ISO/IEC 11801-3

Edition 1.0 2021-04

INTERNATIONAL STANDARD

AMENDMENT 1

Information technology – Generic cabling for customer premises – Part 3: Industrial premises

ISO/IEC 11801-3:2017-11/AMD1:2021-04(en)

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Information technology – Generic cabling for customer premises – Part 3: Industrial premises

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 35.200

ISBN 978-2-8322-9477-2

INFORMATION TECHNOLOGY – GENERIC CABLING FOR CUSTOMER PREMISES –

Part 3: Industrial premises

AMENDMENT 1

FOREWORD

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Amendment 1 to ISO/IEC 11801-3 has been prepared by subcommittee SC 25: Interconnection of information technology equipment, of ISO/IEC joint technical committee 1: Information technology.

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

FDIS	Report on voting
JTC1-SC25/2995/FDIS	JTC1-SC25/3009/RVD

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

The language used for the development of this Amendment is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1, available at www.iec.ch/members_experts/refdocs.

INTRODUCTION TO THE AMENDMENT

This document contains requirements and/or recommendations for deployment of single pair balanced cabling on the industrial cabling specified in ISO/IEC 11801-3:2017.

This document also includes end-to-end link requirements for Class D, E and E_A.

INTRODUCTION

Add the following NOTE below the Figure 1 title:

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

2 Normative references

Add the following normative references:

IEC 63171-6, *Connectors for electrical and electronic equipment – Part 6: Detail specification for 2-way and 4-way (data/power), shielded, free and fixed connectors for power and data transmission with frequencies up to 600 MHz*

IEC 61156-11, *Multicore and symmetrical pair/quad cables for digital communications – Part 11: Symmetrical single pair cables with transmission characteristics up to 600 MHz – Horizontal floor wiring – Sectional specification*

IEC 61156-12[1], *Multicore and symmetrical pair/quad cables for digital communications – Part 12: Symmetrical single pair cables with transmission characteristics up to 600 MHz – Work area wiring*

Replace the ISO/IEC 14763-4 reference with the following new reference:

ISO/IEC 14763-4, *Information technology – Implementation and operation of customer premises cabling – Part 4: Measurement of end-to-end (E2E) links, modular plug terminated links (MPTL) and direct attach cabling*

3 Terms, definitions, abbreviated terms and symbols

3.1 Terms and definitions

Add the following terms and definitions at the end of the list:

3.1.14
balanced 1-pair cabling channel
transmission path between equipment constructed from balanced 1-pair cables, balanced 1-pair connectors and balanced 1-pair cable assemblies to facilitate signal and power delivery

3.1.15
edge distributor
optional additional distributor to accommodate active equipment to allow transition from balanced 4-pair cabling to balanced 1-pair cabling

[1] Under preparation. Stage at time of publication: IEC CDV 61156-12:2020.

3.1.16
end-to-end link
transmission path between equipment including the end connections attached to the equipment

3.1.17
bulkhead connection
connection that serves as an interconnection point located through an enclosure wall

3.1.18
segment
cabling between connectors of an end-to-end link

3.2 Abbreviated terms

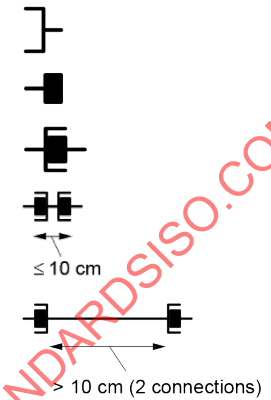
Add the following abbreviated terms at the end of the list:

B	bulkhead connection
C	connection
CP	consolidation point
ED	edge distributor
ffs	for further study
L1	length of end-to-end link
SPE	Single Pair Ethernet
TI	test interface

3.3 Symbols

Replace subclause 3.3 with the following:

Symbols used identically in different parts of ISO/IEC 11801 are defined in ISO/IEC 11801-1:2017, 3.3.



fixed connector

free connector

connection

bulkhead connection with back-to-back fixed connectors acting as one connection

bulkhead connection with separated back-to-back fixed connectors acting as two connections

The symbols shown in Figure 14 define the number of connections in all end-to-end links.

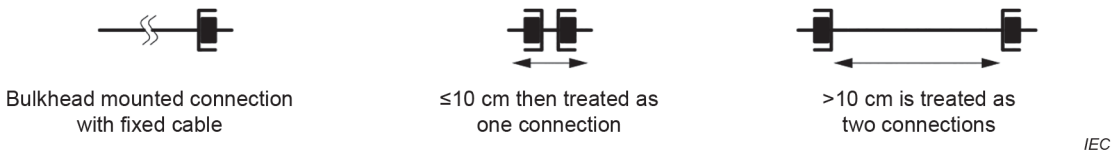


Figure 14 – Symbols for bulkhead connections

NOTE Bulkhead mounted connections with fixed cable can have a variable length to accommodate the installation within the cabinet.

4 Conformance

Add the following list items:

f) in case balanced 1-pair cabling channels are installed between the IID or ED and the NI of an Automation Island, between the IID or ED and the TO or AO, or between the IID and ED, channels shall conform to the requirements of Annex A;

g) in case balanced 1-pair cabling channels are installed between the ID and the NI of an Automation Island, channels shall conform to the requirements of Annex E.

5.3.1 General structure

Replace list item a) with the following:

a) Annex A describes the combined cabling structure of generic and industrial cabling system to connect several AIs via an ID to support critical process control, monitoring and automation data (PCMA).

5.3.3 Floor cabling subsystem

Replace list item b) with the following:

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

5.6.2 Channels and permanent links

Add the following new paragraph after the first paragraph of 5.6.2:

The transmission performance of balanced 1-pair cabling between specific test interfaces is detailed in Annex E for channels.

5.7.2 Distributors

Replace the existing Table 1 with the following new table:

Table 1 – Link lengths equations

Channel	Length m
Intermediate [a]	40
Intermediate	100
Intermediate [b]	1 000
Intermediate + horizontal + building backbone + campus backbone	10 000
NOTE In some implementations of the intermediate cabling subsystem in Clause 8, the ID might not support TOs up to the maximum distance shown. [a] for 40 m balanced 1-pair cabling [b] for 1 000 m balanced 1-pair cabling	

5.7.6 Telecommunications outlet

Add the following to item c) after the second bullet point:

or

- 1-pair of a 1-pair balanced cable;

6.1 General

Delete the sixth and seventh paragraphs.

