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Telecommunications bonding networks for buildings and other structures

bsi.

National foreword

This British Standard is the UK implementation of EN 50310:2016. It supersedes BS EN 50310:2010 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee TCT/7, Telecommunications - Installation requirements.

A list of organizations represented on this committee can be obtained on request to its secretary.

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EUROPEAN STANDARD
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EN 50310

May 2016

ICS 29.120.50; 91.140.50

Supersedes EN 50310:2010

English Version

Telecommunications bonding networks for buildings and other structures

Application de liaison équipotentielle et de la mise à la terre dans les locaux avec équipement de technologie de l'information

Anwendung von Maßnahmen für Erdung und Potentialausgleich in Gebäuden mit Einrichtungen der Informationstechnik

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

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Contents

European foreword

This document (EN 50310:2016) was prepared by the CLC/TC 215, "Electrotechnical aspects of telecommunication equipment".

The following dates are fixed:

• latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2017–04–11
• latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	2019–04–11

This document supersedes EN 50310:2010.

In 2012, EN 50310:2010 had been offered to ISO/IEC JTC 1/SC 25 "Interconnection of information technology equipment" as input to the agreed project to seek global harmonization of the technical requirements for telecommunications bonding networks. This project, ISO/IEC 30129, has been finished successfully. Thus, TC 215 decided to transpose ISO/IEC 30129 into the fourth edition of EN 50310 with minimal editorial changes to fit European needs. In this context, also the title of EN 50310 has been changed to adopt the title of ISO/IEC 30129.

EN 50310 has been produced within the framework of the following considerations.

a) With the ongoing growth of the liberalised telecommunication market, the increasing advent of private telecommunication network operators, and the flourishing use of networking computers, the amount of Information Technology equipment installed in buildings and the complexity of these Information Technology installations are permanently growing.

b) Information Technology equipment is generally installed either as stand-alone equipment (e.g. personal or network computers, small PBXs), or held in racks, cabinets or other mechanical structures (e.g. switching systems, transmission systems, mobile base stations).

c) CENELEC/SC 64B „Electrical installations and protection against electric shock – Protection against thermal effects“ had decided during their meeting in November 1997 not to harmonize IEC 60364-5-548:1996 "*Electrical installations of buildings – Part 5: Selection and erection of electrical equipment – Section 548: Earthing arrangements and equipotential bonding for information technology installations*".

d) This European Standard shall give guidance to network operators, equipment providers and building owners to agree on a standardized bonding configuration that facilitates:

   – compliance of the Information Technology Equipment installation with functional requirements including Electromagnetic Compatibility (EMC) aspects of emission and immunity,

   – compatible building installation and equipment provisions,

   – installation of new equipment in buildings as well as expansion or replacement of installations in existing buildings with equipment coming from different suppliers,

   – a structured installation practice,

   – simple maintenance rules,

- contracting on a common basis,
- harmonization in development, manufacturing, installation and operation.

Introduction

This European Standard

1) specifies assessment criteria to determine the relevant bonding configurations that are appropriate,

2) enables the implementation of any bonding configurations that may be necessary by means of either

   – the provision of a bonding network that utilizes the existing protective bonding network for electrical safety, or

   – the provision of a dedicated bonding network for the telecommunications infrastructure.

This standard is intended for

- building architects, owners and managers,
- designers and installers of electrical and telecommunications cabling installations.

Users of this standard should be familiar with all applicable cabling design and installation standards.

Figure 1 and Table 1 show the schematic and contextual relationships between the standards produced by TC 215 for information technology cabling, namely:

- installation specification, quality assurance, planning and installation practices (EN 50174 series);
- generic cabling design (EN 50173 series);
- application dependent cabling design (e.g. EN 50098 series);
- testing of installed cabling (EN 50346);
- this European Standard (EN 50310).

