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Information technology – Generic cabling – Industrial premises

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INFORMATION TECHNOLOGY – GENERIC CABLING – INDUSTRIAL PREMISES

FOREWORD

1) ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards. Their preparation is entrusted to technical committees; any ISO and IEC member body interested in the subject dealt with may participate in this preparatory work. International governmental and non-governmental organizations liaising with ISO and IEC also participate in this preparation.

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10) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

International Standard ISO/IEC 24702 was prepared by subcommittee 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

ISO/IEC 24702 should be read in conjunction with International Standard ISO/IEC 11801.

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

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

INTRODUCTION

Within premises, the importance of the information technology cabling infrastructure is similar to that of other fundamental building utilities such as heating, lighting and mains power. As with other utilities, interruptions to service can have serious impact. Poor quality of service due to lack of design foresight, use of inappropriate components, incorrect installation, poor administration or inadequate support can threaten an organization's effectiveness.

Historically, the cabling within premises comprised both application-specific and multipurpose networks. The subsequent growth of generic cabling designed in accordance with ISO/IEC 11801 has supported the development of high-data-rate applications based upon a defined cabling model.

This International Standard recognizes the benefit of generic cabling to interconnect several pieces of apparatus within industrial premises or industrial areas within other types of premises (within and between structures and buildings) and should be read in conjunction with ISO/IEC 11801.

This International Standard provides, for industrial premises:

a) users with an application-independent generic cabling system and an open market for cabling components;

b) requirements for infrastructures that support critical automation, process control and monitoring applications in a range of industrial environments;

c) users with a flexible cabling scheme such that modifications are both easy and economical;

d) building professionals, production and control engineers with guidance allowing the accommodation of cabling:

   — before specific requirements are known; i.e. in the initial planning either for construction or refurbishment;

   — by further deployment as the requirements of specific industrial areas are defined;

e) industry and standardisation bodies with a cabling system which supports current products and provides a basis for future product development and applications standardisation.

This International Standard specifies multi-vendor cabling, and is related to

- the associated standard for generic cabling within commercial premises (ISO/IEC 11801),
- standards for cabling components developed by Technical Committees of ISO and IEC,
- standards for the quality assurance and installation of information technology cabling (series ISO/IEC 14763 and IEC 61918) and testing of installed cabling (IEC 61935-1),
- applications developed by the technical committees of IEC, subcommittees of ISO/IEC JTC 1 and study groups of ITU-T (for example Fieldbus, LANs and ISDN).

Within this International standard the cabling, defined between the interfaces shown in Figure 1, contains passive components only.

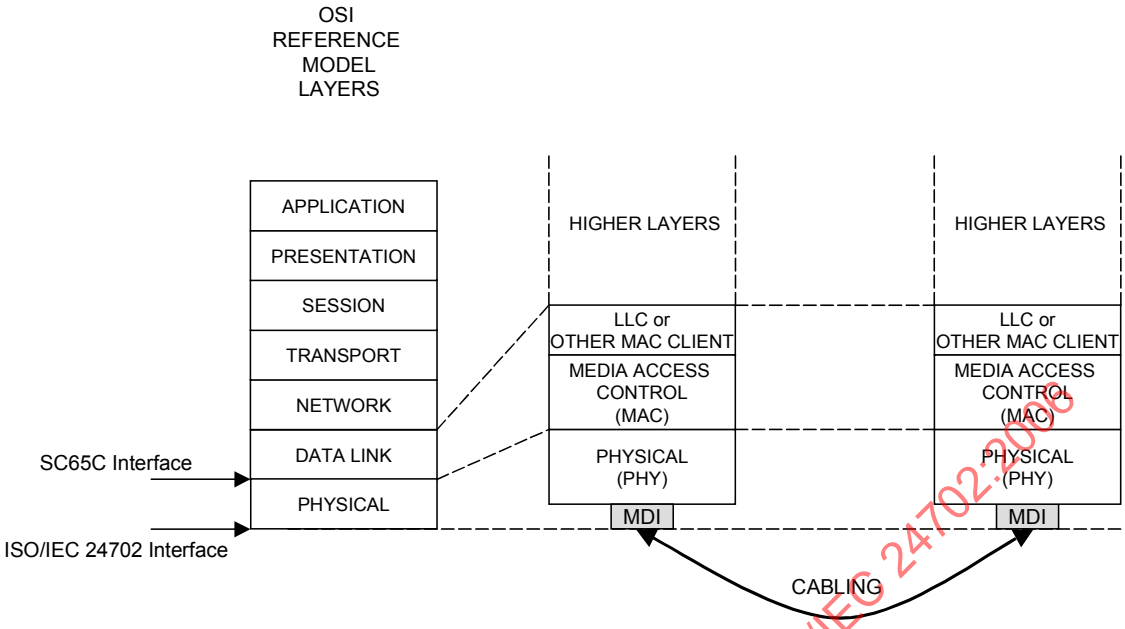

Figure 1 – Cabling specified by ISO/IEC 24702 and its relationship to OSI reference model layers

It is anticipated that the generic cabling system meeting the minimum requirements of this International Standard will have a life expectancy consistent with other infrastructures within industrial premises.

INFORMATION TECHNOLOGY
GENERIC CABLING – INDUSTRIAL PREMISES

1 Scope

This International Standard specifies generic cabling that supports a wide range of communications services including automation, process control and monitoring applications for use within industrial premises or industrial areas within other types of premises, comprising single or multiple buildings on a campus. It covers balanced cabling and optical fibre cabling.

This standard is based upon and references the requirements of ISO/IEC 11801. It contains additional requirements that are appropriate to industrial premises in which the maximum distance over which communications services have to be distributed is 10 000 m. The principles of this International Standard may also be applied to installations that do not fall within this range.

In addition to the requirements of ISO/IEC 11801, this International Standard specifies

a) a modified structure and configuration for generic cabling within industrial premises in which information technology applications are used to support process monitoring and control functions,

b) implementation options,

c) additional requirements that reflect the range of operating environments within industrial premises.

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

2 Normative references

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

IEC 60512-4-1, *Connectors for electronic equipment – Tests and measurements – Part 4-1: Voltage stress tests – Test 4a: Voltage proof*

IEC 60512-4-2, *Connectors for electronic equipment – Tests and measurements – Part 4-2: Voltage stress tests – Test 4b: Partial discharge*

IEC 60512-6-2, *Connectors for electronic equipment – Tests and measurements – Part 6-2: Dynamic stress tests – Test 6b: Bump*

IEC 60512-6-3, *Connectors for electronic equipment – Tests and measurements – Part 6-3: Dynamic stress tests – Test 6c: Shock*

IEC 60512-6-4, *Connectors for electronic equipment – Tests and measurements – Part 6-4: Dynamic stress tests – Test 6d: Vibration (sinusoidal)*

IEC 60512-8, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 8: Connector tests (mechanical) and mechanical tests on contacts and terminations*

IEC 60512-9, *Electromechanical components for electronic equipment; basic testing procedures and measuring methods – Part 9: Miscellaneous tests*

IEC 60512-11-4, *Connectors for electronic equipment – Tests and measurements – Part 11-4: Climatic tests – Test 11d: Rapid change of temperature*

IEC 60512-11-7, *Connectors for electronic equipment – Tests and measurements – Part 11-7: Climatic tests – Test 11g: Flowing mixed gas corrosion test*

IEC 60512-11-9, *Connectors for electronic equipment – Tests and measurements – Part 11-9: Climatic tests – Test 11i: Dry heat*

IEC 60512-11-10, *Connectors for electronic equipment – Tests and measurements – Part 11-10: Climatic tests – Test 11j: Cold*

IEC 60512-11-12, *Connectors for electronic equipment – Tests and measurements – Part 11-12: Climatic tests – Test 11m: Damp heat, cyclic*

IEC 60512-19-3, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 19: Chemical resistance tests – Section 3: Test 19c – Fluid resistance*

IEC 60512-23-3, *Electromechanical components for electronic equipment – Basic testing procedures and measuring methods – Part 23-3: Test 23c: Shielding effectiveness of connectors and accessories*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60603-7, Connectors for frequencies below 3 MHz for use with printed boards – *Part 7: Detail specification for connectors, 8-way, including fixed and free connectors with common mating features, with assessed quality*

IEC 60793-1-40, *Optical fibres – Part 1-40: Measurement methods and test procedures – Attenuation*

IEC 60793-1-41, *Optical fibres – Part 1-41: Measurement methods and test procedures – Bandwidth*

IEC 60793-1-44, *Optical fibres – Part 1-44: Measurement methods and test procedures – Cut-off wavelength*

IEC 60793-2-30, *Optical fibres – Part 2-30: Product specifications – Sectional specification for category A3 multimode fibres*

IEC 60793-2-40, *Optical fibres – Part 2-40: Product specifications – Sectional specification for category A4 multimode fibres*

IEC 60793-2-50, *Optical fibres – Part 2-50: Product specifications – Sectional specification for class B single-mode fibres*

IEC 60794-1-2, *Optical fibre cables – Part 1-2: Generic specification – Basic optical cable test procedures*

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

IEC 60794-3, *Optical fibre cables* – Part 3: Sectional specification – *Outdoor cables*

IEC 61076-2-101, *Connectors for electronic equipment – Part 2-101: Circular connectors – Detail specification for circular connectors M8 with screw- or snap-locking, M12 with screw-locking for low voltage applications*

IEC 61076-3-106, *Connectors for electronic equipment – Product requirements – Part 3-106: Rectangular connectors – Detail specification for protective housings for use with 8-way shielded and unshielded connectors for industrial environments incorporating the IEC 60603-7 series interface*

IEC 61131-2, *Programmable controllers – Part 2: Equipment requirements and tests*

IEC 61156 (all parts), *Multicore and symmetrical pair/quad cables for digital communications – Measurement of coupling attenuation of balances cabling in laboratory conditions*

IEC 61156-5-1 (all parts), *Multicore and symmetrical pair/quad cables for digital communications*

IEC 61156-5-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 5-1: Symmetrical pair/quad cables with transmission characteristics up to 600 MHz – Horizontal floor wiring - Blank detail specification*

IEC 61156-6-1, *Multicore and symmetrical pair/quad cables for digital communications – Part 6-1: Symmetrical pair/quad cables with transmission characteristics up to 600 MHz – Work area wiring – Blank detail specification*

IEC 61300-2-1, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-1: Tests – Vibration (sinusoidal)*

IEC 61300-2-4, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-4: Tests – Fibre(cable retention*

IEC 61300-2-5, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-5: Tests – Torsion/twist*

IEC 61300-2-9, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-9: Tests – Shock*

IEC 61300-2-18, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-18: Tests – Dry heat – High temperature endurance*

IEC 61300-2-22, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-22: Tests – Change of temperature*

IEC 61300-2-30, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-30: Tests – Solar radiation*

IEC 61300-2-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-34: Tests – Resistance to solvents and contaminating fluids*

IEC 61300-2-44, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-44: Tests – Flexing of the strain relief of fibre optic devices*

IEC 61300-2-46, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 2-46: Tests – Damp heat, cyclic*

IEC 61300-3-34, *Fibre optic interconnecting devices and passive components – Basic test and measurement procedures – Part 3-34: Examinations and measurements – Attenuation of random mated connectors*

IEC 61753 (all parts), *Fibre optic interconnecting devices and passive components performance standard – Specification for the testing of optical fibre communication cabling in accordance with ISO/IEC 24702 – Cords – Blank detail specification*

IEC 61754-20, *Fibre optic connector interfaces – Part 20: Type LC connector family*

IEC 61918, *Digital data communications for measurement and control – Installation of communcation networks in industrial control systems*

IEC 61935-1, *Testing of balanced communication cabling in accordance with ISO/IEC 11801 – Part 1: Installed cabling*

IEC 61935-2, *Testing of balanced communication cabling in accordance with ISO/IEC 11801 – Part 2: Patch cords and work area cords*

IEC 62012-1, *Multicore and symmetrical pair/quad cables for digital communications to be used in harsh environments – Part 1: Generic specification*

ISO/IEC 11801:2002, *Information technology – Generic cabling for customer premises*

ISO/IEC 11801, *Information technology – Generic cabling for customer premises*

NOTE Refer to the second edition of ISO/IEC 11801, published in 2002, where this date has been specified. For undated references, use the latest edition of ISO/IEC 11801.

ISO/IEC 14763 (all parts), *Information technology – Implementation and operation of customer premises cabling*

ISO/IEC 14763-1, *Information technology – Implementation and operation of customer premises cabling – Part 1: Administration*

ISO/IEC TR 14763-2, *Information technology – Implementation and operation of customer premises cabling – Part 2: Planning and installation*

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

ISO/IEC 18010, *Information technology – Pathways and spaces for customer premises cabling*

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this International Standard the following definitions apply in addition to those of ISO/IEC 11801.

3.1.1
apparatus
one or more pieces of equipment having specific and defined overall functions within industrial premises served by one or more network interfaces

3.1.2
apparatus attachment cord
cords used to connect a telecommunications outlet (TO) to a network interface

3.1.3
automation island
cabling together with active and passive components within apparatus served by a network interface

3.1.4
bulkhead
a wall or barrier which maintains the ingress and climatic environmental classifications applicable on either side

3.1.5
channel
end-to-end transmission path connecting any two pieces of application-specific equipment

NOTE 1 Equipment and apparatus attachment cords are included in the channel but not the connecting hardware into the application-specific equipment.

NOTE 2 This channel definition covers passive elements only. Active elements, such as transmitters or receivers, are not part of any channel in this standard.

3.1.6
floor cable
cable connecting the floor distributor to the intermediate distributor

3.1.7
floor distributor
distributor used to make connections between the floor cable, other cabling subsystems and active equipment

3.1.8
functional performance
level of transmission performance able to support intended Class of applications

3.1.9
intermediate cable
cable connecting the intermediate distributor to the TO

3.1.10
intermediate distributor
the distributor used to make connections between the intermediate cable, other cabling subsystems and active equipment

3.1.11
MICE
classification system that describes the environment conditions that are local to a channel based upon the following factors:
– mechanical (M),
– ingress (I),
– climatic and chemical (C),
– electromagnetic (E)

3.1.12
network interface
interface between the apparatus attachment cabling and the apparatus network

3.1.13
operating temperature
stabilised temperature of the cabling combining ambient temperature with any increase due to the application being supported

3.1.14
telecommunications
includes the transmission of information in support of automation, process control and monitoring applications

NOTE This definition applies to this International Standard in addition to the definition given in ISO/IEC 11801.

3.1.15
telecommunications outlet (TO)
a fixed connecting device where the intermediate cable terminates and which provides the interface to the apparatus attachment cabling

3.2 Abbreviations

For the purposes of this International Standard the following abbreviations apply in addition to those of ISO/IEC 11801.

AO	automation outlet
ELTCTL	equal level transverse conversion transfer loss
FD	floor distributor
ID	intermediate distributor
MICE	mechanical, ingress, climatic and chemical, electromagnetic
NI	network interface
TCL	transverse conversion loss
TO	telecommunications outlet

4 Conformance

For a cabling system to conform to this International Standard:

a) the structure and configuration shall conform to the requirements of clause 5;

b) the interfaces to the cabling at the telecommunications outlet (TO) shall conform to the requirements of clause 9 with respect to mating interfaces and performance when subjected to environmental conditions, local to the interfaces (see note 1), as defined by the applicable environment of clause 6;

c) connecting hardware at other places in the cabling structure shall conform to the requirements of clause 9 when subjected to environmental conditions, local to the connecting hardware (see note 1), as defined by the applicable environmental Class(es) of clause 6;

d) channels (see note 2) shall conform to the requirements of the applicable transmission performance Class of clause 6 when subjected to environmental conditions, local to the channels (see note 1), as defined by the applicable environment of clause 6. This shall be achieved by one of the following:

- a channel design and implementation ensuring that the prescribed channel performance Class of clause 6 is met;
- attachment of appropriate components to a permanent link design meeting the prescribed performance Class of Annex A. Channel performance shall be assured where a channel is created by adding more than one cord to either end of a permanent link meeting the requirements of Annex A;
- using the reference implementations of clause 7 and compatible cabling components conforming to the requirements of clauses 8, 9 and 10, based upon a statistical approach of performance modelling;

e) local regulations concerning safety and electromagnetic emissions shall be met.

The channel transmission performance requirements of clause 6 are also achieved when subjected to environmental conditions local to the channels, as defined in clause 6 using the reference implementations of Annex C and compatible cabling components conforming to the requirements of clauses 8, 9 and 10, based upon a statistical approach of performance modelling (see note 3).