In the paragraph immediately following Figure 10, delete the word "only".

6.3.2.3 Intermediate cabling

Add the following new paragraphs after the first paragraph:

Generic balanced 1-pair cabling shall comply with the channel performance as required by Annex C and ISO/IEC 11801-1.

For the applications specified in Annex E, 1-pair cabling shall comply with the channel performance as required by Annex C and Annex E.

6.3.2.4 Cable sharing

Add the following new paragraph after the first paragraph:

In the case of cable sharing by using balanced 1-pair cabling channels, additional requirements shall be taken into account for balanced cabling in accordance with ISO/IEC 11801-1 and ISO/IEC TR 11801-9906:2020, Annex D.

7.2 Balanced cabling

Add the following new paragraphs after the first paragraph:

Generic balanced 1-pair cabling shall comply with the link performance as required by Annex C and ISO/IEC 11801-1.

For the applications specified in Annex E, 1-pair cabling shall comply with the link performance as required by Annex C and Annex E.

8.1 General

Add the following after "Clause 6" at the end of the second sentence:

"or performance requirements of Annex E in case balanced 1-pair cabling is installed."

8.2.1 General

Add the following new sentence after the first sentence:

In the case of already installed balanced 1-pair cabling channels for up to 1 000 m the performance shall be ensured.

8.2.2.1 Component choice

Add the following at the end of the subclause:

Using the configurations of 8.2.2.3,

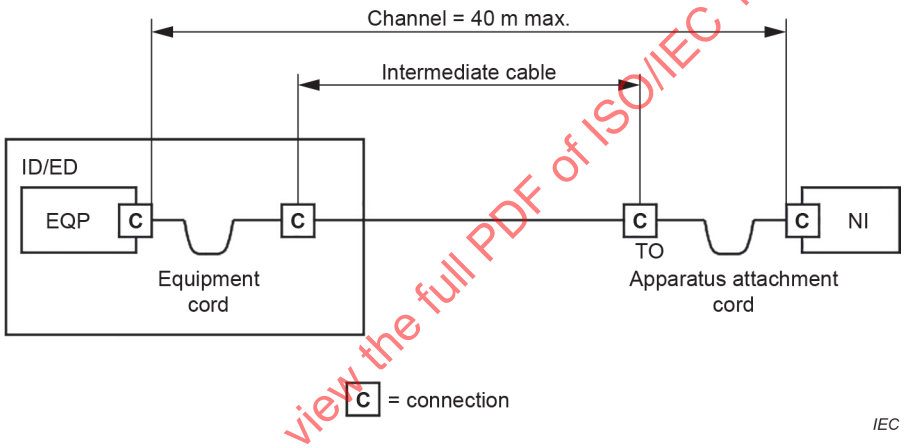
– cables in accordance with IEC 61156-11 and IEC 61156-12 and connectors in accordance with IEC 63171-6 provide cabling performance to the 600 MHz 40 m balanced 1-pair channel of Annex E;

NOTE Cables in accordance with two future parts of IEC 61156 (IEC 61156-13 and IEC 61156-14) and connectors in accordance with IEC 63171-6 will provide cabling performance to the 20 MHz 1 000 m balanced 1-pair channel of Annex E.

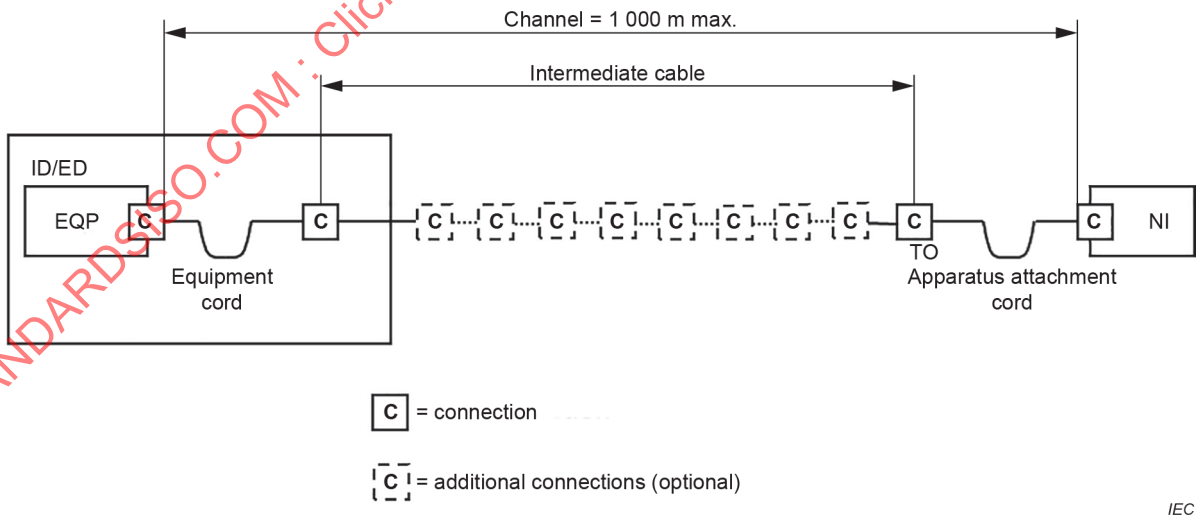
Add the following new subclause after 8.2.2.2:

8.2.2.3 Balanced 1-pair cabling dimensions

Figure 15a) shows a 40 m balanced 1-pair channel (40 m interconnect – TO model). Figure 15b) shows a 1 000 m balanced 1-pair channel (1 000 m interconnect – TO model).



a) Interconnect – TO model balanced 1-pair cabling channel 40 m



b) Interconnect – TO model balanced 1-pair cabling channel 1 000 m with up to 10 connections

Figure 15 – Balanced 1-pair intermediate cabling models

Table 5 and Table 6 contain the length assumptions of the 40 m and the 1 000 m, respectively, balanced 1-pair intermediate cabling.