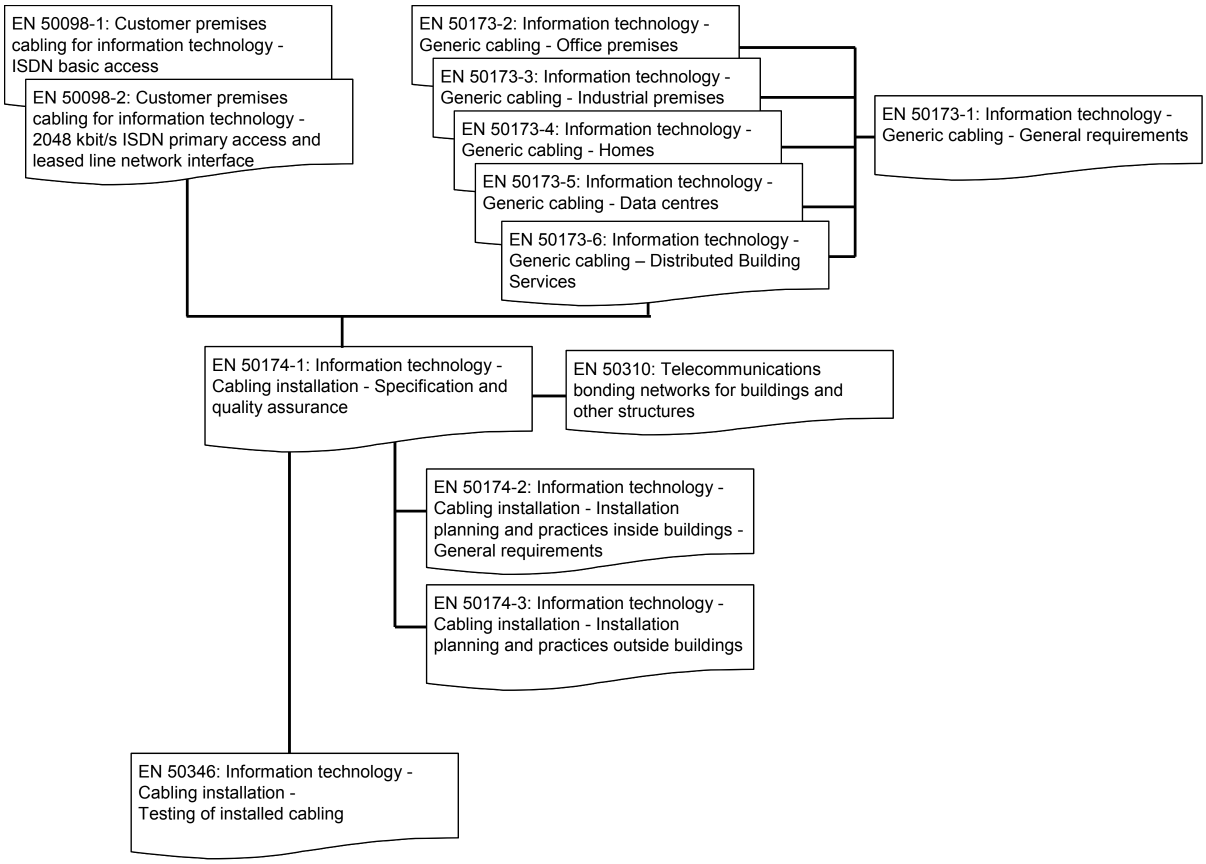

Figure 1 – Schematic relationship between EN 50310 and other relevant standards

Table 1 – Contextual relationship between EN 50310 and other relevant standards

Building design phase	**Generic cabling design phase**	**Specification phase**	**Installation phase**	**Operation phase**
EN 50310 6 Selection of bonding network	**EN 50173 series except EN 50173–4** 4 Structure 5 Channel performance 7 Cable requirements 8 Connecting hardware requirements 9 Requirements for cords and jumpers A Link performance limits	**EN 50174–1** 4 Requirements for specifying installations of information technology cabling 5 Requirements for installers of information technology cabling		**EN 50174–1** 4 Requirements for specifying installations of information technology cabling
		Planning phase		
	and EN 50173–4 4 and 5 Structure 6 Channel performance 8 Cable requirements 9 Connecting hardware requirements 10 Requirements for cords and jumpers A Link performance limits	**EN 50174–2** 4 Requirements for planning installations of information technology cabling 6 Segregation of metallic information technology cabling and mains power cabling 7 Electricity distribution systems and lightning protection **and EN 50174–3 and (for bonding) EN 50310**	**EN 50174–2** 5 Requirements for the installation of information technology cabling 6 Segregation of metallic information technology cabling and mains power cabling **and EN 50174–3 and (for bonding) EN 50310 and EN 50346** 4 General requirements 5 Test parameters for balanced cabling 6 Test parameters for optical fibre cabling	

1 Scope

This European Standard specifies requirements and provides recommendations for the design and installation of connections (bonds) between various electrically conductive elements in buildings and other structures, during their construction or refurbishment, in which information technology (IT) and, more generally, telecommunications equipment is intended to be installed in order to:

a) minimize the risk to the correct function of that equipment and interconnecting cabling from electrical hazards;

b) provide the telecommunications installation with a reliable signal reference – which may improve immunity from electromagnetic interference (EMI).

The requirements of this European Standard are applicable to the buildings and other structures within premises addressed by EN 50174-2 (e.g. residential, office, industrial and data centres) but information given in this European Standard may be of assistance for other types of buildings and structures.

NOTE Telecommunications centres (operator buildings) are addressed by ETSI/EN 300 253.

This European Standard does not apply to power supply distribution of voltages over AC 1 000 V.

Electromagnetic compatibility (EMC) requirements and safety requirements for power supply installation are outside the scope of this European Standard and are covered by other standards and regulations. However, information given in this European Standard may be of assistance in meeting the requirements of these standards and regulations.

2 Normative references

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

EN 50083 series [1)], *Cable networks for television signals, sound signals and interactive services*

EN 50174-2:2009, *Information technology – Cabling installation – Part 2: Installation planning and practices inside buildings*

EN 50174-2:2009/A1:2011, *Information technology – Cabling installation – Part 2: Installation planning and practices inside buildings*

EN 60728 series, *Cable networks for television signals, sound signals and interactive services (IEC 60728 series)*

EN 61140, *Protection against electric shock - Common aspects for installation and equipment (IEC 61140)*

EN 62305-4, *Protection against lightning - Part 4: Electrical and electronic systems within structures (IEC 62305-4)*

HD 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock (IEC 60364-4-41)*

HD 60364-4-444, *Low-voltage electrical installations – Part 4-444: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances (IEC 60364-4-44)*

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1) Being partly replaced by EN 60728 series.

HD 60364-5-54, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements, protective conductors and protective bonding conductors (IEC 60364-5-54)*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 50174-2 and the following apply.

