencing direct stress following installation (where long vertical runs are proposed optical fibre cables may need to deviate from the vertical by the inclusion of short horizontal runs or loops at intervals as recommended by the manufacturer),

g) avoid joints other than those in accordance with the installation specification.

Labels, or equivalent, shall be applied to cable elements where they are not otherwise identified (see 9.2).

Precautions shall be taken during the installation of draw ropes, where used, to prevent the draw ropes becoming entangled with cables.

Where cable is to be installed in shared pathways precautions shall be taken to avoid damage to existing cables or structures within those routes.

The earthing of extraneous metallic elements (e.g. armouring, strain relief members of optical fibre cables) that are part of the information technology cable construction shall be in accordance with local regulations. The procedures used shall be documented.

8.9.2.2 Recommendations

Labels, or equivalent, should be applied to the ends of cables where multiple cables are installed to a closure and where they are not otherwise identified (see 9.2).

8.9.3 Inside buildings

8.9.3.1 Requirements

Following cable installation, pathway systems shall be sealed at the point of entry to buildings to prevent ingress of water.

Information technology cables that do not comply with the minimum recommended performance requirements of IEC 60332-1-2 shall be installed according to the instructions of the planner (see 7.7.1.3).

Measures shall be taken to prevent any liquids and/or gels present within the information technology cable from leaking in pathways.

The position of information technology cables and the location of closures in cable management systems shall be in accordance with the instructions provided by the manufacturers/suppliers of the cable management systems (subject to meeting the segregation requirements of 7.9). When installing cables into cable management systems they shall be secured as specified in the installation specification.

The final placement of cables and cable bundles shall take into account the risk of damage due to external influences.

8.9.3.2 Recommendations

The size of cable bundles should be restricted to a maximum of 24 4-pair balanced cables.

8.9.4 Cable installation in maintenance holes

The following practices shall be applied

- cables shall be installed in lowest conduits first,
- cables shall not be inter-twined,
- support shall be provided to cables to prevent them lying on the floor,
- no excess cable lengths (other than specifically designated in the installation specification) shall remain,

- sufficient floor area shall be maintained to allow work to be undertaken.

Following the installation of cables within maintenance holes

- floors shall be free of debris,
- sump covers shall be removed,
- maintenance hole frames shall be secured,
- access key-holes shall be checked for wear and appropriate action taken,
- maintenance hole covers shall be seated correctly.

8.9.5 Cable installation within closures – Requirements

Cables entering closures shall use appropriate openings, glands and/or fittings to

a) maintain the environmental performance of the closure,
b) provide the necessary cable support and ensure minimum bend radii are as specified by the cable manufacturer, supplier or in accordance with the relevant product standard,
c) provide strain relief for the cable if not already provided by separate fixtures within the closure.

Measures shall be taken to prevent any liquids and/or gels present within the information technology cable from leaking in closures.

A sufficient length of cable shall be provided at each closure to enable

- subsequent access to the closure for terminating, jointing and repairing of the cable (this can also be achieved by the use of service loops in appropriate places),
- cable tests to be undertaken, where required by the quality plan, prior to terminating or jointing of the cable.

Any cabling not contained within a cable management system shall be protected from physical damage by use of appropriate measures. Where the cable elements comprise primary coated optical fibre, sleeves shall be applied to protect the optical fibre from damage within the closure.

Within closures, each cable element shall be uniquely identifiable using one or more of the following methods

- colour coding,
- labelling,
- physical position or routing.

If required by the quality plan, installed cable tests shall be undertaken as soon as practicable following cable installation.

8.10 Jointing and terminating of cables

8.10.1 Requirements

Cables shall be jointed or terminated in accordance with the instructions provided by the manufacturer/supplier of the connecting hardware. If special tools are required for jointing or terminating, then only those recommended by the connecting hardware manufacturer shall be used.

Measures shall be taken to prevent any liquids and/or gels present within the information technology cable from leaking at any termination point.

During and after the jointing and terminating process, the minimum bend radii of cable elements shall be as specified by the cable manufacturer, supplier or in accordance with the relevant product standard.

Following jointing or terminating, the cable elements shall be arranged within the closure in a manner that allows access to individual connectors, joints and cable elements with minimal disruption to neighbouring components during subsequent repair, expansion or extension of the installed cabling.

Cable elements not terminated within connecting hardware shall be treated as detailed in the installation specification.

The presentation of cable elements within joints, terminating connecting hardware and closures shall be in accordance with the installation specification.

8.10.2 Balanced cabling

Balanced cables shall be terminated in accordance with the connecting hardware manufacturer's instructions to maintain the intended performance of connecting hardware.

Where no connecting hardware manufacturer's instructions exist, the connecting hardware used for balanced cabling shall be installed to provide minimal signal impairment by preserving wire pair twists and conductor separation as closely as possible to the point of mechanical termination (by not changing the original twist). In addition, only a minimum of the cable sheath shall be removed.

Care shall be taken to ensure that the removal of the cable sheath does not damage the internal cable construction.

8.10.3 Screened balanced cabling

Cable screens shall be terminated at each termination point. Balanced cabling screens shall be terminated in accordance with the connecting hardware manufacturer's instructions to maintain the intended performance of the cable screen termination to the connecting hardware.

Where instructions for termination of cables are not available from the manufacturer/supplier of the connecting hardware, the conductive surface of the cable screen shall be terminated to conductive surface of the connector screen.

8.10.4 Optical fibre cabling

Joints (fusion or mechanical splices) and their strain relief mechanisms shall be fixed and supported within the optical fibre management system of the closure.