Test methods to ensure conformance with the channel and link requirements of clause 6 and Annex A respectively are specified in IEC 61935-1 and Annex B of this standart. The treatment of measured results that fail to meet the requirements of this clause, or lie within the relevant measurement accuracy, shall be clearly documented within a quality plan as described in ISO/IEC 14763-2.

NOTE 1 The applicable environment of clause 6, local to the cabling or cabling component(s) is that of the external environment or that modified environment created by use of mitigating installation techniques.

NOTE 2 The word “channel” refers to the passive cabling between the interfaces described in clauses 5 and 6 and is used specifically in this context throughout this International Standard. The meaning of the word “channel” as used in other standards is not applicable.

NOTE 3 The use of components suitable for use when subject to certain environmental conditions does not automatically assure that the resulting channel meets the applicable transmission performance Class of clause 6 when subjected to those environment conditions.

Installation and administration of cabling in accordance with this standard should be carried out in accordance with the ISO/IEC 14763 series of standards.

This document does not specify which tests and sampling levels should be adopted. The test parameters to be measured and the sampling levels to be applied for a particular installation should be defined in the installation specification and quality plans for that installation prepared in accordance with ISO/IEC 14763-2.

Specifications marked "ffs" (for further study) are preliminary and are not required for conformance to this International Standard.

5 Structure

5.1 General

This clause identifies the functional elements of generic cabling for industrial premises, describes how they are connected together to form subsystems and identifies the interfaces at which application-specific components are connected. Applications listed in Annex E are supported by connecting active equipment at the TOs and the distributors.

In general, all functional elements, subsystems and interfaces from the campus distributor to the floor distributor as described in ISO/IEC 11801 are applicable.

5.2 Functional elements

In addition to the distributors specified in ISO/IEC 11801 this standard specifies the following functional elements and interfaces of generic cabling for industrial premises:

- floor cable;
- intermediate distributor (ID);
- intermediate cable;
- TO;
- network interface (NI).

As shown in Figure 2, an ID is able to serve TOs on separate pieces of apparatus or multiple TOs on a single piece of apparatus. The type and nature of the apparatus cabling are beyond the scope of this International Standard.

Groups of functional elements are connected together to form cabling subsystems.

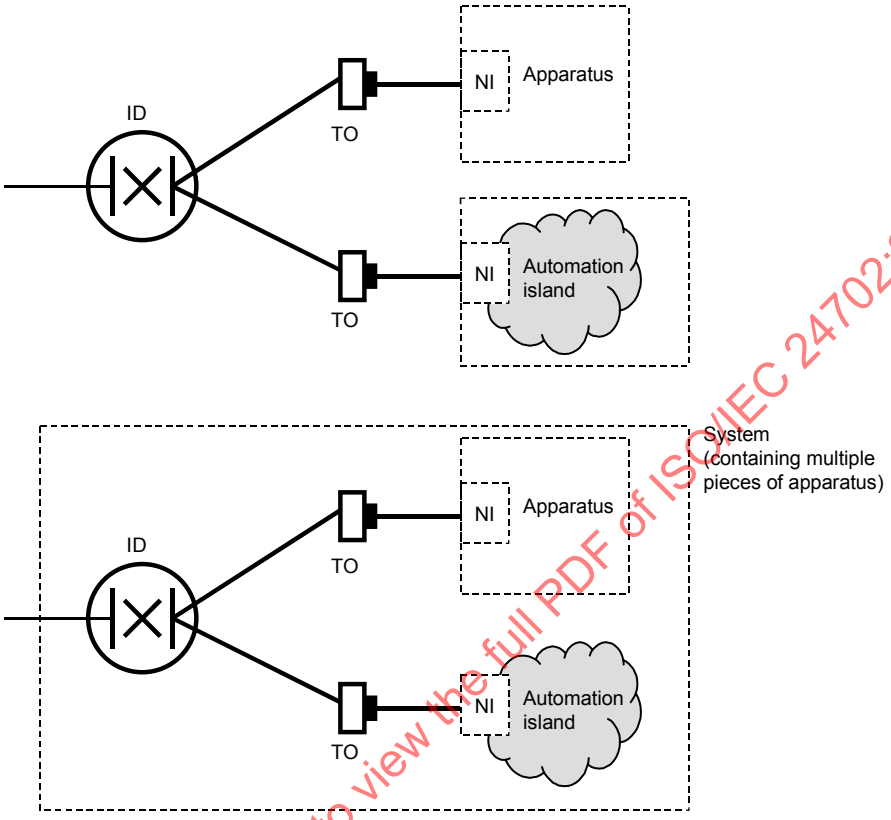

Figure 2 – Configuration of apparatus-based functional elements within industrial premises

5.3 Cabling subsystem

5.3.1 General structure

Generic cabling schemes for industrial premises contain up to four types of cabling subsystems: campus backbone, building backbone, floor and intermediate. In addition, cabling is necessary to connect telecommunication, process control and monitoring equipment to the generic cabling but this cabling is application-specific and therefore not specified by this International Standard. The composition of the subsystems is described in 5.3.2, 5.3.3, 5.3.4 and 5.3.5. The cabling subsystems are connected together to create a generic cabling structure as shown in Figure 3.

The distributors provide the means to configure the cabling to support different topologies such as bus, star and ring. Campus, building and floor distributors can also be used to support cabling in accordance with ISO/IEC 11801.

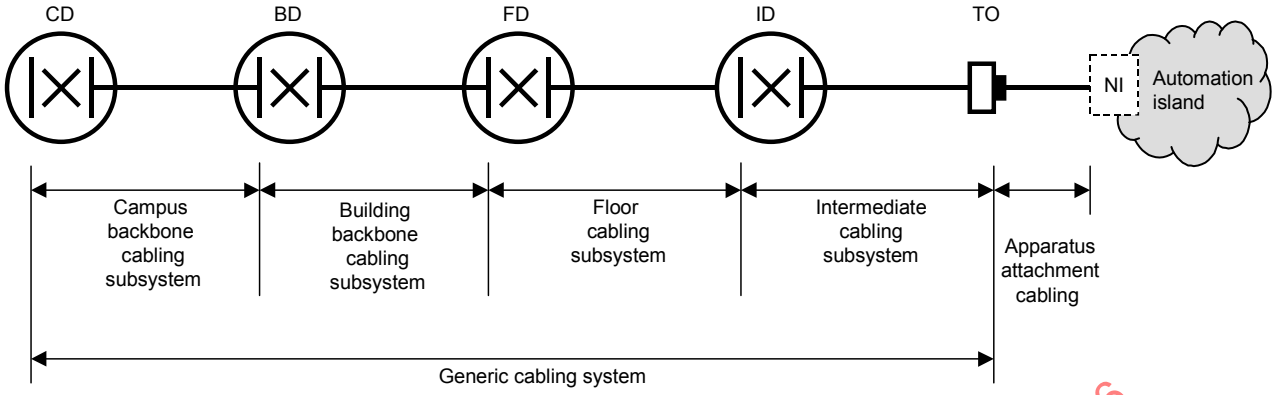

Figure 3 – Structure of generic cabling for industrial environment

The number and type of subsystems that are included in a generic cabling implementation depends upon the size and structure of the campus, building and the strategy of the user.

Connections between cabling subsystems are either active, requiring application-specific equipment or passive. Connection to application-specific equipment adopts either an interconnect or a cross-connect approach (see ISO/IEC 11801). Passive connections between cabling subsystems shall be achieved using cross-connections generally by way of either patch cords or jumpers.

Examples of more complex equipment connection systems that are not in accordance with this clause are described in Annex C and Annex D as follows:

- Annex C describes reference implementations, using the components clauses 8, 9 and 10, which deliver transmission performance in accordance with the Classes of clause 6.

- Annex D describes reference implementations, using the components clauses 8, 9 and 10, that are capable of delivering transmission performance in accordance with the Classes of clause 6 but are not able to be supported in a normative manner by this standart.

5.3.2 Campus backbone cabling subsystem

ISO/IEC 11801 specifies requirements for campus backbone cabling subsystems.

5.3.3 Building backbone cabling subsystem

ISO/IEC 11801 specifies requirements for building backbone cabling subsystems.

5.3.4 Floor cabling subsystem

The floor cabling subsystem extends from a floor distributor (FD) to the IDs connected to it. The subsystem includes

- the floor cables,
- the mechanical termination of the floor cables including the connecting hardware (e.g. of interconnect or cross-connect) at both the FD and IDs together with associated patch cords and/or jumpers,
- any passive connections to the building backbone cabling.

Although equipment cords are included in a channel, they are not considered part of the cabling subsystem because they are application-specific.

The floor cable may also interconnect IDs. However, such connections shall be in addition to those required for the basic hierarchical topology.

5.3.5 Intermediate cabling subsystem

The intermediate cabling subsystem extends from an ID to the TO(s) connected to it. The subsystem includes

- the intermediate cables,
- the mechanical termination of the intermediate cables including the connections at the TO and the ID together with associated patch cords and/or jumpers at the ID,
- the TO.

Although equipment cords and apparatus attachment cords are included in a channel, they are not considered part of the cabling subsystem because they are application-specific.

Connections between an intermediate and floor cabling subsystem are either active, requiring application-specific equipment or passive using either a cross-connect or interconnect approach as defined in ISO/IEC 11801.

Intermediate cables shall be continuous from the ID to the TO(s).

5.3.6 Centralized cabling architecture

ISO/IEC 11801 specifies requirements for centralized cabling architectures.

5.3.7 Design objectives

Generic cabling for industrial premises shall be designed in accordance with the objectives given in ISO/IEC 11801 and shall operate within the environmental conditions defined in clause 6.

5.4 Interconnection of subsystems

In industrial generic cabling, the functional elements of the cabling subsystems are interconnected to form a hierarchical structure as shown in Figure 4.

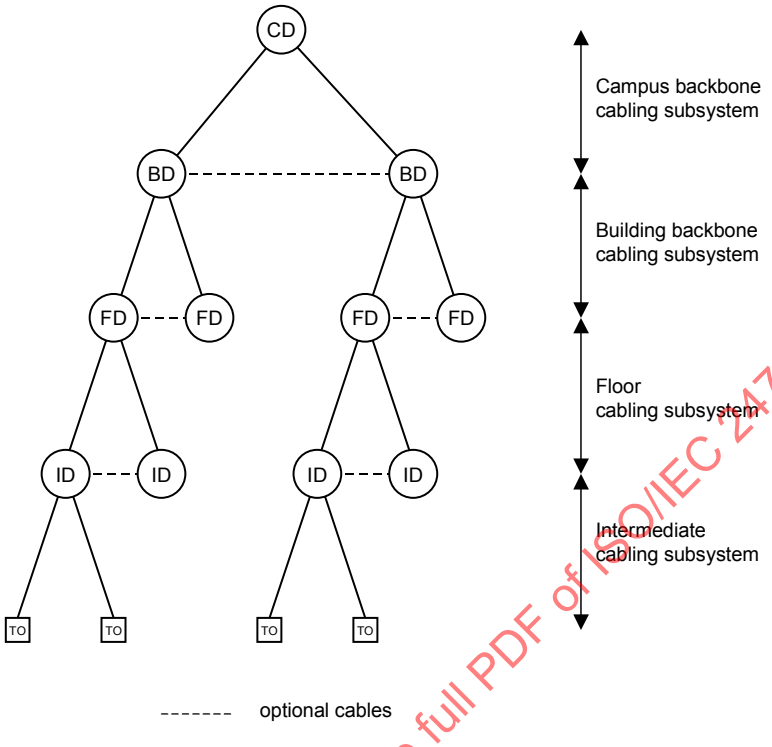

Figure 4 – Hierarchical structure of generic cabling for industrial premises

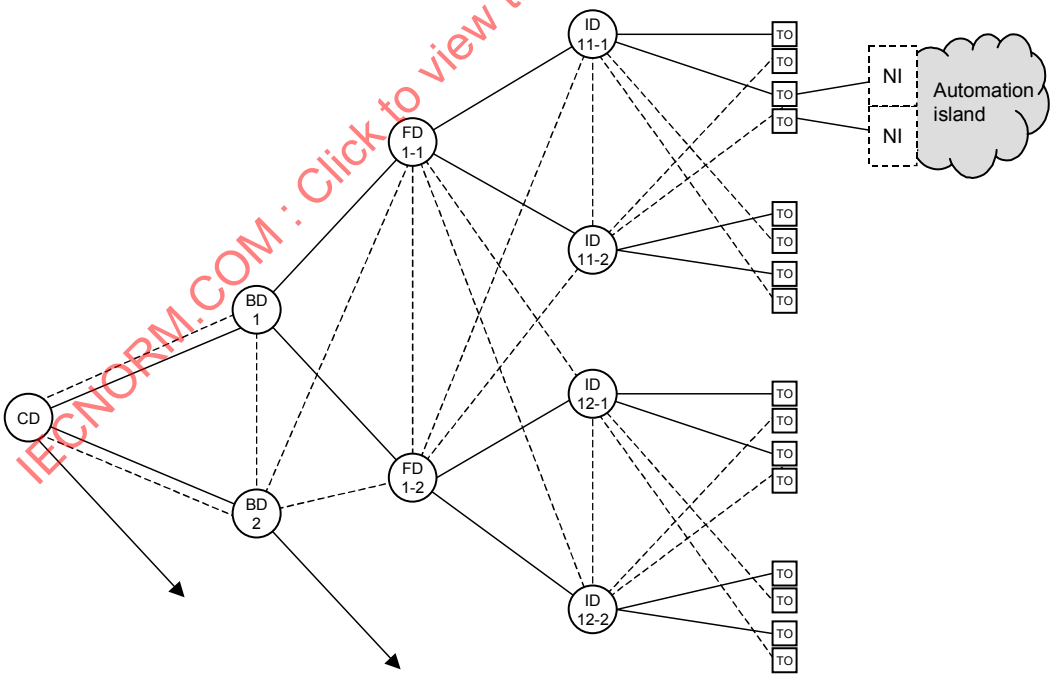

Figure 5 – Inter-relationship of functional elements in an installation with diversity for protection against failure

In certain circumstances, for example for security or reliability reasons, redundancy can be built into a cabling design. Figure 5 is a diagram showing one of many possible examples of the connection of functional elements within the structured framework to provide such redundancy. This might form the basis for the design of generic cabling for a building, providing some protection against such hazards as fire damage or the failure of the external network feeder cable.

5.5 Accommodation of functional elements

Figure 6 shows an example of how the functional elements are accommodated in a building.

FDs and IDs are typically located in industrial enclosures, equipment rooms, telecommunication rooms or adjacent to, on or within, apparatus. Other distributors are typically located in equipment rooms or telecommunications rooms as detailed in ISO/IEC 11801.

Cables are routed using pathways. A variety of cable management systems can be used to support the cables within the pathways including ducts, conduits and trays. Requirements for the pathways and the cable management systems within them are provided in ISO/IEC 18010 and IEC 61918.

TOs are normally located on the fixed building structure. If necessary, the TO can be placed within or on an apparatus.