Table 5 – Length assumptions used in mathematical modelling of the 40 m balanced 1-pair intermediate cabling

Segment	Length m	
	minimum	maximum
ID – TO (no CP) [a]	5	34
Apparatus attachment cord	1	3
Equipment cord	1	3
All cords	–	6
[a] Either consists of 34 m cabling and two 3 m cords or can be an end-to-end link configuration (but end-to-end links do not include a TO).		

Table 6 – Length assumptions used in mathematical modelling of the 1 000 m balanced 1-pair intermediate cabling

Segment	Length m	
	minimum	maximum
ID – TO (no CP) [a]	15	990
Apparatus attachment cord	1	5
Equipment cord	1	5
All cords	–	10
[a] Allows up to two 5 m cords.		

In order to accommodate cables used for apparatus attachment cords, patch cords, jumpers and equipment cords with different insertion loss, the length of the cables used within a channel shall be determined by the equations shown in Table 7.

Table 7 – Balanced 1-pair intermediate link length equations

Model	Figure	Implementation equation	
		new T1 class for 600 MHz 40 m channel	new T1 class for 20 MHz 1 000 m channel
Interconnect – TO (1-pair, 40 m)	15a	ffs	not applicable
Interconnect – TO (1-pair, 1 000 m)	15b	not applicable	ffs
l_i maximum length of the intermediate cable (m) l_a combined length of patch cords/jumpers, equipment and apparatus attachment cords (m) x ratio of cord cable insertion loss (dB/m) to fixed horizontal cable insertion loss (dB/m)			
For operating temperatures above 20 °C, l_i should be reduced by 0,2 % per °C for screened cables; 0,4 % per °C (20 °C to 40 °C) and 0,6 % per °C (> 40 °C to 60 °C) for unscreened cables.			

9.2 Balanced cables

Add the following new sentence and NOTE after the first sentence:

For balanced 1-pair cables with transmission characteristics up to 600 MHz, see IEC 61156-11 and IEC 61156-12.

NOTE Future parts of IEC 61156 (IEC 61156-13 and IEC 61156-14) will specify requirements for balanced 1-pair cables with transmission characteristics up to 20 MHz.

Add the following new subclause after 10.2.2.3.

10.2.2.4 Connecting hardware at the TO using balanced 1-pair cable at the TO

Where balanced 1-pair cabling is installed, connecting hardware meeting the mechanical and physical requirements of IEC 63171-6 shall be used.

For connecting hardware in $M_1I_1C_1E_1$ installation environments within industrial premises, refer to ISO/IEC 11801-1.

11.2.1 General

Add the following NOTE after the first paragraph:

NOTE Requirements for balanced 1-pair cabling will be given in a future Amendment 1 to ISO/IEC 11801-1:2017.

A.2 Industrial intermediate cabling subsystem

Add a new item e) to the list:

e) the ED – optional.

Replace Figure A.2 with the following new figure:

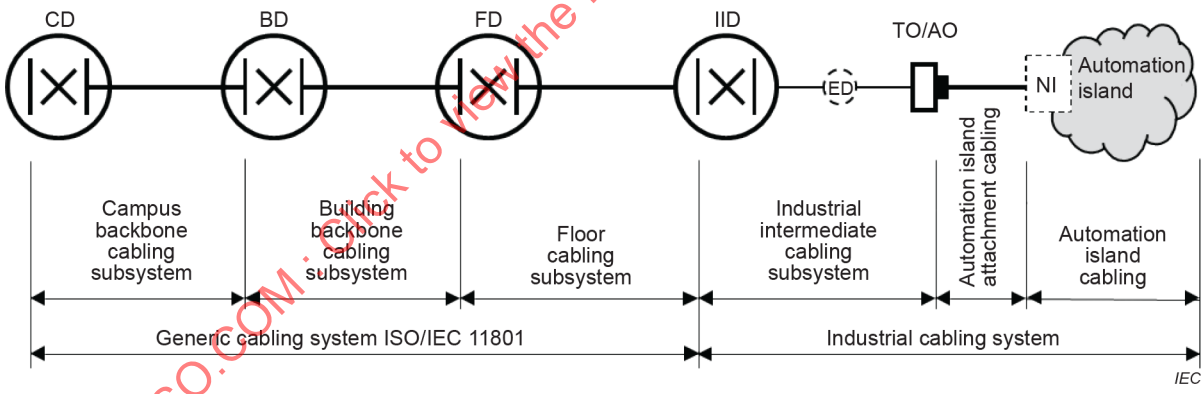


Figure A.2 – Combined structure of generic and industrial cabling system using an IID with optional ED

At the end of the paragraph after Figure A.2, add the following new sentence:

The industrial intermediate cabling may include an edge distributor (ED) to accommodate active equipment to allow transition from balanced 4-pair cabling to balanced 1-pair cabling.

Annex B (normative) Additional reference implementations

B.2.2 Channels with no connections

Replace list item a) with the following new item:

a) an intermediate cabling channel created without intermediate connections,

B.3 Channels using balanced cabling bulkhead connections

Add the following new paragraph before the first paragraph:

Bulkhead connector assemblies can consist of one free and one fixed connector (jack-plug) assembly with a cable attached or two back-to-back jacks meeting the distance specifications defined by IEC 61918 for a specific transmission class.

Add a new Annex D:

Annex D
(normative)

Requirements for end-to-end link configurations

D.1 General

Annex D provides definitions and requirements for end-to-end links.

In addition, this document provides performance specifications to support Class D, Class E and Class E_A balanced cabling channels of ISO/IEC 11801-1. These specifications amend those channel specifications of ISO/IEC 11801-1 by including the impact of the free connectors in accordance with the interfaces specified in ISO/IEC 11801-3 used to terminate the end-to-end link.

Tests shall be carried out in accordance with the test methods specified in ISO/IEC 14763-4.

The end-to-end link configurations can include any type of connection.