If required by the quality plan, optical fibre connector end faces shall be inspected in accordance with ISO/IEC 14763-3.

Identification (by labelling or other means) of optical fibres within closures shall be such that the polarisation of optical fibre connections of more than one optical fibre is known and consistent throughout the installation in accordance with Annex A.

8.11 Cords and jumpers

See Clause 12 for requirements for cord and jumpers installed during the installation process.

8.12 Surge protective devices

Where installed, the earth connection of surge protection devices shall be functionally bonded to both the equipment earth connection and that of the main earthing terminal.

8.13 Acceptance

8.13.1 Inspection

If required by the quality plan, acceptance inspection shall be undertaken as soon as practicable following the

- final assembly of the closure into the desired location,
- labelling in accordance with the installation specification.

8.13.2 Testing

If required by the quality plan, acceptance testing shall be undertaken as soon as practicable following the

- final assembly of the closure into the desired location,
- labelling in accordance with the installation specification.

The testing process shall verify the accuracy of the labelling applied.

9 Documentation and administration

9.1 Symbols and preparation of documents

9.1.1 Requirements

Symbols used in specific documentation shall be compiled (including their description) and shall be provided either on each drawing or on a separate sheet. Symbols used for cabling administration shall be different from those used for the documentation of other building services (such as heating, ventilation and air conditioning).

9.1.2 Recommendations

Documentation of the cabling administration should be based upon the principles of IEC 61082-1.

Symbols to be used for records should be in accordance with the IEC 60617 series.

9.2 Administration

9.2.1 General

This standard addresses the administration of telecommunications infrastructure by

a) specifying elements of information that make up records for each component,
b) specifying the type of database or system to manage the records,
c) assigning identifiers to components of the infrastructure,
d) specifying how components shall be labelled,
e) specifying reports presenting information on groups of records,
f) specifying graphical and symbolic requirements.

The administration system specified by this standard enables management of the following components

a) telecommunications cables,
b) telecommunications terminations, joints and closures containing them,
c) telecommunications pathways and pathway systems,
d) telecommunications spaces including cabinets, frames and racks,
e) telecommunications bonds to earthing networks.

The administration system enables the components of the cabling system to be identified in terms of their type, location, usage and other criteria.

9.2.2 Administration system

9.2.2.1 General

An administration system shall be specified to enable effective operation, maintenance and repair of the cabling infrastructure. All information produced for or by the administration system shall be dated. Change control shall be exercised and records shall be retained for a specified minimum period. Service management shall conform to ISO/IEC 20000-1.

The minimum requirements of an administration system (see 9.2.2.4) are defined based upon the installation complexity level (see 9.2.2.2 and operational complexity level (see 9.2.2.3) of the infrastructure.

9.2.2.2 Installation complexity

The installation complexity level is based upon the type of premises and quantity of cable elements in the fixed cables comprising the installation and should be determined by reference to Table 11. The levels shown are based upon implementations of generic cabling in accordance with the referenced cabling design documents. Other implementations of fixed cabling may require other levels to be applied.

Where areas may have multiple functions (e.g. homes that can be converted to office premises) the more demanding level should apply.

Table 11 – Level of installation complexity

No. of fixed cable elements [a]	2 to 200	201 to 20 000	>20 000
Office	Level 2	Level 2	Level 3
Industrial	Level 3	Level 3	Level 3
Homes	Level 1	Level 1	Level 1
Multi-tenant residential premises	Level 2	Level 2	Level 3
Data centres	Level 2	Level 2	Level 3

[a] This is the number of fixed cables multiplied by the number of cable elements per cable. It is the total for all cables (coaxial, balanced pair and optical fibre).

9.2.2.3 Operational complexity

The operational complexity level is based upon the type of premises and quantity of administered ports and should be determined by reference to Table 12. The number of administered ports is defined as the number of user-accessible equipment interfaces including those on the connected equipment.

Table 12 – Level of operational complexity

No. of administered ports	2 to 100	101 to 5 000	>5 000
Office	Level 1	Level 2	Level 3
Industrial	Level 1	Level 2	Level 3
Homes	Level 1	Level 1	Level 1
Multi-tenant residential premises	Level 1	Level 2	Level 3
Data centres	Level 2	Level 3	Level 3

9.2.2.4 Administration system

9.2.2.4.1 Requirements

The administration system shall meet the requirements of

- Table 13 based upon the installation complexity Level determined from Table 11
- Table 14 based upon the operational complexity Level of Table 12.

Table 13 – Minimum requirements of administration systems

	Administration system		
IDENTIFIERS			
Infrastructure complexity Level	1	2	3
Bonds – functional earth	-	-	Yes
Cabinets/frames	Yes	Yes	Yes
Cables	Yes	Yes	Yes
Closures	-	Yes	Yes
Pathways	-	-	Yes
Spaces	-	Yes	Yes
Termination points including joints	Yes	Yes	Yes
LABELS (fixed to the item or are part of the item)			
Infrastructure complexity Level	1	2	3
Bonds – functional earth (see Note 1)	-	-	-
Cabinets/frames	Yes	Yes	Yes
Cables (see Note 2)	-		Yes
Closures (unless indicated by visible termination point labelling)	-	Yes	Yes
Pathways	-	-	Yes
Spaces (at entrances)	-	Yes	Yes
Termination points including joints (see Note 3)	Yes	Yes	Yes
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Infrastructure complexity Level	1	2	3
Fixed cabling (see Note 4)	Manual	Manual	Electronic

NOTE 1 National or local regulation may require labels to identify their function.

