ISO/IEC 14763-2

Edition 2.0 2019-12

INTERNATIONAL STANDARD

colour inside

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

ISO/IEC 14763-2:2019-12(en)

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INFORMATION TECHNOLOGY – IMPLEMENTATION AND OPERATION OF CUSTOMER PREMISES CABLING –

Part 2: Planning and installation

FOREWORD

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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 second edition cancels and replaces the first edition published in 2012 and Amendment 1:2015. This edition constitutes a technical revision.

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

- the inclusion of planning and installation practices to support remote powering over the telecommunications cabling infrastructure;
- the inclusion of planning and installation practices outside buildings.

The text of this standard is based on the following documents:

FDIS	Report on voting
JTC1-SC25/2909/FDIS	JTC1-SC25/2931/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

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

A list of all parts of the ISO/IEC 14763 series, published under the general title *Information technology – Implementation and operation of customer premises cabling*, can be found on the IEC and ISO websites.

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 use of generic information technology (IT) cabling, termed telecommunications cabling throughout this document (in accordance with the ISO/IEC 11801 series), for an increased number of non-IT services is reflected in the predominant use of the term telecommunications in this document.

The importance of services delivered by telecommunications 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 organization's effectiveness.

There are four phases in the successful implementation of telecommunications 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 document supports the specification, implementation and operation of generic telecommunications 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;
- 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 Clauses 5 to 14 are premises-independent. The following normative annexes include requirements for generic cabling in accordance with specific International Standards:

- Annex C: Cabling in accordance with ISO/IEC 11801-2;

- Annex D: Cabling in accordance with ISO/IEC 11801-3;
- Annex E: Cabling in accordance with ISO/IEC 11801-4;
- Annex F: Cabling in accordance with ISO/IEC 11801-5;
- Annex G: Cabling in accordance with ISO/IEC 11801-6.

Annex H provides information on environmental classes for spaces containing telecommunications equipment.

Annex I provides additional information regarding remote powering.

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

This document is also relevant to

- architects, building designers and builders,
- main contractors,
- designers, suppliers, installers, inspectors (auditors), building managers, maintainers and owners of telecommunications cabling,
- access providers and service providers,
- end users.

This document 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 International Standards and Technical Reports.

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

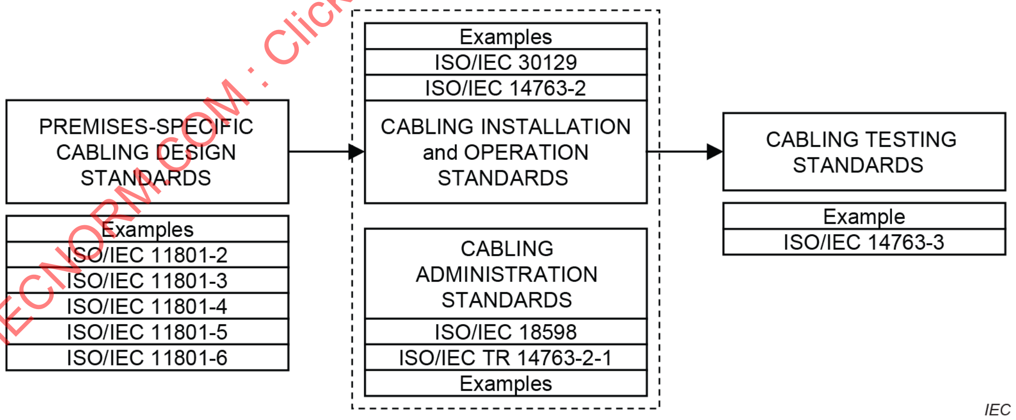


Figure 1 – Schematic relationship between ISO/IEC 14763-2 and other relevant International Standards and Technical Reports

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.

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 telecommunications cabling and cabling infrastructures including cabling, pathways, spaces and telecommunications bonds (other than that specified in ISO/IEC 30129) in support of generic cabling standards and associated documents.

The following aspects are addressed:

a) specification of the installation;
b) quality assurance;
c) installation planning;
d) installation practice;
e) documentation;
f) administration;
g) testing;
h) inspection;
i) operation;
j) maintenance;
k) repair.

The requirements and recommendations of Clauses 5 to 14 are premises-independent. Annexes C through G contain premises-specific amendments of and additions to these requirements and recommendations.

In addition, this document describes the methodology for the assessment of spaces, pathways, pathway systems and cabling (either installed or planned) in support of remote powering objectives.

This document excludes specific requirements applicable to other cabling systems (e.g. power supply cabling); however, it takes account of the effects other cabling systems may have on the installation of telecommunications cabling (and vice versa) and gives general advice.

This document excludes 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 document 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 and electromagnetic compatibility (EMC) requirements are outside the scope of this document and are covered by other standards and regulations. However, information given in this document can be of assistance in meeting these standards and regulations.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 – Wiring systems*

IEC 60825-2, *Safety of laser products – Part 2: Safety of optical fibre communication systems (OFCS)*

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

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 61918:2018, *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 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: Coordination dimensions*

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

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC 62368-3, *Audio/video, information and communication technology equipment – Part 3: Safety aspects for DC power transfer through communication cables and ports*

IEC 62949, *Particular safety requirements for equipment to be connected to information and communication technology networks*

ISO/IEC 11801-1:2017, *Information technology – Generic cabling for customer premises – Part 1: General requirements*

ISO/IEC 11801-2, *Information technology – Generic cabling for customer premises – Part 2: Office premises*

ISO/IEC 11801-3, *Information technology – Generic cabling for customer premises – Part 3: Industrial premises*

ISO/IEC 11801-4, *Information technology – Generic cabling for customer premises – Part 4: Single-tenant homes*

ISO/IEC 11801-5, *Information technology – Generic cabling for customer premises – Part 5: Data centres*

ISO/IEC 11801-6, *Information technology – Generic cabling for customer premises – Part 6: Distributed building services*

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

ISO/IEC 18598, *Information technology – Automated infrastructure management (AIM) systems – Requirements, data exchange and applications*

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

ISO/IEC 30129, *Information technology – Telecommunications bonding networks for buildings and other structures*

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 11801-1, ISO/IEC 11801-2, ISO/IEC 11801-3, ISO/IEC 11801-4, ISO/IEC 11801-5, ISO/IEC 11801-6, ISO/IEC 30129 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
acceptance testing
<of installed cabling> contractual test to confirm that the installed cabling satisfies specific aspects of its specification

3.1.2
access provider space
location of access provider transmission and support equipment

3.1.3
anchor wire
tensioned cable designed to add support to structures

3.1.4
automated infrastructure management system
AIM system
integrated hardware and software system that automatically detects the insertion or removal of cords, documents the cabling infrastructure including connected equipment enabling management of the infrastructure and data exchange with other systems

[SOURCE: ISO/IEC 18598:2016, 3.1.3]

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

3.1.6
cabinet
enclosed construction intended for housing closures and other telecommunications components and equipment

3.1.7
cable management system
system used for the support and/or containment, retention, and protection of all types of cables, information and communication lines, electrical power distribution conductors and their associated accessories

Note 1 to entry: Includes ducts and tubes housing, or intended to house, blown telecommunications cables and/or cable elements.

3.1.8
cabling component
product associated with the cabling installation including cables, connecting hardware, closures, cabinets, frames, racks and pathway systems together with components used to provide bonds to earthing systems

3.1.9
catenary wire
dedicated wire used in aerial applications to which telecommunications cables are attached

3.1.10
closure
fixture or fitting of either open or closed construction intended to contain connecting hardware

3.1.11
closed pathway system
cable management system which does not allow installation of cables by laying without tensile load

3.1.12
electrostatic discharge
transfer of electric charge between bodies of different electric potential in proximity or through direct contact

[SOURCE: IEC 60050-161:2014,161-01-22]

3.1.13
entrance room
space within, or at the boundary of, a building housing the demarcation point where facilities owned by external access and/or service providers interface with the premises cabling

Note 1 to entry: For generic cabling in accordance with ISO/IEC 11801-5, the demarcation point is the external network interface (ENI) and the data centre cabling at that point is the network access cabling.

3.1.14
extraneous-conductive-part
conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth

[SOURCE: IEC 60050-826:2004, 826-12-11; IEC 60050-195:1998, 195-06-11]

3.1.15
frame
open construction, typically self-supporting and floor-mounted, intended for housing closures and other telecommunications equipment

3.1.16
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

Note 1 to entry: An example of a hand hole within a building is called a draw-box.

3.1.17
high-voltage
voltage over 1 000 V RMS or 1 500 V DC

3.1.18
home entrance
space at the boundary of a home that can 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

3.1.19
hot zone
area around a high-voltage installation (e.g. substation, transformer, pylon) whose earth potential rise in normal operation or when an earth fault occurs is over the limits given in ITU-T K.68 for typical fault situations

3.1.20
identifier
unique item of information to distinguish a specific component of the cabling installation

3.1.21
installer
person installing cabling components

Note 1 to entry: No design functions are assumed.

3.1.22
junction box
space within a home that enables cables to be routed between pathway systems

3.1.23
label
means of clearly marking a specific component of the telecommunications infrastructure with its identifier and (optionally) other information

3.1.24
maintenance hole
<telecommunications> vault or 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

3.1.25
metallic telecommunications cable
cable utilizing metallic conductors for signal transmission

3.1.26
metallic telecommunications cabling
cabling utilizing metallic conductors for signal transmission

3.1.27
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

3.1.28
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 when fixed in its final operating position

3.1.29
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

3.1.30
multi-tenant building
building which is designed to accommodate more than one tenant, each of whom has their own tenant entrance facility but who share building entrance facilities (BEF) and associated distribution spaces

3.1.31
non-deformed power supply
power supply that excludes the effects of non-linear loads which generate harmonic currents (e.g. fluorescent lamps, switch mode power supply devices)

3.1.32
open pathway system
pathway system which allows installation of cables by laying without tensile load

3.1.33
openable pathway system
cable management system which restricts access to installed cables but which can be opened to allow installation of cables by laying without tensile load

3.1.34
pathway
<cable route, cable way> defined route for cables between termination points

3.1.35
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

3.1.36
power supply cable
cable whose primary purpose is the supply of electrical power

3.1.37
power supply cabling
cabling whose primary purpose is the supply of electrical power

3.1.38
premises owner
owner of the premises within which cabling is to be installed and who can delegate the responsibilities specified in this document to appointed representatives

Note 1 to entry: Appointed representatives can include designers, specifiers, operators and maintainers of the resulting cabling infrastructures.

3.1.39
primary distribution space
space within a home that houses the home distributor (primary home distributor) of ISO/IEC 11801-4 and associated equipment

3.1.40
protective earth conductor
conductor provided for the purposes of safety, for example protection against electric shock

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

3.1.41
rack
open construction, typically wall-mounted, for housing closures and other telecommunications equipment

3.1.42
rack unit
44,45 mm of vertical mounting space in an IEC 60297 series standard cabinet or rack

Note 1 to entry: 44,45 mm = 1,75 in.

3.1.43
record
collection of information about, or related to, a specific element of the telecommunications infrastructure

3.1.44
referenced cabling design document
relevant International Standard or Technical Report for cabling design

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

3.1.45
remote powering
supply of power to application-specific equipment via balanced cabling

3.1.46
secondary distribution space
space within a home that houses a secondary home distributor of ISO/IEC 11801-4

3.1.47
segregation
physical separation and/or isolation for the purposes of safety, protection of damage to equipment or the prevention of electromagnetic noise from power supply cabling interfering with circuits operating on telecommunications cabling

3.1.48
service loop
excess length of cable or cable element(s)

3.1.49
service provider
operator of any service that furnishes telecommunications content (transmissions) delivered over access provider facilities

Note 1 to entry: The access provider and the service provider can be a single entity.

3.1.50
service provider space
location of service provider transmission and support equipment

3.1.51
space
specified volume (e.g. room, maintenance hole or part thereof) housing closures and/or other telecommunications equipment

3.1.52
surge protective device
device intended to protect the electrical apparatus from high transient overvoltages and to limit the duration and frequently the amplitude of the follow-on current

3.1.53
telecommunications equipment
active or passive equipment necessary to deliver a specific application

EXAMPLES hubs, switches, routers, adapters

3.1.54
termination point
connection, free connector or fixed connector (as appropriate) fitted to an installed cable and housed within a closure

3.1.55
tenant entrance facility
facility that provides all necessary mechanical and electrical services for the entry of telecommunications cables into a tenant's space and which may allow for transition from external to internal cable

3.1.56
work order
collection of information which documents the changes requested and the operations to be carried out on the telecommunications infrastructure

3.2 Abbreviated terms

For the purposes of this document, the abbreviated terms given in ISO/IEC 11801-1, ISO/IEC 11801-2, ISO/IEC 11801-3, ISO/IEC 11801-4, ISO/IEC 11801-5, ISO/IEC 11801-6, ISO/IEC 30129 and the following apply.

AIM	automated infrastructure management
CATV	community antenna television
CAD	computer aided design
CER	common equipment room
CSA	cross-sectional area
CTR	common telecommunications room
EMI	electromagnetic interference
EMS	energy management systems

ENI external network interface

HV high-voltage

HVAC heating, ventilation and air conditioning

LV low-voltage

IS installation specification

MPO multi-fibre push-on

NVP nominal velocity of propagation

QP quality plan

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 document,

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) telecommunications bonding networks shall conform to ISO/IEC 30129,

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

m) 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 telecommunications cabling as agreed between the planners of the lightning protection system and the telecommunications cabling,

n) local regulations shall be met.

5 Specification of installations

5.1 General

Clause 5 in conjunction with Clause 6 describes the key aspects of installation quality assurance as shown in Figure 2.

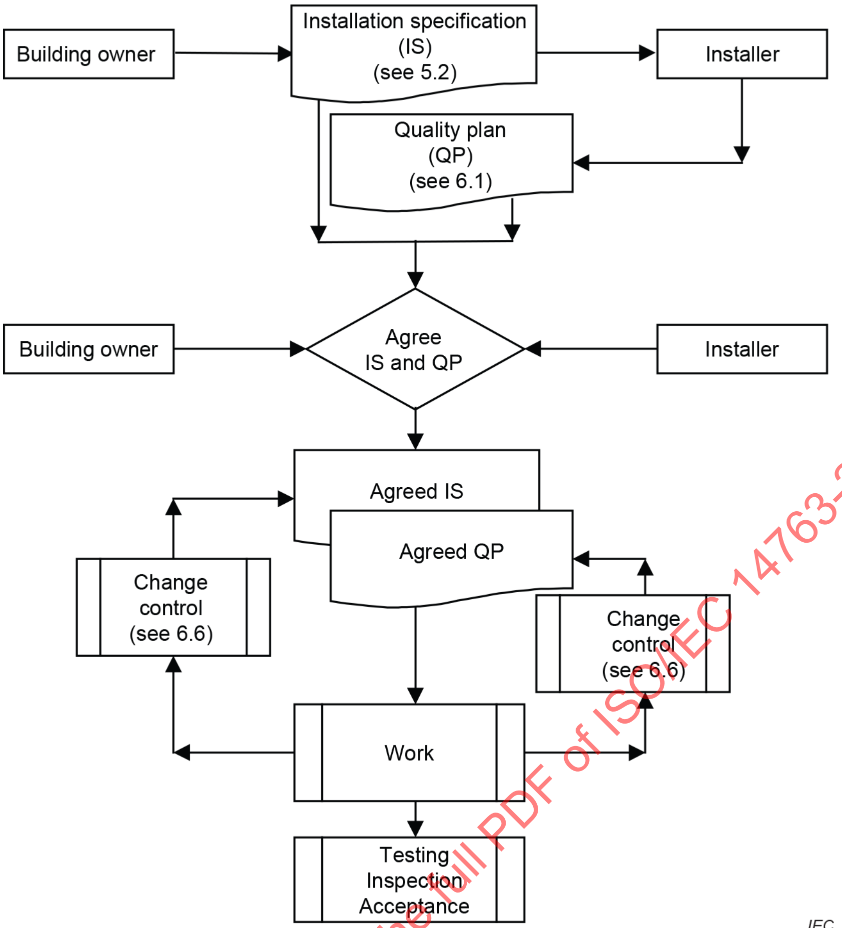


Figure 2 – Quality assurance schematic

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 5.2. 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 have been taken into account:

- other building services such as power supply distribution, earthing and bonding systems;
- building management systems including security and access control;
- 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 D);

- 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 telecommunications cabling components,
- items to be issued to the telecommunications 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 power supply system.

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

The installation specification should contain the elements of the telecommunications 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 telecommunications cabling (see Clause 7),
- resilience planning,
- security requirements and/or 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 Notification of hazards

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 telecommunications equipment and optical fibre telecommunications 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 unauthorized 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 and/or segregation),
- separation from the defined environment.

The technical specification shall detail any remote powering objectives using equipment in accordance with IEC 62368-3.

Failure to specify remote powering objectives indicates that either there are none or that they only apply to cabling which has been designed to support remote powering without the need to apply specific planning or installation practices and have no impact on other cabling in shared pathways and spaces.

For balanced cabling in accordance with the ISO/IEC 11801 series, remote powering equipment shall not supply more than 500 mA per conductor (i.e. $i_c \leq 500$ mA) and the installations shall be designated in one of the following Categories:

- Category RP1: attachment of the remote powering equipment at a distributor is controlled such that the average current for all conductors served by the distributor ($i_{\text{c-average}}$) is no greater than 212 mA.

  Category RP1 installations avoid planning and installation practices but do require documentation and administrative controls during both the attachment of remote powering equipment and any subsequent extensions of the cabling (see 9.2.2.4.1). An additional complexity is that $i_{\text{c-average}}$ is not just a simple average. Instead, $i_{\text{c-average}}$ (A) is calculated as

$$i_{\text{c-average}} = \sqrt{\frac{\sum_{n=1}^{N} i_{\text{c}_n}^2}{N}} \qquad (1)$$

where

n is the index of conductors (including those that carry no current);

N is the total number of conductors (including those that carry no current);

i_{c_n} is the current in conductor with index n (A).

- Category RP2: attachment of the remote powering equipment at a distributor is controlled such that the average current for all conductors served by the distributor ($i_{c\text{-average}}$) is restricted to a specified value between 212 mA and 500 mA;

  Category RP2 installations require planning and installation practices (see Clauses 7 and 8) together with documentation and administrative controls during both the attachment of remote powering equipment and any subsequent extensions of the cabling (see 9.2.2.4.1). An additional complexity is that $i_{c\text{-average}}$ is not just a simple average as described for Category RP1 installations.

- Category RP3: attachment of the remote powering equipment at a distributor is unrestricted subject to the limit of $i_c \leq 500$ mA.

  Category RP3 installations require planning and installation practices (see Clauses 7 and 8) together with documentation and administrative controls during subsequent extensions of the cabling (see 9.2.2.4.1).

These Categories are summarized in Table 1.

Table 1 – Remote powering cabling installation Categories and controls

Category	$i_{c\text{-average}}$	i_c	Controls required during	
			Attachment of remote powering equipment	Planning of subsequent cabling installation
RP1	≤ 212 mA	≤ 500 mA	Yes	Yes
RP2	> 212 mA < 500 mA	≤ 500 mA	Yes	Yes
RP3	-	≤ 500 mA	No	Yes

A consistent Category should be applied to all distributors at which remote powering is applied.

Where the installation specification describes an extension to existing cabling, the Category of the existing installation shall be specified.

Values for i_c and $i_{c\text{-average}}$ for remote powering applications of IEEE 802.3 are shown in Figure 3.

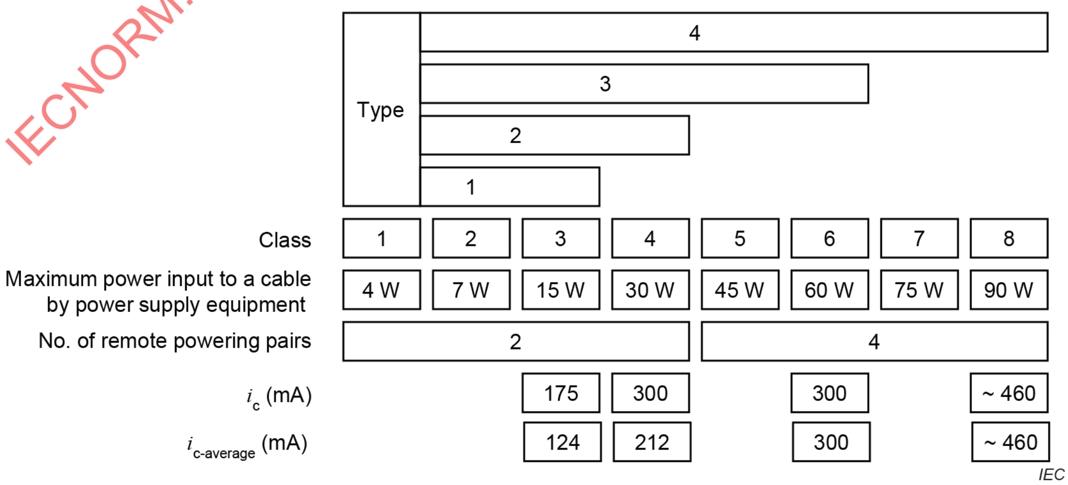


Figure 3 – Conductor current for IEEE 802.3 remote powering applications

Installations of Category RP2 represent an engineered solution and require the application of Clause I.3.

For installation of cabling in accordance with ISO/IEC 11801-2, ISO/IEC 11801-3, ISO/IEC 11801-4 and ISO/IEC 11801-6, the planning, installation and administration requirements of Category RP3 shall be applied.

The capacity of the power supply or supplies to spaces from which remote powering is distributed shall be consistent with the stated objectives and power dissipated from the cabling should be included in the heat load calculation of the environmental control system of the building.

The technical specification shall detail the

- locations where less than the available number of cable elements are terminated at a termination point or joint,
- pin-pair assignment for balanced cable elements at interfaces to the installed cabling,

  Annex A provides information about possible connections between the wires and the pins of telecommunications 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 Annex A contains requirements and recommendations for the maintenance of polarity within cabling terminated with connecting hardware housing multiple optical fibres.

When two cabling links of different specifications, but which are physically similar, are used in the same installation (for example, different performance Categories and cables with different nominal impedance), special precautions are required to ensure that they are properly identified.

The technical specification shall contain the requirements for

- the pathways, pathway systems, spaces, cabinets, frames, racks, closures, cables, termination points and cords (see Clause 7),
- differentiation of pathway systems and cables associated with cabling subsystems installed to provide enhanced reliability within the infrastructure (e.g. tie cabling),
- the bonding of the cabling components to the protective and functional earthing systems (see IEC 60364 series and ISO/IEC 30129).

Spaces, pathways and/or the pathway systems within the pathways shall be able to accommodate components and where necessary provide adequate ventilation, in order that any stated remote powering objectives neither compromise the transmission requirements of the installation specification or the warranty conditions of the components. Information on assessment methods is provided in 7.14.

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 of ISO/IEC 11801-1 (and 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.

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

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 can 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 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,
- connection to bonding systems and protective earthing systems.

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 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 the telecommunications cabling installer,
- items to be issued to the telecommunications 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).

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 document. The quality plan shall be agreed with the premises owner prior to the commencement of the installation and shall address the requirements of 6.1 independent of the provision of the materials or facilities involved.

For installations of cabling in accordance with ISO/IEC 11801-4 in single homes, quality plans are not required but can be requested.

The quality plan describes methods and procedures as detailed below and does not replace the need for the installer to assess, against the requirements of this document, the pathways and spaces (and any other relevant facilities and infrastructures) provided by the premises owner.

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

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

The quality plan shall detail the procedures

- for the transfer of responsibilities between the installer, premises owner and, where relevant, other contractors,
- 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),
- to be adopted to assess compatibility between cabling components to be used during the installation,
- to be adopted to assess compatibility with any existing installed cabling,
- to assess any stated objectives for remote powering for compatibility with the intended operating environment (information on assessment methods is provided in 7.14),
- to address the impact of potential component incompatibilities,
- 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 6.4.

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 6.4.

6.2 Specification of cabling components

Specifications for the cabling components to be used shall be obtained from manufacturers or suppliers including

a) environmental requirements (storage, installation and operation),
b) cord, cable and cable element minimum bend radii (installation, operating static and, if relevant, operating dynamic),
c) cord and cable maximum tensile load,
d) cord and cable crush resistance.