3.1.1
access provider
operator or another entity providing the means to enable external telecommunications services provision to a subscriber

[SOURCE: EN 50700:2014, 3.1.3]

3.1.2
asymmetric cabling
cabling within which the cable elements are asymmetric (unbalanced)

3.1.3
application
system, with its associated transmission method that is supported by telecommunications cabling

[SOURCE: EN 50173-1:2011, 3.1.5]

3.1.4
backbone bonding conductor
telecommunications bonding connection which interconnects telecommunications bonding backbones

3.1.5
balanced application
application designed and optimized to operate over symmetric cabling

3.1.6
common bonding network
set of interconnected conductive structures that combine the functions of a protective bonding network and a telecommunications bonding network

3.1.7
equipment bonding conductor
conductor that connects a protective bonding network to an item of telecommunications equipment

3.1.8
main earthing terminal
terminal or busbar which is part of the earthing arrangement of an installation and enabling the electric connection of a number of conductors for earthing purposes

[SOURCE: IEC 60050-826:2004, 826-13-15, modified – The terms “main earthing busbar main”, “grounding terminal (US)” and “main grounding busbar (US)” have been deleted.]

3.1.9
mesh isolated bonding network
mesh bonding network with a single point of connection to either the protective bonding network or another isolated bonding network

3.1.10
mesh size
maximum length of conducting material between two adjacent connection points that create the grid of the telecommunications bonding network

3.1.11
primary bonding busbar
telecommunications bonding connection element, connected to the main earthing terminal, that is used to attach telecommunications bonding backbone conductors and equipment bonding conductors

3.1.12
protective bonding network
set of interconnected conductive elements to ensure electrical safety

Note 1 to entry: The protective bonding network meets the protective equipotential bonding system as defined in IEC 60050–195:1998, 195.

3.1.13
rack bonding conductor
conductor that connects a rack bonding busbar or items of equipment within a cabinet, frame or rack to the telecommunications bonding network within a local area

3.1.14
rack bonding busbar
attachment element within a cabinet, frame or rack or for multiple unit bonding conductors

3.1.15
secondary bonding busbar
telecommunications bonding connection element for telecommunications systems and equipment in the area, served by a distributor

3.1.16
system block
functional group of equipment depending in its operation and performance on its connection to the same system reference potential plane, inherent to a mesh bonding network

[SOURCE: ETSI/EN 300 253:2015, 3.1.2]

3.1.17
system reference potential plane
conductive solid plane, as an ideal goal in potential equalizing, that is approached in practice by horizontal or vertical meshes

Note 1 to entry: The mesh width thereof is adapted to the frequency range to be considered. Horizontal and vertical meshes may be interconnected to form a grid structure approximating a Faraday cage.

Note 2 to entry: The SRPP facilitates signalling with reference to a common potential.

[SOURCE: ETSI/EN 300 253:2015, 3.1.2]

3.1.18
symmetric cabling
screened or unscreened cabling within which the cable elements comprise balanced pairs or quads

EXAMPLE Twisted pairs or quads.

3.1.19
telecommunications bonding backbone
conductor installed within telecommunications pathways that interconnects a primary bonding busbar to its secondary bonding busbars within the building, and that is intended to minimise potential differences but not intended to serve as a conductor providing a fault current return path

3.1.20
telecommunications bonding conductor
conductor between the primary bonding busbar and the main earthing terminal

3.1.21
telecommunications bonding network
set of interconnected conductive elements that provide functional equipotential bonding for telecommunications equipment

3.1.22
telecommunications equipment bonding conductor
conductor that connects a primary or secondary bonding busbar to a supplementary bonding network, a rack bonding conductor or to an item of telecommunications equipment

3.1.23
telecommunications entrance facility
entrance point where the telecommunications facilities enter the building

Note 1 to entry: The telecommunications entrance facility may also include antenna cable entrances and electronic equipment serving telecommunications functions.

3.1.24
unbalanced application
application not optimised for transmission over symmetric cabling

3.1.25
unit bonding conductor
conductor that connects the telecommunications equipment within a cabinet, frame or rack to the rack bonding busbar or to a rack bonding conductor

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

a.c.	alternating current
BBC	Backbone Bonding Conductor
CBN	Common Bonding Network
d.c.	direct current
EMI	ElectroMagnetic Interference
IACS	International Annealed Copper Standard
MESH-BN	MESH Bonding Network
MESH-IBN	MESH Isolated Bonding Network
MET	Main Earthing Terminal
PBB	Primary Bonding Busbar
PBNC	Protective Bonding Network Conductor
RBB	Rack Bonding Busbar
RBC	Rack Bonding Conductor

SBB	Secondary Bonding Busbar
SBG	Supplementary Bonding Grid
SRPP	System Reference Potential Plane
SPC	Single Point Of Connection
TBB	Telecommunications Bonding Backbone
TBC	Telecommunications Bonding Conductor
TEBC	Telecommunications Equipment Bonding Conductor
TEF	Telecommunications Entrance Facility
TSP	Transient Suppression Plate
UBC	Unit Bonding Conductor

4 Conformance

For bonding infrastructures to conform to this European Standard

a) an assessment in accordance with Clause 6 shall be undertaken,

b) based on the results of the assessment any necessary bonding shall be implemented as follows

   1) the backbone and building entrance bonding shall either

      – use the protective bonding network provided that it delivers the performance required by the assessment of Clause 6, or

      – conform to the requirements of Clause 8 for a dedicated bonding system,

   2) the local bonding shall either

      – conform to Clause 9 in line with the requirements of the assessment of Clause 6, or

      – conform to the requirements of Clause 10 for a dedicated telecommunications bonding system in line with the requirements of the assessment of Clause 6,

   or

   3) a mesh bonding network in accordance with Clause 11,

c) the requirements of Clause 7 shall be applied to all telecommunications bonding networks implemented,

d) the cross-sectional areas of bonding conductors shall conform to the requirements of Clauses 7 to 11,

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

NOTE The proper implementation of the requirements of this European Standard assumes that electrical installations, protective bonding networks and protective measures against overvoltages are undertaken in accordance with the local regulations, as appropriate.