NOTE 2 Labels at both ends.

NOTE 3 Indicating the treatment of cable elements at the joint.

NOTE 4 Manual records include paper-based systems. Electronic records include spreadsheets, databases, etc.

The additional features provided by "Enhanced" administration systems in Table 14 may be required by local regulations regarding security of information technology service delivery.

The administration level shall be specified in the technical specification (see 5.3).

Table 14 – Minimum requirements of operational administration systems

	Administration system			
IDENTIFIERS				
Operational complexity Level	1	2	3	Enhanced
Cords/jumpers	-	-	Yes	Yes
LABELS (fixed to the item or are part of the item)				
Operational complexity Level	1	2	3	Enhanced
Cords/jumpers (see Note 1)	-	-	Yes	Yes
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it				
Operational complexity level	1	2	3	Enhanced
Cord connections (see Notes 2 and 3)	None	Manual	Electronic	Automated
Service delivery (see Note 3)	None	None	None	Automated

NOTE 1 Labels or other means to identify both ends of a cord

NOTE 2 Manual records include paper-based systems. Electronic records include spreadsheets, databases, etc.

NOTE 3 Automated records include the data from automated infrastructure management (AIM) systems that detect connection/disconnection of cords and the presence of discoverable equipment connected to the network. Requirements and recommendations for specifying and operating AIM systems are provided in Annex H.

9.2.2.4.2 Recommendations

Additional labelling should be considered in locations where separation of cabling components during maintenance or repair could result in identification problems during their re-instatement.

9.2.3 Identifiers – Requirements

The elements of the telecommunications infrastructure that are required, by the specified administration level, to be subject to an identifier scheme shall each have an identifier that

- is unique within the administration system,
- explicitly defines the element to which it refers (e.g. closure, cable, outlet etc).

The identifier scheme shall conform to the requirements of ISO/IEC TR 14763-2-1 unless the installation specification requires an alternative scheme that also meets the above requirements.

The identifier serves as the key to finding the record of additional information related to that element.

9.2.4 Component labelling

9.2.4.1 Requirements

Label(s) shall provide a direct link to the identifier within the record within the administration system.

Labels shall be durably affixed. Labels shall be resistant to the environmental conditions at the point of installation (such as moisture, heat, or ultraviolet light), and shall have a design life equal to or greater than that of the labelled component.

Non-machine readable labels shall

- feature permanent and readable text (by use of appropriate size, colour, and contrast),
- be printed, machine-generated or manufactured as part of the component.

Machine readable labels shall

- use permanent media,
- be printed, machine-generated or manufactured as part of the component,
- be located so that each machine readable label can be read uniquely.

Labels shall be located where they can be read without risk of “material” degradation of the transmission performance of the cabling. Additional labels may be applied for convenience of cabling maintenance.

Table 15 contains requirements for labelling the infrastructure elements that are required, by the specified administration level, to be labelled.

Table 15 – Labelling requirements

Element	Requirements for labelling	Specific requirements for labels
Telecommunications spaces	• at the exterior of all entrances either on or adjacent to the doors.	• containing space identifier.
Cabinets, frames, racks	• at the top of the front surface with its identifier; • at the top of the rear surface of the cabinet, rack, or frame if the rear of the cabinet, rack or frame is not in direct contact with a wall.	• containing cabinets/frame/rack identifier.
Cabinet frame, rack row	• at both ends of a row.	• containing row identifier.
Patch panels and blocks	• on an exterior surface	• containing patch panel or block identifier.
Cables	• on both ends, conspicuously displayed just prior to the cable being routed into the termination device; • on each side of any intermediate termination points – such as splices, consolidation points, and local distribution points.	• containing cable identifier.
TOs in accordance with ISO/IEC 11801	• on the exterior surface of the TO closure.	• containing TO identifier.

Protective earthing bonds	• in accordance with local and national regulations • unless otherwise specified by local and national regulations: • on both ends of the bonding conductor conspicuously displayed just prior to each cable being routed into the termination.	
Functional earthing bonds	• on both ends of the bonding conductor conspicuously displayed just prior to each cable being routed into the termination.	

9.2.4.2 Recommendations

9.2.4.2.1 Labelling

Table 16 contains recommendations, in addition to the requirements detailed in Table 15 for labelling the infrastructure elements.

Table 16 – Labelling recommendations (additional)

Element	Recommendations for labelling	Specific recommendations for labels
Telecommunications spaces	at the interior of all entrances either on or adjacent to the doors.	containing space identifier.
Cabinets, frames, racks	on the bottom front and rear surfaces, as the labels at the top may not be visible – particularly on “two post” racks and frames.	
Patch panels and blocks		provided that space is available; with the identifier of the ports/termination points; with the identifier of any distributors to which the cables are routed; with the identifier for the remote ports.
Pathways	at both ends	with their identifiers.
Main earthing terminals and local common bonding network access		with their identifiers.
Cords and jumpers (Figure 11 provides an example of cord and jumper labelling)	two labels on each end to identify the equipment, patch panels, or blocks at both ends of the cable; a third label at each end indicating additional information regarding function of the connection that may be useful when tracing a connection that is routed through multiple patch panels and would be the same on both ends of the cord.	the label closest to each connector should identify the equipment or patch panel to which that cord is attached. the next label toward the far end of the cord identifies the equipment, patch panel, or block at the other end of the cord. the third label may include server name, business partner name, remote office name, circuit number, or name of equipment at each end of the channel.