D.2 Specifications

The specifications for an end-to-end link include the following.

a) The configurations and structure shall meet the specifications outlined in Clause D.3.

b) The interfaces to the cabling shall meet the specifications of ISO/IEC 11801-1 or ISO/IEC 11801-3 with respect to mating interfaces and performance.

c) Connecting hardware at other places in the cabling structure shall meet the performance specifications specified in ISO/IEC 11801-1.

d) Installation shall be performed in accordance with IEC 61918 and ISO/IEC 14763-2.

e) The end-to-end links shall meet the specifications of Clause D.4.

f) Performance testing to the specifications of Clause D.4 shall be used to provide assurance of installed cabling to determine its capacity to support the applications described by IEC 61918 and ISO/IEC 11801-1.

g) The performance of end-to-end link as specified in Clause D.4 shall support the channel specifications specified in ISO/IEC 11801-1. Performance can be achieved by one of the following when the additional connections are included in the test results:

   1) an end-to-end link design and implementation ensuring that the prescribed transmission performance is met;

   2) attachment of appropriate components to a permanent link or CP link meeting the prescribed performance class of ISO/IEC 11801-1;

   3) using compatible cabling components that meet the specifications of ISO/IEC 11801-3 and ISO/IEC 11801-1.

D.3 End-to-end link configurations

There are multiple configurations of end-to-end links that are identified by the number of mated connections in the configuration including those at the ends of the end-to-end link. ISO/IEC TR 11801-9902 describes two-, three-, four-, five-, and six-connection end-to-end links. Figure D.1 shows a worst-case six-connection end-to-end link.

ISO/IEC TR 11801-9902:2017, Annex A provides information regarding CP cords.

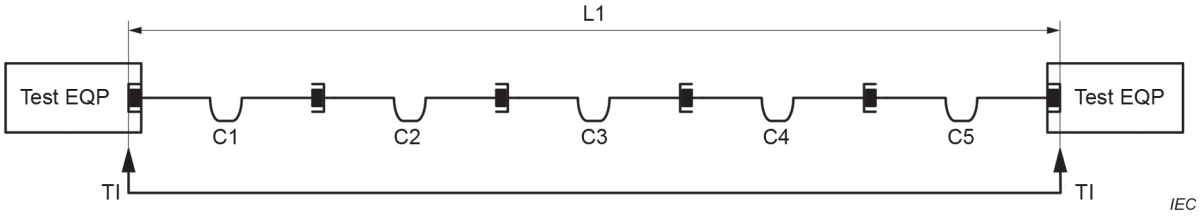


Figure D.1 – Five-segments, six-connections, end-to-end link

D.4 Performance specifications when using end-to-end link limits

D.4.1 General

The performance specifications of D.4.3 are based on the number of connections comprising the end-to-end link. These specifications are based on the modelling techniques described in ISO/IEC TR 11801-9903 using the balanced cabling components of Category 5, Category 6 and Category 6_A of ISO/IEC 11801-1 to provide the specification for Class D, Class E and Class E_A, respectively.

The worst-case limits of D.4.2 show the values calculated using the formulae of D.4.3 to D.4.8 for six connections as in Figure D.1.

D.4.2 Worst-case limits

Table D.1, Table D.2 and Table D.3 contain the informative worst-case limits for end-to-end links containing six connections for Class D, Class E and Class E_A. The tables summarize the values in D.4.3 to D.4.8, and D.4.9 to D.4.16 contain additional parameters and limits.

Table D.1 – Worst-case Class D end-to-end link performance at key frequencies

Frequency	RL	IL	NEXT	PS NEXT	ACR-F	PS ACR-F
MHz	dB	dB	dB	dB	dB	dB
1	16,73	4,00	63,29	60,29	56,28	53,28
4	16,69	4,69	53,51	50,51	44,24	41,24
10	16,61	7,40	46,88	43,88	36,28	33,28
40	13,20	15,17	36,39	33,39	24,24	21,24
100	8,44	24,82	28,82	25,82	16,28	13,28

Table D.2 – Worst-case Class E end-to-end link performance at key frequencies

Frequency	RL	IL	NEXT	PS NEXT	ACR-F	PS ACR-F
MHz	dB	dB	dB	dB	dB	dB
1	18,45	4,00	65,00	65,00	62,80	59,80
4	18,43	4,26	63,01	60,51	50,76	47,76
10	18,40	6,68	56,49	53,91	42,80	39,80
40	15,20	13,60	46,26	43,52	30,76	27,76
100	10,87	22,11	38,98	36,13	22,80	19,80
250	6,00	36,57	30,73	27,77	14,84	11,84

Table D.3 – Worst-case Class E_A end-to-end link performance at key frequencies

Frequency MHz	RL dB	IL dB	NEXT dB	PS NEXT dB	ACR-F dB	PS ACR-F dB
1	19,0	4,0	65,0	62,0	63,3	60,3
16	18,0	8,2	53,2	50,6	39,2	36,2
100	12,0	20,9	39,9	37,1	23,3	20,3
250	8,0	33,9	33,1	30,2	15,3	12,3
500	6,0	49,3	27,9	24,8	9,3	6,3

D.4.3 Return loss (RL) limits

Table D.4 contains the return loss limits for Class D, Class E and Class E_A end-to-end links.

Table D.4 – End-to-end link return loss limits

Class	Frequency MHz	Minimum return loss dB
D	$1 \le f < 20$	$17 - \left(0{,}27 + \left(1{,}29 \times \left(\frac{f-1}{99}\right)\right)\right)$
	$20 \le f \le 100$	$30 - 10\lg(f) - \left(0{,}27 + \left(1{,}29 \times \left(\frac{f-1}{99}\right)\right)\right)$
E	$1 \le f < 10$	$19 - \left(0{,}55 + \left(1{,}47 \times \left(\frac{f-1}{249}\right)\right)\right)$
	$10 \le f < 40$	$24 - 5\lg(f) - \left(0{,}55 + \left(1{,}47 \times \left(\frac{f-1}{249}\right)\right)\right)$
	$40 \le f \le 250$	$32 - 10\lg(f) - \left(0{,}55 + \left(1{,}47 \times \left(\frac{f-1}{249}\right)\right)\right)$
E_A	$1 \le f < 10$	19,0
	$10 \le f < 40$	$24 - 5\lg(f)$
	$40 \le f < 398{,}1$	$32 - 10\lg(f)$
	$398{,}1 \le f \le 500$	6,0

D.4.4 Insertion loss (IL) limits

Table D.5 contains the insertion loss limits for Class D, Class E and Class E_A end-to-end links.