Instructions for the storage, installation and operation of the cabling components shall be obtained from manufacturers or suppliers including

1) pathways and pathway systems,
2) installation tools and installation equipment,
3) termination of cables to connecting hardware.

6.3 Sampling

6.3.1 Balanced cabling

6.3.1.1 General

Table 2 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. Subclauses 6.3.1.2, 6.3.1.3 and 6.3.1.4 specify 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.

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.

6.3.1.2 Permanent link testing

Independent of the requirements of the installation specification, basic verification parameters of Table 2 shall be tested using a sample level of 100 %.

Where the installation specification requires acceptance testing of internal transmission parameters of Table 2 against the permanent link requirements of Classes D, E, E_A, F, F_A, I or II, the sample level applied should be 100 %. If the test equipment is able to measure additional parameters in conjunction with the specified internal parameters of Table 2 then the sample should be 100 %.

Where the installation specification requires acceptance testing of alien (exogenous) transmission parameters of Table 2 against the permanent link requirements of Classes E_A or F_A, the minimum sample level applied should be in accordance with 6.3.1.4.

Table 2 – Installed balanced cabling test parameters

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

NOTE Link or channel length can also be of interest, but is not a pass/fail criterion.

[a] It shall be ensured that continuity is provided by the cabling components and not by alternative connections such as protective earth conductors.

[b] The margin between the measured value of a permanent link and the channel requirement should be reported where possible.

6.3.1.3 Channel testing

Channel tests can 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 2 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 can be applied to channel testing provided that the associated risk of undiagnosed faults is recognized in the quality plan.

In cases d) and e), where the installation specification requires acceptance testing of internal transmission parameters of Table 2 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 2 against the requirements of a specific channel Class, the minimum sample level applied should be in accordance with 6.3.1.4.

6.3.1.4 Alien (exogenous) crosstalk testing

Where the installation specification requires acceptance testing of alien (exogenous) crosstalk transmission parameters of Table 2 of installed permanent links or channels against the requirements of permanent link or channel Classes E_A or F_A of ISO/IEC 11801-1:2017, the minimum sample of disturbed permanent links or channels to be tested should be in accordance with Table 3.

Table 3 – Minimum sample sizes for alien (exogenous) crosstalk testing

Total no. of links/channels N	**Sample size**
3 to 150	3 or ROUNDUP(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 the 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.

6.3.2 Optical fibre cabling

6.3.2.1 General

Table 4 shows three groups of optical fibre cabling transmission parameters (basic verification, basic test group and extended test group) using the parameters that define the links and channels within the referenced cabling design standards. Subclauses 6.3.2.2 and 6.3.2.3 specify 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 4 – Installed optical fibre cabling test parameters

Parameter group	Transmission parameter
Basic verification	Polarity
Basic test group	Attenuation
	Propagation delay [a]
	Length [b, c]
Extended test group	Interface connector attenuation
	Interface connection return loss
	Embedded connecting hardware attenuation
	Embedded connecting hardware return loss

[a] Propagation delay is not a pass/fail criterion.

[b] Length is not a pass/fail criterion.

[c] Length may be determined by sheath marking or physical measurement.

6.3.2.2 Permanent link testing

Where the permanent link contains non-fixed cabling (e.g. CP cable in ISO/IEC 11801-2 and LDP cable in ISO/IEC 11801-5), any result is only applicable to the specific configuration under test.

Independent of the requirements of the installation specification, basic verification parameters of Table 4 shall be tested using a sample level of 100 %.

Where the installation specification requires acceptance testing of transmission parameters of Table 4 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,
- provided that polarity has been confirmed, testing of length/propagation delay can 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.
- where testing of propagation delay/length is undertaken with equipment that also automatically tests verification parameters, a sample level of 100 % should be used (propagation delay testing is only necessary where latency requirements are specified).

Testing of multimode optical fibre may be limited to 850 nm, unless otherwise specified.

6.3.2.3 Channel testing

Channel tests can 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 to create a channel,

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

c) any cords attached to a permanent link (or within a channel) 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 6.3.2 apply.

Testing of multimode optical fibre may be limited to 850 nm, unless otherwise specified.

6.4 Treatment of marginal results

6.4.1 Balanced cabling

6.4.1.1 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.

6.4.1.2 Requirements

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

As examples, the quality plan can 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.

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.

6.4.2 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.

6.5 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. See 10.2.4 and 10.3.2 for further information.

6.6 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

Clause 7 details requirements and recommendations for planning of installations. It covers

- pathways and spaces,
- functional elements of the referenced cabling design standards,

- segregation from power supply cabling,
- support for installation practices (e.g. bend radius, pulling load).

Relevant telecommunication services to be included when the installation is planned include

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

7.2 Safety

7.2.1 General

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

7.2.2 Low voltage power supply cabling

The proper implementation of the requirements of this document assumes that electrical installations, bonding networks and protective measures against overvoltages are undertaken in accordance with the IEC 60364 series and/or local regulations, as appropriate.

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

7.2.3 Telecommunications cables fire performance

Telecommunications cables inside buildings that do not comply with the national or local fire regulations or the minimum recommended performance requirements of IEC 60332-1-2 shall be installed within a cable management system that meets the requirements of a fire barrier in accordance with local fire regulations.

7.2.4 Optical fibre cabling

The hazard classification of areas containing optical fibre telecommunications equipment and optical fibre telecommunications cabling shall be undertaken in accordance with IEC 60825-2.

7.2.5 Transmission and terminal equipment

Telecommunications cabling shall be connected to equipment that complies with IEC 62368-1 or IEC 62949. Where equipment circuits provide direct current (DC) power transfer over the information technology cabling, the equipment shall comply with IEC 62368-3.

7.3 Environment

The MICE concept according to ISO/IEC 11801-1 shall be used to describe the environment where the cabling or parts of the cabling will be located.

Where necessary, product and supporting systems shall be selected 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 bonds between sections, or parts of pathway systems and to earthing 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 access provider(s) and 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 access providers(s) and 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 access providers(s) and service provider(s).

7.5.2 Recommendations

Access providers(s) and 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 can be used are shown in Table 5.

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 might not be suitable for the subsequent installation of other cabling technologies.

Table 5 – 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 Openable pathway system 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. Open pathway system 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). 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. Open pathway system 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. Open pathway system 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. Closed pathway system 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. Closed pathway system Available in metallic or non-metallic form.
Interval support	Open support system. 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 can 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 Requirements

7.6.1.2.1 Pathway and pathway system selection

Pathways shall be planned to accommodate maximum distance restrictions for balanced, coaxial and optical fibre applications by means of the appropriate placement of spaces accommodating transmission and terminal equipment and the provision of suitably direct routes between them.

Where multiple phases of cable installation are anticipated, pathway systems shall be designed (by means of physical dimensions or by internal partitioning) to provide any required segregation to meet operational objectives (e.g. removal, re-installation).

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

Pathway systems shall be selected in accordance with the installation requirements of the telecommunications cabling manufacturer or supplier.

Pathways and the pathway systems within the pathways shall be able to accommodate components and where necessary provide adequate ventilation, in order that any stated remote powering objectives neither compromise the transmission requirements of the installation specification or the warranty conditions of the components. Information on assessment methods is provided in 7.14.

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 on the cabling components and the risk that cable support will disappear following changes made to the supporting system.

NOTE An exception to this is where the telecommunications cabling directly serves a device of the supply system (e.g. water meter).

The grids of suspended ceilings shall not be used as support for pathway systems but can be used as pathways for individual cables serving devices within the suspended ceiling.

The location or construction of pathways within, and pathway systems installed in, escape routes shall prevent the installed cables becoming an obstacle in the event of fire during the periods of evacuation and fire-fighting activity.

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 localized pressure points that can 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.

The external surfaces of existing piping systems shall not be used for the installation of pathway systems or the direct attachment of cables.

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

Separation of cable bundles within pathways (and pathway systems) shall be adequate to support any remote powering objectives defined in the installation specification. Subclause 7.14 provides details of appropriate assessments.

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

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

7.6.1.2.2 Pathway and pathway system capacity planning

Within pathway systems, the usable cross-sectional area is determined as follows:

a) for open or openable pathway systems and cable management systems (e.g. tray or basket), cables are not installed above the sidewalls;

b) bends in the pathway systems can restrict the usable cross-sectional area dependent upon the specified bend radii of the cable to be installed;

c) for pathway systems to which cables are to be attached or supported (e.g. messenger/catenary wires or designated routes), the cross-sectional area is the minimum available area surrounding the pathway system.

NOTE For pathway systems containing cables of a common diameter, the cross-sectional area can be considered to be the number of cables.

During initial planning, the cross-sectional area of the cables shall not exceed 40 % of the cross-sectional area of the pathway system at its most restrictive point.

7.6.1.3 Recommendations

7.6.1.3.1 Pathway and pathway system selection

For access providers. a minimum of two entrance pathways for access providers 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.

The number of pathway systems required within each of the building entrance pathways depends on the number of access providers and the number and type of cables that the access providers will install. The entrance pathway systems should have adequate capacity to handle growth and additional access providers.

For generic cabling, 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.

Additional pathway systems to support future installations should be considered where the cost of subsequent installation can be reduced.

Any maintenance holes, hand holes and closures within the pathways in unsecured areas should be protected against unauthorized access.

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

Pathway systems should be planned 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.

Open or openable pathway systems should provide adequate capacity to allow subsequent installation of additional telecommunications cables whilst maintaining minimum bend radii (see 7.6.2.1.2) and segregation from power supply cabling (see 7.9).

7.6.2 Inside buildings

7.6.2.1 Requirements

7.6.2.1.1 Loading and protection

Co-ordination of cabling pathway and space design in conjunction with architects and other engineers is critical.

If the pathway systems are to be supported from overhead structures, the overhead structure shall have a hanging capacity of 1,2 kPa (minimum) in addition to that required to support any other infrastructures. This requirement shall be communicated to, and coordinated with, the structural engineer.

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.

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 and is not recommended from a maintenance perspective.

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.

Sufficient 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).

Where used, cable bundles shall not contain more than 24 cables.

Grouping of cables (by bundling or other means) and the separation of such groups shall take into account the remote powering objectives of the installation specification (see 5.3.4). Information on assessment methods is provided in 7.14.

Where multiple cables are run in a fixed physical relationship, cables with appropriate performance shall be selected to prevent any impact on transmission performance.

NOTE For example, applications dependent on PS AACR-F can be affected in cables of differing lengths in close proximity.

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 all places where cables change direction and apply in three dimensions. Examples of such techniques are pre-fabricated curved corners and radius limiters as shown in Figure 4.

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. cable bundles, 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.

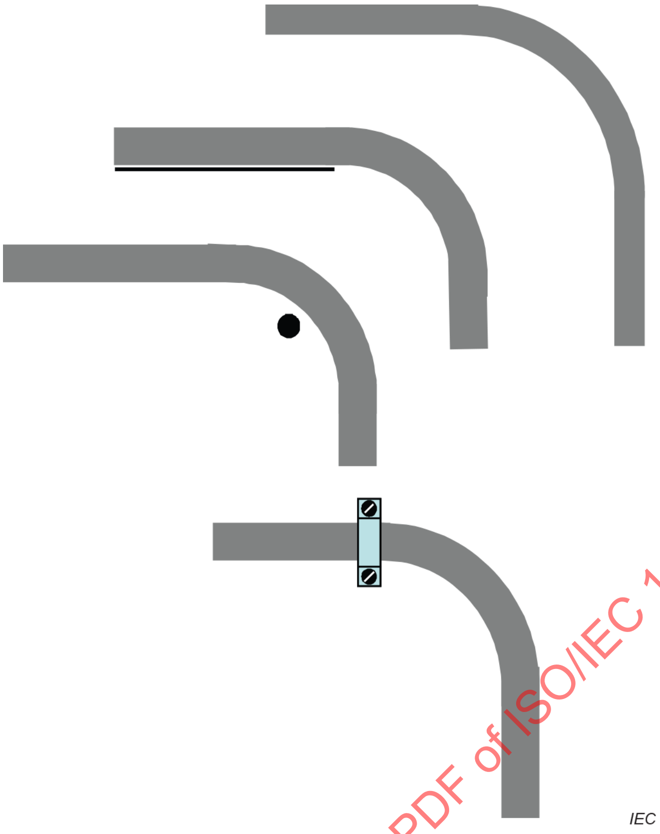


Figure 4a – Examples of non-conformant bend limiting techniques

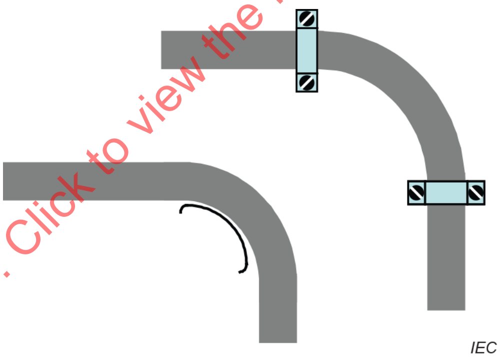


Figure 4b – Examples of conformant bend limiting techniques

Figure 4 – Examples of conformant and non-conformant bend radius management

Minimum bend radius is determined by manufacturer's instructions.

If instructions do not exist, the minimum bend radius shall be the greater of either 50 mm or

- four times the cable diameter for 4-pair balanced cables,
- eight times the cable diameter for other metallic cables,
- 10 times the cable diameter for optical fibre cables,
- 10 times the cable diameter for coaxial cables.

NOTE 1 Pathway systems that do not allow such an approach can 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, can require greater bend radii than those specified above.

7.6.2.1.3 Maximum stacking height

The maximum stacking height in pathway systems is determined by manufacturers' instructions for the cable with the lowest crush resistance to be installed within the pathway system. 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 6.

Table 6 – Stacking height for non-continuous and interval support pathway systems

Distance between supports l (mm)	Formula	Maximum stacking height h (mm)
0	$h = \frac{150}{1+0{,}002 \times l}$	150
100		125
150		115
250		100
500		75
750		60
1 000		50
1 500		37,5
NOTE The requirement for h is based on cables with a crush resistance of at least 5 000 N/m.		

7.6.2.1.4 Conduit

Unless appropriately specified cables and/or installation techniques are to be used

- the maximum distance between pulling points shall be 50 m where conduits are installed without bends,
- the maximum distance between pulling points shall be 30 m where conduits are installed with up to two 90° bends.

Where a conduit contains bends

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

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 six times the internal conduit diameter. Bends in the conduit shall not contain any kinks or other discontinuities that can have a detrimental effect on the cable sheath during cable pulling operations.

The cross-sectional area of the planned/installed cables shall not exceed 40 % of the conduit cross-sectional area.

7.6.2.1.5 Pathway systems under access floors

There shall be adequate space between the top of open cable management systems (e.g. cable tray, wire mesh cable tray) 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, at least 200 mm vertical separation shall be provided between each layer to provide adequate access to lower layers for addition and removal of cables.

7.6.2.1.6 Non-continuous support for cables

The distance between supporting elements of the pathway system shall not exceed 1 500 mm.

7.6.2.2 Recommendations

7.6.2.2.1 Pathway system co-ordination

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). Underfloor pathways should not be located above such equipment unless there is an uncovered (accessible) row of tiles adjacent to these pathways.

If the pathway systems are to be supported from overhead structures, the overhead structure should have a hanging capacity of 2,4 kPa (minimum) in addition to that required to support any other infrastructures. Any resulting requirement shall be communicated to, and coordinated with, the structural engineer.

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 5).

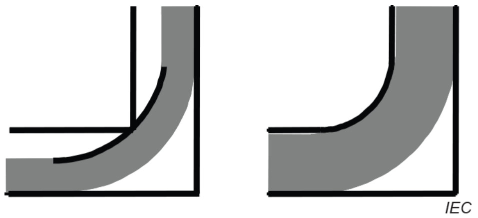


Figure 5 – Example of use of curved corners in pathway systems

7.6.2.2.3 Conduit

Conduits (or ducts) 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.

7.6.2.2.4 Pathway systems under access floors

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 6) or by providing an uncovered (accessible) row of adjacent tiles (as shown in Figure 7),
- 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.

7.6.2.2.5 Overhead pathway systems

Overhead cable pathways can alleviate the need for access floors that do not employ floor-standing systems that are cabled from below. Overhead cable management systems can be stacked to provide additional capacity.

Cable management systems should be suspended from overhead structures where increased operational flexibility is required to

- support the use of cabinets, frames and racks of various heights,
- add or remove cabinets, frames and racks.

Increased operational flexibility can also be achieved by using freestanding structures with integrated pathways provided that they are designed to accommodate the installation and removal of the desired sizes of cabinets, frames or racks.

Cable management systems can be attached to the tops of cabinets, frames and racks where they are of uniform height.

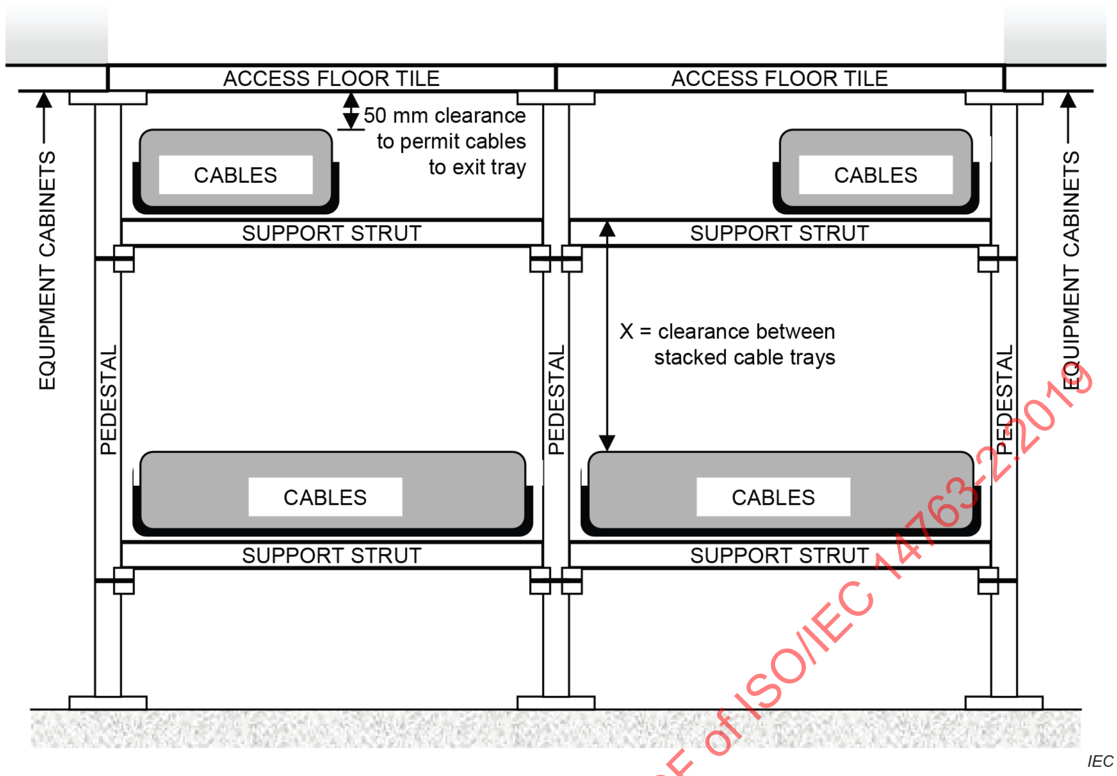


Figure 6 – Example of layered cable trays with smaller width upper trays

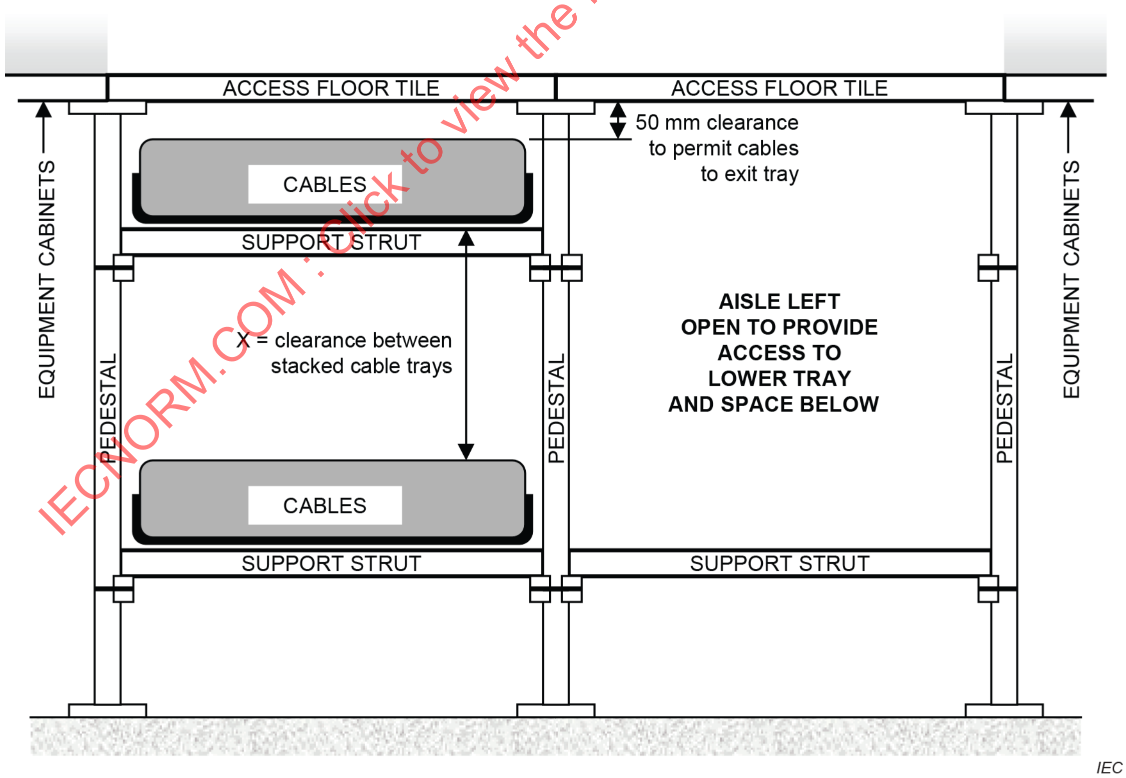


Figure 7 – Example of uncovered (accessible) row of floor tiles to provide access to lower tray

7.6.3 Outside buildings

7.6.3.1 General

In installations outside buildings, such as those shown in the example of Figure 8, it is commonly required to take into account other factors which might have an environmental impact on the telecommunications 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 railway tracks (mechanical impact).

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

Pathways between buildings can use a variety of underground and aerial pathway systems and can use spaces and structures (e.g. hand holes, maintenance holes and telecommunications cabinets) that are constructed to assist cabling installation and to house closures.

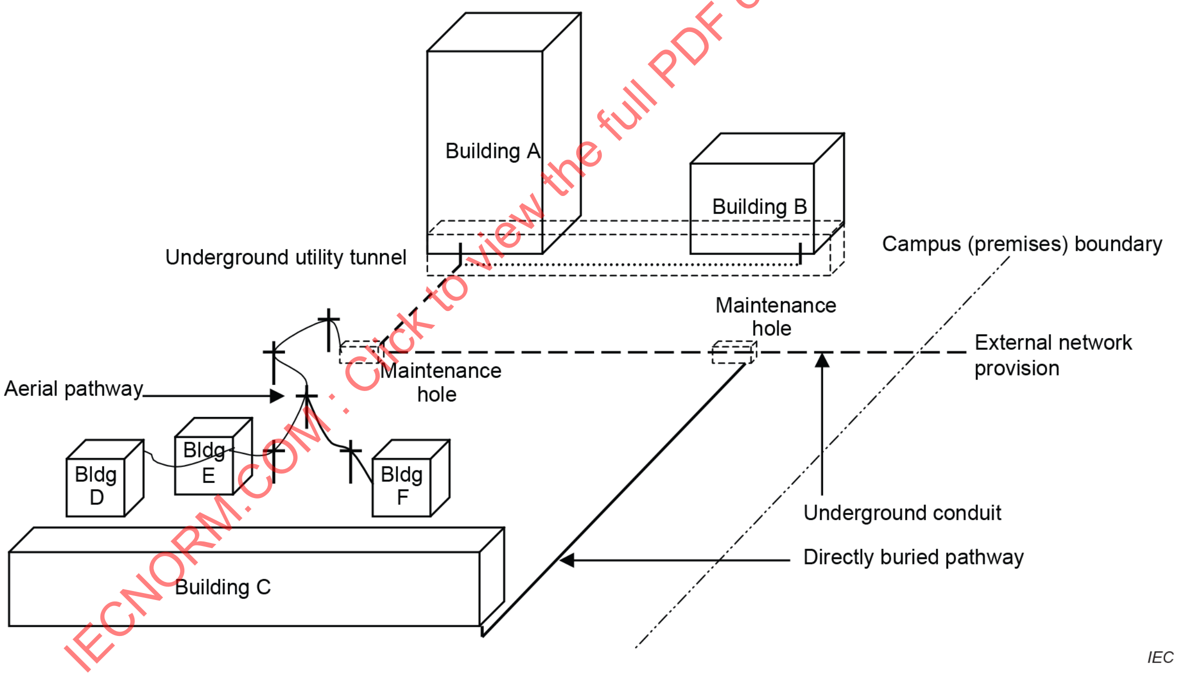


Figure 8 – Example of cabling installations outside buildings

Underground pathways and spaces can be

- dedicated to the installation of telecommunications cables (e.g. direct-buried cable, buried conduit, maintenance holes, hand holes) – Table 7 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 Telecommunications cabling pathways within utility tunnels can consist of indoor pathway systems in accordance with 7.6.1 and 7.6.2.