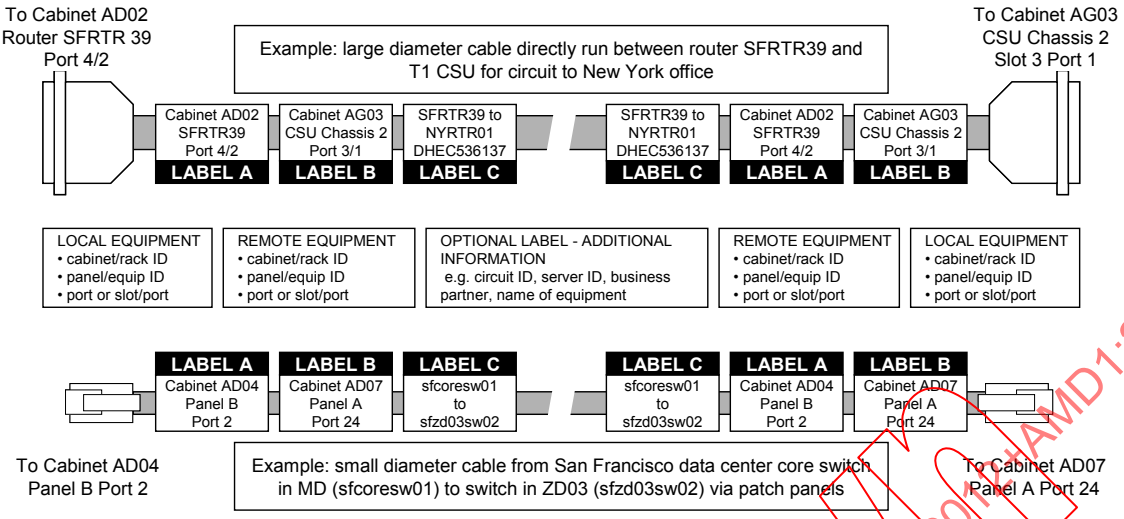


Figure 11 – Examples of cord and jumper labelling

9.2.4.2.2 Colour coding

Colour coding of labels, cables, cords, and termination fields may be used to differentiate between different levels of the cabling system topology, to differentiate between different distributors, or to differentiate between services. To be of most value, such colour-coding should be consistent throughout the system.

9.2.5 Records

9.2.5.1 General

Each component that is uniquely identified in the cabling administration system shall have its own record(s). Records shall be updated whenever changes are made to cabling infrastructure.

Change control shall be exercised and records shall be retained for a specified minimum period.

9.2.5.2 Requirements

Records for each infrastructure element shall include the items listed as “requirements” in Table 17, Table 18, Table 19 and Table 20.

9.2.5.3 Recommendations

Records for each infrastructure element should include the items listed as “recommended” in Table 17, Table 18, Table 19 and Table 20.

9.2.5.4 Optional

Records for each infrastructure element may include, amongst others, the items listed as “optional” in Table 17, Table 18, Table 19 and Table 20.

9.2.5.5 Other recommended documentation

The following additional documentation should be maintained

- floor plans of buildings and campus showing telecommunications spaces and pathways,

- floor plans of telecommunications spaces,
- elevations of cabinets, racks, frames, and walls on which telecommunications hardware is mounted,
- design drawings of building common bonding networks,
- results of link and channel measurements,
- telecommunications cabling system bid documents and change orders,
- telecommunications cabling system warranties,
- work orders.

Table 17 – Infrastructure records for spaces, cabinets, racks, frames and closures

Element	Requirements	Recommendations	Optional
Telecommunication spaces	• space identifier; • location (for example, room number); • type or function of space; • key or access card identification; • contact person; • hours of access; • date of last record update.	• linkage to floor plan drawing indicating location of space in building – for example, active link to drawing or file name of drawing; • linkage to floor plan of telecommunications space – for example, active link to drawing or file name of drawing; • available and utilized power; • cooling capacity.	• cabinets, frames, racks and wall segments located in the space; • telephone number of telephones located in the space; • identifier of local common bonding network access; • location of local common bonding network access; • equipment located in the space.
Cabinet, rack, frame, and wall segment	• cabinet, rack, frame, or wall segment identifier; • identifier of space where cabinet, rack, frame, or wall segment is located; • date of last record update.	• total rack mounting space in rack units; • used rack mounting space in rack units; • available rack mounting space in rack units; • dimensions of space on wall segment for mounting of telecommunications hardware; • used space on wall segment; • available space on wall segment; • manufacturer and part number; • location of earthing or identifier of bonding conductor.	• linkage to cabinet, rack, frame, or wall elevation drawing – for example, active link to drawing or file name of drawing; • equipment located in cabinet, rack, frame, or wall segment; • manufacturers and part numbers of cable management hardware installed on rack, frame, cabinet, or wall segment.

Patch panel and block records	• patch panel or block identifier; • identifier of cabinet, rack, frame, or wall where patch panel or block is located; • location of patch panel or block in cabinet, rack, frame, or wall; • performance category of patch panel or block; • type of ports or connectors; • number of ports or connectors; • unterminated ports or connectors; • ports or connectors with failures; • date of last record update.	• manufacturer and part number of patch panel or block; • location of earthing or identifier of bonding conductor.	• manufacturer of fixed connectors or optical fibre connector adapters (if different from patch panel manufacturer); • size of patch panel or block.