Table D.5 – End-to-end link insertion loss limits

Class	Frequency MHz	Maximum insertion loss dB
D	$1 \le f \le 100$	$(1{,}05)\times\left(1{,}910\,8\times\sqrt{f}+0{,}022\,2\times f+\frac{0{,}2}{\sqrt{f}}\right)+\left(6\times 0{,}04\times\sqrt{f}\right)$
E	$1 \le f \le 250$	$(1{,}05)\times\left(1{,}82\times\sqrt{f}+0{,}016\,9\times f+\frac{0{,}25}{\sqrt{f}}\right)+\left(6\times 0{,}02\times\sqrt{f}\right)$
E_A	$1 \le f \le 500$	$1{,}05\times\left(1{,}82\sqrt{f}+0{,}009\,1\times f+0{,}25/\sqrt{f}\right)+4\times 0{,}02\times\sqrt{f}$ [a]
[a] Insertion loss (IL) at frequencies that correspond to calculated values of less than 4,0 dB shall revert to a maximum requirement of 4,0 dB.		

D.4.5 NEXT limits

Table D.6 contains the NEXT limits for Class D, Class E and Class E_A end-to-end links.

Table D.6 – End-to-end link NEXT limits

Class	Frequency MHz	Minimum NEXT [a] dB
D	$1 \le f \le 100$	$\left(-20\lg\left(10^{\frac{65{,}3-15\lg(f)}{-20}}+2\times 10^{\frac{83-20\lg(f)}{-20}}\right)\right)-\left(1{,}26\times\left(\frac{f-1}{99}\right)\right)$ [b]
E	$1 \le f \le 250$	$\left(-20\lg\left(10^{\frac{74{,}3-15\lg(f)}{-20}}+2\times 10^{\frac{94-20\lg(f)}{-20}}\right)\right)-\left(2{,}38\times\left(\frac{f-1}{249}\right)\right)$ [b]
E_A	$1 \le f \le 500$	$-20\lg\left(10^{\frac{74{,}3-15\lg(f)}{-20}}+2\times 10^{\frac{94-20\lg(f)}{-20}}\right)$ [a, b]
[a] Whenever the Class E_A channel insertion loss at 450 MHz is less than 12 dB, subtract the term $1{,}4((f-450)/50)$ from the formula stated above for the range of 450 MHz to 500 MHz. [b] The terms in the formulas are not intended to imply component performance.		

D.4.6 PS NEXT limits

Table D.7 contains the PS NEXT limits for Class D, Class E and Class E_A end-to-end links.

Table D.7 – End-to-end link PS NEXT limits

Class	Frequency MHz	Minimum PS NEXT [a] dB
D	$1 \le f \le 100$	$\left(-20\lg\left(10^{\frac{62{,}3-15\lg(f)}{-20}}+2\times10^{\frac{80-20\lg(f)}{-20}}\right)\right)-\left(1{,}26\times\left(\frac{f-1}{99}\right)\right)$
E	$1 \le f \le 250$	$\left(-20\lg\left(10^{\frac{72{,}3-15\lg(f)}{-20}}+2\times10^{\frac{90-20\lg(f)}{-20}}\right)\right)-\left(2{,}38\times\left(\frac{f-1}{249}\right)\right)$
E_A	$1 \le f \le 500$	$-20\lg\left(10^{\frac{72{,}3-15\lg(f)}{-20}}+2\times10^{\frac{90-20\lg(f)}{-20}}\right)$ [b, c]

[a] PS NEXT at frequencies that correspond to calculated values of greater than 62,0 dB shall revert to a minimum requirement of 62,0 dB.

[b] Whenever the Class E_A channel insertion loss at 450 MHz is less than 12 dB, subtract the term $1{,}4((f - 450)/50)$ from the formula stated above for the range of 450 MHz to 500 MHz.

[c] The terms in the formulas are not intended to imply component performance.

D.4.7 ACR-F limits

Table D.8 contains the ACR-F limits for Class D, Class E and Class E_A end-to-end links.

Table D.8 – End-to-end link ACR-F limits

Class	Frequency MHz	Minimum ACR-F [a, b] dB
D	$1 \le f \le 100$	$\left(-20\lg\left(10^{\frac{63{,}8-20\lg(f)}{-20}}+4\times10^{\frac{75{,}1-20\lg(f)}{-20}}\right)\right)-1{,}12$
E	$1 \le f \le 250$	$\left(-20\lg\left(10^{\frac{67{,}8-20\lg(f)}{-20}}+4\times10^{\frac{83{,}1-20\lg(f)}{-20}}\right)\right)-0{,}46$
E_A	$1 \le f \le 500$	$-20\lg\left(10^{\frac{67{,}8-20\lg(f)}{-20}}+4\times10^{\frac{83{,}1-20\lg(f)}{-20}}\right)$

[a] ACR-F at frequencies that correspond to measured FEXT values of greater than 70,0 dB are for information only.

[b] The ACR-F limit at frequencies that correspond to calculated values of greater than 65,0 dB shall revert to a minimum requirement of 65,0 dB.

D.4.8 PS ACR-F limits

Table D.9 contains the PS ACR-F limits for Class D, Class E and Class E_A end-to-end links.

Table D.9 – End-to-end link PS ACR-F limits

Class	Frequency MHz	Minimum PS ACR-F [a, b] dB
D	$1 \le f \le 100$	$\left(-20\lg\left(10^{\frac{60{,}8-20\lg(f)}{-20}}+4\times10^{\frac{72{,}1-20\lg(f)}{-20}}\right)\right)-1{,}12$
E	$1 \le f \le 250$	$\left(-20\lg\left(10^{\frac{64{,}8-20\lg(f)}{-20}}+4\times10^{\frac{80{,}1-20\lg(f)}{-20}}\right)\right)-0{,}46$
E_A	$1 \le f \le 500$	$-20\lg\left(10^{\frac{64{,}8-20\lg(f)}{-20}}+4\times10^{\frac{80{,}1-20\lg(f)}{-20}}\right)$

[a] PS ACR-F at frequencies that correspond to calculated PS FEXT values of greater than 67,0 dB are for information only.