5 Overview of bonding networks

This European Standard assumes that buildings, or other structures, containing or intended to contain telecommunications equipment are of vertical extent (where a backbone connects zones of different floors) and/or horizontal extent (where a backbone connects multiple zones on a floor) and feature, as follows:

a) one or more entrance facilities,

b) one or more identifiable areas within each zone containing concentrations of telecommunications equipment (e.g. spaces associated with the generic cabling distributors of standards supported by EN 50174-2),

c) areas in each zone within which telecommunications equipment is distributed (e.g. locations associated with the generic cabling outlets of standards supported by EN 50174-2).

For the purposes of this European Standard

1) the term “backbone” refers to connections between the areas of concentrations of telecommunications equipment and between any given area of concentration and a main earthing terminal (MET),

2) the term “local” refers to connections between a given area of concentration of telecommunications equipment and the area of distributed telecommunications equipment which it serves or other connections within that area.

This is shown schematically in Figure 2 for telecommunications equipment distribution and telecommunications bonding network terminology.

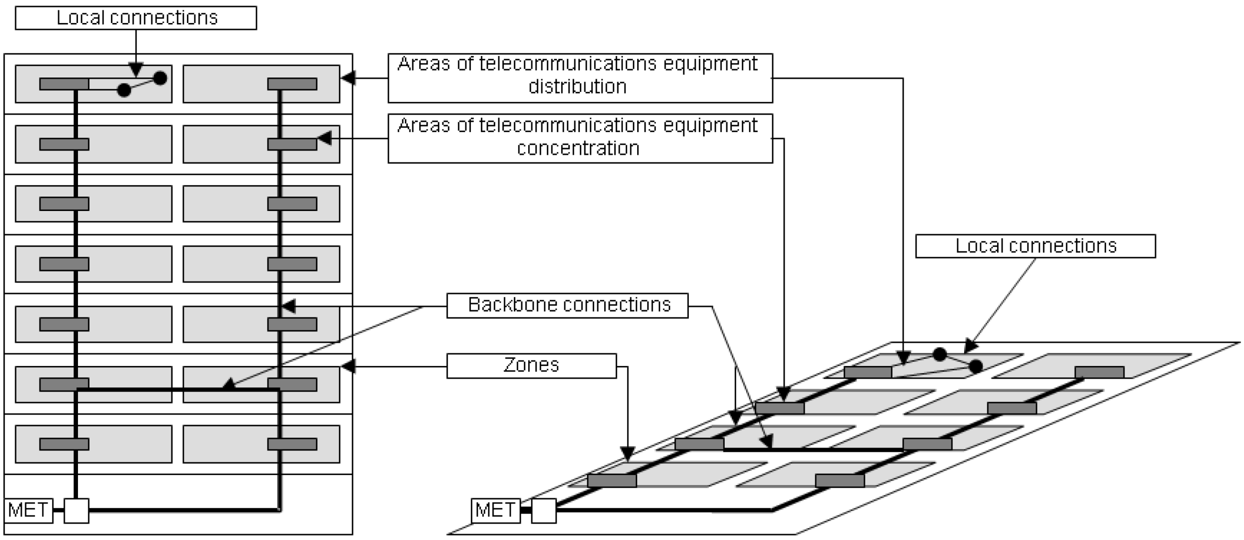


Figure 2 – Schematic of telecommunications equipment distribution and associated bonding connections

The objective of this European Standard is, following the completion of the assessment of Clause 6, to ensure that backbone and local bonding networks

– minimize d.c. and a.c. potential differences in order to reduce the risk to the correct function of telecommunications equipment interconnected by metallic cabling,

– have adequate a.c. and radio frequency performance to provide the telecommunications installation with a reliable signal reference and improved resistance to EMI.

It should be noted that failure to implement correct telecommunications bonding networks can act against this objective.

6 Selection of the telecommunications bonding network approach

6.1 Assessment of the impact of the telecommunications bonding network on the interconnection of telecommunications equipment

The requirements applied to a telecommunications bonding network depend upon the intended type of connectivity between the telecommunications equipment within and between the zones of Figure 2.

The mesh bonded network of Clause 11 is intended to support the most demanding requirements of both cabling media and the applications supported over those media. The mesh bonded network provides complete flexibility in relation to the types and locations of telecommunications equipment that may be installed (subject to the transmission performance limits of the applications when using the selected telecommunications cabling). This is further enhanced by the installation of power distribution systems conforming to TN-S as described in the HD 60364 series of standards.

The installation of such a telecommunications bonding network is most easily implemented during construction or refurbishment of a building or structure. However, within an existing building

a) the cost and complexity of installing a telecommunications bonding network that will support the requirements of applications operating over asymmetric cabling between any two points in a building may be prohibitive,

b) the implementation of an all-optical network has no implications for the telecommunications bonding network but would substantially impact on the cost of transmission and terminal equipment and may not be viable for all intended applications.

Therefore an assessment has to be made based on a balance between complexity of the telecommunications bonding network and the type of cabling media and the application supported over those media between and within the zones described in Figure 2. This assessment has also to take into consideration the transmission performance requirements of the applications when using the selected telecommunications cabling.

The comparative sensitivity of the various types of cabling media and the applications supported using them to a lack of bonding network performance (d.c. resistance and impedance) is shown in Table 2.