Table 18 – Infrastructure records for cables and termination points

Element	Requirements	Recommendations	Optional
Cables	• cable identifier; • cable performance category; • type of terminations or connectors on each end of the cable; • number of terminations or connections (e.g. optical fibres, optical fibre pairs, copper pairs, or 4-pair ports; • identifiers of patch panels, telecommunications outlets, equipment outlets, and terminations on each end of the cable (for example, patch panels or telecommunications outlet and ports); • unterminated conductors or optical fibres; • conductors or optical fibres with failures; • date of last record update.	• cable length; • identifier of spaces or cabinets, frames, racks or walls at each end of the cable (not required as termination identifier should identify the location of the terminations); • manufacturer and part number; • identifiers of pathways in which the cable is installed.	• cable sheath colour; • location of earthing or identifier of bonding conductor; • treatment of shields/screens; • cable test data.
Termination points (including patch panel ports, telecommunications outlets, equipment outlets, or termination points on blocks)	• termination point, port, telecommunications outlet, or equipment outlet identifier; • patch panel or block; • type of ports/connectors; • performance category; • identifier of cable terminated on termination point; • strand, pair, or port of cable terminated on termination point;	• name of patch cord or jumper connected to termination point; • name and port of device connected to termination point; • manufacturer and part number.	• port colour or icon.

	• identifier of termination point at the other end of the cable terminated on the port; • status – for example: • bad (failure); • no cable (no cable terminated on port or connector); • open (no patch cord or jumper); • connected (patch cord or jumper connected to termination point); • date of last record update.		

Table 19 – Infrastructure records

Element	Requirements	Recommendations	Optional
Cords and jumpers		• cord, or jumper identifier; • cord or jumper performance category; • type of termination or connector on each end; • identifiers of termination point at each end of the cord, or jumper (for example, patch panel and port, block and port, telecom outlet and port, device and port); • carrier, local access provider, and circuit identifiers for wide area circuits; • date of last record update.	• manufacturer and part number; • length; • cable sheath colour
Active devices		• identifier of the device; • identifier of room, rack, cabinet, frame, or wall; • location in room, rack, cabinet, frame, or wall; • manufacturer and model number; • type or function of device; • number of slots; • type of module or card in each slot; • number and type of ports in each module or card; • name of owner, user, department, or company; • serial number; • date of last record update.	• connector types for each port; • contact information for device owner, user, department, or company; • power requirements; • assigned power receptacles; • serial numbers (as appropriate); • IP address and hostname (if applicable); • location of earthing or identifier of bonding conductor.
Earthing bonds		• identifier of earthing bond; • identifier of components connected at ends of bonding conductor; • identifier of bonding conductors that tap bonding conductor; • size of bonding conductor; • type and location of each termination and tap; • date of last record update.	• manufacturer and part number of bonding conductor; • length; • cable sheath colour.

Table 20 – Infrastructure records for pathways and premises

Element	Requirements	Recommendations	Optional
Pathways		• identifier of the pathway; • identifier of the spaces at either end of the pathway; • location and routing of pathway; • linkage to floor plan drawing indicating location of pathway building – for example, active link to drawing or file name of drawing; • type of pathway including type of material (metal, plastic, etc.); • dimensions of pathway; • branching points; • cables installed in pathway; • date of last record update.	• manufacturer and part number; • location of earthing or identifier of bonding conductor.
Buildings		• identifier of building used in cabling administration system; • address; • list of all telecommunications spaces; • contact information for access; • access hours.	•
Site or campus		• identifier of site or campus used in cabling administration system; • name of campus or site commonly used within the organization; • address; • linkage to campus or site plan drawing providing locations of buildings and routing of pathways between buildings – for example, active link to drawing or file name of drawing; • contact information for local administrator of infrastructure; • list of buildings at the site or campus; • location of main cross-connect, if applicable; • access hours.	•

9.2.6 Cable administration system

9.2.6.1 General

The minimum requirements for the management of records are defined in Tables 13 and 14.

A computer-based administration system may use a database of records to maintain up-to-date information relating to the cabling. It enables the user to keep control of moves, additions and changes to the cabling and to generate reports on the state of the cabling system.

Records regarding components of cabling, pathways and spaces may be linked to each other using their identifiers and may make reference to further premises records on power, heating, air conditioning systems, lighting, etc.

Figure 12 gives an overview of database records and examples of possible linkages.

Linkages support the retrieval of information about the telecommunications infrastructure from administration records. Each required record type defines a primary indexing identifier to facilitate linkage between infrastructure identifiers and records.

The basic administration database information flow is illustrated by Figure 13.