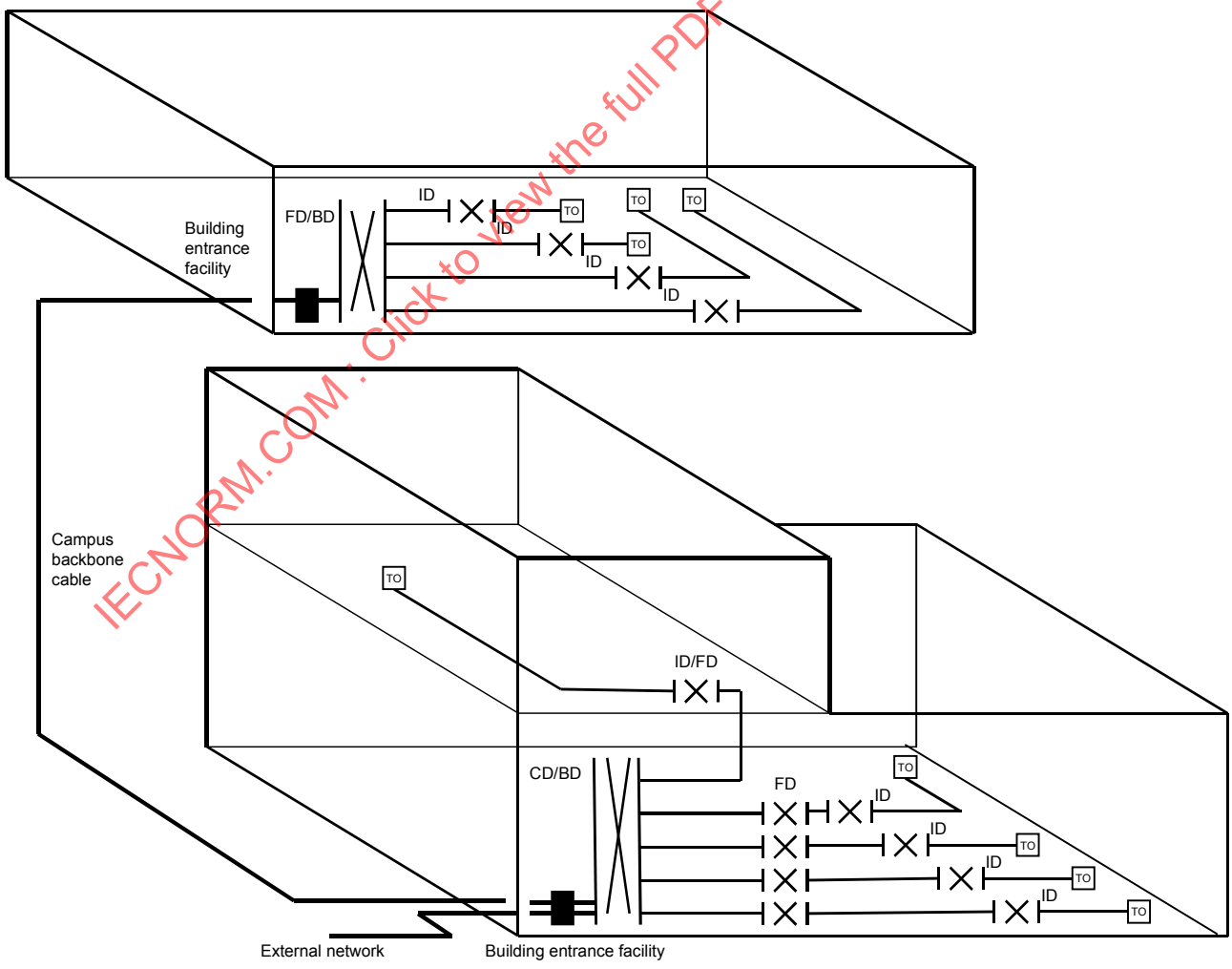

Figure 6 – Accommodation of functional elements

5.6 Interfaces

5.6.1 Equipment interfaces and test interfaces

Equipment interfaces to generic cabling are located at the ends of each subsystem. Any distributor may have an equipment interface to an external service at any port.

Test interfaces to generic cabling are located at the ends of each subsystem.

Figure 7 shows the potential equipment and test interfaces.

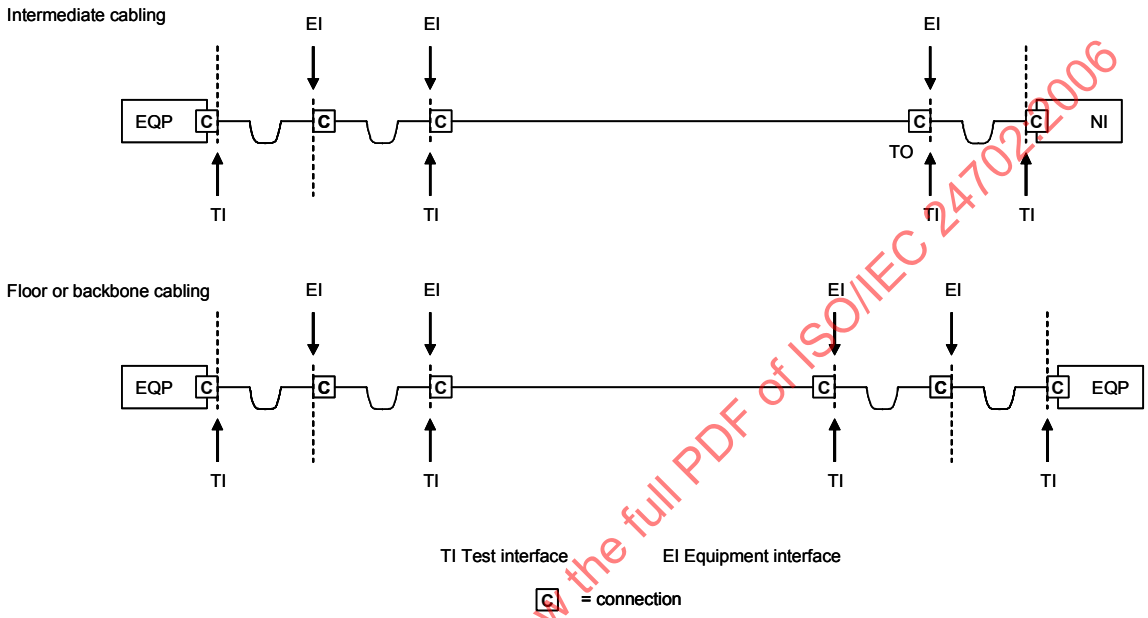

Figure 7 – Test and equipment interfaces

5.6.2 Channels and permanent links

The transmission performance of generic cabling between specific test interfaces is detailed in clause 6 for channels and Annex A for permanent links.

The channel is the transmission path between active equipment interfaces. A typical channel would consist of a cable in the intermediate cabling subsystem together with apparatus attachment and equipment cords. For longer reach services the channel would be formed by the connection of two or more subsystems (as well as with apparatus attachment and equipment cords). It is important that the generic cabling channel is designed to meet the required Class of performance for the applications that are to be supported. The channel excludes the mated connection at the active equipment.

5.6.3 External network interface

See ISO/IEC 11801.

5.7 Dimensioning and configuring

5.7.1 General

ISO/IEC 11801 specifies requirements for dimensioning and configuration for functional elements of generic cabling. The following subclauses specify additional and/or modified requirements for generic cabling for industrial premises.

5.7.2 Distributors

Usually there would be one campus distributor per campus. However, the number of BDs, FDs and IDs shall be determined by the size of the building, the floor space and the disposition of apparatus.

If the premises comprise only a single building that is small enough to be served by a single BD, there is no need for a campus backbone cabling subsystem.

The design of distributors shall ensure that the lengths of patch cords, jumpers and equipment cords are minimised and administration should ensure that the design lengths are maintained during operation. Distributors should be located in such a way that the resulting cable lengths are consistent with the channel performance requirements of clause 6

Where the components of clauses 8, 9 and 10 are used the distributors shall be located in accordance with the reference implementations of clause 7. Where other components are used, distributors shall be located so that the desired performance Class of clause 6 is delivered.

The functions of multiple distributors may be combined.

5.7.3 Cables

Cable types used in the reference implementations of clause 7 are given in clause 8. Hardware for connecting cables shall only provide direct onward attachment for each conductor and shall not provide any contact between more than one incoming or outgoing conductor (e.g. bridge taps shall not be used).

5.7.4 Apparatus attachment and equipment cords

The apparatus attachment cord connects the TO to the network interface. Equipment cords connect active equipment to the generic cabling at distributors. Both are non-permanent and application-specific. Assumptions have been made concerning the length and the transmission performance of these cords; the assumptions are identified when relevant.

The performance contribution of these cords shall be taken into account in the design of the channel. Clause 7 provides guidance on cord lengths for reference implementations of generic cabling.

5.7.5 Patch cords and jumpers

Patch cords and jumpers are used within cross-connect implementations at distributors. The performance contribution of these cords shall be taken into account in the design of the channel. Clause 7 provides guidance on cord/jumper lengths for reference implementations of generic cabling.

5.7.6 TO

The design of generic cabling for industrial premises should provide for TOs to be installed and located according to the requirements of the apparatus.

TOs may be presented singly or in groups, as indicated in the following list:

- each apparatus network shall be served by a minimum of one TO;
- the TO shall be configured with either balanced cable terminated in accordance with 9.4 or optical fibres terminated in accordance with 9.5;

- where balanced cable is used, a 4 pair balanced cable should be terminated at the TO;
  - 2 pairs per TO, terminated in accordance with 9.4.4.2, may be used, however this may require pair reassignment and will not support some applications (see Annex E);
  - 2 pairs per TO, terminated in accordance with 9.4.4.3, may be used, however the interface of 9.4.4.3 cannot provide all the transmission performance options provided by the interface of 9.4.4.2 and will not support some applications (see Annex E);
- there shall be provision for identification, visible to the user, at the location of each TO;
- application-specific devices, if used, shall be external to the TO.

Care should be taken that the initial pair assignment and all subsequent changes are recorded (see ISO/IEC 14763-1 for details of recommended administration schemes). Pair reassignment by means of inserts is allowed.

5.7.7 Telecommunications rooms and equipment rooms

See ISO/IEC 11801.

5.7.8 Industrial enclosures

Industrial enclosures shall provide all the facilities (space, power, etc.), in accordance with national and local regulations, for industrial control equipment, ID and power distribution equipment. IDs will typically be located within industrial enclosures to provide connectivity to equipment within and adjacent to the industrial enclosure. The equipment within the industrial enclosure will conform to the appropriate environmental classes outlined in clause 6. The industrial enclosures may or may not provide incremental environmental protection for their contents.

5.7.9 Building entrance facilities

See ISO/IEC 11801.

6 Channel performance

6.1 General

This clause specifies the minimum channel performance of generic cabling for industrial premises. The channel performance is specified as a combination of environmental performance and transmission performance.

The environmental performance of the cabling is specified in terms of Classes as specified in 6.2.

The transmission performance of the cabling is specified for individual channels for balanced cable and optical fibre in terms of Classes as specified in 6.3.

The environmental and transmission performance of a channel is specified at and between the connections to active equipment as shown in Figure 8. The transmission and environmental performance of the connections at the active equipment are the responsibility of the equipment supplier in support of the applications listed in Annex E.

The channel comprises only passive sections of cable, connections, apparatus attachment cords, equipment cords, patch cords and jumpers.

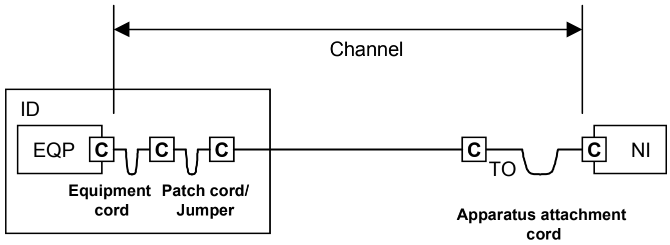

Figure 8 – Transmission performance of a channel

Application support depends on channel transmission performance only, which in turn depends on cable length, the number of connections and the performance of the components within the environments to which the channel is subjected.

The required transmission performance Class shall be met for all environmental performance Classes specified for the channel.

Transmission performance shall be assured by the selection of cabling components suitable for the environmental Class(es) or by the use of pathway systems and installation practices that provide the required protection to the installed cabling.

Channels are implemented using either

- intermediate cabling only,
- floor cabling only,
- building backbone cabling only,
- campus backbone cabling only,
- combinations of the above.

Figure 9 shows an example of a NI connected to a host using two channels; an optical fibre channel and a balanced cabling channel. The optical fibre and balanced cabling channels are connected together using an optical fibre to balanced cable converter. There are four channel interfaces; one at each end of the balanced cabling channel, and one at each end of the optical fibre cabling channel.

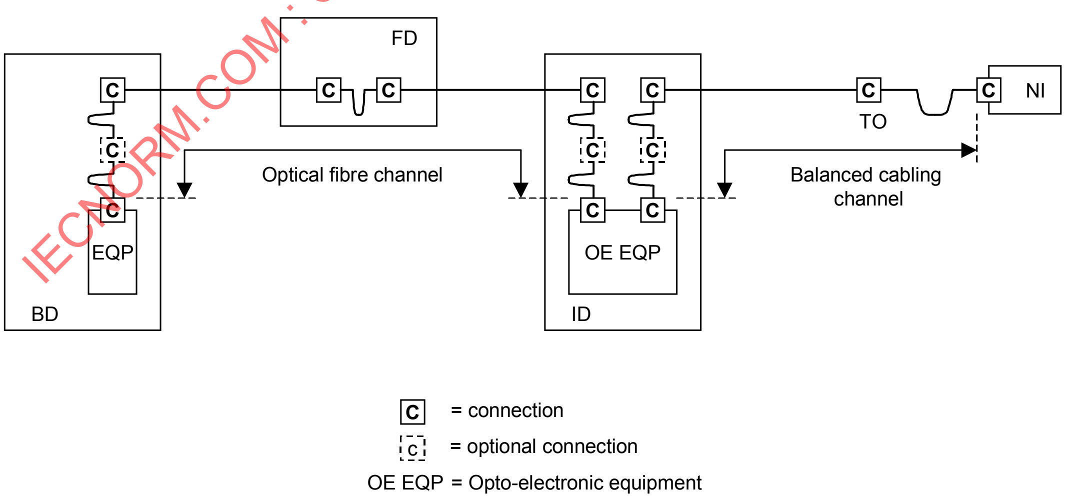

Figure 9 – Example of a system showing the location of cabling interfaces and extent of associated channels

6.2 Environmental performance

6.2.1 General

The environmental performance specifications of channels are classified to cover the different conditions under which channels are required to operate in industrial premises.

The environmental classification described in this clause shall be used for the selection of components and/or the protection afforded to them.

It is possible for the different locations within a channel to be subject to different environments. For example, one end of a channel may be in an office area and the other end of the channel may be subjected to a more severe environment. The description of the channel environment has to be divided up accordingly.

Furthermore, the applicable environment is that local to the cabling components within the channel. The local environment may, where relevant, be created by installation techniques applied to the channel in order to mitigate more extreme environments than exist within the premises.

NOTE With regard to temperature the local environment is considered to be the operating temperature of the cabling.

6.2.2 Environmental classification

This International Standard classifies the environment for generic cabling within industrial premises as defined in Table 1.

Certain environments (e.g. nuclear, chemical, fire, explosive, damage risk from animals, salt mist) demand for additional requirements beyond those of this clause. Further details on specific environments are shown in Annex F.

Table 1 – Channel environments

	1	2	3
Mechanical rating	M_1	M_2	M_3
Ingress rating	I_1	I_2	I_3
Climatic rating	C_1	C_2	C_3
Electromagnetic rating	E_1	E_2	E_3

The definition of a given classification includes the definition of lower classifications i.e. channels designed to operate under environmental conditions defined by M_2 shall continue to operate under environmental conditions defined by M_1.

Channel environments may be classified by using any combination of the MICE scheme, for example $M_1I_2C_3E_1$. Care should be taken to accurately classify the channel environment in such a way as to allow the selection of suitable components.

For the purposes of this standard

- $M_1I_1C_1E_1$ describes a typical environment such as that assumed within ISO/IEC 11801,
- $M_2I_2C_2E_2$ describes a worst case light industrial environment,
- $M_3I_3C_3E_3$ describes a worst case industrial environment as defined by this standard.

The environmental Classes are defined in Table 2 and shall be met by design.

For each M, I, C or E group, the classification of a given environment is determined by the most demanding parameter within the M, I, C or E group. However, the selection of

components shall be based on the specific demands of each of the parameters within the M, I, C or E group, which may be less demanding than the overall classification of the group.

Table 2 – Details of environmental classification

Mechanical	**M_1**	**M_2**	**M_3**
Shock/bump (see a))			
Peak acceleration	40 ms^{-2}	100 ms^{-2}	250 ms^{-2}
Vibration			
Displacement amplitude (2 Hz to 9 Hz)	1,5 mm	7,0 mm	15,0 mm
Acceleration amplitude (9 Hz to 500 Hz)	5 ms^{-2}	20 ms^{-2}	50 ms^{-2}
Tensile force	See b)	See b)	See b)
Crush	45 N over 25 mm (linear) min.	1 100 N over 150 mm (linear) min.	2 200 N over 150 mm (linear) min.
Impact	1 J	10 J	30 J
Bending, flexing and torsion	See b)	See b)	See b)
Ingress	**I_1**	**I_2**	**I_3**
Particulate ingress (∅ max.)	12,5 mm	50 µm	50 µm
Immersion	None	Intermittent liquid jet ≤12,5 l/min ≥6,3 mm jet >2,5 m distance	Intermittent liquid jet ≤12,5 l/min ≥6,3 mm jet >2,5 m distance and immersion (≤1 m for ≤30 min)
Climatic and chemical	**C_1**	**C_2**	**C_3**
Ambient temperature	−10 °C to +60 °C	−25 °C to +70 °C	−40 °C to +70 °C
Rate of change of temperature	0,1 °C per min	1,0 °C per min	3,0 °C per min
Humidity	5 % to 85 % (non-condensing)	5 % to 95 % (condensing)	5 % to 95 % (condensing)
Solar radiation	700 Wm^{-2}	1 120 Wm^{-2}	1 120 Wm^{-2}
Liquid pollution (see c)) Contaminants	Concentration × 10^{-6}	Concentration × 10^{-6}	Concentration × 10^{-6}
Sodium chloride (salt/sea water)	0	<0,3	<0,3
Oil (dry-air concentration) (for oil types see b))	0	<0,005	<0,5
Sodium stearate (soap)	None	>5 × 10^4 aqueous non-gelling	>5 × 10^4 aqueous gelling
Detergent	None	ffs	ffs
Conductive materials	None	Temporary	Present

a) Bump: the repetitive nature of the shock experienced by the channel shall be taken into account.

b) This aspect of environmental classification is installation-specific and should be considered in association with IEC 61918 and the appropriate component specification

c) A single dimensional characteristic, i.e. Concentration × 10^{-6}, was chosen to unify limits from different standards.