[b] The PS ACR-F limit at frequencies that correspond to calculated values of greater than 62,0 dB shall revert to a minimum requirement of 62,0 dB.

D.4.9 DC loop resistance limits

Table D.10 contains the DC loop resistance limits for Class D, Class E and Class E_A end-to-end link.

Table D.10 – End-to-end link segment DC loop resistance

Class	Maximum DC end-to-end link segment loop resistance Ω
D, E, E_A	25

D.4.10 DC resistance unbalance within a pair

The DC resistance unbalance between the two conductors within each pair of a channel shall not exceed 3 % or 0,200 Ω, whichever is greater. The maximum DC resistance unbalance between pairs within a channel shall not exceed 7 % or 100 mΩ, whichever is greater.

NOTE For the purposes of field measurements, calculations that provide values of less than 200 mΩ revert to 200 mΩ.

For applications requiring remote power delivery, see ISO/IEC TS 29125 for the DC resistance and DC resistance unbalance (within, and between pairs) component specifications.

D.4.11 Propagation delay limits

Table D.11 contains the maximum propagation delay limits for Class D, Class E and Class E_A end-to-end links.

Table D.11 – End-to-end link delay

Class	Frequency	Maximum end-to-end link delay ns
D, E, E_A	$1 \le f \le f_u$ [a]	$0{,}534 + 0{,}036/\sqrt{f} + 4 \times 0{,}002\,5$

[a] f_u is the upper frequency of the Class.

D.4.12 Delay skew limits

Table D.12 contains the delay skew limits for Class D, Class E and Class E_A end-to-end links. The delay skew is length dependent.

Table D.12 – End-to-end link delay skew

Class	Maximum end-to-end link delay ns
D, E, E_A	0,050 [a, b]
[a] This is the result of the calculation 0,045 + 4 × 0,001 25.	
[b] Delay skew of any given installed cabling channel shall not vary by more than 0,010 µs within this requirement, due to effects such as the daily temperature variation.	

D.4.13 TCL specifications

Table D.13 contains the TCL limits for Class D, Class E and Class E_A end-to-end links for unscreened cabling.

Table D.13 – End-to-end link TCL

Class	Frequency MHz	Environmental classification		
		E_1	E_2 [c]	E_3 [c]
		Minimum TCL[a] dB		
D, E, E_A	$1 \le f < 30$	$53 - 15 \lg(f)$	$63 - 15 \lg(f)$	$73 - 15 \lg(f)$
	$30 \le f \le f_u$ [b]	$60{,}3 - 20 \lg(f)$	$70{,}3 - 20 \lg(f)$	$80{,}3 - 20 \lg(f)$
[a] Calculated values of greater than 40 dB shall revert to a minimum requirement of 40 dB.				
[b] TCL at frequencies above 250 MHz are for information only, where fu is the upper frequency of the Class.				
[c] The reference implementations of this document and other parts of the ISO/IEC 11801 series do not ensure conformance with this requirement for E_2 or E_3.				

NOTE TCL specifications apply to all end-to-end links.

D.4.14 ELTCTL specifications

Table D.14 contains the ELTCTL limits for Class D, Class E and Class E_A end-to-end links for unscreened cabling.

Table D.14 – End-to-end link segment ELTCTL

Class	Frequency MHz	Environmental classification		
		E_1	E_2	E_3
		Minimum ELTCTL[a] dB		
D, E, E_A,	$1 \le f < 30$	$30 - 20 \lg(f)$	$40 - 20 \lg(f)$	$50 - 20 \lg(f)$
[a] Calculated values of greater than 40 dB shall revert to a minimum requirement of 40 dB.				

D.4.15 Coupling attenuation specifications

Table D.15 contains the coupling attenuation limits for Class D, Class E and Class E_A end-to-end links for screened cabling.

Table D.15 – Minimum end-to-end link coupling attenuation

Class	Frequency MHz	Environmental classification		
		E_1	E_2	E_3
		Minimum coupling attenuation dB		
D, E, E_A	$30 \le f \le 100$	40	50	60
	$100 \le f \le f_u$ [a]	$80 - 20\lg(f)$	$90 - 20\lg(f)$	$100 - 20\lg(f)$
[a] f_u is the upper frequency of the Class.				

D.4.16 Alien crosstalk

Alien crosstalk requirements, applicable to Class E_A end-to-end links, are specified in ISO/IEC 11801-1:2017, 6.3.3.13.

D.5 End-to-end link performance

D.5.1 General

Performance testing can be undertaken either:

a) in a laboratory, where end-to-end links contain cabling components in a specific design configuration; or

b) in the field, after installation, using field test equipment. This testing is independent from any specifications for acceptance testing and is specified as explained in ISO/IEC 14763-2 and IEC 61918.

Performance testing of both kinds may be performed by independent or third party organizations in order to give greater guarantees of compliance. Reference testing is also known as type testing.

D.5.2 Reference performance testing

This testing is performed on a sample of installed cabling in a laboratory where an assessment against the conformance criteria of this document is required. The assessment documentation shall include details of the number of channels or links tested, test evaluation criteria, supplier's declarations and certification, laboratory accreditation and calibration certification.

This testing can also be used for the comparison of measurements performed with laboratory and field test instruments:

a) assessing cabling models in a laboratory environment;

b) assessing parameters that cannot be tested in an installation.

D.5.3 Installation performance testing

This testing is performed in accordance with Clause D.6, on a complete installation of cabling in the field where an assessment against the conformance criteria of an ISO/IEC 11801 series standard is required.