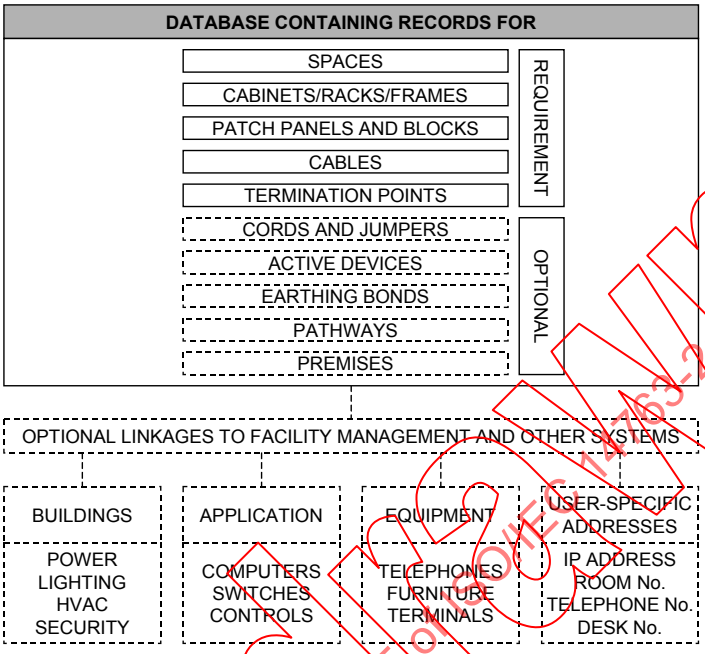


Figure 12 – Cable administration database and possible linkages

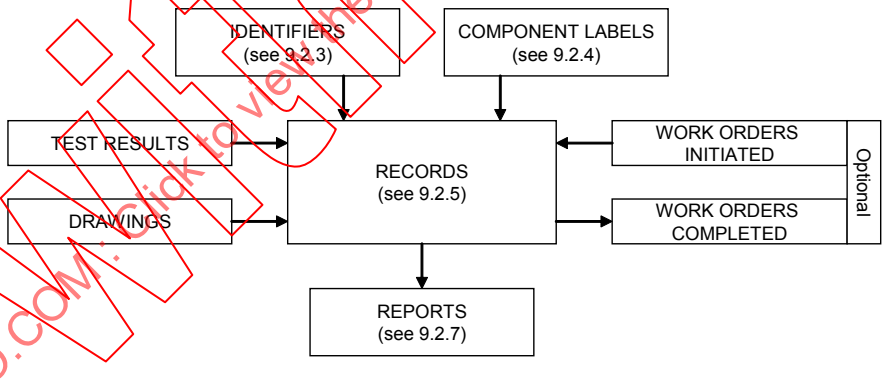


Figure 13 – Basic cabling administration

9.2.6.2 Requirements

When administration is performed with special-purpose cable management software, linkages shall be provided between each appearance of an infrastructure identifier in a record and any record for which that identifier is the primary indexing identifier.

9.2.6.3 Recommendations

The records of the administration system should meet the recommendations of

- Table 21 based upon the installation complexity Level determined from Table 11,
- Table 22 based upon the operational complexity Level of Table 12.

Table 21 – Recommendations of installation administration systems

	Administration system		
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Infrastructure complexity Level	1	2	3
Fixed cabling (see Note)	Manual	Electronic	Electronic
NOTE Manual records include paper-based systems. Electronic records include spreadsheets, databases, etc.			

Table 22 – Recommendations of operational administration systems

	Administration system		
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Operational complexity level	1	2	3
Cord connections (see Note)	None	Electronic	Automated
Service delivery (see Note)	None	None	Automated
NOTE Manual records include paper-based systems. Electronic records include spreadsheets, databases etc. Automated records include the data from AIM systems that detect connection/disconnection of cords and the presence of discoverable equipment connected to the network. Requirements and recommendations for specifying and operating AIM systems are provided in Annex H.			

It is recommended that the principles of administration outlined in this standard be implemented using a computer based administration system. The complexity of the administration system may be related to the size of the telecommunications infrastructure. For a small system, a customised commercial database or spreadsheet programme may be adequate. For a large organisation, the cabling administration system may require a sophisticated database, an efficient data retrieval program and additional features. For example, the computer administration package may input drawings directly from CAD programs or may output reports to external packages or e-mail work orders and automatically update records on completion of work and may also serve as a cabling design tool.

When administration is performed using spreadsheets or paper-based systems, records should be designed and organised to facilitate information retrieval based on primary indexing identifiers. This provides functionality similar to software linkages. Indexes relating record locations to primary identifiers may also be beneficial.

Drawings should be available showing all identified elements of infrastructure. Refer to 9.1 for further information.

Optional or user-defined record types should also define a primary indexing identifier. Linkages to additional records in which the identifier appears are also desirable.

9.2.7 Reports

9.2.7.1 Requirements

Reports are the means by which information about a telecommunications infrastructure is communicated.

Administration systems using special purpose cable management software shall make available to the telecommunications infrastructure operator reports listing all records containing a selected identifier and all information in those records, any desired subset of those records and the recorded information, or any desired union of such information.

9.2.7.2 Recommendations

Paper-based or spreadsheet-based administration systems may require additional record-keeping to provide adequate reporting capabilities. For example, a drawing or graphical representation of the infrastructure would allow the operator to easily locate all telecommunications outlets in a given work area, even if they are connected to links originating from multiple telecommunications spaces.

Reports are generated from information in the data base. Reports may take the form of lists, tables, diagram, forms, etc. Reports may be used for status determination, trouble shooting and may help for planning purposes.

10 Testing

10.1 General

10.1.1 Links and permanent links

As shown in Figure 14 and according to the design standards supported by this standard, a permanent link comprises either

- a single length of fixed cable terminated at both ends or
- a separately defined link comprising a single length of fixed cable (e.g. CP link of ISO/IEC 11801, LDP link of ISO/IEC 24764) connected to a non-fixed cable (e.g. CP cable of ISO/IEC 11801, LDP cable of ISO/IEC 24764).

Tests applied to links are generally used to verify the initial performance of the link.

Where a permanent link contains a non-fixed cable any test result is only applicable to the specific configuration under test.

Although each end of a link features a test interface, definitions of link performance include the connection at these points.

The accuracy of the test system is defined at its reference plane. The reference plane of a link is within the test cord cable next to, and including, the test cord connector which mates to the interface of the link under test. The reference planes for links are defined according to Figure 15.