Gaseous pollution (see c)) Contaminants	Mean/Peak (Concentration × 10^{-6})	Mean/Peak (Concentration × 10^{-6})	Mean/Peak (Concentration × 10^{-6})
Hydrogen sulphide	<0,003/<0,01	<0,05/<0,5	<10/<50
Sulphur dioxide	<0,01/<0,03	<0,1/<0,3	<5/<15
Sulphur trioxide (ffs)	<0,01/<0,03	<0,1/<0,3	<5/<15
Chlorine wet (>50 % humidity)	<0,000 5/<0,001	<0,005/<0,03	<0,05/<0,3
Chlorine dry (<50 % humidity)	<0,002/<0,01	<0,02/<0,1	<0,2/<1,0
Hydrogen chloride	–/<0,06	<0,06/<0,3	<0,6/3,0
Hydrogen fluoride	<0,001/<0,005	<0,01/<0,05	<0,1/<1,0
Ammonia	<1/<5	<10/<50	<50/<250
Oxides of Nitrogen	<0,05/<0,1	<0,5/<1	<5/<10
Ozone	<0,002/<0,005	<0,025/<0,05	<0,1/<1
Electromagnetic	**E_1**	**E_2**	**E_3**
Electrostatic discharge – Contact (0,667 µC)	4 kV	4 kV	4 kV
Electrostatic discharge – Air (0,132 µC)	8 kV	8 kV	8 kV
Radiated RF – AM	3 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz	3 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz	10 V/m at (80 to 1 000) MHz 3 V/m at (1 400 to 2 000) MHz 1 V/m at (2 000 to 2 700) MHz
Conducted RF	3 V at 150 kHz to 80 MHz	3 V at 150 kHz to 80 MHz	10 V at 150 kHz to 80 MHz
EFT/B (comms)	500 V	1 000 V	1 000 V
Surge (transient ground potential difference) – Signal, line to earth	500 V	1 000 V	1 000 V
Magnetic Field (50/60 Hz)	1 Am^{-1}	3 Am^{-1}	30 Am^{-1}
Magnetic Field (60 Hz to 20 000 Hz)	ffs	ffs	ffs

a) Bump: the repetitive nature of the shock experienced by the channel shall be taken into account.

b) This aspect of environmental classification is installation-specific and should be considered in association with IEC 61918 and the appropriate component specification.

c) A single dimensional characteristic, i.e. Concentration × 10^{-6}, was chosen to unify limits from different standards.

6.3 Transmission performance

6.3.1 General

The channel transmission performance specifications are separated into Classes that allow for the transmission of the applications in Annex E.

The channel performance requirements described in this clause shall be used for the design and may be used for verification of any implementation of this International Standard, using the test methods defined, or referred to, by this clause. In addition, these requirements can be used for application development and trouble shooting.

The channel specifications in this clause allow for the transmission of defined Classes of applications over distances other than those of clause 7, and/or using media and components with different transmission performance than those of clauses 8, 9 and 10.

Consideration should be given to measuring performance at worst case temperatures, or calculating worst case performance based on measurements made at other temperatures.

Permanent link performance requirements are specified in Annex A.

6.3.2 Balanced cabling

6.3.2.1 General

A Class A channel is specified so that it will provide the minimum transmission performance to support Class A applications. Similarly, Class B, C, D, E and F channels provide the transmission performance to support Class B, C, D, E and F applications, respectively. Channels of a given Class will support all applications of a lower Class. Class A is regarded as the lowest Class.

The floor and intermediate cabling shall be designed to provide a minimum of Class D channel performance as specified in ISO/IEC 11801. The implementation of channels of a lower Class, incorporating intermediate cabling, is discussed in Annex C and Annex D.

In the case of cable sharing, additional requirements shall be taken into account for balanced cabling. The additional crosstalk requirements for cables are specified in 9.3 of ISO/IEC 11801, ed.2 (2002).

6.3.2.2 Additional requirements

6.3.2.2.1 Transverse conversion loss (TCL)

These requirements replace the requirement for unbalance attenuation, measured as LCL, of clause 6.4.14 of ISO/IEC 11801:2002.

The TCL parameter is applicable to all Classes.

The TCL of each pair of a channel constructed of unscreened cabling components that is intended to be subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 3. The limits shown in Table 4 are derived from the formulae at key frequencies only.

NOTE E_1 requirements in Table 3 and Table 4 are taken from future ISO/IEC 11801, Ed.2, Amendment 1 (see bibliography).

The TCL of each pair of a channel constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The TCL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware. Installation mitigation may be needed when components from a lower performance Category are used in a higher performance system.

Table 3 – Formulae for TCL limits for an unscreened cabling channel

Class	Frequency MHz	Environmental classification		
		E_1	E_2	E_3
		Minimum TCL dB		
A	0,1	30	30	30
B	f = 0,1	45	45	45
	f = 1	20	20	20
C	$1 \le f \le 16$	$30 - 5 \times \lg f$	$30 - 5 \times \lg f$	$30 - 5 \times \lg f$
D	$1 \le f \le 30$	$53 - 15 \times \lg f$, 40 max	$63 - 15 \times \lg f$, 40 max	$73 - 15 \times \lg f$, 40 max
	$30 \le f \le 100$	$60{,}4 - 20 \times \lg f$	$70{,}4 - 20 \times \lg f$	$80{,}4 - 20 \times \lg f$
E	$1 \le f \le 30$	$53 - 15 \times \lg f$	$63 - 15 \times \lg f$, 40 max	$73 - 15 \times \lg f$, 40 max
	$30 \le f \le 250$	$60{,}4 - 20 \times \lg f$	$70{,}4 - 20 \times \lg f$	$80{,}4 - 20 \times \lg f$
F	$1 \le f \le 30$	$53 - 15 \times \lg f$	$63 - 15 \times \lg f$, 40 max	$73 - 15 \times \lg f$, 40 max
	$30 \le f \le 600$	$60{,}4 - 20 \times \lg f$	$70{,}4 - 20 \times \lg f$	$80{,}4 - 20 \times \lg f$
NOTE Values above 100 MHz are for information only.				

Table 4 – Informative TCL limits for an unscreened cabling channel at key frequencies

		Minimum TCL dB					
Frequency MHz		0,1	1,0	16,0	100,0	250,0	600,0
Class A	E_1	30,0	N/A	N/A	N/A	N/A	N/A
	E_2	30,0	N/A	N/A	N/A	N/A	N/A
	E_3	30,0	N/A	N/A	N/A	N/A	N/A
Class B	E_1	45,0	20,0	N/A	N/A	N/A	N/A
	E_2	45,0	20,0	N/A	N/A	N/A	N/A
	E_3	45,0	20,0	N/A	N/A	N/A	N/A
Class C	E_1	N/A	30,0	24,0	N/A	N/A	N/A
	E_2	N/A	30,0	24,0	N/A	N/A	N/A
	E_3	N/A	30,0	24,0	N/A	N/A	N/A
Class D	E_1	N/A	40,0	34,9	20,4	N/A	N/A
	E_2	N/A	40,0	40,0	30,4	N/A	N/A
	E_3	N/A	40,0	40,0	40,0	N/A	N/A
Class E	E_1	N/A	40,0	34,9	20,4	12,4	N/A
	E_2	N/A	40,0	40,0	30,4	22,4	N/A
	E_3	N/A	40,0	40,0	40,0	34,4	N/A
Class F	E_1	N/A	40,0	34,9	20,4	12,4	4,8
	E_2	N/A	40,0	40,0	30,4	22,4	14,8
	E_3	N/A	40,0	40,0	40,0	34,4	24,8
NOTE Values above 100 MHz are for information only.							

The measurement of TCL for installed cabling is under development. TCL of a sample installation may be assessed by laboratory measurements of representative samples of channels assembled, using the components, connector termination practices and installation practices in question. The laboratory testing of TCL is performed using IEC 61935-1.

6.3.2.2.2 Equal level transverse conversion transfer loss (ELTCTL)

The ELTCTL parameter is applicable to Classes D, E and F only.

The ELTCTL of each pair of a channel constructed of unscreened cabling components that is intended to be subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 5. The limits shown in Table 6 are derived from the formulae at key frequencies only.

NOTE E_1 requirements in Table 5 and Table 6 are taken from ISO/IEC 11801, Ed.2, Amendment 1 (see bibliography).

The TCL of each pair of a channel constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The ELTCTL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware. Installation mitigation may be needed when components from a lower performance Category are used in a higher performance system.

Table 5 – Formulæ for ELTCTL limits for an unscreened cabling channel

Class	Frequency MHz	Environmental classification		
		E_1	E_2	E_3
		Minimum ELTCTL (dB)		
D, E and F	$1 \le f \le 30$	$30 - 20 \times \lg f$	$40 - 20 \times \lg f$	$50 - 20 \times \lg f$, 40 max.

Table 6 – Informative ELTCTL limits for an unscreened cabling channel at key frequencies

		Minimum ELTCTL dB		
Frequency MHz		1,0	16,0	30,0
Class D	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5
Class E	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5
Class F	E_1	30,0	5,9	0,5
	E_2	40,0	15,9	10,5
	E_3	40,0	25,9	20,5

The measurement of ELTCTL for installed cabling is under development. ELTCTL of a sample installation may be assessed by laboratory measurements of representative samples of channels assembled using the components, connector termination practices and installation practices in question. The laboratory testing of ELTCTL is performed using IEC 61935-1.

6.3.2.2.3 Coupling attenuation

The coupling attenuation parameter is applicable to Classes D, E and F only.

The coupling attenuation of each pair of a channel constructed of screened cabling components that is intended to be subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 7. The limits shown in Table 8 are derived from the formulae at key frequencies only.

NOTE E_1 requirements in Table 7 and Table 8 are taken from future ISO/IEC 11801 Ed.2 Amendment 1 (see bibliography).

The coupling attenuation of each pair of a channel constructed of unscreened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The coupling attenuation requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware. Installation mitigation may be needed when components from a lower performance Category are used in a higher performance system.

Table 7 – Formulæ for coupling attenuation limits for a screened cabling channel

Class	Frequency MHz	Environmental classification		
		E_1	E_2	E_3
		Minimum coupling attenuation (dB)		
D	$30 \le f \le 100$	40	50	60
E	$30 \le f \le 250$	$80 - 20 \times \lg f$, 40 max.	$90 - 20 \times \lg f$, 50 max.	$100 - 20 \times \lg f$, 60 max.
F	$30 \le f \le 600$	$80 - 20 \times \lg f$, 40 max.	$90 - 20 \times \lg f$, 50 max.	$100 - 20 \times \lg f$, 60 max.
NOTE Coupling attenuation applies to maximum frequency specified for the Class, and beyond that to 1 GHz for general EMC information.				

Table 8 – Informative coupling attenuation limits for a screened cabling channel at key frequencies

		Minimum coupling attenuation dB			
Frequency MHz		30,0	100,0	250,0	600,0
Class D	E_1	40,0	40,0	N/A	N/A
	E_2	50,0	50,0	N/A	N/A
	E_3	60,0	60,0	N/A	N/A
Class E	E_1	40,0	40,0	32,0	N/A
	E_2	50,0	50,0	42,0	N/A
	E_3	60,0	60,0	52,0	N/A
Class F	E_1	40,0	40,0	32,0	24,4
	E_2	50,0	50,0	42,0	34,4
	E_3	60,0	60,0	52,0	44,4

The measurement of coupling attenuation for installed cabling is under development. Coupling attenuation of a sample installation may be assessed by laboratory measurements of representative samples of channels assembled using the components, connector termination

practices and installation practices in question. The laboratory testing of coupling attenuation is performed using the applicable part of IEC 61156.

6.3.3 Optical fibre cabling

6.3.3.1 General

A given Class of optical fibre cabling channel is specified in such a way that it will support this Class of application when constructed from the appropriate type of optical fibre cables as detailed in Annex E.

This International Standard uses the optical fibre cabling channel Classes of clause 8 of ISO/IEC 11801 Ed.2 (2002), as given in the following list:

- Class OF-300 channels support applications listed in Annex E using all-silica optical fibre cables in accordance with 8.4.1 to a minimum of 300 m;
- Class OF-500 channels support applications listed in Annex E using all-silica optical fibre cables in accordance with 8.4.1 to a minimum of 500 m;
- Class OF-2000 channels support applications listed in Annex E using all-silica optical fibre cables in accordance with 8.4.1 to a minimum of 2 000 m.

In addition, this International Standard specifies the following Classes for optical fibre cabling channels:

- Class OF-25 channels support applications listed in Annex E using plastic optical fibre cable in accordance with 8.4.2 to a minimum of 25 m;
- Class OF-50 channels support applications listed in Annex E using plastic optical fibre cable in accordance with 8.4.2 to a minimum of 50 m;
- Class OF-100 channels support applications listed in Annex E using plastic or plastic clad silica optical fibre cables in accordance with 8.4.2 and 8.4.3 respectively, to a minimum of 100 m;
- Class OF-200 channels support applications listed in Annex E using plastic or plastic clad silica optical fibre cables in accordance with 8.4.2 and 8.4.3 respectively, to a minimum of 200 m;
- Class OF-5000 channels support applications listed in Annex E using all-silica optical fibre cable in accordance with 8.4.1 to a minimum of 5 000 m;
- Class OF-10000 channels support applications listed in Annex E using all-silica optical fibre cable in accordance with 8.4.1 to a minimum of 10 000 m.

The requirements for the wavelength multiplexing and de-multiplexing components will be found in the application standards. There are no special requirements for generic cabling concerning wavelength multiplexing.

6.3.3.2 Channel attenuation

The channel attenuation shall not exceed the values shown in Table 9.

The attenuation of a channel shall be measured according to ISO/IEC 14763-3. The attenuation of channels at a specified wavelength shall not exceed the sum of the specified attenuation values for the components at that wavelength (where the attenuation of a length of optical fibre cable is calculated from its attenuation coefficient multiplied by its length).

Table 9 – Channel attenuation of optical fibre cabling channels

Class	Constructed from optical fibre types of clause 8	Maximum channel attenuation dB			
		650 nm	850 nm	1 300 nm	1 550 nm
OF-25	OP1, OP2 (see Note 1)	8,0	4,0 (see Note 2)	4,0 (see Note 2)	–
OF-50	OP1, OP2 (see Note 1)	13,0	5,0 (see Note 2)	5,0 (see Note 2)	–
OF-100	OP1, OP2, OH1 (see Note 1)	23,0	7,0 (see Note 2)[3]	7,0 (see Note 2)	–
OF-200	OP2, OH1(see Note 1)	23,0	11,0	11,0	–
OF 300	OM1, OM2, OM3, OS1, OS2	See ISO/IEC 11801			
OF 500	OM1, OM2, OM3, OS1, OS2	See ISO/IEC 11801			
OF 2000	OM1, OM2, OM3, OS1, OS2	See ISO/IEC 11801			
OF 5000	OS1, OS2	–	–	4,0 (see Note 3)	4,0
OF 10000	OS1, OS2	–	–	6,0 (see Note 3)	6,0
NOTE 1 The modal conditions under which the measurement is made are ffs.					
NOTE 2 Not applicable for channels implemented using OP1 of clause 8.					
NOTE 3 For singlemode channels the nominal wavelength is 1 310 nm.					

6.3.3.3 Assumptions regarding total connecting hardware attenuation within channels

6.3.3.3.1 OF-25, OF-50, OF-100 and OF-200

The values in Table 9 are based on a total allocation of 3,0 dB for connections. Additional connectors and splices may be used if the optical power budget of the application allows.

6.3.3.3.2 OF-300, OF-500 and OF-2000

See ISO/IEC 11801.

6.3.3.3.3 OF-5000 and OF-10000

The values in Table 9 are based on a total allocation of 2,0 dB for connections. Additional connectors and splices may be used if the optical power budget of the application allows.

6.3.3.4 Propagation delay

For some applications, knowledge of the delay of fibre channels is important to ensure compliance with end- to-end delay requirements of complex networks consisting of multiple cascaded channels. For this reason, it is important to know the lengths of the optical fibre channels. It is possible to calculate propagation delay based on cable performance (see clause 8).