Direct burial solutions include

- cable constructions which provide the required environmental protection to the transmission media,
- conduits, which can contain sub-conduits, into which cables, cable bundles or cable elements (typically optical fibre) are installed using compressed air; in which case the conduits shall provide the required environmental protection to the cable elements.

NOTE The common term for such conduits and sub-conduits is ducts and sub-duct or microduct, respectively. This does not match the definition of duct used by IEC TC 23/SC 23A who treat duct as non-circular conduit.

Aerial pathways can comprise

a) poles, towers, catenary (or suspension) wires, anchor wires, stays, struts and closures – see Table 7 for a non-exhaustive list of design and planning issues,

b) self-supporting cables, which may include a catenary wire – see Table 7 for a non-exhaustive list of design and planning issues.

Aerial pathways can support

1) cable constructions, which shall provide the required environmental protection to the transmission media,

2) conduits, which can contain sub-conduits, into which cable elements (typically optical fibre) are installed using compressed air; in which case the conduits shall provide the required environmental protection to the cable elements.

NOTE The common term for such conduits and sub-conduits is ducts and sub-duct or microduct, respectively. This does not match the definition of duct used by IEC TC 23/SC 23A who treat duct as non-circular conduit.

The external surfaces of existing piping systems shall not be used for the installation of pathway systems or the direct attachment of cables.

Table 7 – 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
			Bonding
		Catenary wire	Type of strand
			Strand tension

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 building entrance facilities (BEFs),
- risk assessment of accidental or intentional damage to the installation,
- thermal performance characteristics when supporting cables are used for remote powering.

In areas accessible to the public, telecommunications 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

The use of underground pathways of 7.6.3.2.3 and 7.6.3.2.4 should take into consideration the following:

- the risk of future accidental excavation;
- damage to the pathway system and/or cable caused by ground movement (including moisture content related soil expansion (e.g. frost) and contraction, landslips and earthquakes);
- damage to the pathway system and/or cable caused due to flood event related erosion.

The placement of pathways shall be in accordance with national and local regulations in relation to proximity to

- existing underground services,
- trees and tree roots,
- building foundations.

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.

It shall be assumed that dedicated underground pathways will become at least partially water filled due to leaking and condensation, unless specific design features are employed to prevent ingress. 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.

Utility tunnels are normally dry but conditions can vary on a temporary basis. The environmental performance of cables installed in utility tunnels shall be compatible with the predicted conditions.

For pathways between a premises boundary and a BEF

- in commercial or multi-tenant residential premises, conduits without sub-conduits shall be 90 mm minimum internal diameter,
- on residential premises, conduits without sub-conduits shall be of 38 mm (consistent with Size 40 conduits of the IEC 61386 series) minimum diameter.

7.6.3.2.3 Direct burial

Underground cables without suitable protection should be drawn into conduits, pipes or other suitable structures to protect them from mechanical, electrolytic or chemical danger.

Unless otherwise specified by national or local regulations, the minimum planned depths of pathways shall be in accordance with the requirements of Table 8, unless additional measures are to be applied to protect the cable(s). The depths indicated are additional to the diameters of the cable(s) such that the top of the installed cable(s) shall meet the requirements of Table 8.

The depth of dig can be significantly greater than that shown in Table 8 in order to allow any protective layers to be installed below the cables.

Pathways that do not meet the requirements of planned depths of Table 8 without effective mitigation are considered to be sacrificial.

Table 8 – Requirements and recommendations for pathway depths below finished surface

Location of pathway	Requirement	Recommendation
Footpath	0,5 m	0,5 m
Road – including parking areas	0,6 m	0,6 m
Motorway	1,0 m [a]	1,0 m [a]
Railway	1,0 m [a]	1,0 m [a]
Agricultural land	0,9 m	0,9 m
Uncultivated or landscaped land	0,5 m	0,9 m

[a] Increased depths can be required in accordance with agreements between the planner and the owners/operators of the land.

The width of the planned route shall allow adequate space for the installation process.

Requirements for marker tapes or equivalent products shall comply with national or local regulations.

Cables shall be installed inside protective conduits at crossings with roadways and railways.

At crossings of railways the conduits shall provide protection and insulation and shall extend to the base of the slope of the railway embankment and shall extend at least 1,75 m beyond the outside edge of the outermost rails.

7.6.3.2.4 Conduit

Conduit-based pathways take two forms:

a) conduits, which can contain sub-conduits, into which cables are installed using compressed air or water; in which case the combined performance of the conduit and the cable construction shall provide the required environmental protection to the transmission media;

b) conduits, which can contain sub-conduits, into which cable elements (typically optical fibre) are installed using compressed air; in which case the conduits shall provide the required environmental protection to the cable elements.

NOTE The common term for such conduits and sub-conduits is ducts and sub-duct or microduct, respectively. This does not match the definition of duct used by IEC TC 23/SC 23A who treat duct as non-circular conduit.

Unless otherwise specified by national or local regulations the minimum planned depths of pathways shall be in accordance with the requirements of Table 8, unless additional measures are to be applied to protect the conduit(s). The depths indicated are additional to the diameters of the conduit(s) such that the top of the installed conduit(s) shall meet the requirements of Table 8.

The depth of dig can be significantly greater than that shown in Table 8 in order to allow any protective layers to be installed below the conduits.

Pathways that do not meet the requirements of planned depths of Table 8 without effective mitigation are considered to be sacrificial.

The width of the planned route shall allow adequate space for the installation process.

Conduit shall be selected to

1) withstand the predicted mechanical loading,
2) avoid colours of cable management systems which are used exclusively by other services (e.g. power, gas, water),
3) allow the installation and replacement of sub-conduits, cables or cable elements (as applicable).

When used with blown installation methods, the conduits, sub-conduits and accessories shall be able to support the air pressure required to blow the cables or cable elements.

Requirements for marker tapes or equivalent products shall comply with national or local regulations.

With conduits between any two access points including the premises boundary and the BEF

- there shall not be more than one pre-formed bend of up to 90 degrees,
- deviations shall not exceed a total of 90 degrees.

The inside radius of a bend in conduit shall be at least six times the internal conduit diameter. Bends within conduit 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,
- cables are to be removed before any additional installation takes place.

7.6.3.2.5 Aerial pathways

Supporting structures, e.g. poles, shall be selected to be of dimensions and strength suitable for their length and the load they are intended to carry, taking into account influences due to climatic and soil conditions.

Supporting structures shall be suitably treated to prevent decay and any such treatment shall be suitable for the environment in which the structures are to be erected, taking account of the risk of contamination of the water table (see ITU-T L.88 for additional information).

The planning of installations requires detailed information regarding

a) the type and location of supporting structures,
b) the local variation of temperature,
c) local wind and ice loads.

A survey shall be undertaken of all supporting structures that are to be used and shall document the following:

1) the distances between supporting structures;
2) physical/mechanical condition of supporting structures;
3) restrictions of installation access below or between towers or poles.

The survey shall identify

- the nature and extent of work required at each point of support,
- requirements for replacement, refurbishment or strengthening (such as anchor wires or stays) of any supporting structures,
- storage locations for installation equipment, cable drums (or reels),
- installation methods and special tools,
- fittings required to attach telecommunications cabling to the supporting structures (including special fitting to implement changes in direction or gradient at towers or poles),
- the location of joint closures and service loops on supporting structures.

The position and selection of supporting structures and associated strengthening components (anchor wires, stays, struts) shall be designed to allow repair, development or removal of telecommunications cables without affecting the mechanical strength of supporting structures. Any anchor points installed on building structures or supplementary poles shall be at least 2,5 m above the ground.

The telecommunications cable route shall be installed to respect the minimum clearances above ground given in Table 9.

Table 9 – Minimum installed clearances above ground for aerial cables

Location	Clearance
Motorway, main roads	6 m
Non-electric railway	6 m
Minor road crossings, areas accessible to vehicular traffic, field path, campus entrance	5,5 m
Minimum clearance no traffic crossing	4 m
Non-navigable waterways	5 m

The sag during operation (including any maintenance activities) of the telecommunications cable between supporting structures shall be determined based upon the information provided by the supplier of the telecommunications cable (or catenary wire, if present) that is relevant to the following conditions:

- the distance between supporting structures;
- the predicted supplementary loadings of wind, ice and maintenance activity;
- the predicted temperature range.

The minimum height of cables shall comply with national or local regulations during installation, maintenance and operation.

Where multiple cables are to be installed on a common aerial pathway, the sag of the different cables shall be calculated and measures taken to prevent risk of damage.

For aerial crossings of waterways (navigable rivers, canals and other stretches of water), details shall be obtained in respect of the stipulated minimum clearance between the cables at maximum sag and the surface of the water at the highest navigable water level. Any measures required for the protection of shipping shall be ascertained from the authorities responsible for waterways and shipping.

For crossings of high water protection installations (dykes), the presence of above ground telecommunications cables shall not interfere with the maintenance of such installations; the responsible authorities shall be involved at the planning stage of the telecommunications cabling.

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.

Adequate clearance shall be provided for overhead routes that run parallel to or cross railways, tramways, trolley bus cables, cable railways, cable ways, ski and chair lifts, motorways, roads and navigable rivers and waterways.

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, telecommunications cables shall be installed lower than power cables.

7.6.3.2.6 Aerial pathway systems dedicated to telecommunications cabling

Components of the pathway systems include

a) fittings to attach the telecommunications cables to the supporting structures,

b) fittings to accommodate service loops on the supporting structures,

c) joint closures installed on the supporting structures,

d) fittings to attach the joint closures to the supporting structures,

e) wind vibration dampers.

The following shall be implemented for all supporting structures:

1) adjacent supports for telecommunications cabling shall be separated by at least 0,3 m;
2) crossing of telecommunications cable bundles is not allowed unless an additional support at the pole is used;
3) protection against lightning and proximity of lightning rods.

Where stays or struts are used to strengthen the supporting structure (e.g. at the resultant load points of the cables or at road crossings), they shall be suitably insulated when required (e.g. when passing power supply cables), and also when using a metallic catenary wire.

7.6.3.2.7 Aerial pathway systems shared with overhead power supply infrastructures

An agreement shall be reached with the owner of the overhead power supply infrastructure (and where relevant, also the owner of the supporting structures) for joint use including

a) the voltage in the power supply system,
b) the mechanical capacities of supporting structures (e.g. poles or towers),
c) the requirements described in this document for bonding to earthing systems, aerial to underground junctions and aerial connections.

Before undertaking mechanical calculations, it is necessary to determine the following:

1) the technical characteristics of the power supply system;
2) future possible modifications, such as the transformation of LV into HV;
3) the reservation of zones of the overhead power supply infrastructure to allow subsequent installation of light fittings.

Overhead power supply infrastructures can be shared by more than one telecommunications system provided that agreement has been reached with the owners of the overhead power supply infrastructure and the telecommunications systems.

The planning of installations requires detailed information regarding

- the type and location of supporting structures,
- the available moment of inertia capacity of supporting structures to be used (i.e. the difference between the initial moment of inertia capacity of the most stressed tower or pole and the moment of inertia capacity used by the installation of the overhead power supply cabling and related equipment, including any reserve maintained to allow the installation of additional power supply cabling on the same structures),
- the voltages carried by the overhead power supply cabling,
- layout of power conductors on the supporting structures,
- the local variation of temperature,
- local wind and ice loads.

A survey shall be undertaken of all supporting structures that are to be used to support the telecommunications cabling. The survey shall document the following:

- the type (e.g. line, angle-turn, terminating, special purpose) and height of supporting structures;
- the distances between supporting structures;
- physical/mechanical condition of supporting structures;
- anti-corrosion protection (metallic structures);
- the height above the ground of the planned suspension points of the telecommunications cabling;

- restrictions of installation access below or between supporting structures.

The information obtained during the survey shall be used to determine the following:

- requirements for refurbishment or replacement of supporting structures;
- clearances and separations on supporting structures available to be used by the telecommunications cabling;
- storage locations for installation equipment;
- fittings required to attach telecommunications cabling to supporting structures (including special fitting to implement changes in direction or gradient at towers or poles);
- the location of joint closures and service loops on supporting structures.

Where the physical characteristics of the telecommunications cable in combination with its proposed location of the cable on the supporting structure uses more than the available moment of inertia capacity, the supporting structures shall be replaced or be strengthened, e.g. by installing stays or struts.

The telecommunications cable route shall be installed to respect the minimum clearances above ground given in Table 9.

The sag during operation (including any maintenance activities) of the telecommunications cable between supporting structures shall be determined based upon the information provided by the supplier of the telecommunications cable (or suspension wire, if present) that is relevant to the following conditions:

- the distance between supporting structures;
- the predicted supplementary loadings of wind, ice and maintenance activity;
- the predicted temperature range.

The minimum height of cables shall comply with national or local regulations during installation, maintenance and operation.

The sag of the telecommunications and power supply cables shall be calculated and measures taken to ensure that the segregation requirements of 7.11 are maintained.

Where an earthing system exists on a supporting structure then, unless technical and contractual agreement for joint use has been obtained, it shall be dedicated to only one of the following applications:

- power supply cabling;
- lighting;
- telecommunications cabling.

The planning of pathway systems depends on the voltages supported by the overhead power supply infrastructure and the type of telecommunications cable to be installed.

Components of the pathway systems can include

a) fittings to attach the telecommunications cables to the supporting structures,
b) fittings to accommodate service loops on the supporting structures,
c) joint closures installed on the supporting structures,
d) fittings to attach the joint closures to the supporting structures,
e) insulation components used to separate any metallic components from the supporting structures,
f) wind vibration dampers,

g) fittings to allow electrostatic discharge of the telecommunications cable sheath at each end of the pathway.

For metallic telecommunications cables, the positioning of the fittings on the supporting structures shall be in accordance with the segregation requirements of 7.11 and shall be arranged to allow staff access to the circuits mounted above them without risk of accident. On conducting structures, all fittings and closures of the telecommunications system shall be either

1) insulated from the supporting structure, or
2) connected to the earthing system of the power supply system; this connection also includes that of accessible conductive elements of the cables.

The earthing of extraneous-conductive-parts (e.g. armouring, strain relief members of optical fibre cables) that are part of the telecommunications cable construction shall be in accordance with 8.9.1.1.1.

Conductive elements of the catenary and telecommunications cables (not signal conductors) and closures shall be bonded to the earthing system at least at the ends of the shared routes.

For all-dielectric self-supporting (ADSS) cables, the positioning of the fittings on the towers or poles shall be in accordance with the segregation requirements of 7.11. The position of fittings on the towers or poles shall ensure that the lowest point of the telecommunications cables between any two towers or poles, taking the sag into account, shall be in accordance with Table 9 for towers or poles supporting power supply cables < 25 kV. To avoid corona, tracking or arcing phenomena between the telecommunications cable sheath and the structure of the tower or pole (which reduces the operational life of the cable), the position of the fittings shall be in locations where the potential to earth, created by the power conductors, does not exceed

a) 10 kV for all-dielectric cables with a high-density polyethylene sheath,
b) 20 kV for all-dielectric cables with a high-density polyethylene sheath and containing an anti-tracking foil.

The information required to determine the potential to earth on a given tower or pole shall be obtained from the owner of the overhead power supply infrastructure.

Arcing phenomena are created due to the build-up of conductive particles (e.g. soot), which become embedded with the cable sheath over time. Cables in accordance with IEC 60794-4-20 shall have specified performance in relation to these phenomena.

7.6.3.2.8 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 4. 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. cable bundles, 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 manufacturer's 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 can 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, can require greater bend radii than those specified above.

7.6.3.3 Recommendations

7.6.3.3.1 General

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

Separation between telecommunications and power supply cables should be at least 1 m throughout pathways and within spaces.

Where the telecommunications cable contains metallic cable elements, surge protection in accordance with IEC 62305-3 should be applied at all building entrances.

7.6.3.3.2 Underground pathways

Where practicable, pathways should be chosen to allow the subsequent construction of maintenance holes, hand holes or structures.

In view of the cost and disruption associated with the excavation of underground pathways, pathway systems in excess of those initially required should be planned.

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;
  - 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 multiplied by 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 can be required to support distributed services (for cabling in accordance with ISO/IEC 11801-6) using different media or under separate ownership.

The provision of effective drainage should be considered in the design, installation and operation of access points (see 7.7).

Conduit pathways should follow point-to-point straight lines with maintenance holes or hand holes installed at all points where deviation will exceed 3° horizontally or 1,5° vertically.

7.6.3.3.3 Direct burial

Soil conditions should be considered when a cable is to be buried directly in the ground. For example, if subsoil conditions are known to be corrosive, the cable can require additional protection and the cable supplier should be consulted.

7.6.3.3.4 Conduit

Conduits under roads and railways should be installed in co-operation with the relevant authorities in order to define requirements for

- access,
- safety,
- reinstatement including depth of cover and materials (see 8.5.1.3.1).

7.6.3.3.5 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.

Aerial pathways should not be used to cross roads. Where there is no practicable alternative

a) the pathway should cross the road using the shortest possible route,
b) stays or struts should be used to reinforce the stability of two poles adjacent to the road.

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 design margin,
- avoided in earthquake zones.

The telecommunications cable route should be as straight as possible.

Stays or struts, cables, closures, cabinets and accessories should be positioned in such a way to facilitate safe access for installers and maintainers.

To avoid placing an unbalanced load on support poles, temporary or permanent stays, struts or anchor wires should be installed at any location where the cable is to be tensioned.

7.6.3.3.6 Aerial pathway systems dedicated to telecommunications cabling

Wind vibration damping should be provided where high winds are identified as a risk.

Solutions include the following:

- cables with intrinsic resistance to Aeolian vibration;
- where aerial cables are integrated with a catenary wire in a “figure of eight” cross-section, the cable should be twisted between each point of suspension (or with one twist per 10 m between points of suspension);
- for other cables, wind vibration dampers should be added as shown in the example in Figure 9).

NOTE The dampers reduce Aeolian vibrations (resonant vibration caused by low velocity wind blowing across a cylindrical cable under tension.

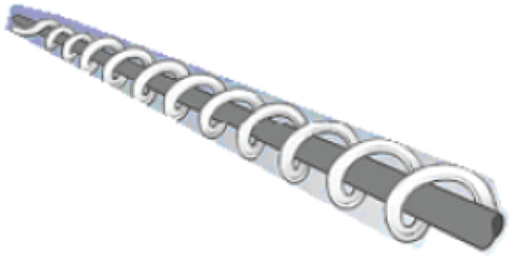


Figure 9 – Example of wind vibration damper

7.7 Spaces

7.7.1 Requirements

7.7.1.1 Spaces and structures inside buildings

7.7.1.1.1 General

Spaces shall not be located

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

Where risk of water ingress exists, a means of evacuating water from the space shall be provided (e.g. a floor drain with backflow prevention).

Dimensions of spaces allocated to entrance facilities and distributors shall take into account the initial volume and future expansion of telecommunications 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) shall be restricted as specified in Annex B.

Signage shall be in accordance with the safety and security objectives for the premises.

7.7.1.1.2 Entrance facilities

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

Upon entering buildings, telecommunications cables that do not comply with the national or local fire regulations or the minimum recommended performance requirements of IEC 60332-1-2 shall either be

- terminated in an entrance facility which is outside the external fire barrier of the building, or
- 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 a cable management system that meets the requirements of 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.

7.7.1.1.3 Equipment rooms

Equipment rooms shall be provided with doors that

- are at least 1 m wide and at least 2,13 m 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.

Where cables are routed using high-level or ceiling-mounted pathway systems, the height of cabinets, frames and racks shall not exceed 75 % of the unobstructed height between the finished floor and any overhead objects such as sprinklers, lighting fixtures, or cameras. Unless the range of cabinets, frames and racks to be used is to be restricted, spaces shall provide a minimum of 2,6 m unobstructed height.

NOTE Cooling requirements or the use of overhead pathway systems or cabinets, frames and racks taller than 2,13 m can necessitate increased unobstructed height requirements.

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.

Floor loading capacity in the equipment room shall be adequate to bear

- both the distributed and concentrated loads of the installed equipment with associated cabling and media,
- loads 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 minimize the generation of dust.

In order to support the operation of a wide range of telecommunications equipment, the temperature and humidity at the air intake of operating equipment shall meet the requirements specified in Class A2 of Table H.1. Increasing the range to A3, A4 or B can restrict the range of equipment that can be accommodated in the equipment room.

7.7.1.1.4 Rooms intended to contain distributors

The room dimensions shall be 3,0 m × 3,0 m minimum.

To provide additional space for equipment installation and maintenance, the minimum room dimensions for distributors containing up to 500 outlets shall be 3,2 m (length) × 3,0 m (width) (see Figure 10a).

NOTE 1 These requirements 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 the front and back of the cabinets or rack to install additional cabling and equipment (see 7.8.2.3).

For distributors containing more than 500 outlets, the minimum room size shall 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 10b).

NOTE 2 This requirement is 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 the front and back of the cabinets or rack to install additional cabling and equipment (see 7.8.2.3).

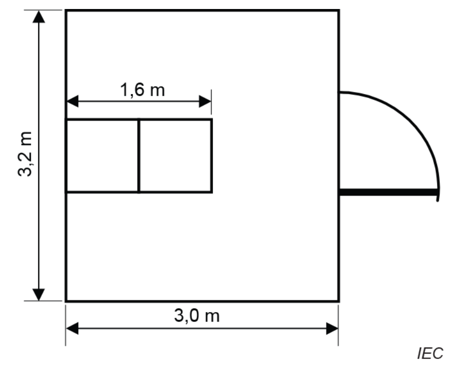


Figure 10a – Minimum room dimensions to support distributors containing up to 500 outlets

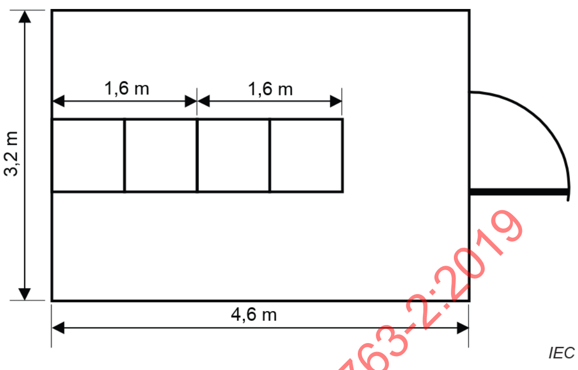


Figure 10b – Minimum room dimensions to support distributors containing between 501 and 1 000 outlets

Figure 10 – Dimensions of rooms intended to contain distributors

Rooms intended to contain distributors shall be provided with access at least 0,9 m wide and at least 2 m high.

Rooms in which cables are routed to cabinets, frames, or racks using underfloor pathways shall be provided with raised floor with an 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 can 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 – in order to support the operation of the widest range of telecommunications equipment the temperature and humidity at the air intake of the operating equipment shall meet the requirements specified in Class B of Table H.1,
- adequate power supply 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.

7.7.1.1.5 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 power supply shall be provided,
- bonds, where required, shall be in accordance with ISO/IEC 30129.

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.

7.7.1.1.6 Access floors

The area of the access floor tile opening shall be at least 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 should be increased to accommodate the support mechanisms for the grommets and brushes.