Table 2 – Sensitivity of cabling media to bonding network performance

Cabling medium	Sensitivity to bonding networking performance
Asymmetric cabling or symmetric cabling (unbalanced applications)	**High**
Symmetric cabling (screened or unscreened with balanced applications)	⇕
Optical fibre cabling	**Low**

Based upon the outcome of this assessment, the appropriate requirements of this standard shall be applied to the relevant infrastructures to be used to provide an adequate telecommunications bonding network as detailed in Table 3.

Table 3 – Telecommunications bonding network requirements

		Transmission (subject to maximum channel length limits)	
Media		**Between zones**	**Within a zone**
Asymmetric cabling or symmetric cabling (unbalanced applications)	Using the protective bonding network	d.c. resistance and impedance control requirements of 6.3.1.1	d.c. resistance and impedance control requirements of Clause 9
	Using a dedicated telecommunications bonding network	d.c. resistance and impedance control requirements of 6.3.1.2	d.c. resistance and impedance control of Clause 10
Symmetric cabling (screened or unscreened with balanced applications)	Using the protective bonding network	d.c. resistance requirements of 6.3.1.1	d.c. resistance control requirements of Clause 9
	Using a dedicated telecommunications bonding network	d.c. resistance requirements of 6.3.1.2	d.c. resistance control of Clause 10
Optical fibre cabling		No requirements	No requirements

6.2 Telecommunications bonding networks

Telecommunications equipment is generally connected to a protective bonding network that meets basic safety requirements in accordance with the HD 60364 series. If the design or measured performance of the protective bonding network fails to meet the requirements of 6.3 then either

a) supplementary telecommunications bonding solutions shall be employed as defined in Clauses 8, 9, 10 or 11, or

b) restrictions shall apply in relation to the interconnection of telecommunications equipment as described in Clause 6.

For the construction of a new building, or structure, and when it is desired to employ the most flexible approach for the accommodation of telecommunications equipment then the mesh bonded network of Clause 11 shall be applied provided that the lightning protection is in accordance with EN 62305-4.

NOTE Where other lightning protection has been installed, including “isolated lightning protection” according to EN 62305–3, specific restrictions can be applicable to the implementation of the telecommunications cabling, the telecommunications bonding network and the lightning protection.

Where the requirements of Clause 11 are determined to be inappropriate but an effective telecommunications bonding network is required then

1) Clause 8 provides requirements and recommendations for the construction of a dedicated telecommunications backbone bonding network,

2) Clause 9 provides requirements and recommendations for the construction of a local telecommunications bonding network for connection to protective bonding networks,

3) Clause 10 provides requirements and recommendations for the construction of a local telecommunications bonding network for connection to a dedicated telecommunications backbone bonding network.

6.3 Telecommunications bonding network performance

6.3.1 General

6.3.1.1 Protective bonding networks

Protective bonding networks may provide adequate performance for the telecommunications infrastructure. Where a protective bonding network is found not to comply with the requirements of 6.3.2.1 and 6.3.2.2, options for its improvement should be considered before decisions are taken in relation to the implementation of the telecommunications bonding network.

The backbone protective bonding network is considered to connect the primary electrical power distribution units within each zone to the main earthing terminal (MET).

For a backbone protective bonding network to be considered adequate for a telecommunications bonding network, it shall meet requirements for impedance of 6.3.2.1 and the d.c. conductor resistance as detailed in 6.3.2.2.

With each zone, the local protective bonding network shall have one of the forms as described in Clause 9. The requirements for the supplementary telecommunications bonding networks are described in Clause 9.

For a local protective bonding network to be considered adequate for a telecommunications bonding network, it shall meet requirements for impedance of 6.3.2.1 and the d.c. conductor resistance as detailed in 6.3.2.2.

6.3.1.2 Dedicated telecommunications bonding networks

When the protective bonding network fails to provide adequate performance for the telecommunications bonding infrastructure or other factors take precedence then a dedicated telecommunications bonding network shall be installed in accordance with Clause 8 and Clause 10.

For a dedicated backbone bonding network to be considered adequate for a telecommunications bonding network it shall meet requirements for impedance of 6.3.2.1 and the d.c. conductor resistance as detailed in 6.3.2.3.

The dedicated bonding network extends from the backbone into each zone via a local telecommunications bonding network. The requirements for the supplementary telecommunications bonding networks are described in Clause 10.

For a local bonding network to be considered adequate for a telecommunications bonding network it shall meet requirements for impedance of 6.3.2.1 and the d.c. conductor resistance as detailed in 6.3.2.3.

6.3.2 Requirements

6.3.2.1 General requirements

The bonding network shall have busbars with sufficient capacity for the attachment of planned telecommunications equipment and cabling.

If required by the approach taken to the bonding network (see 6.1), adequate impedance performance of the bonding network requires that

a) the pathways in which the bonding network is installed are close to the pathways in which the telecommunications network is installed to reduce loop area inductance to improve high frequency performance,

b) there is sufficient and easy access to add supplemental bonding conductors for impedance control as described in Clauses 7, 8, 9 and 10 to improve the high frequency performance of the protective bonding network.

6.3.2.2 Protective bonding networks

The protective bonding network shall comply with local safety requirements and provide a safe environment for the telecommunications installers and equipment.

The d.c. resistance between points of a protective bonding network shall meet the requirements of Table 4.

Table 4 – DC resistance requirements for protective bonding networks

Connections between	**Requirement** maximum mΩ/m
All telecommunications equipment and closest protective bonding network terminal	1,67

6.3.2.3 Dedicated bonding networks

The d.c. resistance between points of the telecommunications bonding network shall meet the requirements of Table 5.