7 Reference implementations

7.1 General

This clause describes implementations of generic cabling that utilise components referenced in clauses 8, 9 and 10. These reference implementations meet the requirements of clause 5 and, when installed in accordance with ISO/IEC 14763 (series) and IEC 61918, comply with

the channel transmission performance requirements of 6.3 when subjected to environmental conditions as defined by the applicable environmental Class(es) of 6.2.

Equivalent channel performance can be achieved over greater lengths by the use of fewer connections or by using components with higher performance.

7.2 Balanced cabling

7.2.1 General

See the requirements of 7.2.1 of ISO/IEC 11801. Where the temperature range exceeds the values defined in ISO/IEC 11801 the manufacturer's information shall be consulted regarding required reductions in cable length.

7.2.2 Intermediate cabling

7.2.2 of ISO/IEC 11801 Ed.2 (2002) specifies reference implementations for horizontal cabling. These reference implementations are applicable to intermediate cabling subject to the following:

- intermediate cabling does not include the concept of a CP;
- components used shall meet the environmental requirements of clauses 8, 9 and 10 of this International Standard.

7.2.3 Backbone cabling

7.2.3 of ISO/IEC 11801 specifies reference implementations for backbone cabling. Components used shall meet the environmental requirements of clauses 8, 9 and 10 of this International Standard.

7.3 Optical fibre cabling

7.3.1 General

Optical fibre channels shall be comprised of components that comply with clauses 8, 9 and 10. These clauses specify physical construction (core/cladding diameter and numerical aperture) and transmission performance. Within the reference implementations of this clause, the optical fibres used in each cabling channel shall have the same specification.

When more than one physical construction or cable Category is used in a cabling subsystem the cabling shall be marked to allow each cabling type to be clearly identified.

7.3.2 Component choice

The selection of optical fibre components will be determined by the channel lengths required and the applications to be supported. Refer to Annex E for guidance.

7.3.3 Maximum channel lengths

The maximum lengths of optical fibre cabling channels of a given Class are specified in 6.3.3.

Using the cables of 8.4 and mated connections in accordance with 9.5 and where the number of mated connections within the channel exceeds two, the channel length shall be reduced by the length differentials of Table 10 for each additional connection. In addition, where splices in accordance with 9.5 are included, the channel length shall be reduced by the length differentials of Table 10 for each additional splice.

For a given length of channel, additional connections may be used if the optical power budget of the application allows it (see Annex E).

Table 10 – Optical fibre channel length equivalence for connecting hardware

OF cable	Applicable channel Class	Channel length differential (m)					
		Wavelength (nm)	650	850	1 300	1 310	1 550
OP1	OF-25, OF-50, OF-100	Mated connection	7,5	–	–	–	–
		Splice		–	–	–	–
OP2	OF-25, OF-50, OF-100, OF-200	Mated connection	15,0	37,5	37,5	–	–
		Splice	–	–	–	–	–
OH1	OF-100, OF-200	Mated connection	–	150,0	150,0	–	–
		Splice	–	–	–	–	–
OM1/OM2/OM 3	OF-300, OF-500, OF-2000	Mated connection	–	214,0	500,0	–	–
		Splice	–	90,0	200,0	–	–
OS1	OF-300, OF-500, OF-2000	Mated connection	–	–	–	750,0	750,0
		Splice	–	–	–	300,0	300,0
OS2	OF-300, OF-500, OF-2000, OF-5000, OF-10000	Mated connection	–	–	–	1 875,0	1 875,0
		Splice	–	–	–	750,0	750,0

8 Cable requirements

8.1 Introduction

This clause provides guidelines and requirements for cables used with generic cabling.

8.2 Operating environment

For each M, I, C or E group, the classification of a given environment is determined by the most demanding parameter within the M, I, C or E group. However, the selection of components shall be based on the specific demands of each of the parameters within the M, I, C or E group, which may be less demanding than the overall classification of the group.

In general, conformance to the limits and test methods specified by, and product specifications referenced in this clause for individual transmission parameters cannot be considered to provide assurance of performance when simultaneously subjected to the full range of environmental conditions of a given environmental classification.

It is assumed that if a channel is constructed entirely of components meeting requirements based on a $M_1I_1C_1E_1$ classification, according to the reference implementations of clause 7, then the required channel transmission performance is achieved in a $M_1I_1C_1E_1$ environment based upon a statistical approach of performance modelling.

The maintenance of functional performance under specific combinations of environmental conditions within a given environmental classification of Table 2 should be indicated by the supplier. Agreement shall be reached between customer and supplier that the product maintains transmission performance when subjected to specific combinations of environmental conditions.

8.3 Balanced cables

Balanced cables shall meet the requirements of Category 5, 6 or 7 cable referenced in ISO/IEC 11801 as appropriate in conjunction with a completed detail specification using IEC 61156-5-1 and IEC 61156-6-1.

Detail specifications based upon the blank detail specifications IEC 61156-5-1 and IEC 61156-6-1 shall be used to specify cable performance requirements under the environmental classifications of Table 2. Table 11 shows the elements of Table 2 that are not covered by these blank detail specifications and have to be specified separately.

Table 11 – Environmental performance specifications for balanced cables (in addition to IEC 61156-5-1 and IEC 61156-6-1)

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Bending	As required	As required	As required	IEC 62012-1
Flexing (flexible cables)	As required	As required	As required	IEC 62012-1
Torsion (flexible cables)	As required	As required	As required	IEC 62012-1
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Solar radiation	na	ffs	ffs	
Oil resistance	As required	As required	As required	IEC 62012-1
a) Cables shall maintain mechanical and electrical performance during exposure to the relevant environmental conditions described in Table 2 b) Although not contained in Table 2 “weld splatter” may also be considered during the development of a detail specification.				

8.4 Optical fibre cables

8.4.1 All-silica optical fibre cables

Multimode optical fibre cables shall meet the requirements of OM1, OM2 and OM3 cable referenced in ISO/IEC 11801, as appropriate, in conjunction with a completed detail specification based upon those within IEC 60794-2 or IEC 60794-3, as appropriate.

Singlemode optical fibre cables shall meet the requirements of OS1 cables specified in ISO/IEC 11801 or OS2 cables specified in Table 12, as appropriate, in conjunction with a completed detail specification based upon those within IEC 60794-2 or IEC 60794-3, as appropriate.

Detail specifications based upon the blank detail specifications of IEC 60794-2 or IEC 60794-3 shall be used to specify cable performance requirements under the environmental classifications of Table 2. Table 13 shows the elements of Table 2 that are not covered by these blank detail specifications and which have to be specified separately.

Table 12 – Singlemode optical fibre cable (Category OS2) performance requirements

Wavelength nm	**Maximum attenuation** dB/km
1 310	0,4
1 383	0,4
1 550	0,4
a) The optical fibre shall comply with B1.3 fibre of IEC 60793-2-50. b) The attenuation shall be measured in accordance with IEC 60793-1-40. c) The cut-off wavelength of singlemode optical fibre cables shall be less than 1 260 nm when measured in accordance with IEC 60793-1-44.	

Table 13 – Environmental performance specifications for optical fibre cables (in addition to IEC 60794-2 and IEC 60794-3)

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Bending	As required	As required	As required	IEC 60794-1-2
Flexing	As required	As required	As required	IEC 60794-1-2
Torsion	As required	As required	As required	IEC 60794-1-2
Solar radiation	na	ffs	ffs	ffs
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Solar radiation	na	ffs	ffs	
Oil resistance	As required	As required	As required	IEC 60794-1-2
a) Cables shall maintain mechanical and optical performance during exposure to the relevant environmental conditions described in Table 2. b) Any optical fibre cables containing metallic elements shall be subjected to the voltage proof test applied to balanced cables. c) Although not contained in Table 2 “weld splatter” may also be considered during the development of a detail specification.				

8.4.2 Plastic optical fibre cables

OP1 optical fibre shall have an outer cladding diameter of nominal 1 000 µm cladding diameter in accordance with A4d IEC 60793-2-40. Each optical fibre in the cable shall meet the performance requirements of Table 14. Both attenuation and modal bandwidth shall be measured in accordance with IEC 60793-1-40 and IEC 60793-1-41, respectively.

OP2 optical fibre shall be multimode, plastic optical fibre with nominal 490 µm cladding diameter in accordance with A4f fibre of IEC 60793-2-40. Each optical fibre in the cable shall meet the performance requirements of Table 14. Both attenuation and modal bandwidth shall be measured in accordance with IEC 60793-1-40 and IEC 60793-1-41 respectively.

Table 14 – Optical fibre cable performance requirements

Category	Maximum attenuation dB/km (mode distribution ffs)			Minimum modal bandwidth MHz·km		
	650 nm	850 nm	1 300 nm	650 nm	850 nm	1 300 nm
OP1	200	na	na	10	na	na
OP2	100	40	40	80	150	150
OH1	ffs	10	ffs	ffs	5	ffs
NOTE Although the attenuation and the modal bandwidth values are quoted in dB/km and MHz·km respectively, the qualification measurement may be carried out using 100 m lengths.						

Plastic optical fibre cables shall meet the requirements of OP1 or OP2 cables specified in Table 14 as appropriate when subject to the applicable environmental classification of Table 2.

8.4.3 Plastic clad silica optical fibre cables

The optical fibre shall be multimode optical fibre with nominal 200/230 µm core/cladding diameter complying with A3c fibre of IEC 60793-2-30. Each optical fibre in the cable shall meet the performance requirements of the Category OH1 in Table 14. Both attenuation and modal bandwidth shall be measured in accordance with IEC 60793-1-40 and IEC 60793-1-41, respectively.

Plastic clad silica optical fibre cables shall meet the requirements of OH1 cables specified in Table 14 when subject to the applicable environmental classification of Table 2.

8.4.4 Propagation delay

A conservative conversion value for unit propagation delay of 5,00 ns/m (0,667 c) may be used. This value can be used to calculate channel delay without verification (see clause 7).

9 Connecting hardware requirements

9.1 Introduction

This clause provides guidelines and requirements for connecting hardware used with generic cabling. For the purposes of this clause, connecting hardware (sometimes referred to as a connection) is considered to consist of a device or a combination of devices used to connect cables or cable elements. For the purpose of this clause, a connector is a component normally attached to a cable or mounted on an enclosure (excluding an adapter) for joining separable parts of a cabling system. Unless otherwise specified, this International Standard specifies the minimum requirements of mated connectors as part of a permanent link or channel. These requirements apply to individual connectors, which include TOs, patch panels, bulkhead connectors, splices and cross-connects. Performance requirements do not include the effects of cross-connect jumpers or patch cords. Requirements for balanced cords are provided in clause 10.

For the purpose of this clause the environmental requirements apply to connections (including connections to application-specific equipment).

This clause uses connecting hardware as specified in clause 8 of ISO/IEC 11801, with additional requirements as described in the following subclauses.

NOTE This clause does not address requirements for devices with passive or active electronic circuitry, including those whose main purpose is to serve a specific application or to provide compliance with other rules and regulations. Examples include media adapters, impedance matching transformers, terminating resistors, LAN equipment, filters and protection apparatus. Such devices are considered to be outside the scope of generic cabling and may have significant detrimental effects on network performance. Therefore, it is important that their compatibility with the cabling system and equipment be considered before use.

9.2 General requirements

9.2.1 Location

Connecting hardware is installed

a) in a campus distributor permitting connections to the building backbone and the campus backbone cabling and equipment (if provided),

b) in a building distributor permitting connections to the building backbone cabling and equipment (if provided),

c) in a floor distributor providing the cross-connections between the building backbone and the floor cabling and permitting connections to equipment (if provided),

d) in an intermediate distributor providing the cross-connections between the floor and intermediate cabling and permitting connections to equipment (if provided),

e) at/for/in bulkheads,

f) at the TO,

g) in the building entrance facility.

Connecting hardware shall be compatible with the environment at its intended location as defined by the classification of 6.2.

9.2.2 Design

In addition to its primary purpose, connecting hardware should be designed to provide

a) a means to identify cabling for installation and administration as described in ISO/IEC 14763-1,

b) a means to permit orderly cable management,

c) a means of access to monitor or test cabling and equipment,

d) protection against physical damage and ingress of contaminants,

e) a termination density that is space efficient, but that also provides ease of cable management and ongoing administration of the cabling system,

f) a means to accommodate screening and bonding requirements, when applicable.

When connections of the same mechanical type as the TO are used at the campus distributor, building distributor, floor distributor or intermediate distributor, they shall meet the transmission requirements as those specified for the TO, and they shall meet the environmental requirements as specified at that location.

It shall be possible to protect connecting hardware in a non-mated state to meet the stated environmental class of clause 6. Such protection may take the form of blind inserts, protective caps or overall enclosures of the connection or connections.

9.2.3 Mounting

Connecting hardware should be designed to provide flexibility for mounting, either directly or by means of an adapter plate or enclosure (e.g., on walls, in walls, in racks or on other types of distribution frames, bulkheads and mounting fixtures).

9.2.4 Marking and colour coding

Connecting hardware shall be marked or colour coded for identification purposes. The means of identification shall indicate transmission and environmental performance in accordance with this clause. The means of identification may be an element of the administration system.

Where a protective housing prevents the identification of the connecting hardware type, the protective housing shall be suitably marked or colour coded.

9.3 Operating environment

For each M, I, C or E group, the classification of a given environment is determined by the most demanding parameter within the M, I, C or E group. However, the selection of components shall be based on the specific demands of each of the parameters within the M, I, C or E group, which may be less demanding than the overall classification of the group.

In general, conformance to the limits and test methods specified by, and product specifications referenced in, this clause for individual transmission parameters cannot be considered to provide assurance of performance when simultaneously subjected to the full range of environmental conditions of a given environmental classification.

It is assumed that if a channel is constructed entirely of components meeting requirements based on a $M_1I_1C_1E_1$ classification according to the reference implementations of clause 7 then the required channel transmission performance is achieved in a $M_1I_1C_1E_1$ environment based upon a statistical approach of performance modelling.

The maintenance of functional performance under specific combinations of environmental conditions within a given environmental classification of Table 2 should be indicated by the supplier. Agreement shall be reached between customer and supplier that the product maintains transmission performance when subjected to specific combinations of environmental conditions.

9.4 Connecting hardware for balanced cabling

9.4.1 General requirements

The following requirements apply to all connecting hardware used to provide electrical connections with balanced cables that comply with the requirements of clause 8.

9.4.2 Performance marking

Connecting hardware intended for use with balanced cabling should be marked to designate transmission performance at the discretion of the manufacturer. The markings, if any, shall be visible during installation.

9.4.3 Operating environment

Connecting hardware shall meet the mechanical and transmission performance requirements of ISO/IEC 11801 as appropriate in conjunction with the performance requirements detailed in Table 15 for the relevant environmental classifications of Table 2.

Table 15 – Environmental performance specifications for balanced cabling connecting hardware

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Bump	See a)	See a)	See a)	IEC 60512-6-2
Shock	See a)	See a)	See a)	IEC 60512-6-3
Vibration sinusoidal	See a)	See a)	See a)	IEC 60512-6-4
Tensile strength, free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	IEC 60512-8 Test 16d
Cable clamp resistance to cable torsion	See b)	See b)	See b)	IEC 60512-9 Test 17d
Cable clamp resistance to rotation	See b)	See b)	See b)	IEC 60512-9 Test 17d
Ingress	**I_1**	**I_2**	**I_3**	
Particulate	IP 2X	IP 6X	IP 6X	IEC 60529
Liquid / Immersion	IP X0	IP X5	IP X5 and X7	IEC 60529
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Ambient temperature	See a)	See a)	See a)	IEC 60512-11-9 and IEC 60512-11-10
Rapid change of temperature	See a)	See a)	See a)	IEC 60512-11-4
Solar radiation	See a)	See a)	See a)	ffs
Damp heat cyclic	See a)	See a)	See a)	IEC 60512-11-12
Fluid resistance	See a)	See a)	See a)	IEC 60512-19-3
Flowing mixed gas corrosion test	See a)	See a)	See a)	IEC 60512-11-7
Electromagnetic	**E_1**	**E_2**	**E_3**	
Shielding effectiveness	See a)	See a)	See a)	IEC 60512-23-3, and IEC 60512-4-2 for partial discharge
RF	See a)	See a)	See a)	IEC 60512-23-3
Voltage proof	See a)	See a)	See a)	IEC 60512-4-1

a) Connecting hardware shall maintain mechanical and electrical performance during exposure to the relevant environmental conditions described in Table 2.

b) Connecting hardware shall maintain mechanical and electrical performance during exposure to the relevant environmental conditions.

c) Although not contained in Table 2 “weld splatter” may also be considered during the development of a detail specification.