7.7.1.2 Spaces and structures outside buildings

7.7.1.2.1 General

Access to pathways between buildings is provided by spaces and structures that typically comprise maintenance holes, hand holes and telecommunication cabinets.

Criteria for the selection of the type of spaces and structures include

a) access volume required,

b) location,

c) available space,

d) local regulations,

e) risk of damage.

Maintenance holes and hand holes are used to

- facilitate a safe and secure pathway system between buildings,
- ease the installation or removal of cables,
- enable changes of direction of underground pathway systems.

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.

Covers for maintenance holes and hand holes shall be selected to

- support anticipated physical loads,
- provide appropriate levels of security against unauthorized access to the maintenance hole.

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

7.7.1.2.2 Maintenance holes

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. cable bundles, 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.

Maintenance holes shall be used to enable

- changes of depth of underground pathway systems,
- changes in volume and quantity of underground pathway systems,
- the future installation of additional pathway systems,
- the accommodation of closures.

Maintenance holes shall be used on both sides of a road or rail crossing.

The location and distances between maintenance holes shall be determined in accordance with the relevant instructions for the cables to be installed and the installation technique to be employed.

Routing of cables through maintenance holes shall comply with the installation requirements of 8.9.3.

Pathway systems connected to the maintenance holes shall not act as a drain. However, it is expected that water will pass through the pathway system in some circumstances.

The appropriate type of maintenance holes shall be selected following an analysis of ground water table conditions. A sump-sealed maintenance hole shall not be used where the water table can damage it and/or the pathway systems connected to it.

Sealed (sump-sealed) maintenance holes are useful where the ground water table is low but shall be expected to fill with water. For sump-pumped maintenance holes, the pump shall be maintained in order to prevent gradual ingress of water.

7.7.1.2.3 Hand holes

The location and distances between hand holes shall be determined in accordance with the relevant instructions for the cables to be installed and the installation technique to be employed.

Routing of cables through hand holes shall comply with the installation requirements of 8.9.

7.7.1.2.4 Telecommunications cabinets

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

The design of the telecommunications cabinets shall include any requirements for the accommodation of climate control equipment, electrical connections (including uninterruptible power supplies) and alarm systems to advise of unauthorized access.

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 power supply 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.

7.7.2 Recommendations

7.7.2.1 Spaces and structures inside buildings

7.7.2.1.1 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 telecommunications equipment intended to be housed within the space.

7.7.2.1.2 Entrance facilities

The location of entrance facilities should minimize, as far as practicable,

- the length of bonding conductors to the main earthing terminal of the building,
- the electromagnetic interference produced by electrical service rooms.

The number of pathways and pathway systems to each entrance facility depends both on the number and type of cables to be installed and any segregation requirements imposed by 7.9 or by the access providers.

The pathways and pathway systems to each entrance facility should have adequate capacity to handle growth and additional external service providers.

7.7.2.1.3 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 minimize heat load and increase security.

The minimum distributed floor loading capacity should be 12 kPa.

In equipment rooms containing aisles, separate aisles should be used for telecommunications and power supply cabling.

Where it is not possible to allocate separate aisles to telecommunications cabling and power supply cabling, both horizontal and vertical segregation should be provided by

- using different rows of tiles in the aisles for power and telecommunications cabling, with the power and telecommunications cables as far apart from each other as is practicable,
- installing the telecommunications 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.

7.7.2.1.4 Rooms intended to contain distributors

Floors, walls and ceiling should be selected and treated to minimize 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.

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.

7.7.2.1.5 Access floors

Access floor tile openings should

- be no larger than required and should use gaskets, brushes, or other method to minimize loss of underfloor pressure,
- have edging or grommets that do not interfere with placement of frames and cabinets.

Access floor tile openings for cabinets should be placed under the cabinets, where cabinets are intended to be placed or at another 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.

7.7.2.2 Spaces and structures outside buildings

Telecommunications cabinets should be provided with

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

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.

Where telecommunications cabling and power supply cabling are contained within a closure, access to power supply cabling shall be restricted according to local regulations.

NOTE If power supply cabling and telecommunications cabling are installed without physical barrier between the two systems, work on either cabling system can 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 telecommunications 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 telecommunications cabling shall not be interchangeable with the sockets or plugs used for power supply 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 can 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

7.8.1.4.1 General

Cabinets, frames and racks (or the closures within them) shall provide the necessary levels of physical and environmental protection for the telecommunications 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 telecommunications 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. cable bundles, 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. cable bundles, 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 and allow the required airflow into and out of equipment as specified by the equipment manufacturer/supplier,
- fittings are provided for bonding of telecommunications equipment and cabling to the protective and functional earthing systems,
- adequate ventilation is provided for anticipated telecommunications equipment,
- cable segregation requirements of 7.9 are met.

7.8.1.4.2 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.

7.8.1.4.3 Cabinets, frames and racks containing, or intended to contain, active equipment

In addition to the recommendations of 7.8.1.4.2, 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 7.8.1.4.2 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.

7.8.1.5 Closures

The closures shall be large enough to allow management of the cable and cable elements to be accommodated, taking into account the bend radius requirements defined in the instructions provided by the telecommunications cable manufacturer and/or supplier. Where instructions are not available,

- for closures containing cables the radius applied shall be in accordance with 7.6.2.1.2,

- for closures containing cable elements, the radius shall be 30 mm.

The closures shall be located such that it is possible to undertake subsequent measurements, repair, expansion or extension of the installed cabling with minimal disruption.

The cable entrance to closures shall

- maintain the environmental performance of the closure,
- provide the necessary cable support and prevent kinking at the point of entry into the closure,
- provide strain relief for the cable if not already done by separate fixtures within the closure,
- be capable of accepting suitable glands.

7.8.2 Recommendations

7.8.2.1 Distributors within rooms

Distributors should be located in dedicated rooms.

Distributors should be located in cabinets, frames or racks.

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 telecommunications cabling and power supply 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.

Connection points within floor-standing cabinets, frames and racks should be located between 0,15 m and 2,1 m above the finished floor.

7.9 Segregation of telecommunications cabling and power supply cabling inside buildings

7.9.1 General

Subclause 7.9 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 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 for conducted and radiated disturbances (e.g. power supply cabling),
- the 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,

  NOTE 1 "Deformed" power supplies are outside the scope of this document and can require additional engineering practices.

- the telecommunications 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) between defined groups of power supply and telecommunications cables. The general reduction of electromagnetic interference within buildings is primarily achieved by the use of effective bonding networks (see ISO/IEC 30129). Local regulations for safety can contain different segregation requirements. In these circumstances, safety has highest priority but the more stringent requirement shall take precedence.

NOTE 2 Power supply cabling outside buildings can carry high voltages and currents which render the above assumptions invalid and separation distances of many metres can be required.

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 should be increased.

Specific items of electrical equipment and the power supply cabling associated with them can 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 10 provides minimum recommended separation distances between metallic telecommunications 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 product 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. 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 10 – Separation recommendations between metallic telecommunications 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 telecommunications cables and power supply cables depend upon

- the electromagnetic immunity of the telecommunications cable measured as
  - coupling attenuation for screened balanced cables,
  - transverse conversion loss (TCL) for unscreened balanced cables,
  - screening attenuation for unbalanced (coaxial) and twin axial cables,
- the construction of the power supply cable,
- the quantity of, and type of electrical circuit provided by, the power supply cables,
- the presence of dividers between the telecommunications cables and power supply cables.

The divider can take the form of a separate pathway system/cable management system for the telecommunications cable and/or the power supply cables or a physical divider within a common pathway system. In the latter situation, electromagnetic performance of the barrier shall be at least that of the pathway/cable management system.

The minimum separation requirement, A, is calculated by multiplying the minimum separation, S, obtained from Table 12 by the power cabling factor, P, from Table 13. The value of S obtained from Table 12 depends upon the classification of the telecommunications cable of Table 11 as shown in Figure 11. A flowchart approach to this calculation is shown in Figure 12.

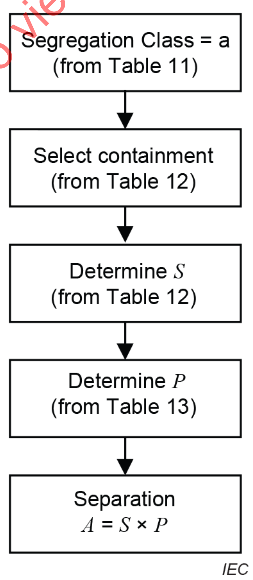


Figure 11 – Process of determining cable separation

The separation requirements for segregation Class a in Table 12 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.

Table 11 – Classification of telecommunications cables

Telecommunications cable			Segregation Class
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	
≥ 80 [a]	≥ 70 − 10 × lg f	≥ 85 [e]	d
≥ 55 [b]	≥ 60 − 10 × lg f	≥ 55	c
≥ 40 [c]	≥ 50 − 10 × lg f [d]	≥ 40	b
< 40	< 50 − 10 × lg f	< 40	a

[a] Balanced cables meeting the Type I coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class d.

[b] Balanced cables meeting the Type II coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class c.

[c] Balanced cables meeting the Type III coupling attenuation requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class b.

[d] Balanced cables meeting the Level 2 TCL requirements of IEC 61156-5 and IEC 61156-6 meet segregation Class b. These cables can deliver performance of segregation Class c or d provided that the relevant requirements are also met.

[e] Coaxial cables in accordance with IEC 61196-7 (ISO/IEC 11801-1, Category BCT-C) meet segregation Class d.

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 12 represent the minimum requirements of this document, 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 12 can restrict the type and use of cables installed in the pathways and cable management systems selected.

Future expansion of both the power supply and telecommunications 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 can require a barrier or greater separation than calculated using this approach.

The free space separation of Table 12 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 12.

Table 12 – Minimum separation, S

Segregation Class (from Table 11)	Free space separation (i.e. without electromagnetic barrier) mm	Containment applied to telecommunications or power supply cabling		
		Open metallic containment [a] mm	Perforated metallic containment [b,c] mm	Solid metallic containment [d] mm
d	10	8	5	0
c	50	38	25	0
b	100	75	50	0
a	300	225	150	0

[a] Applicable to containment with screening performance (DC to 100 MHz) equivalent to welded mesh steel wire mesh cable tray of mesh size 50 mm × 100 mm. 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.

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

[c] Applicable to containment with 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. The screens or armouring of power cables are considered to act as perforated metallic containment if they do not meet this constructional equivalent of solid metallic containment.

[d] Applicable to containment with 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. The assumption underlying the material performance of the conduit is that the product of the permeability and conductivity is greater than 38 H·S/m^2. This performance is not provided by stainless steel, aluminium and non-magnetic materials. A 1,0 mm wall thickness of the same material does not support S = 0 mm.

Table 13 – Power cabling factor, P

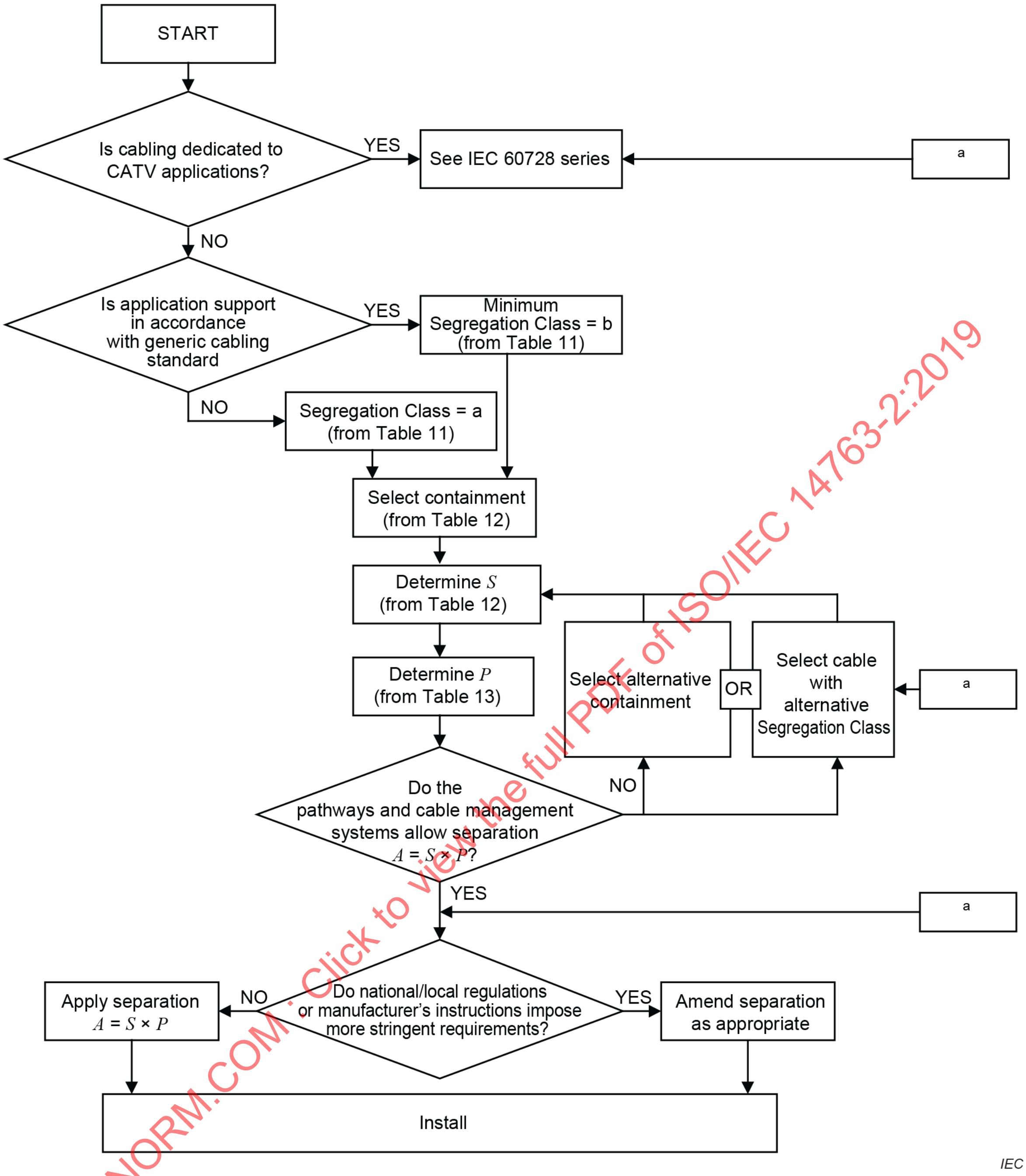
Electrical circuit type [a,b,c]	Quantity of circuits	Power cabling factor, P [d]
20 A 230 V 1-phase	1 to 3	0,2
	4 to 6	0,4
	7 to 9	0,6
	10 to 12	0,8
	13 to 15	1,0
	16 to 30	2
	31 to 45	3
	46 to 60	4
	61 to 75	5
	> 75	6

[a] The power cabling factor shall be used as a multiplier for the calculation of distance A in conjunction with S from Table 12.

[b] 3-phase cables shall be treated as three 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 their current ratings, i.e. a 100 A 50 V DC cable = five 20 A cables (P = 0,4).



[a] 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 12 are applied.

Figure 12 – Flowchart for cable separation calculation

The applicable minimum separation requirement, A, is the minimum separation between the telecommunications cables and power supply 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 telecommunications cables and power supply cables within a single pathway system, or in parallel pathway systems, without dividers,

a) A is the minimum separation between the telecommunications cables and power supply cables including all allowances for cable movement between their fixing points (see Figure 13a and Figure 15),

b) where no fixing or restraint is present, A is assumed to be 0 mm (see Figure 13b).

For telecommunications cables and power supply 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 14a), 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 14b), unless additional cable fixing or restraint is present (see a) above).

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

Power supply cables and cables of other "trades" shall not be installed within the same cable bundle or in the same compartment of a pathway or pathway system as telecommunications cables unless physical separation is maintained or provided.

Where power supply 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 7.9.2 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 each side,
- the telecommunications cables and power supply cables are enclosed in separate trunking or conduit,
- local regulations concerning fire barriers are complied with,
- IEC 60364-5-52 is taken into account.

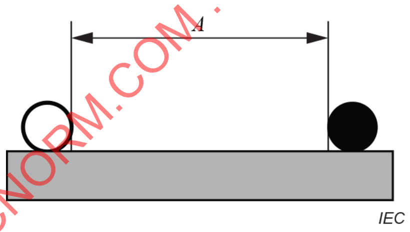


Figure 13a – Separation with restraint

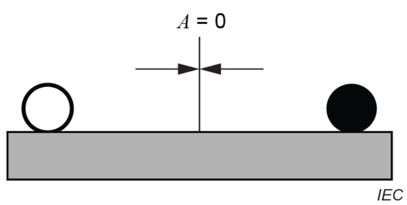


Figure 13b – Separation without restraint

● = mains power cabling
○ = telecommunications cabling

Figure 13 – Separation of power supply and telecommunications cables without dividers

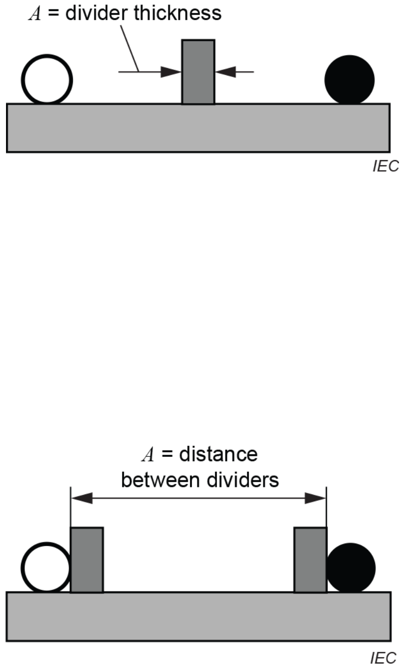


Figure 14a – Separation with single divider

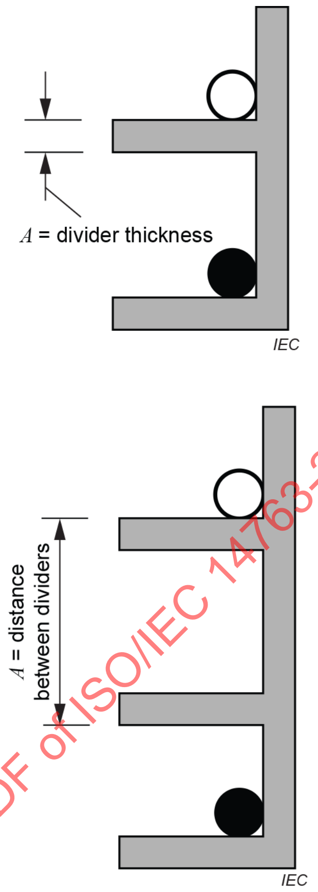


Figure 14b – Separation with multiple dividers

● = mains power cabling

○ = telecommunications cabling

Figure 14 – Assumed minimum separation of power supply and telecommunications cables with dividers

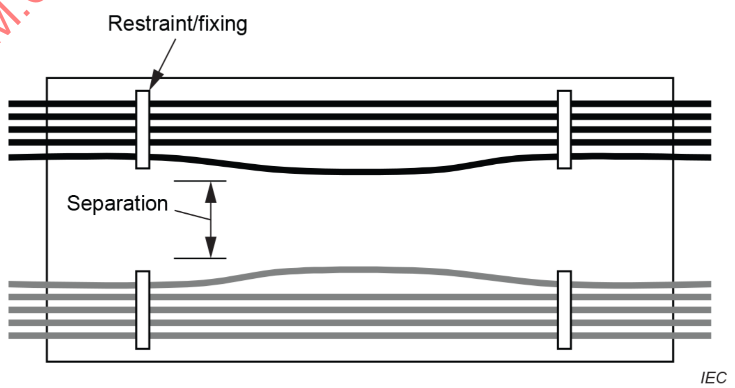


Figure 15 – Example of cable separation distance

7.9.2.2 Conditions for zero segregation

The following conditions for zero segregation are additional to those provided by solid metallic containment of Table 12.

No segregation is required between telecommunications cabling and power supply cabling (other than that required by national or local regulation or IEC 60364-5-52) provided that the telecommunications cabling is application(s)-specific and the application(s) support(s) a zero segregation relaxation.

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

- the telecommunications cables meet the requirements of segregation Classes b, c or d of Table 11, and
- the environmental classification of the space containing the telecommunications cabling complies with electromagnetic classification E_1 of ISO/IEC 11801-1, and
- the power supply conductors comprising a circuit are either
  – within an overall sheath and provide a total current no greater than 100 A, or
  – twisted, taped or bundled together and provide a total power no greater than 10 kVA.

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 The selection of this segregation approach and the planning of the pathway can 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 Segregation of underground telecommunications cabling and power supply cabling outside buildings

7.10.1 General

Subclause 7.10 specifies requirements and recommendations for unscreened and screened balanced, and coaxial, cables used within cabling in accordance with the ISO/IEC 11801 series. Where appropriate, the requirements and recommendations are specific to particular cable specifications.

The segregation requirements and recommendations of 7.10 are applicable to all telecommunications cables containing conducting components (whether or not used for signal transmission) and power supply cabling operating at ≤ 25 kV.

The segregation requirements and recommendations of 7.10 are those required with regard to protection (of the telecommunications cabling and attached equipment from physical damage) and electromagnetic interference (EMI). Local regulations for safety can contain different segregation requirements. In all circumstances, safety has highest priority but the more stringent requirement shall take precedence.

Where manufacturers' instructions require more stringent installation practices, these shall be followed.

7.10.2 Power supply cabling ≤ AC 1 000 V RMS or DC 1 500 V

7.10.2.1 Requirements (protection)

The minimum separation between telecommunications cables and power supply cables shall be 0,05 m.

7.10.2.2 Recommendations (protection)

Where the telecommunications cables and power supply cables are required to cross, an additional barrier should be installed between the cables to provide electrical isolation.

7.10.2.3 Requirements (EMI)

The minimum separation from telecommunications cables shall be in accordance with the requirements of 7.9.2. Where information enabling the calculations of 7.9.2 is not available the minimum separation shall be 1 m.

Where the telecommunications cables and power supply cables are required to cross, the angle of their crossing shall be maintained at 90 degrees on both sides of the crossing for a distance no less than the relevant minimum separation.

7.10.2.4 Recommendations (EMI)

None

7.10.3 Power supply cabling > AC 1 000 V RMS or DC 1 500 V

7.10.3.1 Requirements (protection)

Unless either the telecommunications cables or the power supply cables are installed in non-conducting conduit or duct or separated by a non-conducting barrier, the minimum separation between telecommunications cables and power supply cables shall be 0,3 m (see Figure 16).

If either the information technology cables or the power supply cables are installed in non-conducting conduit or duct or they are separated by a non-conducting barrier of equivalent insulation performance, then no separation is required (additional to that provided by the barrier).

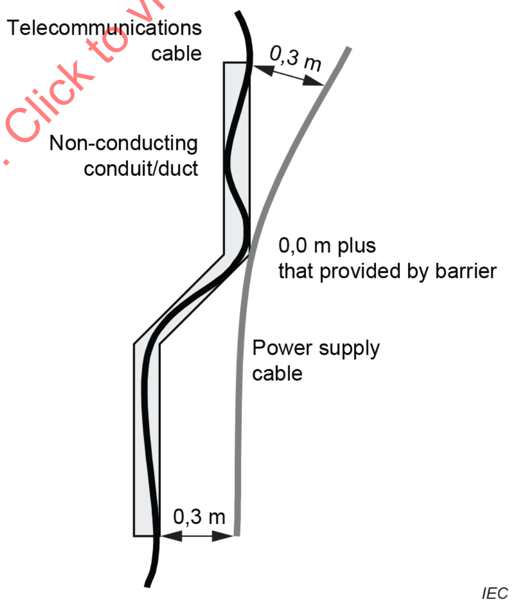


Figure 16 – Example showing the protection of underground information technology cables when located next to power supply cables

Where the telecommunications cables and power supply cables are required to cross (see 7.10.3.3),

- the upper cable shall be the telecommunications cable,

- if a minimum separation of 0,3 m is maintained at the point of crossing, the telecommunications cable shall be provided with mechanical protection, extending at least 0,5 m each side of the crossing,
- if a minimum separation of 0,3 m cannot be maintained at the point of crossing, both the telecommunications cable and the power supply cable shall be installed in a non-conducting conduit or duct or separated by a non-conducting barrier, extending at least 0,5 m each side of the crossing.

7.10.3.2 Recommendations (protection)

None.