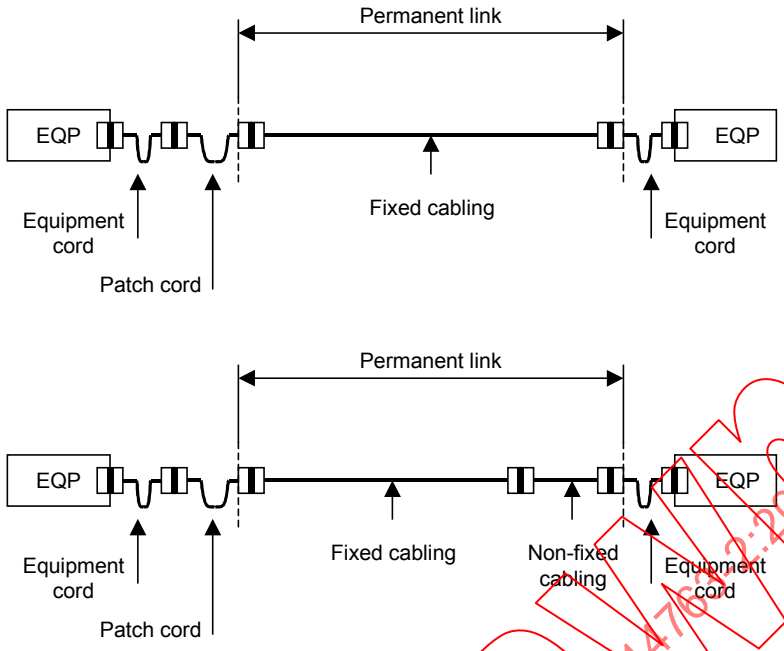


Figure 14 – Examples of cabling permanent links

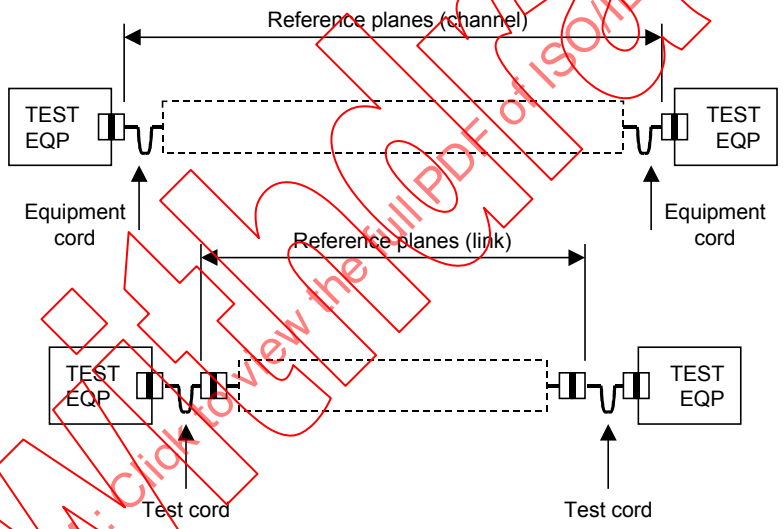


Figure 15 – Reference planes for link and channels (point-to-point)

10.1.2 Channels

A channel contains one or more permanent links interconnected by jumpers and cords (see Figure 3 of ISO/IEC 11801:2002). Although the equipment cords are terminated at both ends, definitions of channel performance exclude the connection at the transmission/terminal equipment.

The approach adopted by the installation specification defines the characteristics (length, transmission performance, etc.) of cords to be attached to permanent links and that are necessary to provide the required channel performance.

Testing of channels is not generally applied where such cords are attached to a permanent link of a given Class to provide a channel of the same Class.

However, channel tests for balanced cabling may be used to determine performance where required by the installation specification, see 6.2.1.3.

Tests may also be applied to channels for application trouble-shooting.

Where channel tests are carried out, the actual cords used to create the channel shall be used and installed in the as-built configuration.

Although each end of a channel features a test interface, definitions of channel performance exclude the connection at these points.

The accuracy of the test system is defined at its reference plane. The reference plane of a channel is within the equipment cable next to, but excluding, the equipment cord connector into the test equipment. The reference planes for channels are defined according to Figure 16.

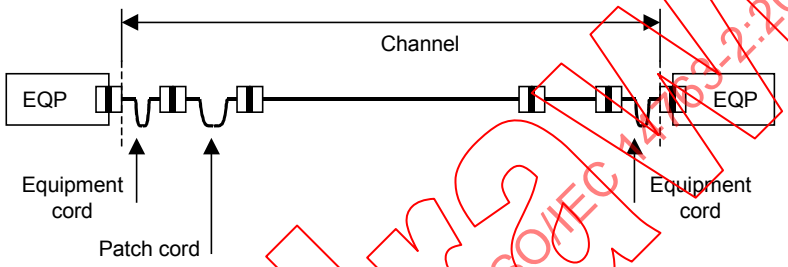


Figure 16 – Example of a cabling channel

10.1.3 Cabling interface adaptors

The design of test equipment and/or the requirements of a test procedure may necessitate the use of cabling interface adaptors (e.g. test cords or fixtures).

A maximum operational lifetime shall be defined for the cabling interface adaptors.

This may be expressed as a time period or a maximum number of mating cycles to the test equipment and/or cabling under test. Alternatively, if the test equipment offers a “self-test” process, including artefacts, to assess the condition of the adapters, such processes shall be applied.

Where no information exists as to the maximum operational lifetime of a particular cabling interface adaptor, it shall be replaced with products known to meet the required performance.

For optical fibre cabling, temporary index matching materials (gels and/or fluids) in mated connectors under test shall not be used.