Table 5 – DC resistance requirements for dedicated telecommunications bonding networks

Connections between	**Requirement** maximum mΩ/m
Any point of the bonding network and the MET	1,67
Any primary bonding busbar (PBB) and a connected secondary bonding busbar (SBB)	1,67
Any point of connection to the bonding network within a zone and the connected secondary bonding busbar (SBB)	1,67
Primary bonding busbar (PBB) or secondary bonding busbar (SBB) to structural steel	1,67

6.3.3 DC resistance measurements

6.3.3.1 General

The test is performed using a resistance tester that is configured for a continuity test, otherwise known as a two-point test or a “dead earth” test.

The earth ground resistance tester generates a specific alternating current (a.c.) test current; this current is less susceptible to the influences of stray currents in the telecommunications bonding network and is a more accurate testing device than a standard volt-ohm-milliampere meter.

Prior to testing

a) a visual inspection shall be performed to verify that the telecommunications bonding network is installed in accordance with this standard,

b) due to the possibilities of faults travelling through the telecommunications bonding network system, a voltage test should be performed prior to conducting the two-point continuity test and verified with the test equipment manufacturer’s instructions,

c) it shall be ensured that any other electrical installation or maintenance activity will not affect the test result.

The testing shall be undertaken before the telecommunications equipment is installed otherwise parallel paths may invalidate test results.

6.3.3.2 Dedicated bonding networks

The test is typically performed by connecting one meter lead to the building's nearest MET and a specific point on the telecommunications bonding network such as the PBB. This same test can also verify continuity between any two points of the telecommunications bonding network such as between the PBB and a SBB.

7 Common features

7.1 General

The requirements and recommendations of this clause apply to the implementations of telecommunications bonding networks of Clauses 8, 9, 10 and 11 in the absence of local regulations. Such regulations may apply independent schemes of approval, certification or licensing schemes to the components, how and where they are used and the performance requirements, which they shall meet.

7.2 Protective bonding networks

7.2.1 Protective bonding network conductors (PBNCs)

The installation of PBNCs shall be in accordance with HD 60364-4-41, HD 60364-4-444, HD 60364-5-54 and EN 61140 (requirements for installations in buildings).

7.2.2 Main earthing terminal (MET)

Each building shall be provided with at least one designated MET.

7.3 Telecommunications entrance facility (TEF)

Each building shall be provided with at least one designated TEF. The TEF shall be placed as close as possible to either the MET or designated points providing connections to the MET.

In order to minimize surge voltages and effects of surge currents entering the building, groups of conducting components should enter the building in close proximity to each other. Such components include pipes, pathway systems and cables containing either extraneous conductive parts (e.g. armouring, strain relief members of optical fibre cables, cable screens) and/or signal (cable) elements. Where these are bonded to the MET, the connection shall use the shortest practicable route.

The treatment of extraneous conductive parts that are part of the construction of cable entering the building shall be in accordance with local or national regulations and the procedures used shall be documented.

Where no local or national regulations exist then one of the following options shall be applied:

a) the extraneous conductive parts of the cable shall be bonded in the TEF at both ends and a parallel bonding conductor of minimum cross-sectional area of 16 mm^2 (see Table 6), and greater than total cross-sectional area of the extraneous conductive parts in the cable, shall be installed in association with the cable and shall be bonded at both TEFs;

b) only one end of the extraneous conductive parts shall be bonded, and

   1) the other end shall be insulated to at least 1 000 V a.c.,

2) labelling shall be applied to the insulation, which indicates possible presence of hazardous voltages beneath that insulation,

3) if an isolation gap is created in the extraneous conductive parts beneath the insulation, then the extraneous conductive parts on the building side of the gap shall be bonded to the MET.

Signal conductors shall be connected to surge protection devices (SPDs) as required.

7.4 Telecommunications bonding network components

7.4.1 Telecommunications bonding network conductors

7.4.1.1 Materials

The dimensional requirements of bonding conductors specified in this European Standard assume the use of copper of ≥ 95 % International Annealed Copper Standard (IACS) conductivity.

NOTE 100 % IACS = 1,724 1 × 10^{-8} Ω·m ≅ 5,8 × 10^{7} S/m.

The use of other materials requires

a) appropriate changes to be made to the conductor dimensions in order to provide equivalent d.c. resistance,

b) assessment of component compatibility (see 7.4.2 and Annex A) to ensure maintenance of contact resistance values at junctions with other conductive materials.

Where bonding conductors are insulated, the insulation shall be in accordance with HD 60364-5-54.

7.4.1.2 Installation

The installation of telecommunications bonding conductors shall be in accordance with HD 60364-4-41, HD 60364-4-444, HD 60364-5-54 and EN 61140 (requirements for installations in buildings).

Telecommunications bonding conductors shall be installed in accordance with the applicable minimum bend radius (installation, operating-static and operating-dynamic) and shall not be coiled nor doubled back on themselves.

Where multiple bonding conductors are installed between any two points in order to provide impedance control or in support of the requirements of Clause 11, they shall be separated by at least 150 mm, except where physical constraints (e.g. points of connection or routes through building structures) force a reduction of this separation. The lengths over which this separation is not provided shall be minimized.

Multiple bonding conductors shall not be attached to a single connection point where there is a risk of interruption of all connections during maintenance or repair.

Bonding conductors for telecommunications should not be placed in ferrous metallic conduit. If this cannot be avoided then in order to maintain the function of the bonding conductor it shall be bonded to each end of the conduit with conductors of a minimum cross-sectional area of 16 mm^2 (see Table 6) and with appropriate fittings meeting the requirements of 7.4.2.