7.10.3.3 Requirements (EMI)

Where the telecommunications cables and power supply cables are required to cross, the angle of their crossing shall be maintained at 90 degrees on both sides of the crossing for a distance no less than the applicable minimum separation requirement.

7.10.3.4 Recommendations (EMI)

None.

7.10.4 Earthing systems

7.10.4.1 General

Where there are buried parts of earthing systems, clearances should be maintained from earth electrodes and, in general, from metallic buried parts of power cables.

7.10.4.2 Requirements (protection)

The segregation requirements of Table 14 apply between telecommunications cabling and parts of buried earthing systems provided that

- if the telecommunications cable is direct buried its sheath has a dielectric strength of at least 1,5 kV at 50 Hz,
- if the telecommunications cable is installed in a non-conducting conduit or duct, the conduit or duct is constructed of a material having an equivalent dielectric strength.

Further information is provided in ITU-T K.88.

In locations identified as containing hot zones, the installer shall contact the owner of the HV installation concerning the risks (probability, duration) and the size of the hot zone.

7.10.4.3 Recommendations (protection)

In all cases as great a separation as is practicable should be provided between the telecommunications cables and buried metallic parts of power cables.

Where it is necessary to run cables closer together than the distances given in Table 14 and Table 15, cables containing metallic parts shall be fitted in an insulated outer sheath. The outer sheath should extend sufficiently to ensure compliance with the limits.

Table 14 – Minimum distance between telecommunications cables and earthed electrodes of power systems in rural and urban environments

Soil resistivity [a] Ωm	Low voltage (≤ 1 kV) (neutral earthing electrode [b])	High-voltage (≤ 25 kV) earthing system (with isolated neutral or arc suppression coil)		High-voltage (≤ 25 kV) earthing system (directly earthed neutral)	
		Rural	Urban	Rural	Urban
< 50		2 m	See 7.10.3.1	4 m	See 7.10.3.1
50 to 500		4 m		8 m	
500 to 5 000	2 m	8 m		20 m	
5 000 to 10 000		8 m		40 m	
> 10 000		8 m		80 m	

[a] There is no International Standard for such a measurement; however further information can be found in IEEE Std 81.

[b] This distance is considered sufficient to avoid irreparable damage to the cable elements or construction of the telecommunications cables due to lightning on the power supply cabling.

Table 15 – Minimum distance between telecommunications cables and earthed electrodes of power systems in accordance with ITU-T K.8

Soil resistivity [a] Ωm	High-voltage (≤ 132 kV) earthing system (with isolated neutral or arc suppression coil)		High-voltage (≤ 132 kV) earthing system (directly earthed neutral)	
	Rural	Urban	Rural	Urban
< 50	5 m	2 m	10 m	5 m
50 to 500	10 m	5 m	20 m	10 m
500 to 5 000	10 m	10 m	100 m	50 m
5 000 to 10 000	20 m	10 m	100 m	50 m
> 10 000	20 m	10 m	200 m	50 m

[a] There is no International Standard for such a measurement; however further information can be found in IEEE Std 81.

7.10.5 Other infrastructures

7.10.5.1 Recommendations

Unless national or local regulations specify other requirements, the segregation and protective measures of Table 16 should be observed. Additional separation can be applied to allow access for maintenance and repair of the information technology cabling and pathways.

Table 16 – Minimum clearances and protective measures at crossings between telecommunications cables and various underground services

Other services	Clearances at crossing	Protection measures to be applied to the telecommunications cabling
Inflammable gas or liquid ducts (operating pressure ≤ 500 kPa)	0,5 m	Conduit or duct extending for at least 1,0 m each side of the crossing.
Inflammable gas or liquid ducts (operating pressure > 500 kPa)	1,5 m	Conduit or duct extending for at least 1,0 m (ffs) each side of the crossing.
Water pipes sewers and ducts	0,3 m	Conduit or duct extending for at least 0,5 m each side of the crossing.
District heating pipes	1,0 m	Conduit or duct extending for at least 0,5 m (ffs) each side of the crossing.
ffs – for further study		

7.11 Segregation of aerial telecommunications cabling

7.11.1 General

Subclause 7.11 specifies requirements and recommendations for unscreened and screened balanced, and coaxial, cables within cabling in accordance with the ISO/IEC 11801 series. Where appropriate, the requirements and recommendations are specific to particular cable specifications.

The segregation requirements and recommendations of 7.11 are those required with regard to protection (of the telecommunications cabling and attached equipment from physical damage) and electromagnetic interference (EMI). Local regulations for safety can contain different segregation requirements. In all circumstances, safety has highest priority but the more stringent requirement shall take precedence.

The proximity and crossing of telecommunications cabling and overhead power supply infrastructures is addressed in 7.11.2.

The sharing of telecommunications cabling with overhead infrastructures carrying power supply cables ≤ AC 1 000 V RMS or DC 1 500 V is addressed in 7.11.3.

The sharing of telecommunications cabling with overhead infrastructures carrying power supply cables > AC 1 000 V RMS or DC 1 500 V is addressed in 7.11.4.

Precautions shall be taken in order to avoid contact with parts of power supply cables and associated equipment. Telecommunications cables shall be lower than power supply cables.

The methods (components and construction techniques) employed to maintain the segregation requirements shall take into account all relevant operating and environmental conditions (e.g. sun, rain, wind, ice).

7.11.2 Overhead power supply infrastructures

7.11.2.1 Requirements (protection)

Unless national or local regulations specify other requirements, the segregation and protective measures of 7.11.2 shall be applied.

If the supporting structures of the telecommunications cabling are non-conducting (e.g. wooden) or insulated, the minimum clearance between aerial telecommunications and overhead power supply cabling shall be as specified in Table 17.

Table 17 – Minimum clearances between aerial telecommunications and overhead power supply cabling

Infrastructure element	Overhead power supply ≤ AC 1 000 V RMS or DC 1 500 V			Overhead power supply > AC 1 000 V RMS or DC 1 500 V	
	Power supply cables (insulated)	Power supply cables (uninsulated)	Power supply poles	Power supply cables/ conductors	Power supply poles
Telecommunications cables	0,5 m	1,0 m	0,5 m	2 m	1,0 m
Telecommunications poles	0,5 m	1,0 m	0,5 m	2 m	1,0 m

Where power supply cables (≤ 1 000 V AC or 1 500 V DC) and telecommunications cables are fixed on the external surfaces of buildings or other structures, they shall be separated by at least

- 1,0 m if one or both are uninsulated,
- 0,2 m if both are insulated.

7.11.2.2 Recommendations (protection)

The horizontal separation between telecommunications and power supply cabling infrastructures should be greater than the height of the highest infrastructure (see Figure 17) unless

- measures are implemented to avoid possible contact between aerial telecommunications cables and overhead power supply cables following mechanical faults (e.g. fallen wires or supporting structures), or
- the telecommunications cables are insulated to the highest voltage present.

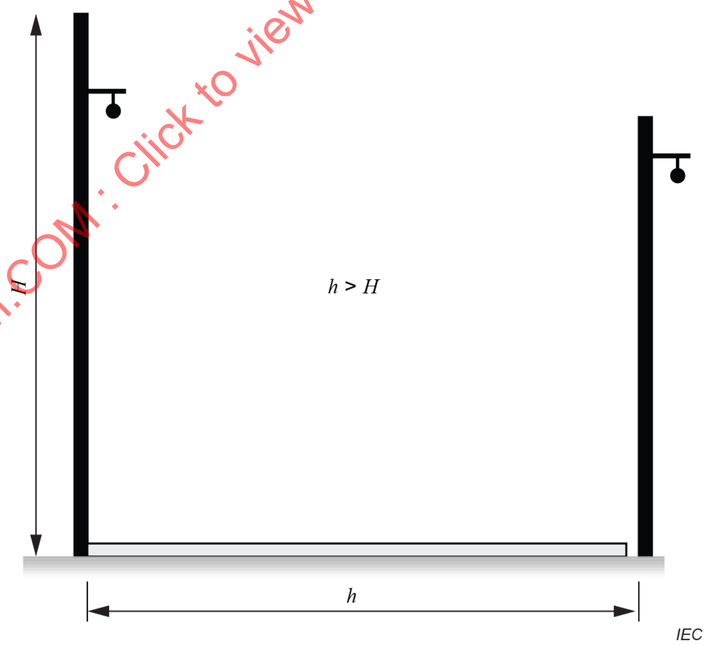


Figure 17 – Separation of adjacent infrastructures

The pathway system for telecommunications cables should be underground rather than overhead when crossing under HV lines exceeding 25 kV.

7.11.2.3 Requirements (EMI)

See ITU-T K.109 for further information.

7.11.2.4 Recommendations (EMI)

None

7.11.3 Sharing of infrastructures carrying ≤ 1 000 V AC (1 500 V DC)

7.11.3.1 Requirements (protection)

The sharing of supporting structures with power supply cabling for telecommunications cabling implies the installation of

- telecommunications cables,
- fittings used to attach the telecommunications cabling to the poles,
- stays or struts,
- closures and accessories (connection, protection, amplification, radio).

Fittings used to attach the telecommunications cabling to the supporting structures shall be specified to have a voltage insulation of 4 kV at 50 Hz for one minute (minimum).

Telecommunications cables shall always be fixed below power supply cabling and associated equipment (including lighting device and feeder cables).

Closures and accessories shall be installed below the telecommunications cables. The dimensions and locations of such closures and accessories shall be agreed between the owner of the supporting structure and the installer of the telecommunications cabling.

The telecommunications cabling shall be supported such that the minimum vertical distance on the supporting structure between power supply and telecommunications cabling and fittings is at least

a) 1 m in cases where power supply conductors have no insulation (see Figure 18),

b) 0,50 m in cases of power supply cables (insulated) (see Figure 18).

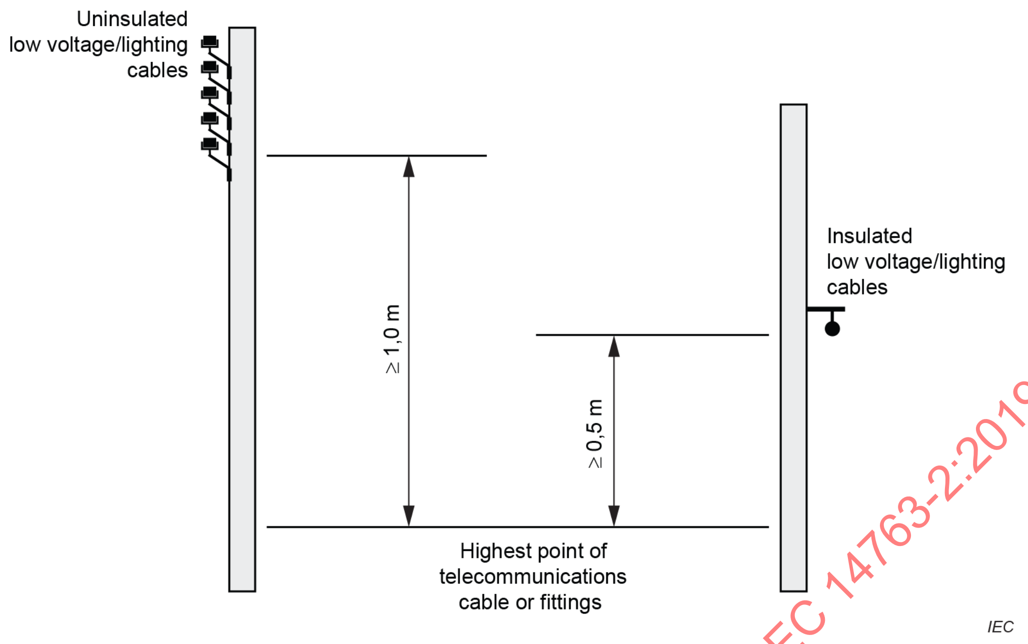


Figure 18 – Separation distances on supporting structures

The minimum separation at any point, allowing for sag produced by operating and environmental conditions, between telecommunications cables and insulated power supply cables shall be 0,3 m.

If the supporting structure has, or can in the future have, a lighting device fitted, the telecommunications cabling and fittings shall be installed at least 0,2 m below the lowest point of the location of the device and its feeder cable (see Figure 19).

Unless technical and contractual agreement for joint use has been obtained, earthing systems for telecommunications cabling shall not be installed on poles containing, or intended to contain, the earthing systems of the power supply cabling.

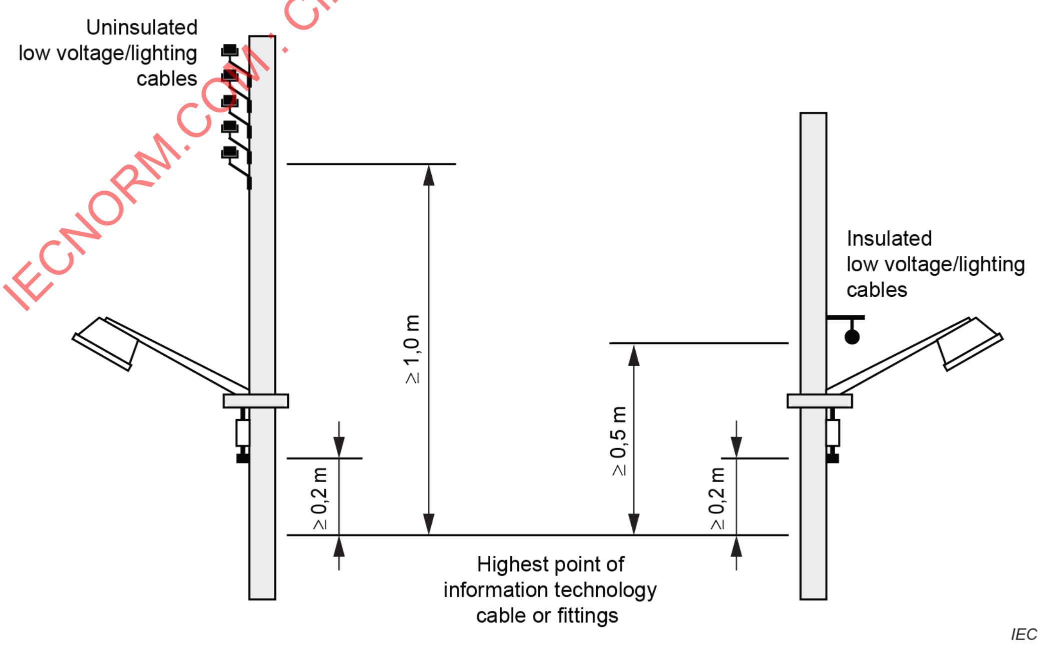


Figure 19 – Separation distance on supporting structures with lighting devices

7.11.3.2 Recommendations (protection)

A marker should be placed to show the voltage levels of cables above the telecommunications cables.

7.11.3.3 Requirements (EMI)

See ITU-T K.108 for further information.

7.11.3.4 Recommendations (EMI)

None.

7.11.4 Sharing of infrastructures carrying > 1 000 V AC (1 500 V DC)

7.11.4.1 Requirements (protection) of infrastructures

The following requirements apply to the sharing of infrastructure carrying < 25 kV AC.

The telecommunications cabling shall be supported such that the minimum vertical distance on the supporting structures between power supply and telecommunications cabling and fittings, is at least 2 m.

The minimum separation at any point, allowing for sag produced by operating and environmental conditions, between telecommunications cables and insulated power supply cables shall be 2,0 m.

Unless technical and contractual agreement for joint use has been obtained, earthing systems for telecommunications cabling shall not be installed on poles containing, or intended to contain, the earthing systems of the power supply cabling.

7.11.4.2 Recommendations (protection)

A marker should be placed to show the voltage levels of cables above the telecommunications cables.

7.11.4.3 Requirements (EMI)

See ITU-T K.108 for further information.

7.11.4.4 Recommendations (EMI)

None

7.12 Planning for repair

The planning of the installation should take into account the procedures to be applied following damage to the installed cabling – which is assumed to occur during the lifetime of an installation.

Planning options which address the practicality of repairs include

a) the provision of resilience by means of cabling redundancy which affects the timescale within which a repair needs to be effected,

b) the selection of pathway and pathway systems and/or the installation of service loops to simplify the repair process,

c) the sub-division of the fixed cabling to introduce cable sections to simplify replacement of such sections taking account of predicted operational access restrictions,

d) the allocation of performance margin to allow for the chosen repair procedures,

e) the maintenance of service provision by means of temporary repairs which precede the final corrective action.

Where damage occurs, corrective actions include one or more of the following procedures:

- repair of damaged components;
- replacement of damaged components;
- installation of additional components to provide the required function.

The selection of the appropriate procedure should take into account

1) the available margin between the initial (i.e. pre-damaged) performance of the cabling and the requirements of the service provided over the cabling,
2) the objectives of the user for the transmission performance of the cabling, e.g. to maintain the initial performance (perhaps to support network evolution) or to allow for gradual degradation during repair(s) subject to the available margin,
3) financial constraints taking into account the available margin and the objectives of the user,
4) the media and type of cables to be repaired,
5) practicality constraints,
6) time constraints which can be affected by a range of factors including the practicality constraints.

The user should ensure that documentation exists which defines contingency planning, procedures for fault analysis and for initiating, monitoring and recording all repairs undertaken.

7.13 Cabling – Requirements

7.13.1 General

The installation of the cabling shall be in accordance with 7.14.

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-conductive-parts (e.g. armouring, strain relief members of optical fibre cables) that are part of the telecommunications cable construction shall be in accordance with 8.9.1.1.1.

7.13.2 Unscreened cabling

The cabling shall be terminated in accordance with 8.10.2.

7.13.3 Screened cabling

The cabling shall be terminated in accordance with 8.10.2 and 8.10.3.

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

7.13.4 Optical fibre cabling

None

7.14 Planning and assessment of cabling in support of remote powering objectives

7.14.1 General

The principal concerns associated with the delivery of power are

a) global impact: the associated increase of channel attenuation/insertion loss due to the increased temperature of installed cables, which unless balanced by reduced installed lengths, will have a negative effect on channel attenuation and associated parameters (which can affect system performance),

b) localized impact: increases in the operating temperature of the cables (exceeding their maximum specified operating temperature),

c) damage to connecting hardware contacts: where mating and de-mating occurs while the power supply current is flowing.

Further information is provided in ISO/IEC TS 29125:2017.

Planning and assessment of remote powering installations of Category RP3 (as specified in 5.3.4) in relation to the effects of elevated temperatures is addressed in 7.14.2.

Planning and assessment of remote powering installations of Category RP2 (as specified in 5.3.4) in relation to the effects of elevated temperatures is specified in Clause I.3.

Remote powering installations of Category RP1 (as specified in 5.3.4) do not require planning and assessment in relation to the effects of elevated temperatures but restrict the use of evolving remote powering applications.

The planning and assessment of cabling in relation to connecting hardware is addressed in 7.14.3.

7.14.2 Remote powering installations of Category RP3

7.14.2.1 General

Table 18 summarizes the limitations of channel lengths of Class D to F_A with regard to global impact of thermal effects of elevated temperatures (due to either remote powering or ambient temperature).

Table 18 – Technology-independent channel length vs. temperature

T_{global} °C	Channel length m		
	Total length of cords m		
	10	15	20
20	100	98	95
25	98	95	93
30	95	93	90
35	93	90	88
40	90	88	86
45	88	85	83
50	85	83	81
55	83	80	78
60	80	78	76
NOTE The channel length values assume the use of cords with an attenuation premium of 50 % and an interpolated temperature coefficient of 0,5 % per °C between 20 °C and 60 °C.			

The application of Table 18 is critical to both planning of new installations and assessment of existing installations. The temperature T_{global} which is used in Table 18 shall be determined as in Equation (2):

$$T_{\text{global}} = \frac{1}{L} \times \sum_{n=1}^{n} \left(T_{\text{ambient-}n} + \Delta T_n\right) \times L_n \tag{2}$$

where

L is the total length of link/channel;

L_n is the length of link/channel having common thermal characteristics – lengths of less than 1 m shall not be considered due to axial dissipation effects;

$T_{\text{ambient-}n}$ is the ambient temperature within length L_n;

ΔT_n is the additional temperature within length L_n due to remote powering.

NOTE Equation (2) assumes that the temperature of the cords is lower than T_{global}. Where this is not the case, the more detailed Equation (I.1) in Clause I.2 can be applied.

The calculation of T_{global} requires knowledge of the predicted ΔT_n due to remote powering and the ambient temperatures $T_{\text{ambient-}n}$ (actual or predicted) at all points along the length of the link/channel.

Table 19 provides information on predicted temperature rises (i.e. localized impact) due to the installation of multiple cables in different installation conditions.

Table 19 contains values of ΔT_n due the installation of different numbers of cables in approximately circular cable bundles within different installation environments. Table 19 includes data for the number of cables in a cable bundle (N) of up to 216. The same data would be applicable to cable bundles of 24 cables in close proximity as indicated in configurations of Table 19.

In all cases it is assumed that each cable contains eight conductors and that each conductor is carrying 0,5 A.

Table 19 comprises four different installation environments (designated as A, B, C and E/F as described in IEC 60364-5-52) and described in Clause I.4. The three examples of cables shown in Table 19 are specified in terms of resistance R (Ω/m) and diameter D (m). Table 19 also includes, for each installation environment, a formula which is a simplified approximation to the model defined in ISO/IEC TS 29125:2017. This allows the calculation of ΔT_n for other cables for which the values of R and D are known.

In all cases, values of ($T_{\text{ambient-}n}$ + ΔT_n) shall be ≤ 60 °C (or the manufacturer's specified upper temperature of operation).

Table 19 – Temperature changes for various cable bundle sizes

Installation condition E/F – Ventilated								
Cable R and D[a]	ΔT (°C) $\approx \left(0{,}8\times N+\frac{0{,}0578\times\sqrt{N}}{D}\right)\times R$							
	No. of cables (N)							
	6	12	24	48	72	96	144	216
0,095 Ω/m 5,0 mm	3,0	5,0	7,0	11,0	15,0	18,0	24,0	32,5
0,075 Ω/m 7,0 mm	2,0	3,0	4,5	7,0	9,5	12,0	16,0	22,0
0,065 Ω/m 7,7 mm	1,5	2,5	4,0	6,0	8,0	10,0	13,5	18,5
[a] Within the formula, D is in metres, e.g. for cable diameter 5 mm, D = 0,005.								

Installation condition C – Unperforated tray								
Cable R and D[a]	ΔT (°C) $\approx \left(0{,}8\times N+\frac{0{,}0772\times\sqrt{N}}{D}\right)\times R$							
	No. of cables (N)							
	6	12	24	48	72	96	144	216
0,095 Ω/m 5,0 mm	4,0	6,0	9,0	14,0	18,0	21,5	28,5	38,0
0,075 Ω/m 7,0 mm	2,5	3,5	5,5	8,5	11,5	14,0	18,5	25,0
0,065 Ω/m 7,7 mm	2,0	3,0	4,5	7,0	9,5	11,5	15,5	21,0
[a] Within the formula, D is in metres, e.g. for cable diameter 5 mm, D = 0,005.								

Installation condition B – Trunking/conduit								
Cable R and D[a]	ΔT (°C) $\approx \left(0{,}8\times N+\frac{0{,}12\times\sqrt{N}}{D}\right)\times R$							
	No. of cables (N)							
	6	12	24	48	72	96	144	216
0,095 Ω/m 5,0 mm	6,0	9,0	13,0	19,5	25,0	29,5	38,0	**
0,075 Ω/m 7,0 mm	3,5	5,0	7,5	12,0	15,0	18,5	24,0	32,0
0,065 Ω/m 7,7 mm	2,8	4,0	6,0	9,5	12,5	15,0	19,5	26,0
NOTE ** indicates a temperature in excess of 60 °C (assuming an ambient of 20 °C), which represents unacceptable localized heating.								
[a] Within the formula, D is in metres, e.g. for cable diameter 5 mm, D = 0,005.								

Installation condition A – Insulation								
Cable R and D[a]	**ΔT (°C)** $\approx \left(0{,}8\times N+\frac{0{,}27\times\sqrt{N}}{D}\right)\times R$							
	No. of cables (N)							
	6	12	24	48	72	96	144	216
0,095 Ω/m 5,0 mm	13,0	18,5	27,0	39,0	**	**	**	**
0,075 Ω/m 7,0 mm	7,5	10,5	15,5	23,0	29,0	34,0	**	**
0,065 Ω/m 7,7 mm	6,0	8,5	12,5	18,5	23,0	27,5	35,0	**

NOTE ** indicates a temperature in excess of 60 °C (assuming an ambient of 20 °C), which represents unacceptable localized heating.