9.4.4 Mechanical and electrical characteristics of balanced connecting hardware

9.4.4.1 General

Connecting hardware shall meet the general requirements of this clause and the mechanical and electrical requirements specified in ISO/IEC 11801.

9.4.4.2 Mechanical characteristics of balanced connecting hardware using 4 pairs at the TO

Where required by the design or the environmental classification of the location, the protective housing shall meet the general requirements of this clause and the mechanical and physical requirements of IEC 61076-3-106, Variant 4.

Where connections provide dedicated support for applications specified by IEC 61918, the Automation Outlet (AO) interfaces of IEC 61918 should be used120.

Pin and pair grouping assignments shall be as shown in Figure 10. All unused pairs within the same cable sheath shall be terminated to match the nominal impedance of the cable.

Pair rearrangement at the TO should not involve modification of the intermediate cable terminations. If pair rearrangement is used at the TO, the configuration of the outlet terminations shall be clearly identified.

When two physically similar cabling links 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.

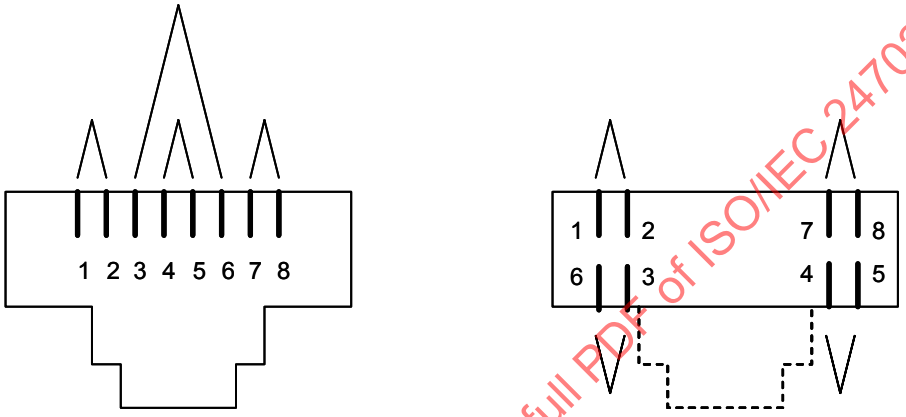

Figure 10 – Eight position jack pin and pair grouping assignments (front view of connector)

9.4.4.3 Mechanical characteristics of balanced connecting hardware using 2 pairs at the TO

Where a smaller housing is required and where the provision of only two balanced pairs is acceptable, connecting hardware meeting the mechanical and physical requirements of IEC 61076-2-101 Type D with 4 poles may also be used as an alternative to that specified in 9.4.4.2.

Pin and pair grouping assignments shall be as shown in Figure 11.

When two physically similar cabling links 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.

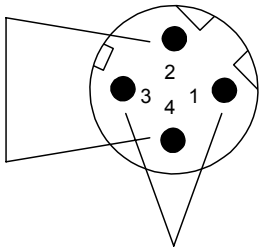

Figure 11 – Four position jack pin and pair grouping assignments (front view of connector)

9.5 Connecting hardware for optical fibres

9.5.1 Operating environment

Connecting hardware shall meet the mechanical and transmission performance requirements of ISO/IEC 11801 as appropriate in conjunction with the performance requirements detailed in Table 16 for the relevant environmental classifications of Table 2.

Table 16 – Environmental performance specifications for optical fibre cabling connecting hardware

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Bump	See a)	See a)	See a)	New requirements under consideration
Shock	See a)	See a)	See a)	IEC 61300-2-9
Vibration sinusoidal	See a)	See a)	See a)	IEC 61300-2-1
Tensile strength, Free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	IEC 61300-2-4
Cable clamp resistance to cable torsion	See b)	See b)	See b)	IEC 61300-2-5
Cable clamp resistance to rotation	See b)	See b)	See b)	IEC 61300-2-44
Ingress	**I_1**	**I_2**	**I_3**	
Particulate	IP 2X	IP 6X	IP 6X	Under consideration
Liquid / Immersion	IP X0	IP X5	IP X5 and X7	Under consideration
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Ambient temperature	See a)	See a)	See a)	IEC 61300-2-18
Rapid change of temperature	See a)	See a)	See a)	IEC 61300-2-22
Solar radiation	See a)	See a)	See a)	IEC 61300-2-30
Damp heat cyclic	See a)	See a)	See a)	IEC 61300-2-46
Fluid resistance	See a)	See a)	See a)	IEC 61300-2-34
Flowing mixed gas corrosion test	See a)	See a)	See a)	New requirements under consideration

a) Connecting hardware shall maintain mechanical and optical performance during exposure to the relevant environmental conditions described in Table 2.

b) Connecting hardware shall maintain mechanical and optical performance during exposure to the relevant environmental conditions.

c) Although not contained in Table 2 “weld splatter” may also be considered during the development of a detail specification.

9.5.2 Connecting hardware for all-silica optical fibres

9.5.2.1 General requirements

The following requirements together with the general requirements of this clause apply to all connecting hardware used to provide optical connections with all-silica optical fibres that comply with the requirements of clause 8.

Connecting hardware shall meet the requirements of this clause and the mechanical and optical requirements specified in ISO/IEC 11801.

9.5.2.2 Marking and colour coding

The connectors and adaptors should be coloured to distinguish between singlemode and multimode optical fibres.

Additional colours or labels may be required to distinguish between the optical fibre types. In addition, keying and the identification of fibre positions may be used to ensure that correct polarity is maintained for duplex links.

NOTE 1 These markings are in addition to, and do not replace, other markings specified in ISO/IEC 14763-1, or those required by local codes or regulations.

NOTE 2 The following colour codes apply for IEC 61754-20 (LC connectors):

Multimode 50 µm and 62,5 µm:	Beige
Singlemode PC:	Blue
Singlemode APC:	Green

9.5.2.3 Mechanical characteristics of all-silica optical fibre connecting hardware at the TO

The connecting hardware shall be as specified in IEC 61754-20 (LC connector family).

Where required by the design or the environmental classification of the location, the protective housing shall meet the general requirements of this clause and the mechanical and physical requirements of IEC 61076-3-106 Variant 4 by use of appropriate inserts IEC 61754-20 (all standard interfaces).

Where connections provide dedicated support for applications specified in IEC 61918, the AO interfaces of IEC 61918 should be used.

9.5.3 Connecting hardware for plastic optical fibres

9.5.3.1 General requirements

The following requirements together with the general requirements of this clause apply to all connecting hardware used to provide optical connections with plastic optical fibres that comply with the requirements of clause 8.

9.5.3.2 Optical characteristics

The insertion loss of a mated connection shall not exceed 1,5 dB when measured in accordance with IEC 61300-3-34. The modal conditions under which the measurement is made are for further study.

9.5.3.3 Marking and colour coding

The connectors and adaptors should be coloured to distinguish between optical fibre types. In addition, keying and the identification of fibre positions may be used to ensure that correct polarity is maintained for duplex links.

NOTE These markings are in addition to, and do not replace, other markings specified in ISO/IEC 14763-1, or those required by local codes or regulations.

9.5.3.4 Mechanical characteristics of plastic optical fibre connecting hardware at the TO

The connecting hardware shall be as specified in IEC 61754-20 (LC connector family).

Where required by the design or the environmental classification of the location, the protective housing shall meet the general requirements of this clause and the mechanical and physical requirements of IEC 61076-3-106, Variant 4 by use of appropriate inserts, see IEC 61754-20 (all standard interfaces).

Where connections provide dedicated support for applications specified by IEC 61918, the AO interfaces of IEC 61918 should be used.

9.5.4 Connecting hardware for plastic clad silica fibres

9.5.4.1 General requirements

The following requirements together with the general requirements of this clause apply to all connecting hardware used to provide optical connections with plastic clad silica optical fibres that comply with the requirements of clause 8.

9.5.4.2 Optical characteristics

The insertion loss of a mated connection shall not exceed 1,5 dB when measured in accordance with IEC 61300-3-34. The modal conditions under which the measurement is made are for further study.

9.5.4.3 Marking and colour coding

The connectors and adaptors should be coloured to distinguish between optical fibre types. In addition, keying and the identification of fibre positions may be used to ensure that correct polarity is maintained for duplex links.

NOTE These markings are in addition to, and do not replace, other markings specified in ISO/IEC 14763-1, or those required by local codes or regulations.

9.5.4.4 Mechanical characteristics of plastic clad silica fibre connecting hardware at the TO

The connecting hardware shall be as specified in IEC 61754-20 (LC connector family).

Where required by the design or the environmental classification of the location, the protective housing shall meet the general requirements of this clause and the mechanical and physical requirements of IEC 61076-3-106 Variant 4 by use of appropriate inserts, see IEC 61754-20 (all standard interfaces).

Where connections provide dedicated support for applications specified by IEC 61918, the AO interfaces of IEC 61918 should be used.

10 Cords

10.1 General

The performance of channels is dependent upon the performance of cords. The moves, additions and changes made using cords represent a greater risk to operational channel performance than that of installed intermediate, floor or backbone cables.

This clause specifies the requirements for terminated cables used as apparatus attachment cords, equipment cords and patch cords within intermediate, floor and backbone cabling.

The use of cables and connecting hardware suitable for use when subject to certain environmental conditions does not automatically assure that the cord meets the applicable transmission performance of this clause when subjected to those environment conditions.

10.2 Operating environment

For each M, I, C or E group, the classification of a given environment is determined by the most demanding parameter within the M, I, C or E group. However, the selection of components shall be based on the specific demands of each of the parameters within the M, I, C or E group, which may be less demanding than the overall classification of the group.

In general, conformance to the limits and test methods specified by, and product specifications referenced in, this clause for individual transmission parameters cannot be considered to provide assurance of performance when simultaneously subjected to the full range of environmental conditions of a given environmental classification.

It is assumed that if a channel is constructed entirely of components meeting requirements based on a $M_1I_1C_1E_1$ classification, according to the reference implementations of clause 7, then the required channel transmission performance is achieved in a $M_1I_1C_1E_1$ environment based upon a statistical approach of performance modelling.

The maintenance of functional performance under specific combinations of environmental conditions within a given environmental classification of Table 2 should be indicated by the supplier. Agreement shall be reached between customer and supplier that the product maintains transmission performance when subjected to specific combinations of environmental conditions.

10.3 Balanced cords

10.3.1 General

This subclause specifies the minimum requirements for balanced cords used in the intermediate, floor and backbone channels specified in clause 5.

Cords shall be assembled using flexible cables in accordance with 8.3 and connectors in accordance with clause 9 with the exception of the equipment connectors used on apparatus attachment and equipment cords that lie outside the scope of this International Standard.

The construction of the flexible cables shall reflect the specified bend radius and any requirements for repetitive bending/flexing of the cord during installation and operation.

The cable and, where appropriate, cable screens, shall be fitted to the connectors following the procedures and using the tools specified by the manufacturers of the connecting hardware.

The connecting hardware and the interconnected pin assignment shall be in accordance with the intended use of the cord and shall be a logical extension to the cabling interface(s) to which it is to be connected.

Balanced cables shall meet the requirements of Category 5, 6 or 7 cable, as appropriate, referenced in ISO/IEC 11801 in conjunction with a completed detail specification using IEC 61156-6-1 (see 8.3).

Connecting hardware shall meet the mechanical and transmission performance requirements of 9.4 in conjunction with the performance requirements detailed in Table 15 for the relevant environmental classifications of Table 2.

10.3.2 Cable insertion loss

Most IEC 60603-7 connecting hardware are limited to maximum insulated conductor diameters of 1,02 mm. For cables containing stranded conductors the insulated conductor diameter influences the maximum conductor diameter for a given cable construction which, in turn, influences the insertion loss of the cable.

The maximum insertion loss ratio of flexible cables in accordance with 8.3, defined as their insertion loss (dB/100 m) compared to that of installation cables, is 1,5. However, cable constructions having insertion loss ratios below 1,5 are supported by the reference implementation rules of clause 7.

The maintenance of channel performance requires that flexible cables of the correct insertion loss ratio shall be used as defined by the implementation rules.

10.3.3 Identification

Each cord shall be identified to indicate:

- length;
- the design attenuation ratio of the cable;
- category of cable;
- wire-map status where a direct pin-pin relationship does not exist (i.e. cross-over cords).

10.3.4 Operating environment

Detail specifications based upon the blank detail specification IEC/PAS 61935-2-20 (see bibliography) shall be used to specify cord performance requirements under the environmental classifications of Table 2. Table 17 shows the elements of Table 2 that are not covered by these blank detail specifications and which have to be specified separately.

Table 17 – Environmental performance specifications for balanced cords (in addition to IEC/PAS 61935-2-20)[a)]

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Tensile strength, free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	
Cable clamp resistance to cable torsion	Note 1	Note 1	Note 1	
Cable clamp resistance to rotation	Note 1	Note 1	Note 1	
Bending and flexing	Note 1	Note 1	Note 1	
ffs				
Ingress	**I_1**	**I_2**	**I_3**	
ffs				
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Oil resistance	As required	As required	As required	
ffs				
Electromagnetic	**E_1**	**E_2**	**E_3**	
ffs				
NOTE 1 Cables shall maintain functional performance during exposure to the relevant environmental conditions described in Table 2 NOTE 2 Although not contained in Table 2 “weld splatter” may also be considered during the development of a detail specification				
a) See bibliography for this reference.				

10.3.5 Electrical performance requirements for patch cords

10.3.5.1 Insertion loss

Insertion loss measurements of cords shall not exceed the insertion loss requirements of the connection at each end plus the insertion loss requirement for the cable, scaled for length. The insertion loss performance is achieved by design.

10.3.5.2 Return loss

See ISO/IEC 11801.

10.3.5.3 Near-end crosstalk loss (NEXT)

When measured in accordance with IEC 61935-2, cords shall meet the NEXT requirements of 5.7.5 of IEC 61935-2.

10.4 Optical fibre cords

10.4.1 General

This clause specifies the minimum requirements for optical cords used in the intermediate, floor and backbone channels specified in clause 5.

Cords shall be assembled using flexible cables in accordance with 8.4 and connectors in accordance with clause 9 with the exception of the equipment connectors used on apparatus attachment and equipment cords that lie outside the scope of this International Standard.

The construction of the flexible cables shall reflect the specified bend radius and any requirements for repetitive bending/flexing of the cord during installation and operation.

The cable shall be fitted to the connectors following the procedures and using the tools specified by the manufacturers of the connections.

The connecting hardware and the means of maintaining polarity within the cord shall be in accordance with the intended use of the cord and shall be a logical extension to the cabling interface(s) to which it is to be connected.

Optical fibre cables shall meet the requirements of

- Category OM1, OM2, OM3 or OS1 as specified in ISO/IEC 11801,

or

- OS2, OP1, OP2 or OH1 as specified in 8.4,

as appropriate, in conjunction with the relevant completed detail specification (see 8.4).

Connecting hardware shall meet the mechanical and transmission performance requirements of 9.5 in conjunction with the performance requirements detailed in Table 16 for the relevant environmental classifications of Table 2.

10.4.2 Identification

Each cord shall be identified to indicate:

- length;
- the core diameter;
- Category of cable;
- port-map status where a direct port-port relationship does not exist (i.e. cross-over cords).

10.4.3 Performance requirements for patch cords

10.4.3.1 Attenuation/insertion loss

Attenuation/insertion loss measurements of cords shall not exceed the attenuation/insertion loss requirements of the connection at each end plus the attenuation/insertion loss requirement for the cable, scaled for length. The attenuation/insertion loss performance is achieved by design.

10.4.4 Operating environment

Detail specifications based upon the performance specifications in the IEC 61753 series shall be used to specify cord performance requirements under the environmental classifications of Table 2. Table 18 shows the elements of Table 2 that are not covered by these IEC 61753 series and which have to be specified separately.

Table 18 – Environmental performance specifications for optical fibre cords (in addition to IEC 61753-X)

Mechanical	**M_1**	**M_2**	**M_3**	**Reference**
Tensile strength, Free connector to cable	25 N (ffs)	300 N (ffs)	500 N (ffs)	
Cable clamp resistance to cable torsion	See a)	See a)	See a)	
Cable clamp resistance to rotation	See a)	See a)	See a)	
Bending and flexing	See a)	See a)	See a)	
ffs				
Ingress	**I_1**	**I_2**	**I_3**	
ffs				
Climatic and chemical	**C_1**	**C_2**	**C_3**	
Oil resistance	As required	As required	As required	
ffs				
Electromagnetic	**E_1**	**E_2**	**E_3**	
ffs				

a) Cables shall maintain functional performance during exposure to the relevant environmental conditions described in Table 2.

b) Although not contained in Table 2 “weld splatter” may also be considered during the development of a detail specification.