7.4.2 Telecommunications bonding network connections

The design and installation of bonding network connections are unrestricted (unless specified within the detailed implementations of Clauses 8, 9, 10 or 11) but shall

a) be mechanically stable under the intended operational conditions (including inspection during maintenance procedures),

b) protect the connection from oxidation.

Bonding connectors and the fastenings and processes used to connect them to the conductive elements of bonding networks shall be designed to provide and maintain a d.c. contact resistance of ≤ 0,1 mΩ.

The mating surfaces of all bonding components shall be of a material that provides an electro-chemical potential of ≤ 300 mV (with reference to EN 60950-1). See A.3.1 for additional requirements and information.

7.5 Cabinets, frames and racks

7.5.1 External connections to a bonding network

7.5.1.1 Requirements

Cabinets, frames and racks (and other enclosures) containing, or intended to contain, information technology equipment or metallic information technology cable shall either be bonded to the

a) protective bonding network within the zone (for telecommunications networks in accordance with Clause 9),

b) SBB or PBB within the zone (for telecommunications networks in accordance with Clause 10).

Each cabinet, frame and rack shall have a connection point to which the rack bonding conductor (RBC) can be terminated meeting the requirements of 7.4.2.

The RBC may be connected to one of the following

1) the telecommunications equipment bonding conductor of Clause 10,

2) the primary or secondary bonding busbars of Clause 8,

3) the local protective bonding network of Clause 9.

In all cases each cabinet, frame and rack shall be connected with its own dedicated RBC(s). The cabinets, frames and racks shall not be bonded serially.

Figure 3 shows the various approaches that may be applied for the external and internal connections to cabinets, racks and frames.

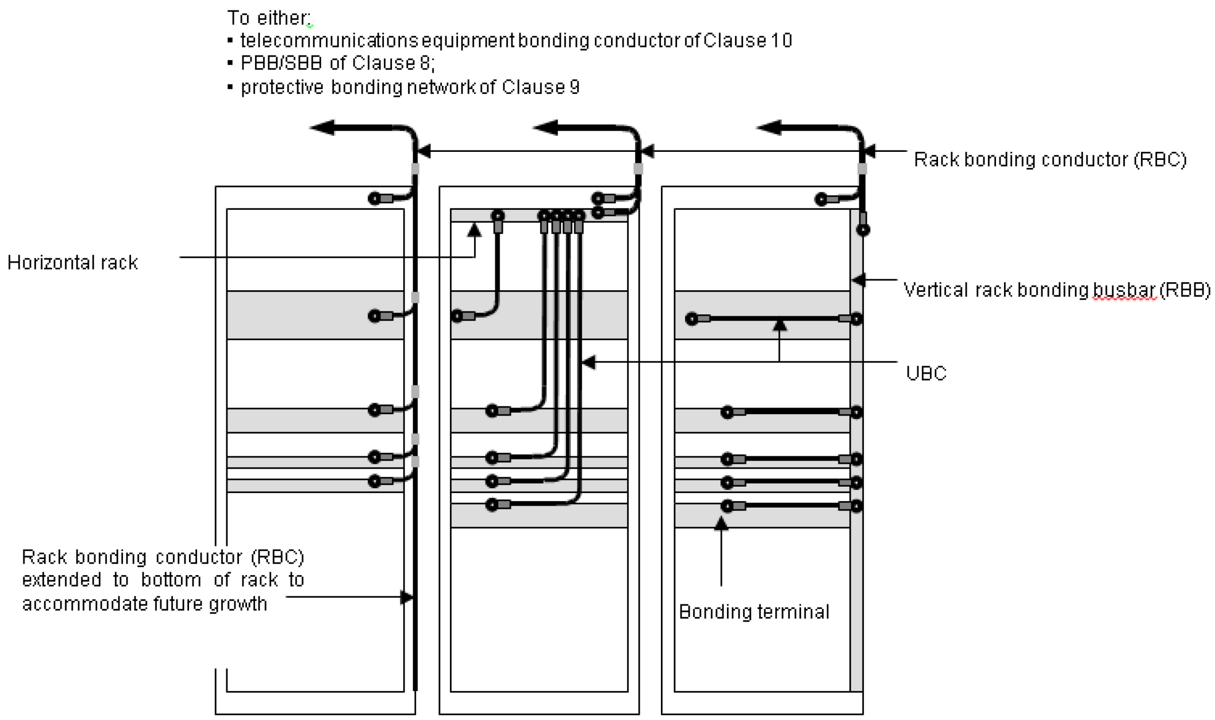


Figure 3 – Example of three methods of equipment and rack bonding

7.5.1.2 Recommendations

Cabinets, frames and racks containing multiple items of telecommunications equipment and other conductive items should be provided with horizontal or vertical rack bonding busbars (RBB).

7.5.2 Rack bonding conductors

7.5.2.1 Rack bonding conductors for d.c. resistance control

The RBC shall have a cross-sectional area in accordance with HD 60364-5-54 and shall be

a) of minimum cross-sectional area of 4 mm^2 for a cabinet, frame or rack of ≤ 21 U,

b) of minimum cross-sectional area of 16 mm^2 (see Table 6) for a cabinet, frame or rack of > 21 U.

NOTE U is a unit of height equal to 44,45 mm as defined in EN 60297–3-105.

7.5.2.2 Rack bonding conductors (RBC) for impedance control

7.5.2.2.1 Requirements

In addition to the requirements of 7.5.2.1, *n* additional bonding conductors of minimum cross-sectional area of 4 mm^2 shall be installed if the length, *l*, of the RBC exceeds 6 m, where *n* = ROUNDUP(*l*/6) − 1.