[a] Within the formula, D is in metres, e.g. for cable diameter 5 mm, D = 0,005.

7.14.2.2 Planning of new cabling

The planning process shall start with the assumption that all cables support remote powering per conductor (i_c) of 500 mA, which allows Table 19 to be employed to calculate ΔT_n along the length of the link/channel.

If the parameters R (Ω/m) and D (m) of the telecommunications cables are not known then the values shown in Table 19 for R = 0,095 Ω/m and D = 0,005 m shall be used.

Subclauses 7.6.2.1.1 and 8.9.2.1 require that cable bundles not contain more than 24 cables. Table 19 assumes these cable bundles to be a generally circular configuration. A circular configuration has the lowest possible surface area for a given cross-sectional area and the temperature rises in such cable bundles are considered to be the greatest. However, it is recognized that installation conditions C, E/F can contain many more than 24 cables in close proximity. However, the larger surface area of such groups of cables with a rectangular cross-section will result in a reduced thermal impact. Where such cable groups are planned, the values of ΔT for the relevant N of Table 19 should be multiplied by the relevant factor shown in Table 20.

Table 20 – Reduction factors for rectangular cable groups

Width:height ratio of cable group	1:1	2:1	3:1	4:1	5:1	6:1	7:1	8:1	9:1	10:1
ΔT multiplier	0,89	0,84	0,77	0,71	0,66	0,62	0,59	0,56	0,53	0,51

Following the calculation of T_{global} for the worst-case link design (in terms of N and installation environment), the physical characteristics of the building shall be assessed to determine if any resulting reductions in channel length from Table 18 can be accepted.

NOTE For example, if a channel length of 90 m can be accepted (e.g. 80 m + 10 m) then from Table 18 the allowable T_{global} = 45 °C.

If the reduced channel lengths are acceptable in terms of the physical characteristics of the building, then no further action is required and no additional administration overhead is required.

If the reduced channel lengths are incompatible with the physical characteristics of the building, then either

a) a Category RP2 implementation may be considered by determining an average current over all conductors ($i_{c\text{-}average}$) of less than 500 mA (by application of Clause I.3) with an administrative overhead which forces operational controls, or

b) a series of possible mitigations can be considered to lower ΔT_n in order to support the Category RP3 objective including
   1) separation of cable bundles to render N = 24 (see 8.9.2.2),
   2) creation of smaller cable bundles with separation to reduce N further (see 8.9.2.2),
   3) cables with lower R and/or higher D,
   4) changes to the installation environment,
   5) reduction in $T_{\text{ambient-}n}$.

7.14.2.3 Assessment of existing cabling

An existing installation cannot be amended to produce lower link/channel length values and the installation environment is generally fixed with few possibilities for mitigation. It is necessary to review the documentation for the installation for the relevant maximum values of links and channels.

For assessment the longest channels/links shall be analysed to determine the acceptable value of T_{global} from Table 18.

The process of determining compatibility with the acceptable T_{global} uses information of Table 19 and Table 20 for the actual cable design (R (Ω/m) and D (m)) in conjunction with measured values of $T_{\text{ambient-}n}$. This will allow the comparison of the real installation with the viable value of T_{global}.

If the result is lower than the allowed T_{global} then no more needs to be done.

If the result is higher than the allowed T_{global} then possible mitigations can be considered, including

a) a Category RP2 implementation may be considered by determining an average current over all conductors ($i_{\text{c-average}}$) of less than 500 mA (by application of Clause I.3) with an administrative overhead which forces operational controls,

   or

b) a series of possible mitigations can be considered to lower ΔT_n in order to support the Category RP3 objective, including
   1) separation of cable bundles to reduce N,
   2) improvement in ventilation to improve ρ_{u} values within the model of ISO/IEC TS 29125:2017,
   3) reduction in $T_{\text{ambient-}n}$.

Recommendations for cable bundle separation are described in 8.9.2.2.

7.14.3 Connecting hardware

7.14.3.1 General

The repeated de-mating of connections under load can cause damage to the contact sources within the connecting hardware and also, for certain designs of connections, damage to the circuitry within the connecting hardware which is critical to transmission performance.

Further information can be found in IEC 60512-5-2, IEC 60512-9-3 and IEC 60512-99-001.

7.14.3.2 Planning of new cabling

Product test standards have been developed to assess performance under such conditions. Connecting hardware meeting those standards should be employed for new installations of cabling to support remote powering where de-mating under load can occur.

However, if repeated de-mating under load is expected to take place then solutions shall be employed to reduce the technical and/or commercial impact of any physical or electrical damage that can occur.

Reduction of technical impact measures includes

a) labelling and warnings at connection points,

b) simplification of replacement of connections that can be subject to damage (e.g. the use of additional connections to allow cords to be used as a means of repair).

Reduction of contractual impact measures includes labelling and warnings at connection points (see 9.2.2.4.1).

7.14.3.3 Assessment of existing cabling

An existing installation cannot generally be amended to enable simple replacement of damaged connections and, in such circumstances, any restrictions of de-mating under load are limited to administrative actions such as labelling and warnings at connection points (see 9.2.2.4.1).

8 Installation practices

8.1 General

Installations shall be carried out in accordance with the installation specification (see Clause 5), quality planning (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 document. Local regulations, including safety, shall be met.

8.2.2 Power supply cabling

The proper implementation of the requirements of this document assumes that electrical installations, bonding networks and protective measures against overvoltages are undertaken in accordance with the IEC 60364 series and/or local regulations, as appropriate.

8.2.3 Telecommunications cables fire performance

See 7.2.3 and 7.7.1.1.2.

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.

8.2.7 Maintenance holes

Frames and covers of maintenance holes shall be correctly seated.

8.2.8 Closures

Before installing telecommunications cabling within closures containing power supply 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

8.5.1.1 General

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.

Where it is necessary, and relevant permission has been obtained, to open

- covers of maintenance holes or cable management systems, only the minimum number shall be removed and these shall be replaced on completion of works,
- fire barriers and gas seals, they shall be opened only when necessary and resealed on completion of works, and adequate fire stopping shall be installed when the installation is left unattended

8.5.1.2 Inside buildings

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.

8.5.1.3 Outside buildings

8.5.1.3.1 Underground

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

8.5.1.3.2 Aerial

Supporting structures shall be suitably treated to prevent decay.

8.5.2 Recommendations

8.5.2.1 Outside buildings

8.5.2.1.1 Underground

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

8.5.2.1.2 Aerial

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 performance margin,
- avoided in earthquake zones.

8.6 Spaces

8.6.1 Requirements

8.6.1.1 General

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.

8.6.1.2 Maintenance holes and hand holes

The installer shall identify proposed locations, the accessibility and availability of maintenance holes and hand holes according to the installation programme.

The cable entrance to maintenance holes and hand holes shall

a) maintain the environmental and functional conditions of the maintenance hole or hand hole,
b) provide the necessary cable support and prevent kinking at the point of entry,
c) provide strain relief for the cable if not already done by separate fixtures.

Covers of maintenance holes shall be sized according to the maximum foreseeable load.

8.6.1.3 Telecommunications cabinets outside buildings

Telecommunications cabinets shall be installed in a position according to the installation plan and shall

a) minimize the impact on the surrounding environment,
b) be positioned as far as practicable from any source of possible interference (e.g. electricity substation, aerial power plant, radio transmitters),
c) permit easy access for repair and maintenance.

Telecommunications cabinets shall be labelled and identified according to the installation specification.

Any electrical equipment in cabinets shall be installed in a way that avoids damage to it from water.

The cable entrance to a telecommunications cabinet shall

1) maintain the environmental and functional conditions of the cabinet,
2) provide the necessary cable support and prevent kinking at the point of entry,
3) provide strain relief for the cable if not already done by separate fixtures.

8.6.1.4 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 7.7.1.1.2.

8.6.1.5 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 7.7.1.1.4 and 7.7.1.1.5.

8.6.1.6 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.

8.6.1.7 Closures

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

8.6.1.8 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.

8.6.2 Recommendations

8.6.2.1 Maintenance holes and hand holes

Any cabling not installed within a cable management system should be protected from physical damage by use of appropriate sleeving.

8.6.2.2 Telecommunications cabinets outside buildings

Where possible, power supply distribution equipment should be separated from cabling, patch panels and other passive components.

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.

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 specified for the hazard classification of the location (see 5.3.3 and 7.2.4). Optical fibre adapters 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

8.9.1.1 General

8.9.1.1.1 Requirements

Installation of cables and cords shall be in accordance with the instructions supplied by the manufacturers/suppliers of the cables, cords 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 localized 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 telecommunications cabling and power supply cabling shall be segregated in accordance with the requirements of 7.9.

When installing cables, 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 – where no manufacturer's information exists, the tensile load applied shall not exceed 110 N,

   NOTE Unless otherwise stated in the supplier's/manufacturer's specification, the maximum tensile load applied to a cable bundle is that specified for a single cable.

d) protect cables from damage during installation (e.g. stepping on cables or hanging of cable 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 should 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.

Provided that there is no risk of damage to cables or the pathway system, cables may be installed within pathway systems according to the following rules:

1) using all the usable cross-sectional area within
   a) open pathway systems and cable management systems,
   b) openable pathway systems and cable management systems from which covers are removed before installation of cables;
2) using up to 40 % of the usable cross-sectional area within closed pathway systems (e.g. conduit) unless the pathway system contains multiple sections some of which are empty).

The earthing of extraneous-conductive-parts (e.g. armouring, strain relief members of optical fibre cables) that are part of the telecommunications cable construction shall be in accordance with local regulations. Where no local regulation exists, the default procedure is to bond the conductive parts in accordance with ISO/IEC 30129.

8.9.1.1.2 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).

8.9.2 Inside buildings

8.9.2.1 Requirements

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

Telecommunications 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 7.7.1.1.2).

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

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

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

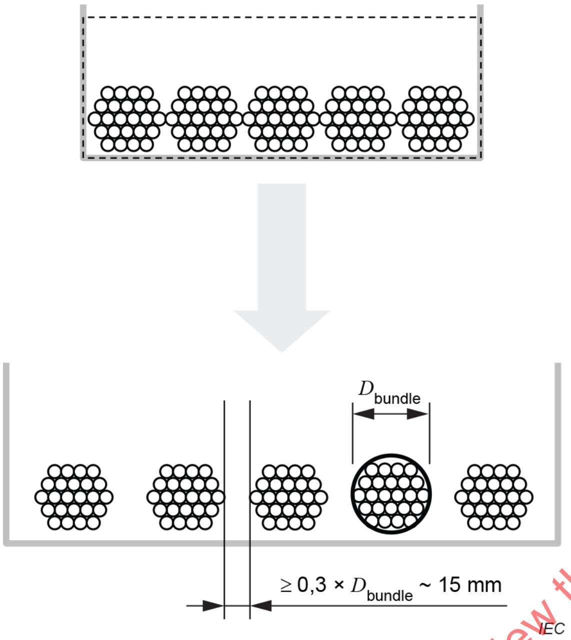
8.9.2.2 Recommendations

Groups of cable bundles subject to remote powering produce higher temperature rises since the centre cables are essentially unventilated.

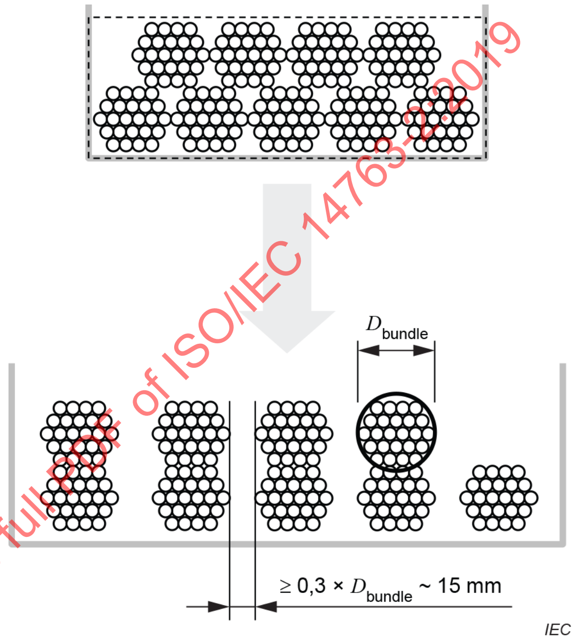
The following recommendations apply to groups of cable bundles of lengths in excess of 1 m. Shorter constructions (e.g. within fire barriers) are known to cool axially.

To minimize the heating within groups of single rows of cable bundles of balanced cables (containing up to 24 4-pair balanced cables in accordance with 8.9.2.1), the cable bundles should be separated by vertical “chimneys” allowing each cable bundle to cool by convection. Figure 20a shows this in a schematic form. A chimney width of 0,3 times the cable bundle diameter (D_{bundle}) has been shown to provide adequate cooling such that each cable bundle behaves as a single, isolated, cable bundle in the applicable installation condition.

To reduce the heating within multiple rows of cable bundles of balanced cables (containing up to 24 4-pair balanced cables in accordance with 8.9.2.1), the cable bundles should be separated by vertical chimneys allowing each cable bundle to cool by convection. However, a chimney width of 0,3 times the cable bundle diameter (D_{bundle}) as shown in Figure 20b only provides limited mitigation and the temperature rise in a cable bundle should be assumed to be twice that of a single, isolated, cable bundle in the applicable installation condition.



a) A single row of cable bundles



b) Multiple rows of cable bundles

Figure 20 – Separation of cable bundles to minimize heating

8.9.3 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.

8.9.4 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 telecommunications 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. Where the cable elements comprise primary coated optical fibre, sleeves shall be applied to protect the optical fibre from damage within the closure.

The bend radii of telecommunications cables and telecommunications cable elements within closures shall be in accordance with the instructions provided by the telecommunications cable manufacturer and/or supplier. Where instructions are not available,

- for closures containing cables the radius applied shall be in accordance with 7.6.2.1.2,
- for closures containing cable elements the radius shall be 30 mm.

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 telecommunications 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) and any untwist length shall not exceed 13 mm. In addition, only a minimum of the cable sheath shall be removed.

The removal of the cable sheath shall 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 the 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 polarization 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 cords and jumpers installed during the installation process.

8.12 Surge protective devices

When telecommunications surge protective devices are installed, bonding of the earth connection of the surge protective device, the information technology equipment and the earthing system shall use a low impedance connection and shall be in accordance with manufacturers' instructions.

If screened cables are used, the screen of the incoming and outgoing cables from the SPD shall be connected to the same potential.

For further information see IEC 61643-22 and ITU-T K.66.

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 document 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 document enables management of the following components:

1) telecommunications cables;
2) telecommunications terminations, joints and closures containing them;
3) telecommunications pathways and pathway systems;
4) telecommunications spaces including cabinets, frames and racks;
5) telecommunications bonding 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 21. The levels shown are based upon implementations of generic cabling in accordance with the referenced cabling design documents.

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

Table 21 – Level of installation complexity

Location	Level of installation complexity		
	No. of fixed cable elements [a]		
	2 to 200	201 to 20 000	> 20 000
External to buildings	Level 3	Level 3	Level 3
Office premises	Level 2	Level 2	Level 3
Industrial premises	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 22. The number of administered ports is defined as the number of user-accessible equipment interfaces including those on the connected equipment.

Table 22 – Level of operational complexity

Location	Level of operational complexity		
	No. of administered ports		
	2 to 100	101 to 5 000	> 5 000
Office premises	Level 1	Level 2	Level 3
Industrial premises	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 23 based upon the installation complexity Level determined from Table 21,
- Table 24 based upon the operational complexity Level of Table 22.

Table 23 – Minimum requirements of administration systems

Infrastructure component	Administration system		
	Infrastructure complexity Level		
	1	2	3
IDENTIFIERS			
Bonds	-	-	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	-	-	-
Cabinets/frames	Yes	Yes	Yes
Cables [a]	-		Yes
Closures (unless indicated by visible termination point labelling)	-	Yes	Yes
Pathways	-	-	Yes
Spaces (at entrances)	-	Yes	Yes
Termination points including joints [b]	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
Termination points including joints [b]	Yes	Yes	Yes
Fixed cabling [c]	Manual	Manual	Electronic

Infrastructure component	**Administration system**		
	Infrastructure complexity Level		
	1	**2**	**3**
IDENTIFIERS			
Bonds	-	-	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	-	-	-
Cabinets/frames	Yes	Yes	Yes
Cables [a]	-		Yes
Closures (unless indicated by visible termination point labelling)	-	Yes	Yes
Pathways	-	-	Yes
Spaces (at entrances)	-	Yes	Yes
Termination points including joints [b]	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
Termination points including joints [b]	Yes	Yes	Yes
Fixed cabling [c]	Manual	Manual	Electronic

[a] Labels at both ends.

[b] Indicating the treatment of cable elements at the termination point or joint and the presence, if any, of unused electrical contacts or optical fibre locations within the connecting hardware.

[c] Manual records include paper-based systems. Electronic records include spreadsheets and databases.

The additional features provided by "enhanced" administration systems in Table 24 can be required by local regulations regarding security of telecommunications service delivery.

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

Table 24 – Minimum requirements of operational administration systems

Infrastructure component	Administration system		
	Operational complexity Level		
	1	2	3
IDENTIFIERS			
Cords/jumpers	-	-	Yes
LABELS (fixed to the item or are part of the item)			
Cords/jumpers [a]	-	-	Yes
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Cord connections [b c]	None	Manual	Electronic
Service delivery [c]	None	None	None

[a] Labels or other means to identify both ends of a cord.

[b] Manual records include paper-based systems. Electronic records include spreadsheets and databases.

[c] 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 ISO/IEC 18598.

Automated infrastructure management systems shall meet the requirements of ISO/IEC 18598.

Category RP1 and RP3 installations described in 5.3.4 restrict the current levels on the conductors (for the average of all conductors), which serves to either mitigate or negate planning and installation practices. When compared to the universal approach of a Category RP3 infrastructure, the disadvantages of Category RP1 and RP2 installations are that

a) the pathways and spaces may restrict the subsequent implementation of a remote powering installation of a higher Category,

b) administrative controls are required to monitor the current loads applied to the cables at distributors to ensure that the average current loading conditions are met.

A Category RP3 remote powering installation described in 5.3.4 represents a universal approach which requires planning and installation practices that avoid the administration associated with controlling current loads applied to the cables at distributors.

Cabinets, racks or frames in distributors shall be labelled to indicate the Category of remote powering installation.

Labels for Category RP1 and RP2 installations shall provide a warning related to unauthorized attached remote powering equipment. Labels for Category RP3 installations are used to highlight the existence of planning rules.

Examples of labels are shown in Figure 21.

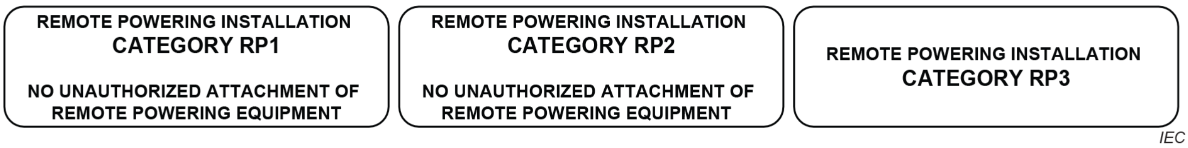


Figure 21 – Examples of labels indicating RP Category of remote powering installation

Appropriate warning labelling shall be applied in close proximity at all locations where de-mating under load presents a risk of technical damage or contractual liability.

All planning and installation practices initiated to address the Category of the remote powering installation shall be documented and maintained.

At all locations where de-mating under load presents a risk of technical damage or contractual liability, appropriate warning labelling shall be applied in close proximity.

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).

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 can be applied for convenience of cabling maintenance.

Table 25 contains requirements for labelling the infrastructure elements that are required, by the specified administration level, to be labelled.

Table 25 – 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 cabinet/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
TE outlets in accordance with ISO/IEC 11801-1	• on the exterior surface of the closure – indicating the treatment of cable elements and the presence, if any, of unused electrical contacts or optical fibre locations within the connecting hardware	• containing identifier
Bonds	• in accordance with ISO/IEC 30129	

9.2.4.2 Recommendations

9.2.4.2.1 Labelling

Table 26 contains recommendations, in addition to the requirements detailed in Table 25, for labelling the infrastructure elements.

Table 26 – 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	
Patch panels and blocks		• 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
Cords and jumpers (Figure 22 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 to enable 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 can include server name, business partner name, remote office name, circuit number, or name of equipment at each end of the channel

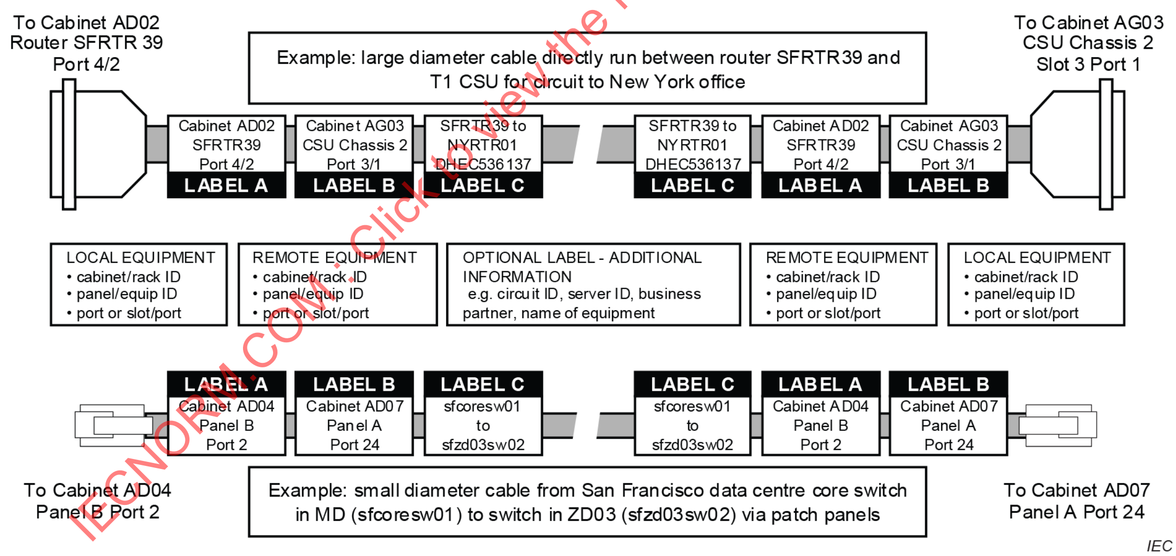


Figure 22 – Examples of cord and jumper labelling

9.2.4.2.2 Colour coding

Colour coding of labels, cables, cords, and termination fields can 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 27, Table 28, Table 29 and Table 30.

9.2.5.3 Recommendations

Records for each infrastructure element should include the items listed as "recommendations" in Table 27, Table 28, Table 29 and Table 30.

9.2.5.4 Optional

Records for each infrastructure element can include, amongst others, the items listed as "optional" in Table 27, Table 28, Table 29 and Table 30.

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 philosophy of ISO/IEC 30129 and the as-built bonding conductor implementation;
- results of link and channel measurements;
- telecommunications cabling system bid documents and change orders;
- telecommunications cabling system warranties;
- work orders.

Table 27 – Infrastructure records for spaces, cabinets, racks, frames and closures

Element	Requirements	Recommendations	Optional
Telecommunications 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 • location of local common bonding network • 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 connection to earthing system 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 connection to earthing system 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 28 – 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 connection to earthing system or identifier of bonding conductor • treatment (i.e. termination or isolation) 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 • 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.	• 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

Table 29 – 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, telecommunications 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 connection to earthing system or identifier of bonding conductor
Bonding conductor		• identifier of 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 30 – 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 (e.g. metal, plastic) • dimensions of pathway • branching points • cables installed in pathway • date of last record update	• manufacturer and part number • location of connection to earthing system 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 Table 23 and Table 24.

A computer-based administration system can 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 can be linked to each other using their identifiers and can make reference to further premises records on power, heating, air conditioning systems and lighting.

Figure 23 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 24.