10.1.4 Calibration

The test operator shall have evidence, in the form of a valid calibration certificate or equivalent, to support the use of the test equipment at the time the tests are carrieed out.

The test operator shall ensure that the test system has been normalised in accordance with the appropriate testing standard or test equipment manufacturers instructions prior to the test being undertaken. This requirement may be part of the specified test procedure.

10.1.5 Equipment protection

Transmission and terminal equipment shall be removed from the interfaces to the cabling under test.

10.1.6 Measurement conditions

Measurements shall either

a) be made under environmental conditions which are representative of the intended operational environment, or

b) have correction factors applied to the measured results in accordance with manufacturers specifications to reflect the intended operating environment, or

c) be clearly documented as being carried out in unrepresentative conditions.

The ambient temperature shall be recorded in the test result documentation.

10.2 Test procedures for balanced cabling

10.2.1 General

Where testing is required by the installation specification and detailed in the quality plan then

- for links and channels of Classes D, E, E_A, F or F_A
  - the test procedures are specified in IEC 61935-1,
  - testing should be carried out using equipment in accordance with IEC 61935-1,
  - testing of individual parameters within the parameter groups of Table 1 should not be applied;
- for links and channels of other Classes
  - it is only necessary to test individual parameters within the internal transmission group,
  - test procedures and equipment other than those in accordance with IEC 61935-1 may be used.

10.2.2 Measurement of length-related parameters

The nominal velocity of propagation (NVP) of the cable shall be determined and input, as necessary, to test equipment before testing is carried out.

10.2.3 Treatment of marginal test results

The treatment of marginal results shall be as detailed in the quality plan (see 6.3.1.2).

10.2.4 Treatment of unacceptable test results

Where results are obtained that do not meet the requirements of the installation specification, the following steps may be considered

- re-verification of the normalisation of the test system,
- repetition of the measurement using a test system with an improved measurement accuracy.

Where the test result continues to be unacceptable, the appropriate corrective actions and re-testing of repaired links or channels (and any other cabling affected by the repair activity) shall be carried out and documented in accordance with the procedures defined in the quality plan.

10.2.5 Test result format

Test results shall be given in the native format of the tester manufacturer including reader software. Alternatively, results shall be delivered in a standardised document format as agreed between the installer and premises owner such as .pdf, .odf or .xml but no adulteration of the test result is allowed.

10.2.6 Test result documentation

10.2.6.1 Equipment in accordance with IEC 61935-1

The documentation for each parameter shall include

a) test equipment,
   1) type and manufacturer,
   2) serial number and calibration status,
   3) level and software version,
b) details of the cabling interface adaptors (type, reference numbers and manufacturer),
c) details of the cabling under test,
d) the date of the test (the time of the test may also be recorded),
e) relevant environmental conditions,
f) the test operator.

10.2.6.2 Other equipment

In addition to the items in 10.2.6.1 the documentation for each parameter shall include

a) details of the parameter,
b) details of the test system,
c) the measured result,
d) the required result.

10.3 Test procedures for optical fibre cabling

10.3.1 General

The performance Classes of links and channels within the referenced cabling design standards contain requirements for some or all of the parameters in Table 3 against which installed cabling may be tested.

Where testing of optical fibre cabling links and channels is required by the installation specification and detailed in the quality plan, it shall be carried out in accordance with ISO/IEC 14763-3.

Permanent link testing in accordance with ISO/IEC 14763-3 does not reflect the reference planes of Figure 14. ISO/IEC 14763-3 contains information on the appropriate modifications to the test limits which reflect this difference.

Channel testing in accordance with ISO/IEC 14763-3 adopts the reference planes of Figure 16. However, the test limits are modified due to the use of reference connections on the test cords. The test results obtained cannot be directly compared with the requirements of application support such as those in Annex F of ISO/IEC 11801:2002. ISO/IEC 14763-3 contains information on the appropriate modifications to the test limits which reflect this difference.

10.3.2 Treatment of unacceptable test results

Where results are obtained that do not meet the requirements of the installation specification then the following steps may be applied

- re-verification of the normalisation of the test system,
- repetition of the measurement using a test system with an improved measurement accuracy.

Where the test result continues to be unacceptable, the appropriate corrective actions and re-testing of repaired links or channels (and any other cabling affected by the repair activity) shall be carried out in accordance with and documented by the procedures defined in the quality plan.

10.3.3 Test result documentation

The documentation for each parameter shall include

a) details of the parameter
   1) details of the test system,
   2) test equipment,
   3) type and manufacturer,
   4) serial number and calibration status,
   5) level and software version,
b) details of the cabling interface adaptors (type, reference numbers and manufacturer),
c) the stated uncertainty of measurement (measurement accuracy),
d) details of the cabling under test,
e) reference measurement numbers,
f) the date of the test (the time of the test may also be recorded),
g) relevant environmental conditions,
h) the test operator,
i) the measured result,
j) the required result.

11 Inspection

11.1 General

This clause defines levels of inspection that may be referenced from the installation specification of Clause 5. The inspection may be implemented by the installer (and would be indicated in the quality planning of Clause 6) or by a third-party operating independently and subject to a separate contract; or, according to 6.2, shall be applied in accordance with local regulations.

Inspection combines visual and physical inspection with some type of testing. Where the testing is that included within the quality plan and implemented by the installer, the sampling requirements of 6.2 apply.

Where the testing of the inspection is separate from that carried out by the installer of the quality plan and is implemented by the third-party, the inspector shall apply a sampling scheme that provides the required assurance.