D.5.4 Installation performance testing of end-to-end links

Testing to determine performance with the specifications of Clause D.3 is optional. Testing shall be performed in the following cases:

a) end-to-end links with lengths exceeding, or having more components than, those specified in reference implementations of the cabling design documents;

b) end-to-end links using components whose transmission performance is lower than those described in ISO/IEC 11801-1;

c) end-to-end links created by adding more than one cord to either end of a link meeting the specifications of ISO/IEC 11801-1;

d) evaluation of cabling to determine its capacity to support a certain group of applications;

e) confirmation of performance of cabling designed in accordance with the reference;

f) free connector at the end of end-to-end link is terminated in the field.

Table D.16 contains the test regime for reference performance and installation performance.

Table D.16 – Test regime for reference performance and installation performance for balanced cabling of Classes D, E and E_A

Transmission parameter [a]	Reference performance testing	Installation performance testing
Return loss	N	N
Insertion loss	N	N
Pair-to-pair NEXT	N	N
PS NEXT	C	C
Pair-to-pair ACR-N	C	C
PS ACR-N	C	C
Pair-to-pair ACR-F	N	N
PS ACR-F	C	C
Direct current (DC) loop resistance	N	N
Direct current (DC) resistance unbalance within a pair	N	O
Direct current (DC) resistance unbalance between pairs	N	O
Propagation delay	N	N
Delay skew	N	N
Unbalance attenuation, near-end (TCL)	N	O
Unbalance attenuation, far-end (ELTCTL)	N	O
Coupling attenuation	N	O
PS ANEXT	N	N_s
$PS\ ANEXT_{avg}$	C	C
PS AACR-F	N	N_s
$PS\ AACR\text{-}F_{avg}$	C	C
Wire-map	N	N

Transmission parameter [a]	Reference performance testing	Installation performance testing
Continuity: • signal conductors; • screen conductors (if present); • short circuits; • open circuits.	N	N
Length [b]	I	I
C is calculated with pass/fail criteria. I is informative testing without pass/fail criteria, if not met by design. N is normative (100 %) testing with pass/fail criteria, if not met by design. N_S is normative (sampled) testing, if not met by design. The sample size to be tested should be in accordance with ISO/IEC 14763-2. O is optional testing with pass/fail criteria, if not met by design.		
NOTE The term "met by design" refers to a requirement which can be met by the selection of appropriate materials and installation techniques.		
[a] Only those parameters specified for each Class of cabling need to be tested, as required in Clause D.4. [b] Length is not a pass/fail criterion.		

D.6 Testing of end-to-end links

Refer to ISO/IEC 14763-4 for testing of end-to-end links.

NOTE The measurement of Class E and Class E_A end-to-end links is specified in ISO/IEC 14763-4:2021.

Add a new Annex E:

Annex E
(normative)

Requirements for 1-pair cabling channels up to 600 MHz

E.1 Balanced 1-pair cabling channels

E.1.1 General

Channel signal transmission specifications for balanced 1-pair cabling are referenced from three physical layer specifications, namely ISO/IEC/IEEE 8802-3:2017/AMD4, ISO/IEC/IEEE 8802-3:2017/AMD1 and IEEE 802.3cg; they cover five link segment specifications: 1000BASE-T1 Type A, 1000BASE-T1 Type B, 100BASE-T1, 10BASE-T1S and 10BASE-T1L. IEEE single-pair Ethernet (SPE) link segment specifications and physical layer standards are summarized in ISO/IEC TR 11801-9906:2020, Annex C.

The SPE link segment specifications are identified by their respective upper frequency specification, i.e. 600 MHz, 66 MHz, and 20 MHz.

The SPE signal transmission functional space covered by the five link segment specifications is given in Table E.1.

Table E.1 – SPE signal transmission functional space

Upper frequency	Frequency range	Reach	Screen type	Data rate	SPE link segment	Physical layer standard
MHz	MHz	m		Mb/s	Specification	
600	$1 \leq f \leq 600$	15	Screened and unscreened	1 000	1000BASE-T1 Type A	ISO/IEC/IEEE 8802-3:2017/AMD4
600	$1 \leq f \leq 600$	40	Screened	1 000	1000BASE-T1 Type B	ISO/IEC/IEEE 8802-3:2017/AMD4
66	$0,3 \leq f \leq 66$	15	Unscreened	100	100BASE-T1	ISO/IEC/IEEE 8802-3:2017/AMD1
20	$0,1 \leq f \leq 20$	15	Screened and unscreened	10	10BASE-T1S	IEEE 802.3cg
20	$0,1 \leq f \leq 20$	1 000	Screened and unscreened	10	10BASE-T1L	IEEE 802.3cg

NOTE Limits involving more than one pair within a channel; the following parameters are not applicable to balanced 1-pair cabling channels: NEXT, PS NEXT, ACR-F, PS ACR-F, ACR-N, PS ACR-N, delay skew and pair-to-pair resistance unbalance.

E.1.2 Component specifications

Balanced 1-pair cabling channel characteristics are specified using balanced 1-pair cabling component specifications. Balanced 1-pair cable and connector component specification references are given in Annex A and Annex B of ISO/IEC TR 11801-9906:2020, respectively.

The characteristics of a channel are specified between connections to active equipment. The channel comprises only passive sections of cable, connecting hardware and cords. The connections at the hardware interface to active equipment are not taken into account.

Application support depends on channel performance, which in turn depends on cable length, number of connections, connector termination practices, workmanship and performance. It is possible to achieve equivalent channel performance over greater lengths by the use of fewer connections or by using components with higher performance.

E.1.3 Environmental classifications

ISO/IEC 11801-1 classifies the environments for generic cabling according to three "MICE" levels.

The balanced 1-pair cabling specifications referenced in ISO/IEC/IEEE 8802-3:2017/AMD1, ISO/IEC/IEEE 8802-3:2017/AMD4 and IEEE 802.3cg include channel EMC related specifications for electromagnetic isolation levels E_1, E_2 and E_3, which are defined according to the MICE standard environmental characterization system specified in ISO/IEC 11801-1.

The channel EMC related specifications are unbalance attenuation, coupling attenuation, and alien (exogenous) crosstalk, which are specified for channels and components in accordance with E_1, E_2 and E_3.