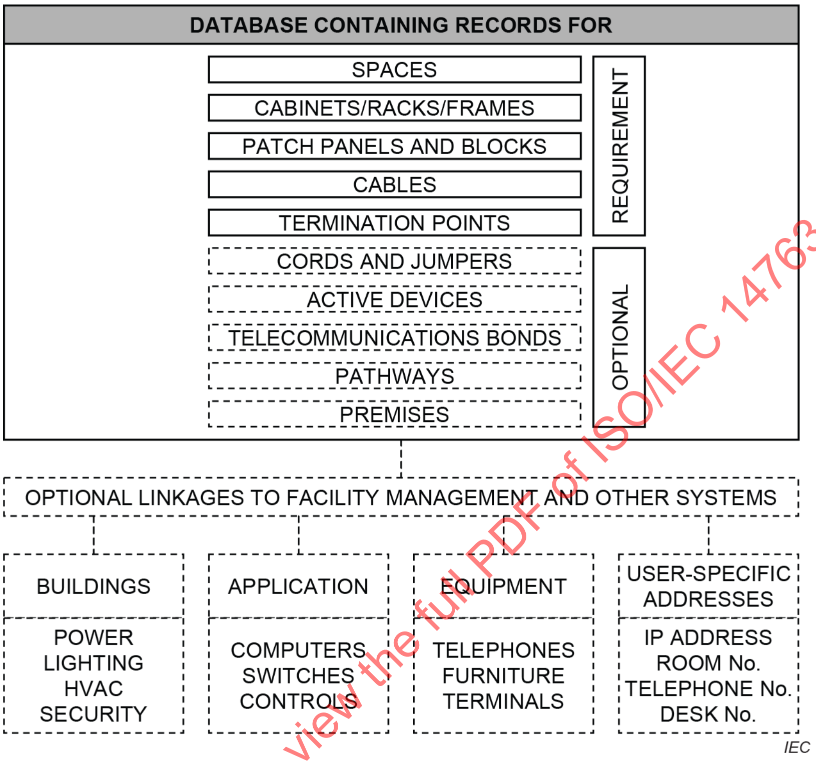


Figure 23 – Cable administration database and possible linkages

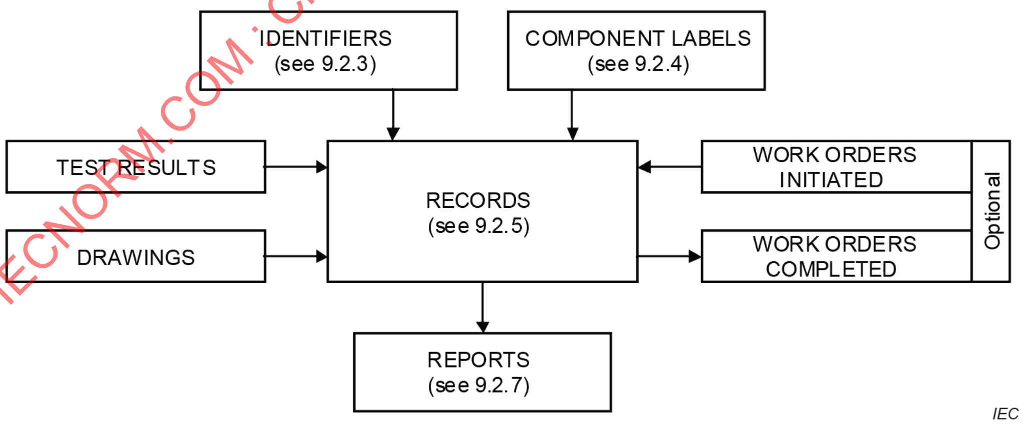


Figure 24 – Basic cabling administration

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 31 based upon the installation complexity Level determined from Table 21,
- Table 32 based upon the operational complexity Level of Table 22.

Table 31 – Recommendations of installation administration systems

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

Table 32 – Recommendations of operational administration systems

Infrastructure component	Administration system Operational complexity Level 1	 2	 3
RECORDS (AND/OR DRAWINGS) that provide information about the item together with other items related to it			
Cord connections [a]	None	Electronic	Automated
Service delivery [a]	None	None	Automated
[a] Manual records include paper-based systems. Electronic records include spreadsheets and databases. 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 ISO/IEC 18598.			

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

When administration is performed using spreadsheets or paper-based systems, records should be designed and organized to facilitate information retrieval based on primary indexing identifiers. This provides functionality similar to software linkages. Indexes relating record locations to primary identifiers can 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 can 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 database. Reports can take the form of lists, tables, diagrams and forms. Reports can be used for status determination, troubleshooting and can help for planning purposes.

10 Testing

10.1 General

10.1.1 Links and permanent links

As shown in Figure 25 and according to the design standards supported by this document, 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 11801-2, LDP link of ISO/IEC 11801-5) connected to a non-fixed cable (e.g. CP cable of ISO/IEC 11801, LDP cable of ISO/IEC 11801-5).

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 26.

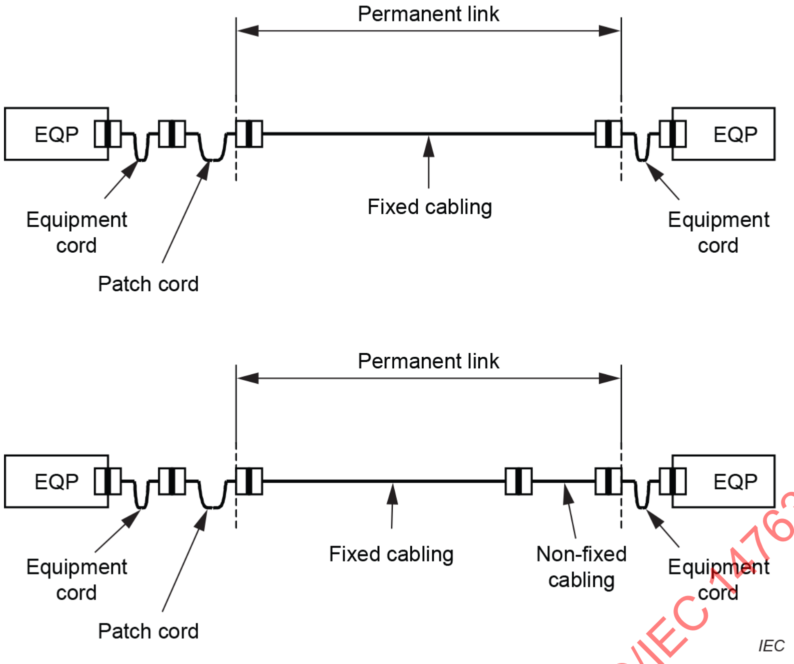


Figure 25 – Examples of cabling permanent links

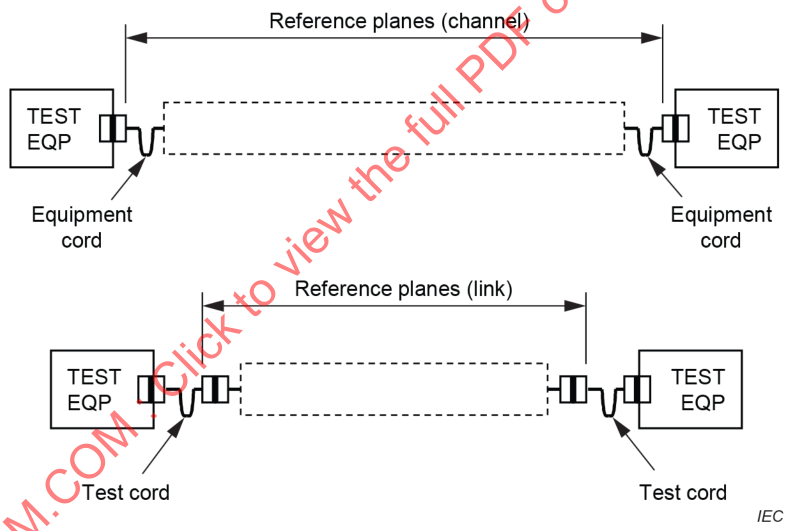


Figure 26 – Reference planes for link and channels (point-to-point)

10.1.2 Channels

A channel contains one or more permanent links interconnected by jumpers and cords. 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 (e.g. length, transmission performance) 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 can be used to determine performance where required by the installation specification, see 6.3.1.3.

Tests can also be applied to channels for application troubleshooting.

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 27.

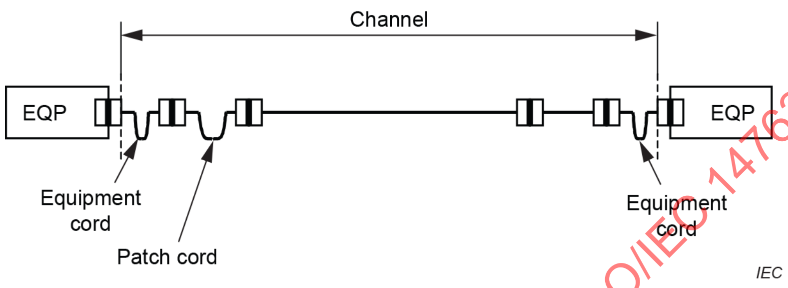


Figure 27 – Example of a cabling channel

10.1.3 Cabling interface adapters

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

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

This can 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 adapter, 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 carried out.

The test operator shall ensure that the test system has been normalized in accordance with the applicable testing standard or test equipment manufacturer's instructions prior to the test being undertaken. This requirement can 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 the manufacturer's 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

If 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, F_A, I and II

- 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 2 should not be applied;

and 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 can 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 6.4.1.2).

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 can be undertaken:

- re-verification of the normalization 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, 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 standardized 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 adapters (type, reference numbers and manufacturer),
c) details of the cabling under test,
d) the date of the test (the time of the test can 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.

10.2.6.3 Results relating to remote powering performance

The documentation shall include the DC resistance per unit length (normally produced by measurement of DC loop resistance and cable length).

10.3 Test procedures for optical fibre cabling

10.3.1 General

The performance requirements of links and channels within the referenced cabling design standards contain requirements for some or all of the parameters in Table 4 against which installed cabling can 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 adopts the reference planes of Figure 26. However, the test limits are modified due to the use of reference connections on the test cords. 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 26. 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 of ISO/IEC 11801-1. 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, the following steps can be undertaken

- re-verification of the normalization 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, 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,

b) test equipment:

   1) type and manufacturer,

   2) serial number and calibration status,

   3) level and software version,

c) details of the cabling interface adapters (type, reference numbers and manufacturer),

d) the stated uncertainty of measurement (measurement accuracy),

e) details of the cabling under test,

f) reference measurement numbers,

g) the date of the test (the time of the test can also be recorded),

h) the test operator,

i) details of the test system,

j) the measured result,

k) the required result.

11 Inspection

11.1 General

Clause 11 defines levels of inspection that can be referenced from the installation specification of Clause 5. The inspection can 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) of the installation specification,
- basic verification parameters of Table 2 and Table 4 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 document and provides additional confidence that specific applications are supported. Inspection at this level can 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 can 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 2 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 4 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 standardized document format such as .pdf, .odf or .xml.

12 Operation

12.1 Connection of equipment

Equipment connected to generic cabling shall conform to IEC 62368-1 and IEC 62368-3.

Open (unconnected) coaxial interfaces shall be fitted with impedance-matching devices.

Light levels in spaces shall be adequate to allow operations on the cabling. The requirements for rooms are specified in 7.7.1.1. Other spaces shall be lit at least on a temporary basis at equivalent light levels to those specified in 7.7.1.1.

12.2 Standard operating procedure

12.2.1 Requirements

The records relating to the infrastructure shall be retained as physical or electronic records (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.

12.2.2 Recommendations

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

12.3 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, 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 minimize the effects of twisting (e.g. figure-of-eight).

12.4 Optical fibre adapters

Unmated optical fibre adapters 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 the following.

- 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 programme relies on accurately defined thresholds which can only come with experience.
- “Run-to-failure” maintenance: essentially a maintain-by-repair policy (i.e. an absence of maintenance), which can 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 can be amortized over a period of time. By comparison, “run-to-failure” maintenance approaches defer the cost until repair is required and, in addition, any redundancy is an upfront cost.

13.1.2 Requirements

A risk analysis using the information provided in 13.1.1 shall be performed. The maintenance approach selected following the risk assessment should be based on a balance of efficiency and reliability.

NOTE Clause D.13 provides further details for industrial premises which can be useful in other types 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).

13.2 Maintenance procedures

13.2.1 Requirements

Maintenance operations shall be performed according to the contract.

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

Maintenance operations should address cleanliness, temperature and humidity of spaces together with periodic inspection or remote surveillance of hidden areas (e.g. under raised floors).

Maintenance activities should include

- assessment to confirm that installation is still electromagnetically compatible with its environment,
- inspection and periodic maintenance of
  - connection points in harsh environments,

– bond connections,
– connections to surge protection devices.

All maintenance and repair operations performed near active equipment should minimize the risk of electrostatic 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 can 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 shown in Table A.1 (described as an historic colour code in IEC TR 63194). Other conventions exist for the colour-based identification of optical fibres as indicated in IEC TR 63194. The requirements and recommendations of Annex A are applicable independently of the actual colour scheme adopted.

Table A.1 – Optical fibre colour code scheme used in Annex A

Optical fibre number	Colour
01	Blue
02	Yellow
03	Red
04	White
05	Green
06	Violet
07	Orange
08	Grey
09	Turquoise
10	Black
11	Brown
12	Pink

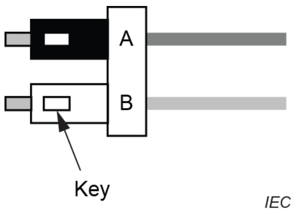
NOTE The figures in Annex A show connectors labelled with position numbers. This is done for reference purposes only; it is not a requirement of Annex A that connectors be labelled with a position number.

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

A.2 Duplex connecting hardware interfaces

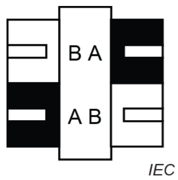
A.2.1 Duplex plugs, adapters and cords

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 hardware 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.

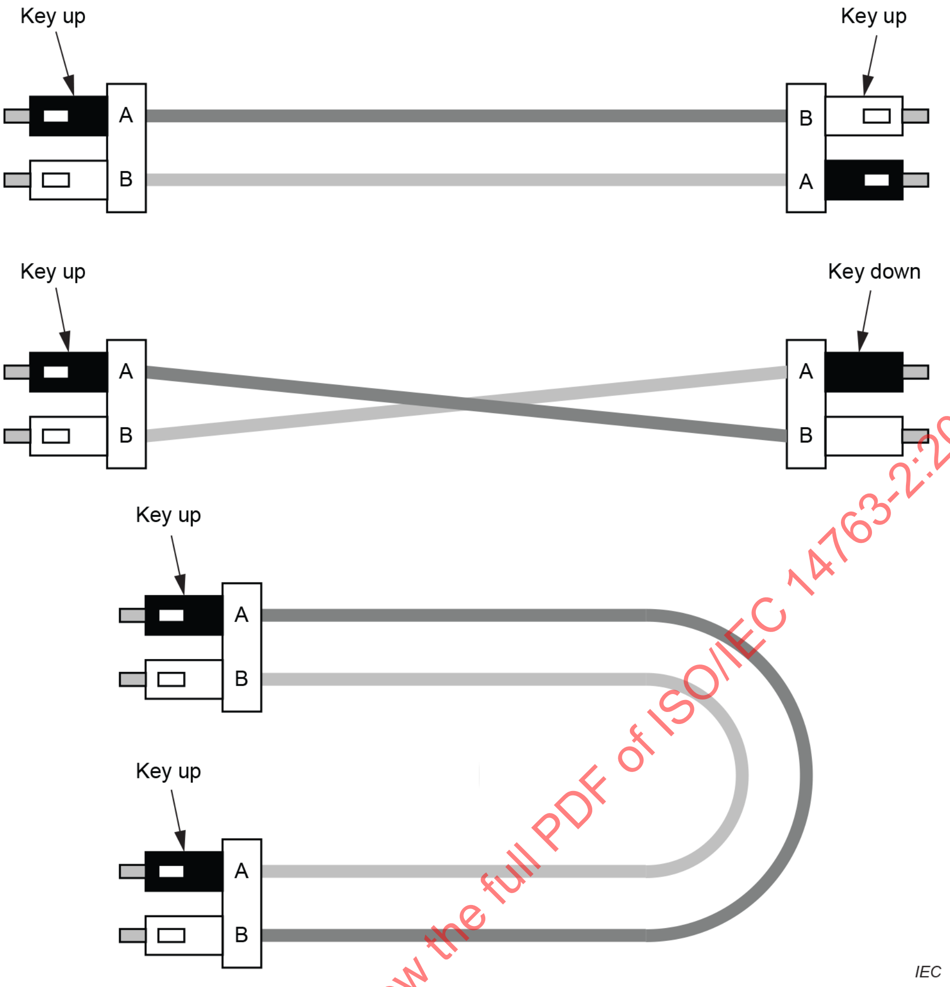


Figure A.4 – Views of crossover patch cords

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 RGB 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.

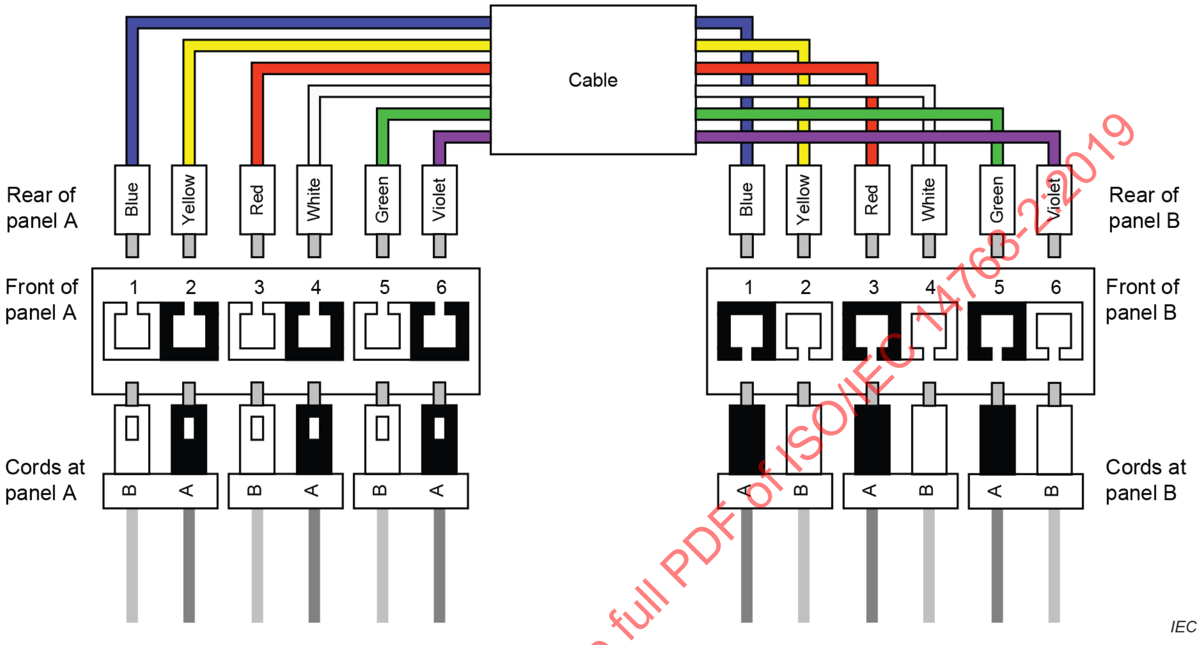


Figure A.5 – Optical fibre sequences and adapter orientation in patch panel for the symmetrical position method

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 can 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, 1 (yellow), 2 (blue), 3 (white), 4 (red), etc).

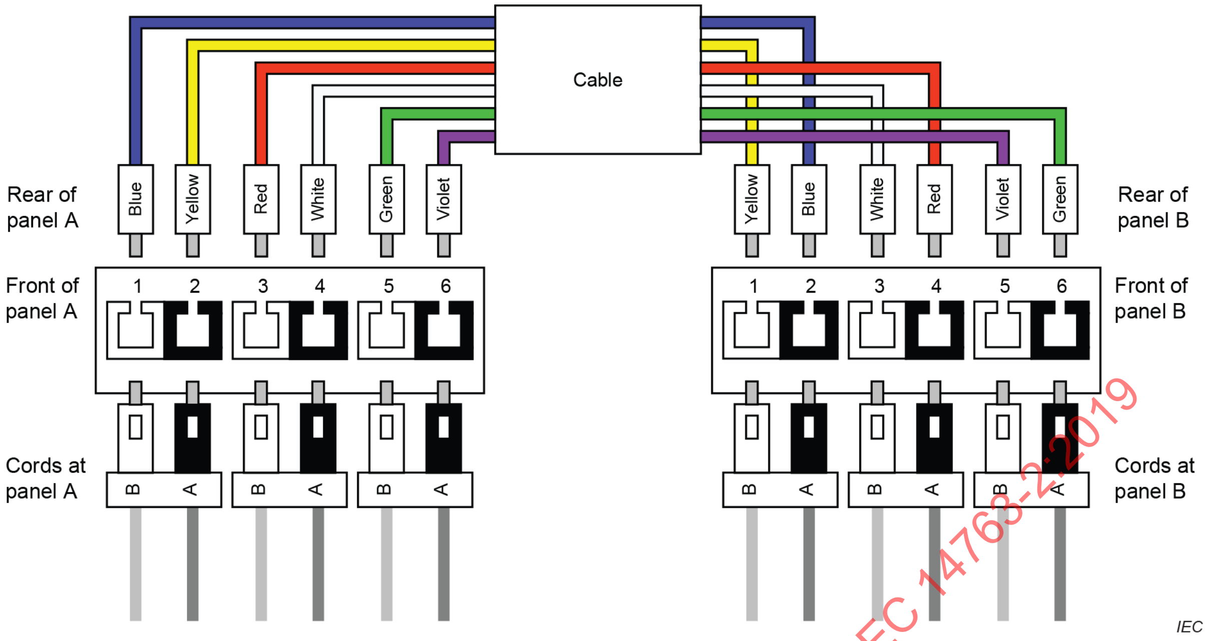


Figure A.6 – Optical fibre sequences and adapter orientation in patch panel for the reverse-pair position method

A.3 Connecting hardware interfaces for arrays with 12 optical fibres per row

A.3.1 General

Array connecting hardware enables the installation of pre-terminated cables containing multiple optical fibres. The optical fibres within the cables can 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. The implementation is applicable to optical fibre interfaces including MPO-type both physical contact (PC) and angled physical contact (APC).

The same approach should be applied when the interfaces comprise multiple rows of optical fibres.

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

Subclause A.3.2.2 describes an approach for the termination of cables and patch cords. Subclause A.3.2.3 describes an approach for the configuration of array connection adapters. Subclause 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.

For array connectors with multiple rows of optical fibres, a similar approach should be used to minimize the number of component configurations.

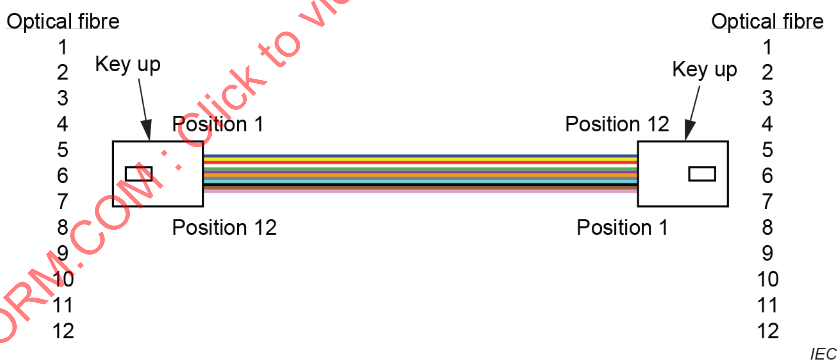
Alternative approaches to those described in A.3.2.2 to A.3.2.4 can be applied but will require implementations other than those of A.3.3 in order to maintain the correct optical fibre polarity. In addition, a greater number of component configurations can be required, e.g. different designs of transition 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, using the connectors shown 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 should 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.