Annex A
(normative)

Permanent link performance limits

A.1 General

This annex contains performance requirement formulae for permanent links, as shown in Figure A.1, and relates to Annex A of ISO/IEC 11801.

The cabling under test in Configurations A, B and C is termed the permanent link:

In all configurations the test configuration reference plane of a link is within the test cord cable next to, and including, the test cord connection which mates to the termination point of the link under test.

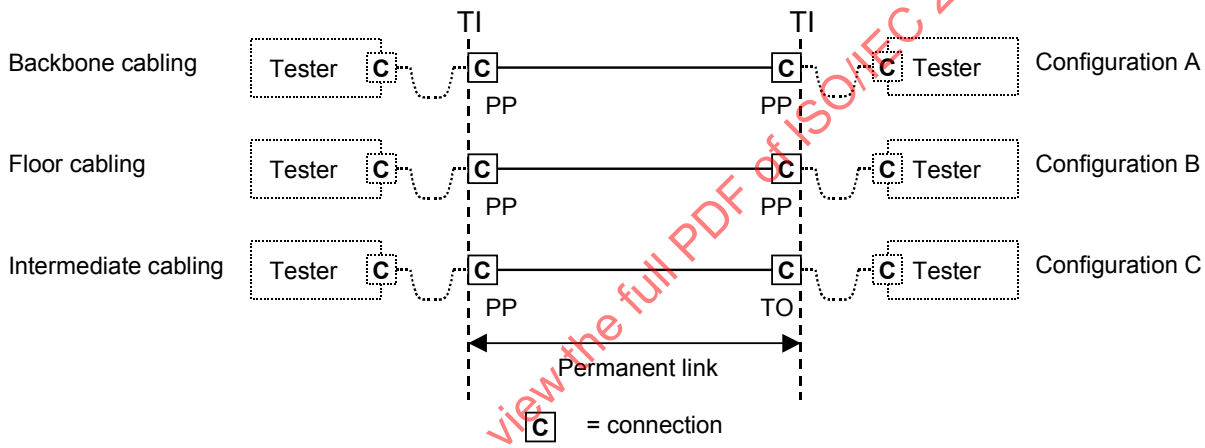

Figure A.1 – Permanent link options

A.2 Balanced cabling

A.2.1 General

The parameters specified in this Annex apply to balanced permanent links with screened or unscreened cable elements, with or without an overall screen, unless explicitly stated otherwise. The nominal impedance of balanced permanent links is 100 Ω. This is achieved by suitable design and appropriate choice of cabling components (irrespective of their nominal impedance).

Consideration should be given to measuring performance at worst case temperatures or calculating worst case performance based on measurements made at other temperatures.

In the case of cable sharing, additional requirements shall be taken into account for balanced cabling. The additional crosstalk requirements are specified in 9.3 of ISO/IEC 11801 (2002).

The permanent links shall comply with the requirements of the appropriate Class of ISO/IEC 11801.

A.2.2 Additional requirements

A.2.2.1 TCL

These requirements replace the requirement for unbalance attenuation, measured as LCL, of 6.4.14 of ISO/IEC 11801.

The TCL parameter is applicable to all Classes.

The TCL of each pair of a channel constructed of unscreened cabling components that is intended to be subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 3. The limits shown in Table 4 are derived from the formulae at key frequencies only.

The TCL of each pair of a channel constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The TCL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware. Installation mitigation may be needed when components from a lower performance category are used in a higher performance system.

The measurement of TCL for installed cabling is under development. TCL of a sample installation may be assessed by laboratory measurements of representative samples of permanent links assembled using the components, connector termination practices and installation practices in question. The laboratory testing of TCL is performed using IEC 61935-1.

A.2.2.2 ELTCTL

The ELTCTL parameter is applicable to Classes D, E and F only.

The ELTCTL of each pair of a channel constructed of unscreened cabling components that is intended to be subjected to an environmental classification E_x shall meet the limits computed, to one decimal place, using the formulae of Table 5. The limits shown in Table 6 are derived from the formulae at key frequencies only.

The TCL of each pair of a channel constructed of screened cabling components that is subjected to an environmental classification E_x is not specified (ffs).

The ELTCTL requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware. Installation mitigation may be needed when components from a lower performance category are used in a higher performance system.

The measurement of ELTCTL for installed cabling is under development. ELTCTL of a sample installation may be assessed by laboratory measurements of representative samples of permanent links assembled using the components, connector termination practices and installation practices in question. The laboratory testing of ELTCTL is performed using IEC 61935-1.

A.2.2.3 Coupling attenuation

The coupling attenuation parameter is applicable to Classes D, E and F only.

The coupling attenuation of each pair of a channel constructed of screened cabling components that is intended to be subjected to an environmental classification E_x shall meet

the limits computed, to one decimal place, using the formulae of Table 7. The limits shown in Table 8 are derived from the formulae at key frequencies only.

The coupling attenuation of each pair of a channel constructed of unscreened cabling components that is subjected to an environmental classification E_X is not specified (ffs).

The coupling attenuation requirements shall be met at both ends of the cabling and shall be achieved by the appropriate choice of cables and connecting hardware. Installation mitigation may be needed when components from a lower performance category are used in a higher performance system.

The measurement of coupling attenuation for installed cabling is under development. Coupling attenuation of a sample installation may be assessed by laboratory measurements of representative samples of permanent links assembled using the components, connector termination practices and installation practices in question. The laboratory testing of coupling attenuation is performed using the appropriate part of IEC 61156.

A.2.3 Optical fibre cabling

A.2.3.1 All-silica optical fibre permanent links

The permanent link requirements of ISO/IEC 11801 apply.

A.2.3.2 Plastic optical fibre permanent links

The attenuation of a permanent link at a specified wavelength shall not exceed the sum of the specified attenuation values for the cabling components at that wavelength (where the attenuation of a length of optical fibre cable is calculated from its attenuation coefficient multiplied by its length).

The test methods are for further study.

A.2.3.3 Plastic clad silica optical fibre permanent links

The attenuation of a permanent link at a specified wavelength shall not exceed the sum of the specified attenuation values for the cabling components at that wavelength (where the attenuation of a length of optical fibre cable is calculated from its attenuation coefficient multiplied by its length).

The test methods are for further study.

Annex B
(normative)

Test methods

B.1 General

B.1.1 Visual inspection

B.1.1.1 General

The objective of the visual inspection is to verify that the installation and the test results are in accordance with the requirements.

The documentation shall be a basis for the operation and maintenance of the installation.

B.1.1.2 Conformance of the components

The components shall comply with

- their Category of qualification according to the IEC specifications,
- the environmental specification.

The visual inspection shall verify that the installation and specifically the connection between connectors and cables shall comply with the manufacturer's specification.

B.1.1.3 Conformance of the labeling

The visual inspection shall verify that labeling is in agreement with this International Standard, the installation specification and local regulations, if applicable.

The visual inspection shall verify the labeling at each TO and that the test reports use the same or aggregate references.

B.1.1.4 Conformance of the documentation

The documentation of the tests shall be in accordance of the description above for each parameter for balanced and optical fibre cabling. Furthermore the documentation shall meet the specific requirements of the client (e.g. characterisation traces for the balanced cabling).

NOTE The installer shall provide the software or at least the revision number to read the results of the test results database.

B.1.2 Measurements

B.1.2.1 Location of measurement (test) interfaces

B.1.2.1.1 Cabling under test

The cabling under test shall be either a channel or a permanent link. Termination resistors shall be removed from all termination points connected to the cabling under test unless required by the test method.

B.1.2.1.2 Reference planes for balanced and optical fibre cabling

The accuracy of the test system is defined at its reference plane. The reference planes for channels and links are defined according to Figure B.1.

The test configuration reference plane at each end of a channel is within the equipment cable next to, but excluding, the connection of the equipment cable into the test equipment.

The test configuration reference plane of a link is within the test cord cable next to, and including, the test cord connection which mates to the termination point of the link under test.

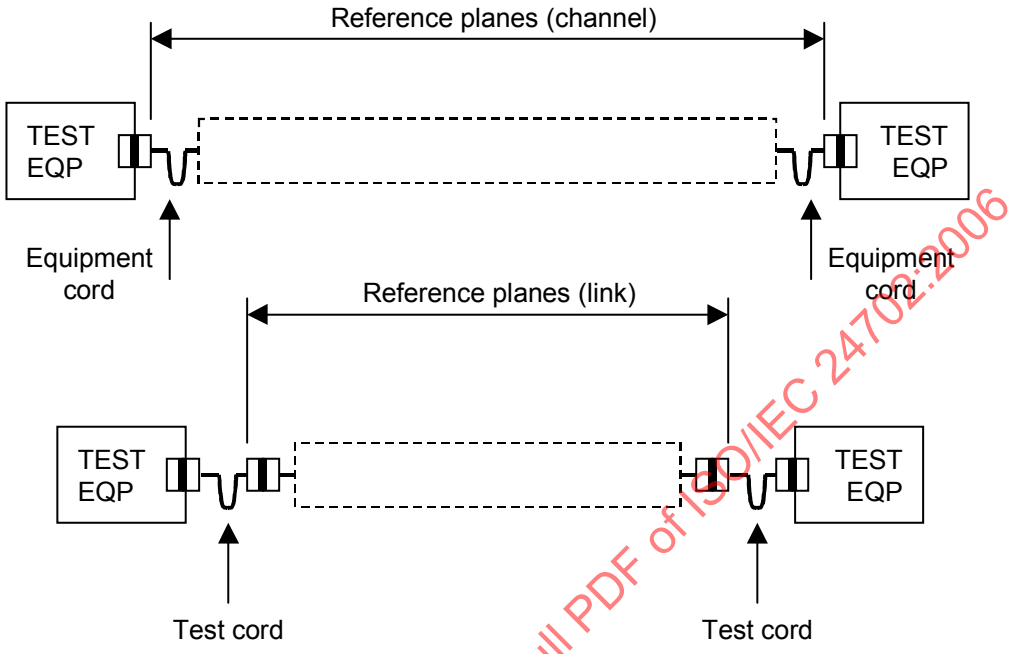

Figure B.1 – Reference planes for link and channels (point-to-point)

B.1.2.2 Safety requirements for test procedures

B.1.2.2.1 Safety

Relevant national and local regulations covering safe working practices shall be observed.

B.1.2.2.2 Equipment protection

Transmission and terminal equipment shall be removed from the termination points connected to the cabling under test.

B.1.2.3 Test system

B.1.2.3.1 Introduction

This International Standard specifies test procedures for the measurement of cabling transmission performance on installed cabling comprising balanced or optical fibre cabling. The test methods refer to existing standards-based procedures where they exist.

The test system shall be specified for each test. The test system comprises local test equipment and remote test equipment (where required) together with any cabling interface adaptors which enable the connection of the test equipment to the cabling under test (see Figure B.2). The test equipment and cabling interface adaptors shall be used in accordance with IEC 61935-1.

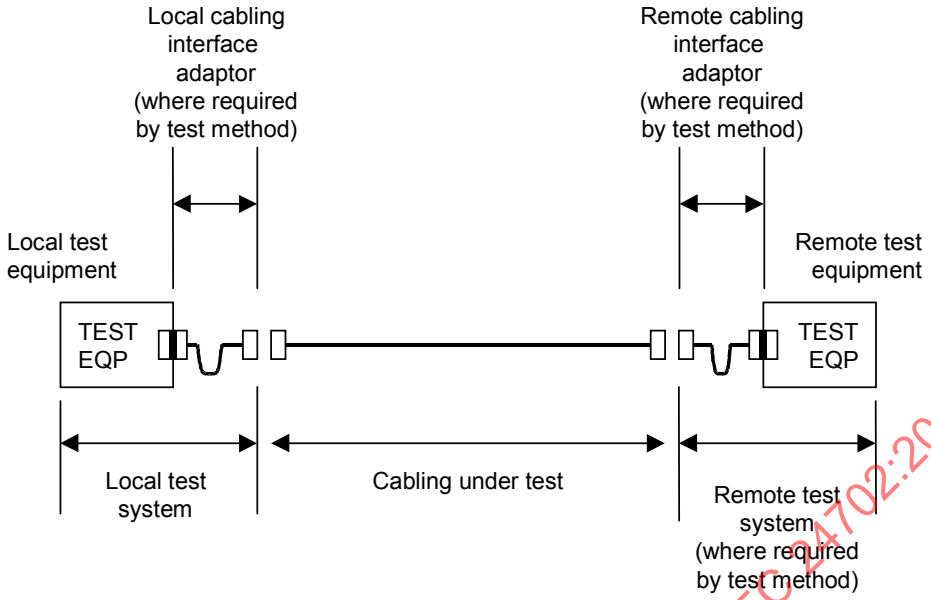

Figure B.2 – The test system and the cabling under test

The uncertainty of measurement for a given parameter is the accuracy of the test system. The test system is defined as the test equipment together with the cabling interface adaptors.

The test equipment and cabling interface adaptors shall be in accordance with B.1.2.3.2 and B.1.2.3.3 respectively.

B.1.2.3.2 Test equipment

The appropriate type of test equipment and any specific requirements for that equipment shall be referenced by the test procedure.

B.1.2.3.3 Cabling interface adaptors

The cabling interface adaptors may take the form of test cords, terminations, impedance matching devices or more complex combinations of components.

For balanced cabling, cabling interface adaptors define the number of pairs and the configuration of those pairs under test in accordance with the relevant cabling or application standard.

For optical fibre cabling, cabling interface adaptors define the number of optical fibres under test in accordance with the relevant cabling or application standard.

Cabling interface adaptors have an effect on the uncertainty of measurement.

The test system designer shall define a maximum operational lifetime for the cabling interface adaptor (e.g. a time period or a maximum number of connector mating cycles to the test equipment and/or cabling under test) or provide a method to determine an acceptable adaptor performance.

For optical fibre cabling, adaptors shall not use gels when testing channels or links.

B.1.2.4 Normalisation and calibration

The test system designer shall define a process for the normalisation of the test system in order that the stated measurement accuracy is achieved. The test operator shall ensure that the test system has been normalised in accordance with this process prior to the test being carried out.

The normalisation process shall include a traceable calibration procedure for the test equipment. The test operator shall have evidence, in the form of a valid calibration certificate, to support the use of the test equipment at the time the tests are carried out.

B.1.2.5 Environmental conditions

B.1.2.5.1 Contamination

The presence of dust, dirt and other contaminants at the interfaces to the cabling under test may produce misleading results and in some cases damage the cabling under test and/or the cabling interface adaptor.

The mating connector end faces of cabling interface adaptors and the cabling under test shall be cleaned in accordance with the connecting hardware manufacturer's instructions prior to mating.

B.1.2.5.2 Test equipment

External effects (for example, environmental, electromagnetic or physical) can affect the test equipment thereby influencing the measured results. The effects shall either be quantified or eliminated.

The minimum level of accuracy of the test equipment for measuring a Class (channel or permanent link) shall be in accordance with the Table B.1.

Table B.1 – Level of accuracy for balanced cabling tester

Class	D	E	F
Level IEC 61935-1	II	III	IV

B.1.2.5.3 Cabling under test

Measurement of attenuation (insertion loss), d.c. loop resistance and related parameters applied to cabling that will be subjected to high temperatures during operation may produce misleading results if the tests are conducted at lower temperatures.

The temperature of the testing time shall be noted.

Transmission testing shall be performed in a passive environment.

Measurements shall either

- be made under environmental conditions which are representative of the intended operational environment, or
- have correction factors applied to the measured results in accordance with manufacturers' specifications in order to reflect the intended operating environment, or
- be clearly documented as being carried out in unrepresentative conditions.

B.1.2.6 Test results

B.1.2.6.1 Generic cabling

Test limits and required results are defined in ISO/IEC 11801.

B.1.2.6.2 Application-specific cabling

The application standard or equipment documentation of the manufacturer shall be consulted to determine the appropriate test limits. The required results shall be consistent with the length and configuration of the installed cabling.

B.1.2.6.3 Treatment of marginal test results

Marginal results may be treated in a number of ways including

- verification of the normalisation of the test system,
- acceptance of all marginal results,
- rejection of all marginal results,
- acceptance of marginal pass results and rejection of marginal fail results,
- repetition of the measurement using a test system with improved measurement accuracy.

It is recommended that the approach to be adopted is agreed upon before the testing is carried out.