E.1.4 Channel reference implementations

The 15 m channel comprises a 2 m cord (50 % derated), attached at each end of a permanent link of 11 m length and four connectors, based on components referenced in Annex A and Annex B of ISO/IEC TR 11801-9906:2020.

The 40 m channel comprises a 2 m cord (50 % derated), attached at each end of a permanent link of 36 m length and four connectors, based on components referenced in Annex A and Annex B of ISO/IEC TR 11801-9906:2020.

The 1 000 m channel comprises a 2 m cord (50 % derated), attached at each end of a permanent link of 996 m length and 10 connectors, based on components referenced in Annex A and Annex B of ISO/IEC TR 11801-9906:2020.

E.2 Balanced 1-pair cabling channel signal transmission specifications

E.2.1 Return loss (RL)

The balanced 1-pair cabling channel return loss (RL) specifications are given using the formulae in Table E.2.

Table E.2 – Balanced 1-pair cabling channel return loss (RL)

Upper frequency	Frequency range	RL	Length	Screen type
MHz	MHz	dB	m	
600	$1 \le f \le 10$	19,0	15	Screened and unscreened
	$10 < f \le 40$	$24 - 5 \lg(f)$		
	$40 < f \le 130$	16		
	$130 < f \le 400$	$37 - 10 \lg(f)$		
	$400 < f \le 600$	11		
600	$1 \le f \le 10$	19,0	40	Screened
	$10 < f \le 40$	$24 - 5 \lg(f)$		
	$40 < f \le 130$	16		
	$130 < f \le 400$	$37 - 10 \lg(f)$		
	$400 < f \le 600$	11		
66	$0,3 \le f \le 20$	18,0	15	Unscreened
	$20 < f \le 66$	$31 - 10 \lg(f)$		
20	$0,1 \le f \le 10$	14	15	Screened and unscreened
	$10 < f \le 20$	$14 - 10 \lg(f/10)$		
20	$0,1 \le f \le 0,5$	$9 + 9f$	1 000	Screened and unscreened
	$0,5 < f \le 20$	13,5		

E.2.2 Insertion loss (IL)

The balanced 1-pair cabling channel insertion loss (IL) specifications are given using the formulae in Table E.3.

Table E.3 – Balanced 1-pair cabling channel IL

Upper frequency	Frequency range	Channel IL	Length	Screen type	IEC cable
MHz	MHz	dB	m		**61156-x**
600	$1 \le f \le 600$	$0,42 \times \left(1,8\sqrt{f} + 0,0050 f + \frac{0,25}{\sqrt{f}}\right) + 4 \times 0,02\sqrt{f}$	15	Screened and unscreened	-11, -12
600	$1 \le f \le 600$	$0,152 \times \left(3,36\sqrt{f} + 0,015 f + \frac{0,42}{\sqrt{f}}\right) + 4 \times 0,02\sqrt{f}$ [a,b]	40	Screened	-11, -12
66	$0,3 \le f \le 66$	$0,152 \times \left(5,06\sqrt{f} + 0,059 f + \frac{0,53}{\sqrt{f}}\right) + 4 \times 0,02\sqrt{f}$ [a,b]	15	Screened and unscreened	-11, -12
20	$0,1 \le f \le 20$	$0,152 \times \left(5,06\sqrt{f} + 0,059 f + \frac{0,53}{\sqrt{f}}\right) + 4 \times 0,02\sqrt{f}$ [a,b]	15	Screened and unscreened	[c]
20	$0,1 \le f \le 20$	$10 \times \left(1,23\sqrt{f} + 0,01 f + \frac{0,2}{\sqrt{f}}\right) + 10 \times 0,02\sqrt{f}$	1 000	Screened and unscreened	[c]

[a] This channel was created by rearranging the link segment formula.

[b] The ($a\sqrt{f} + bf + c/\sqrt{f}$) factor in the "cable" IL term, factored from the corresponding link segment IL specifications, see Annex C of ISO/IEC TR 11801-9906:2020, is for information, for comparison and modelling purposes.

[c] Cables with transmission characteristics up to 20 MHz will be specified in future parts of IEC 61156 (IEC 61156-13 and IEC 61156-14).

E.2.3 Unbalance attenuation and coupling attenuation

E.2.3.1 General

Unbalance attenuation parameters, transverse conversion loss (TCL) and equal level transverse conversion transfer loss (ELTCTL), are used for differential-mode-to-common-mode conversion loss specifications, for unscreened cabling.

Coupling attenuation is used for differential-mode-to-common-mode conversion loss specifications, for screened cabling.

Differential-mode-to-common-mode conversion loss specifications correspond to balanced 1-pair cabling channel EMC specifications in accordance with E_1, E_2 and E_3 electromagnetic characterizations.

See ISO/IEC 11801-1 for detailed information on balanced cabling, unbalance attenuation parameters and E_1, E_2 and E_3 environment characterization specifications.

E.2.3.2 Transverse conversion loss (TCL)

The balanced 1-pair cabling channel transverse conversion loss (TCL) specifications are given using the formulae in Table E.4.

Table E.4 – Balanced 1-pair cabling channel TCL

Upper frequency	Frequency range	TCL			Length	Screen type
		E_1	E_2	E_3		
MHz	MHz	dB	dB	dB	m	
600	$1 \le f \le 600$	Not specified	Not specified	Not specified	15	Screened and unscreened
600	$1 \le f \le 600$	Not specified	Not specified	Not specified	40	Screened
66	$0{,}3 \le f \le 33$	43,0	Not specified	Not specified	15	Screened and unscreened
	$33 < f \le 200$	$43 - 20 \lg(f/33)$	Not specified	Not specified		
20	$0{,}1 \le f \le 20$	$53 - 15 \lg(f)$	$63 - 15 \lg(f)$	Not specified	15	Screened and unscreened
20	$0{,}1 \le f \le 20$	$53 - 15 \lg(f)$	$63 - 15 \lg(f)$	Not specified	1 000	Screened and unscreened

E.2.3.3 Equal level transverse conversion transfer loss (ELTCTL)

The balanced 1-pair cabling channel equal level transverse conversion transfer loss (ELTCTL) specifications are given using the formulae in Table E.5.