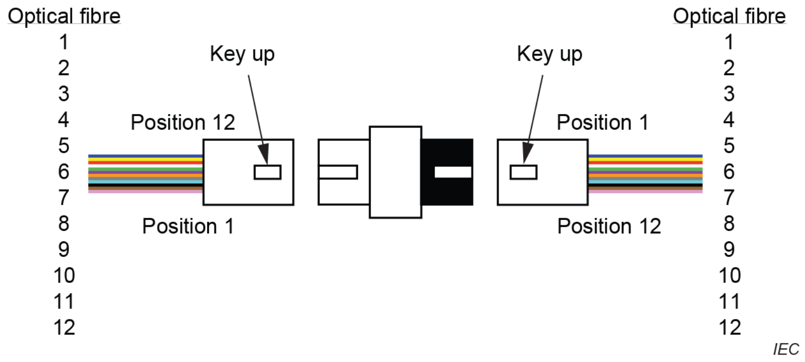


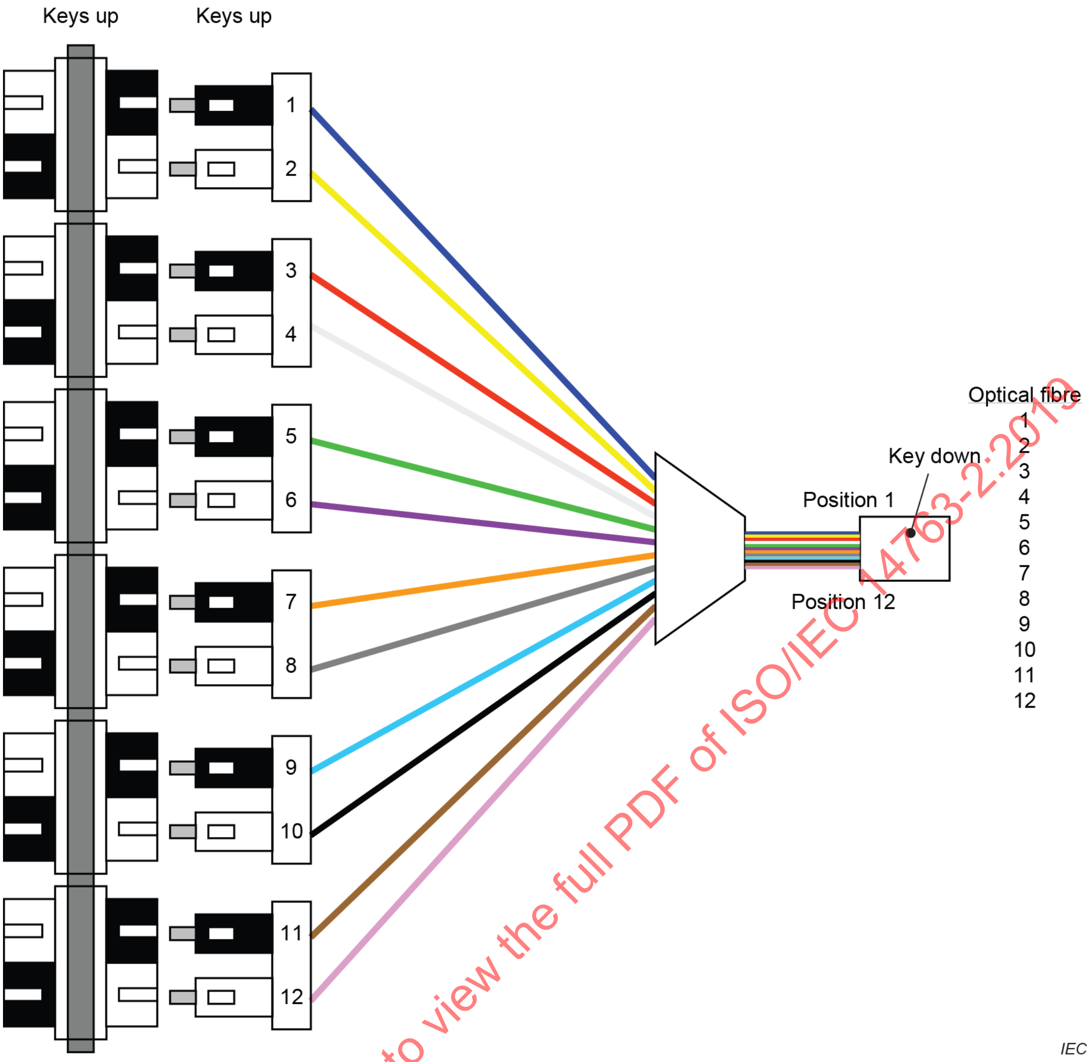
Figure A.8 – Array adapter with aligned keyways

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° rotation of one of the transition assemblies is not feasible, a port mapping labelling scheme should 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.

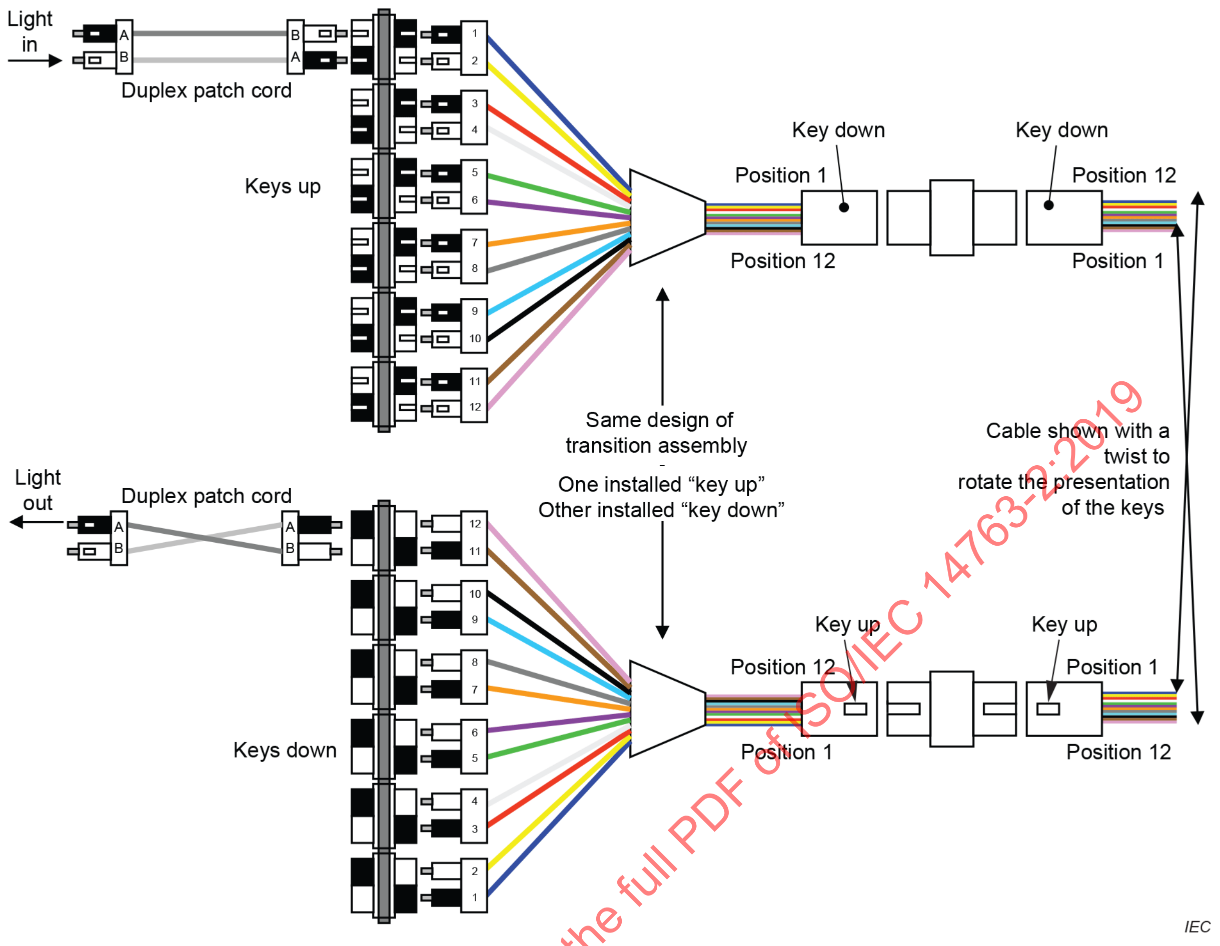
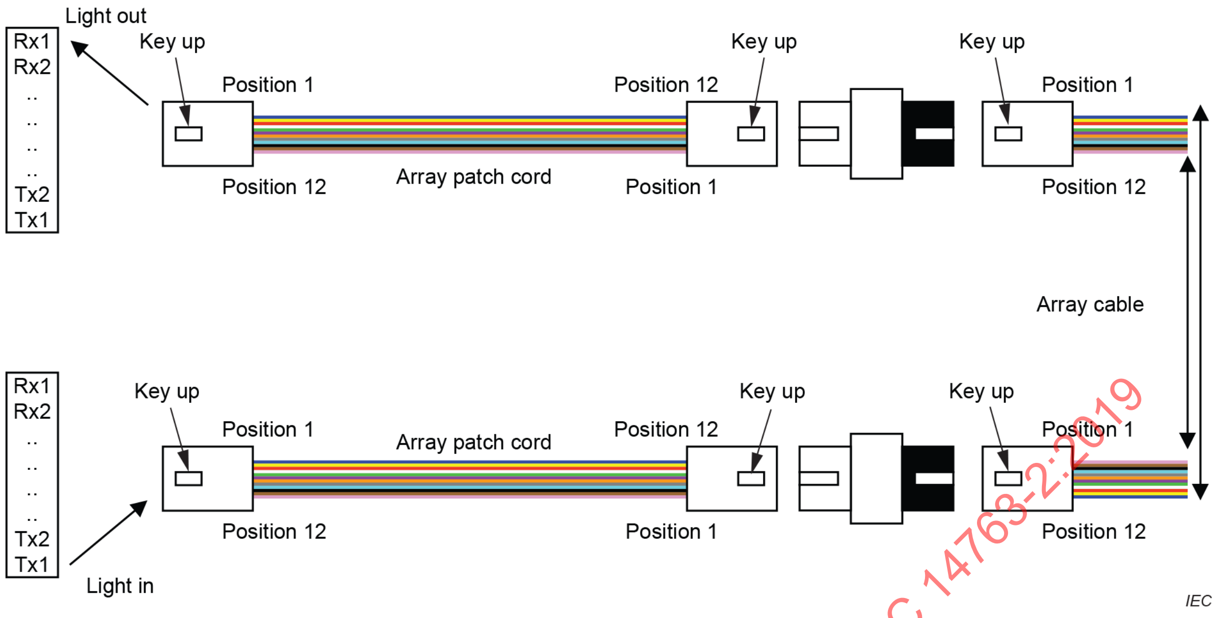


Figure A.10 – Connectivity method for duplex signals

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

A.4 Connecting hardware interfaces for arrays with more than 12 optical fibres per row

A.4.1 General

Array connecting hardware enables the installation of pre-terminated cables containing multiple optical fibres. The optical fibres within the cables can 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 make use of several parallel optical fibre channels.

An implementation of the type described in A.4.2 and A.4.3 should be used to provide the required control of optical fibre polarity through array interfaces, transition assemblies and attached cords. The implementation is applicable to optical fibre interfaces including MPO-type both physical contact (PC) and angled physical contact (APC).

The same approach should be applied when the interfaces comprise multiple rows of optical fibres.

Where the array connection is created using a combination of pinned and unpinned connectors, the pinned connector is 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.4.2 Array connecting hardware components

A.4.2.1 General

Subclause A.4.2.2 describes the approach for the termination of cables and patch cords. Subclause A.4.2.3 describes the approach for the configuration of array connection adapters. Subclause A.4.2.4 describes the approach for the implementation of duplex transition assemblies.

The use of these components as described in A.4.3 ensures the maintenance of the correct optical fibre polarity using the minimum number of component configurations.

A.4.2.2 Cables and array connector patch cords

As shown in Figure A.12, 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, ..., 14, 15, 16) 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 (16, 15, 14, ..., 3, 2, 1) from left to right as viewed looking at the end-face of the connector with the connector key up.

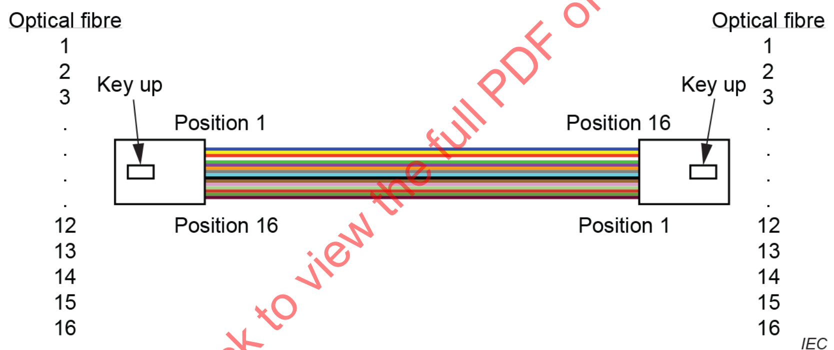


Figure A.12 – Array connector cable or patch cord (key-up to key-up)

NOTE The cable shown is unpinned on both ends, using the connectors shown in A.4.1. In some instances (such as when supporting parallel signals as shown in Figure A.16) it will be necessary to use a combination of unpinned and pinned array connectors on cables and patch cords.

A.4.2.3 Array adapters

Array adapters should be built such that they mate two array connectors with the connector keys aligned (i.e. key-up to key-up) as depicted in Figure A.13.

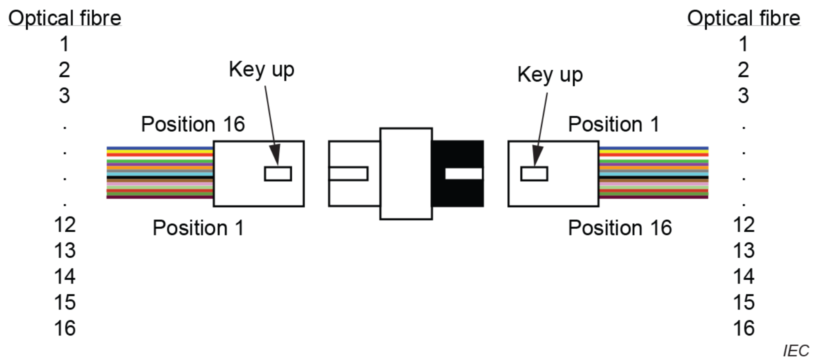


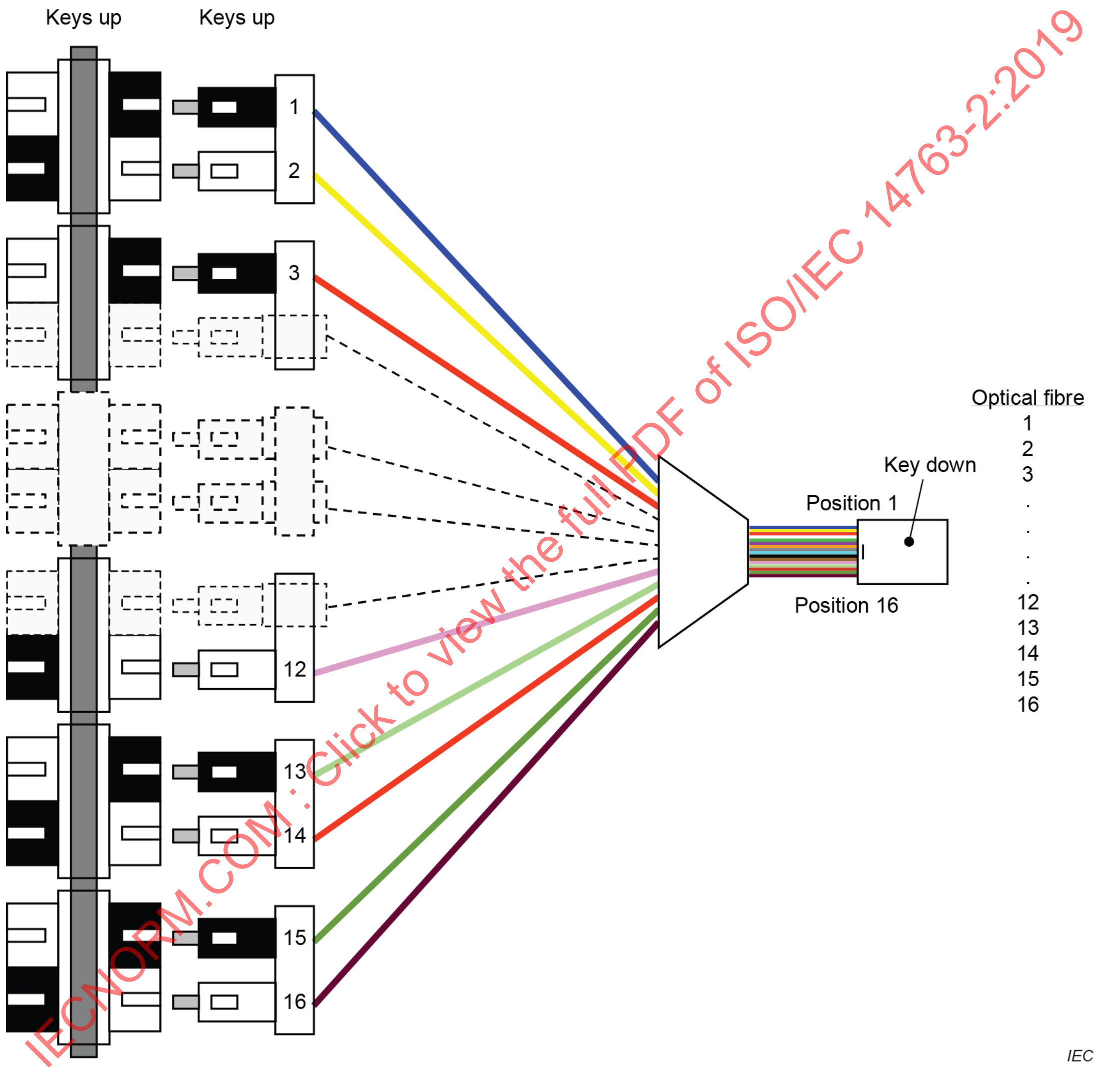
Figure A.13 – Array adapter with aligned keyways

A.4.2.4 Transition assemblies for duplex cabling

As shown in Figure A.14, 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 number (1, 2, 3, ..., 14, 15, 16) 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, ..., 14, 15, 16) 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.14 – Transition assembly

A.4.3 Array connectivity method

A.4.3.1 Duplex cabling

Implementation of the array connectivity method for duplex signals is shown in Figure A.15.

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° rotation of one of the transition assemblies is not feasible, a port mapping labelling scheme should 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.

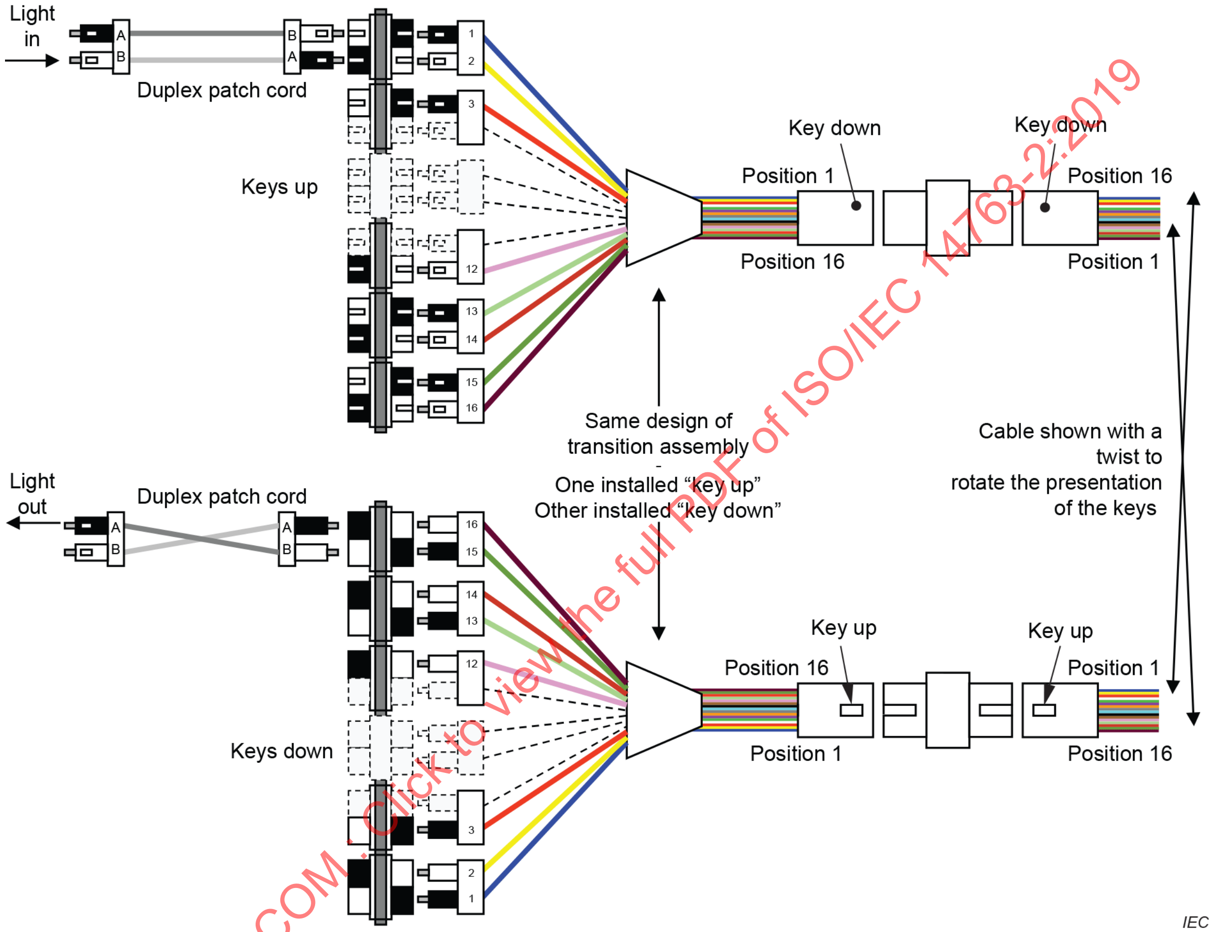
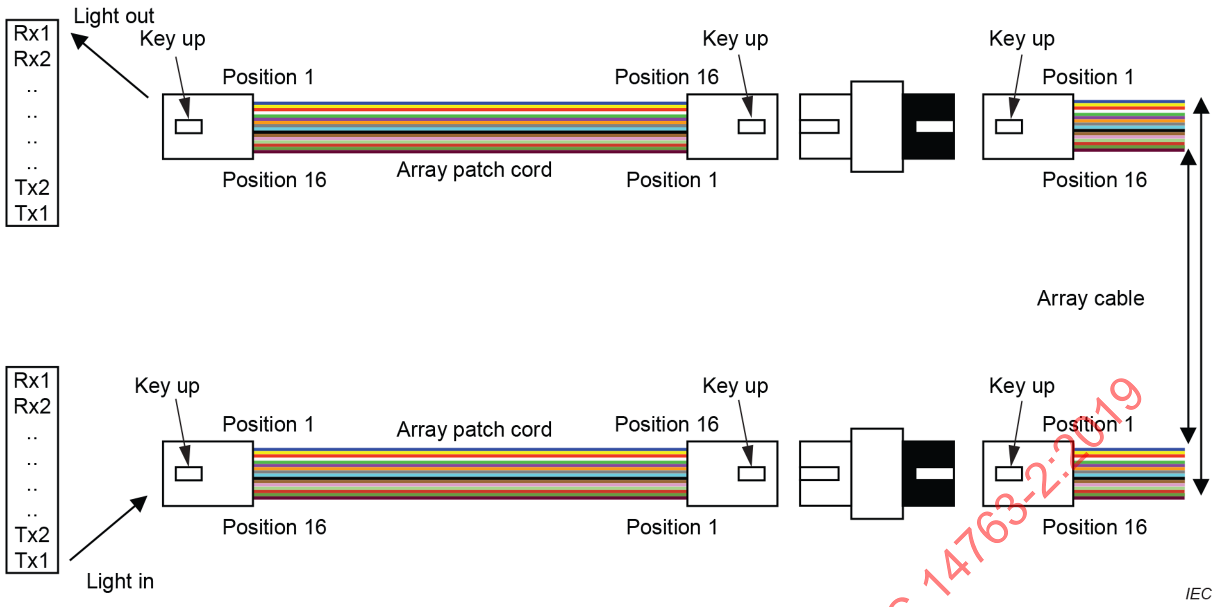


Figure A.15 – Connectivity method for duplex cabling

A.4.3.2 Array cabling

Implementation of the connectivity method for parallel signals is shown in Figure A.16.

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.16 – Connectivity method for array cabling