B.1.2.7 Documentation

The documentation for each parameter shall include:

a) details of the parameter,
b) details of the test system,
c) test equipment,
   1) type and manufacturer,
   2) serial number and calibration status,
   3) level and software version.
d) details of the cabling interface adaptors (type, reference numbers, manufacturer and relevant performance),
e) the stated uncertainty of measurement (measurement accuracy),
f) details of the cabling under test,
g) reference numbers,
h) the date of the test (the time of the test may also be recorded),
i) relevant environmental conditions,
j) note the ambient temperature
k) the presence and location of termination resistors (where required by the test method),
l) the test operator,
m) the measured result,
n) the required result.

NOTE 1 NEXT: If the 4 dB rule is used, it should be clearly indicated.

NOTE 2 RL: If the 3 dB rule is used, it should be clearly indicated.

B.2 Test parameters for balanced cabling

B.2.1 General

Cabling characteristics to be tested for acceptance, compliance and reference shall meet or exceed the requirements as given in Table B.2 for balanced cabling.

Table B.2 – Cabling characteristics of balanced cabling for acceptance, compliance, and reference testing

Characteristics of balanced cabling	Testing for		
	Acceptance	Compliance	Reference
Return loss	I	N	N
Insertion loss	I	N	N
NEXT	I	N	N
PS NEXT	C	C	C
ACR	I	N	N
PS ACR	I	C	C
ELFEXT	I	N	N
PS ELFEXT	C	C	C
DC loop resistance	I	N	N
Propagation delay	I	N	N
Skew	I	N	N
TCL			N
ELTCTL			N
Coupling attenuation[a]			N
Length[b]	I	I	N
Wire-map	N	N	N
Continuity of conductors, screens (if applicable), short and open circuits	N	N	N
KEY I = Information N = Normative C = Computed			
[a] According to Table 2. [b] Length is not a pass/fail criterion.			

B.2.2 Wire map

Test method, see 5.3.2.2 of IEC 61935-1.

B.2.3 Length

Test method, see 5.3.4 of IEC 61935-1.

B.2.4 Propagation delay

Test method, see 5.3.3 of IEC 61935-1.

B.2.5 Delay skew

Test method, see 5.3.3 of IEC 61935-1.

B.2.6 Attenuation (insertion loss)

B.2.6.1 Parameter

The term attenuation, widely used throughout the cabling industry, refers to a parameter more correctly described and measured as “insertion loss”. In this International Standard the two terms are used in parallel with the understanding that the parameter measured is “insertion loss”.

B.2.6.2 Test method

See 5.3.5 of IEC 61935-1 for the measurement of attenuation (insertion loss) on installed cabling at frequencies up to the maximum frequency specified for the cabling Class using portable field test equipment.

B.2.7 Near end crosstalk loss (NEXT, pair-to-pair and power sum)

See 5.3.6 of IEC 61935-1 for the measurement of NEXT (pair-to-pair and power sum) on installed cabling at frequencies up to the maximum frequency specified for the cabling Class using portable field test equipment.

The cable within the cabling interface adaptor shall be as short as possible.

B.2.8 Equal level far end crosstalk loss (ELFEXT, pair-to-pair and power sum)

See 5.3.7 of IEC 61935-1 for the measurement of ELFEXT (pair-to-pair and power sum) at frequencies up to the maximum frequency specified for the cabling Class using portable field test equipment.

The cable within the cabling interface adaptors shall be as short as possible.

B.2.9 Attenuation to crosstalk ratio (ACR, pair-to-pair and power sum)

B.2.9.1 ACR (pair-to-pair)

ACR (pair-to-pair) is the difference between the NEXT and the attenuation (insertion loss) of the cabling in decibel.

B.2.9.2 Power sum ACR

Power sum ACR of pair is computed from power sum NEXT and attenuation (insertion loss).

B.2.10 Return loss

See 5.3.8 of IEC 61935-1 for the measurement of return loss on installed cabling at frequencies up to the maximum frequency specified for the cabling Class using portable field test equipment.

The cable within the cabling interface adaptor shall be as short as possible.

B.2.11 Coupling attenuation

These measurements are not mandatory but could be made in harsh environment. Measurement methods for sample links in a laboratory environment are contained in the appropriate parts of IEC 61156.

B.2.12 Direct current (d.c.) loop resistance

See 5.3.9 of IEC 61935-1 for the measurement of d.c. loop resistance on installed cabling.

B.3 Test parameters for optical fibre cabling

B.3.1 General

Cabling characteristics to be tested for acceptance, compliance and reference shall meet or exceed the requirements as given in Table B.3 for fibre cabling.

Table B.3 – Cabling characteristics of optical fibre cabling for acceptance, compliance, and reference testing

Characteristics of optical fibre cabling	Testing for		
	Acceptance	Compliance	Reference
Optical attenuation	N	N	N
Multimode modal bandwidth			N
Propagation delay	I	N	N
Length	C	C	C
Continuity and maintenance of polarity	N	N	N
KEY I = Information N = Normative C = Computed			

B.3.2 All-silica optical fibre

Test methods shall be conducted according to ISO/IEC 14763-3.

B.3.3 Plastic optical fibre

For further study.

B.3.4 Plastic clad silica optical fibre

For further study.

Annex C
(normative)

Reference implementations (not conforming to clause 5)

C.1 Introduction

This annex describes reference implementations, using the components referenced in clauses 8, 9 and 10, which deliver transmission performance in accordance with the Classes of clause 6 for cabling structures that are not supported by clause 5.

These reference implementations are in addition to those supported in a normative manner by this International Standard.

C.2 Connection-less channels

C.2.1 General

Some implementers believe patch panel and TO's connections to be potential points of failure and prefer to minimize or avoid such connections as much as possible. C.2.2 discusses channels with no intermediate connections. C.2.3 discusses cross-connections only.

C.2.2 Channels with no connections

Figure C.1 shows

- an intermediate cabling channel and a floor distribution channel created without intermediate connections,
- a floor distribution channel created without intermediate connections,
- a combined intermediate and floor distribution channel created without intermediate connections.

For balanced cabling the length of the cable C shall be determined by using N = 0 and F = 0 within the equations shown in Table C.1.

In order to verify transmission performance, test systems shall take into account the specific assignment of cable elements at the ends of the cable as required by the application-specific equipment.

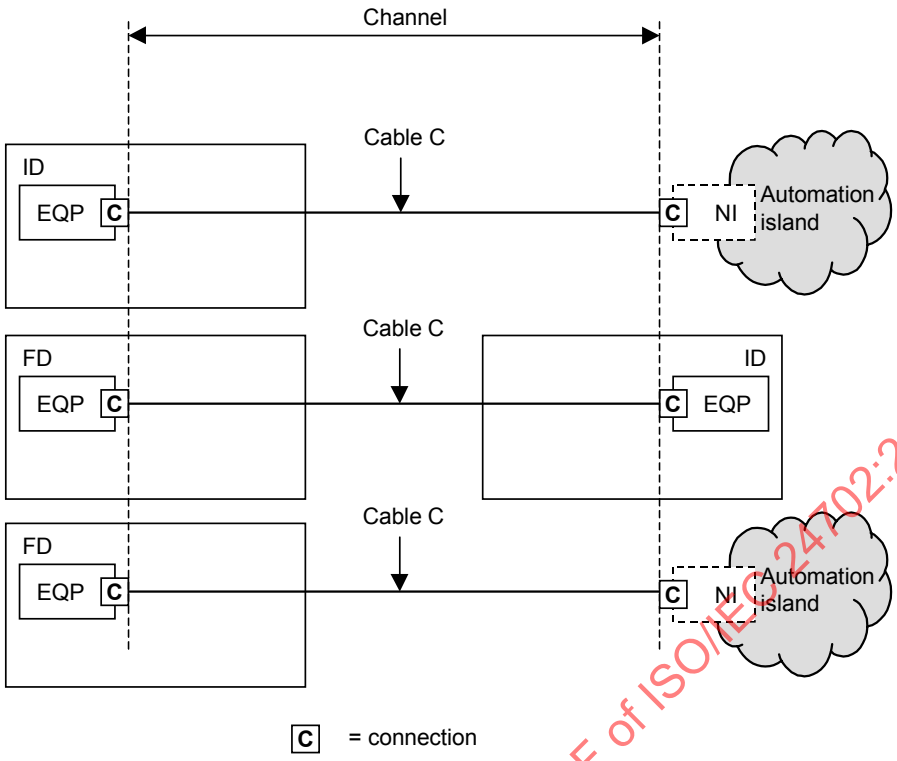

Figure C.1 – Balanced cabling channel configurations with no connections

C.2.3 Channels with inter-connections

Figure C.2 shows the channels of Figure C.1 with the addition of an inter-connect panel and an equipment cord at the distributor(s).

For balanced cabling the length of the cable C shall be determined by the equations shown in Table C.1.

In Table C.1 it is assumed that

- the flexible cable within the equipment cord(s) has a higher insertion loss specification than the one used in the fixed cable (see clause 8),
- the cables within these cords in the channel have a common insertion loss specification.

The maximum length of the fixed cable will depend on the total length of cords to be supported within a channel. During the operation of the installed cabling, a management system should be implemented to ensure that the cords used to create the channel conform to the design rules for the floor, building or installation.

In order to verify transmission performance, test systems shall take into account the specific assignment of cable elements at the ends of the cables as required by the application-specific equipment.

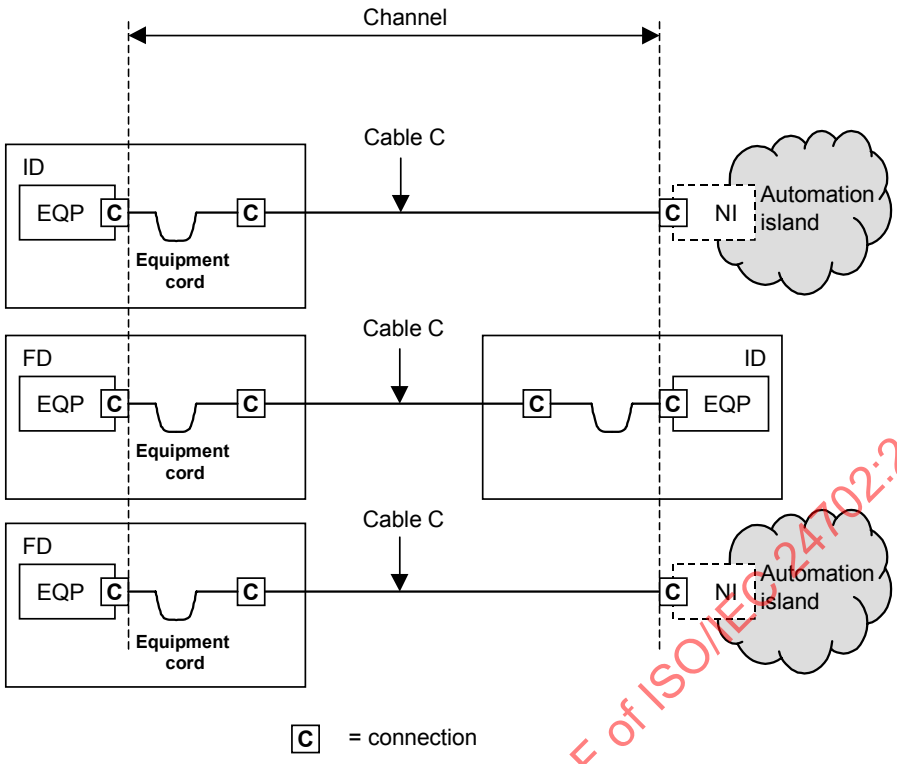

Figure C.2 – Balanced cabling channel configurations of Figure C.1 with interconnection at distributor

Table C.1 – Channel equations for balanced cabling

Com-ponent	Cable length C (m) [a]					
Category	**Class A**	**Class B**	**Class C**	**Class D**	**Class E**	**Class F**
5	C = 2 000	C = (258-2N-F•Y)/X	C = (178-2N-F•Y)/X	C = (113-2N-F•Y)/X	–	–
6	C = 2 000	C = (268-N-F•Y)/X	C = (193-N-F•Y)/X	C = (115-N-F•Y)/X	C = (106-N-F•Y)/X	
7	C = 2 000	C = (268-N-F•Y)/X	C = (198-N-F•Y)/X	C = (119-N-F•Y)/X	C = (109-N-F•Y)/X	C = (106-N-F•Y)/X
KEY N = number of connections in the channel F = combined length of the equipment cords (m) X = ratio of the insertion loss of the cable C (dB/m) to fixed cable attenuation (dB/m), see clause 8. Y = ratio of the equipment cord cable insertion loss (dB/m) to fixed cable attenuation (dB/m), see clause 8.						
[a] Applications limited by propagation delay or skew may not be supported if channel lengths exceed 100 m.						
For operating temperatures above 20 °C, B should be reduced by 0,2 % per °C for screened cables and 0,4 % per °C (20 °C to 40 °C) and 0,6 % per °C (> 40 °C to 60 °C) for unscreened cables. Where the operating temperature exceeds 60 °C then manufacturers' information shall be consulted regarding required reductions in cable length.						

C.3 Channels using balanced cabling bulkhead connections

Figure C.3 shows an intermediate cabling channel and a floor distribution channel created using a fixed cable terminated at a closure bulkhead.

The length of the fixed cable used within a channel shall be determined by the equations shown in Table C.2.

In Table C.2 it is assumed that

- the flexible cable within these cords has a higher insertion loss specification than that used in the fixed cable (see clause 8),
- the cables within these cords in the channel have a common insertion loss specification.

The maximum length of the fixed cable will depend on the total length of cords to be supported within a channel. During the operation of the installed cabling, a management system should be implemented to ensure that the cords used to create the channel conform to the design rules for the floor, building or installation.

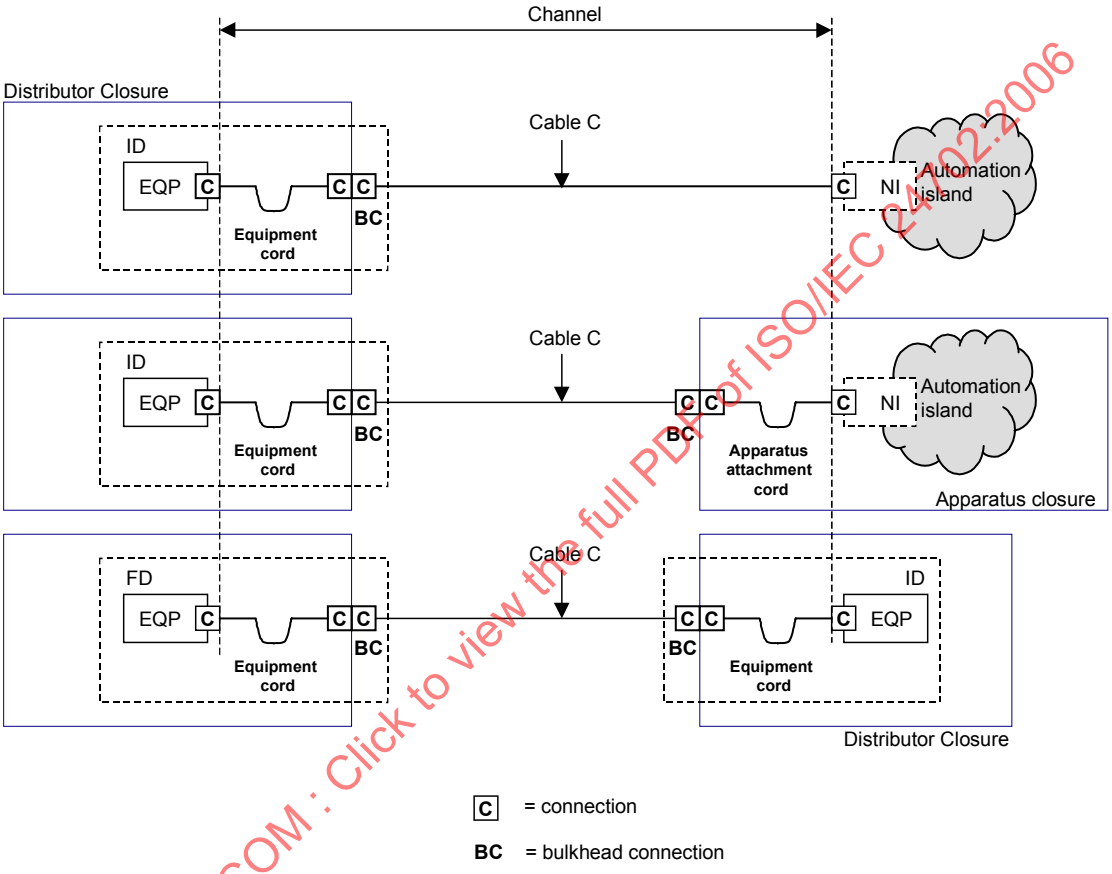

Figure C.3 – Balanced cabling channel configurations with bulkhead connections