7.5.2.2.2 Recommendations

In addition to the requirements of 7.5.2.1, *n* additional bonding conductors of minimum cross-sectional area of 4 mm^2 should be installed if the length, *l*, of the RBC exceeds 3 m, where *n* = ROUNDUP(*l*/3) − 1.

7.5.3 Internal connections

7.5.3.1 Requirements

Telecommunications equipment containing metallic parts within a cabinet, frame and rack that have a bonding connection point shall be bonded to the telecommunications bonding network in accordance with the manufacturer's instructions. These bonds shall be implemented using either RBCs, or unit bonding conductors (UBC) to the RBB.

Where instructions are not given, all UBCs shall be of minimum cross-sectional area of 4 mm^2.

In order to reduce the radiation of EMI all conductive items within a cabinet, frame and rack (e.g. doors, panels, shelves and cable organizers) shall be bonded either by bonding conductors or through the cabinet, frame or rack structure (see 7.5.3.2) to the connection point on the cabinet where the cabinet bonding conductor connects to the cabinet. Where the items to be bonded are fixed, the bonding conductors shall meet the requirements of the UBC. Where the items to be bonded are detachable metallic parts (e.g. doors, side panels and top panels) the bonding conductors shall be connected by stranded, high strand count conductors having the same effective cross-sectional area as the UBC.

The bonding conductors attached to all detachable metallic parts (e.g. doors, side panels and top panels) should have an easily visible quick connect to facilitate their detachment and reattachment. These bonding conductors shall be implemented using manufacturer's instructions. Figure 4 shows an example of a solution.

Figure 4 – Example of a bond connection from a cabinet to the cabinet door

Where screened cables are terminated within a cabinet, frame or rack, the point of screen termination shall be bonded in accordance with EN 50174-2:2009/A1:2011, 5.3.6.

7.5.3.2 Structural bonding within cabinets, frames and racks

For a welded cabinet, frame or rack, the welded construction serves as the method of bonding the structural members of the cabinet/rack together.

For a cabinet, frame or rack which is constructed or stabilized with fasteners such as bolts, bonding continuity shall not be assumed unless specified by the manufacturer's instructions.

Construction hardware, such as bolts, washers, nuts and screws, shall only be used to meet the requirements of 7.4.2 provided that either

a) these and their interconnections are specifically designed for this purpose and installed in accordance with manufacturer's/supplier's instructions, or

b) any paint shall be removed from all bonding contact areas.

7.6 Miscellaneous bonding connections

7.6.1 General

The requirements and recommendations of 7.6.2 and 7.6.3 apply to bonding conductors not otherwise specified in this standard.

7.6.2 Bonding conductors for d.c. resistance control

Bonding conductors shall be of minimum cross-sectional area of 4 mm^2.

Where the conductor is used as part of a d.c. return path it shall comply with the requirements of HD 60364-4-44.

7.6.3 Bonding conductors for impedance control

7.6.3.1 Requirements

In addition to the requirements of 7.6.2, *n* additional bonding conductors (independent of cross-sectional area or shape) shall be installed if the distance, *l*, between bonding points exceeds 1 m, where *n* = ROUNDUP(*l*)−1.

7.6.3.2 Recommendations

In addition to the requirements of 7.6.2, *n* additional bonding conductors (independent of cross-sectional area or shape) should be installed if the distance, *l*, between bonding points exceeds 0,5 m, where *n* = ROUNDUP(2 × *l*) − 1.

Suitable conductors, including metal strips, metal braids or round cables, may be used. However, only metal strips or braids are recommended for high frequency performance as a circular conductor has a higher impedance than a flat conductor with the same material cross-section.

The length:width ratio of bonding conductors should not exceed 5:1 (see Figure 5).

a) Conformant (*l* < 5 × *w*)

b) Non-conformant (*l* > 5 × *w*)

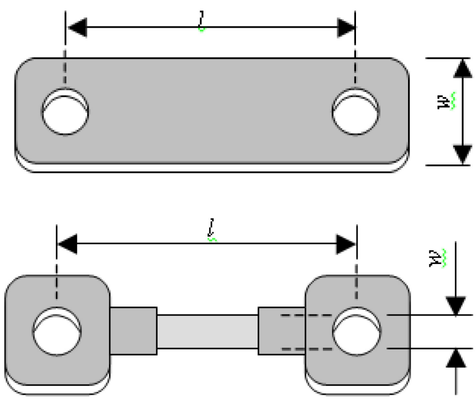


Figure 5 – Example of bonding straps

7.7 Documentation

If a bonding system network is a part of the structure of a new building, all connections shall be documented in a scheme and as pictures.

8 Dedicated telecommunications bonding network

8.1 General

Within a building (see illustrative examples in Figure 6 and Figure 7), the dedicated telecommunications bonding network originates at the MET and extends throughout the building. It includes the following major components

1) primary bonding busbar (PBB),

2) telecommunications bonding conductor (TBC),

and may also include the following:

3) telecommunications bonding backbone (TBB);

4) secondary bonding busbar (SBB);

5) backbone bonding conductor (BBC).

These telecommunications bonding components are intended to work with a building's telecommunications pathways and spaces, installed cabling, and administration system.

Where buildings have multiple METs and a separate PBB is installed in association with each MET, the PBBs shall not be interconnected unless it has been determined to be safe to do so. Also, SBBs connected to separate PBBs shall not be interconnected unless it has been determined to be safe to do so. Following such a determination, the conductor installed between the PBBs shall be implemented using a BBC in accordance with 8.2.3.3. Where impedance control is also required between the PBBs as indicated in Table 3 then 8.2.4.2 shall be applied.

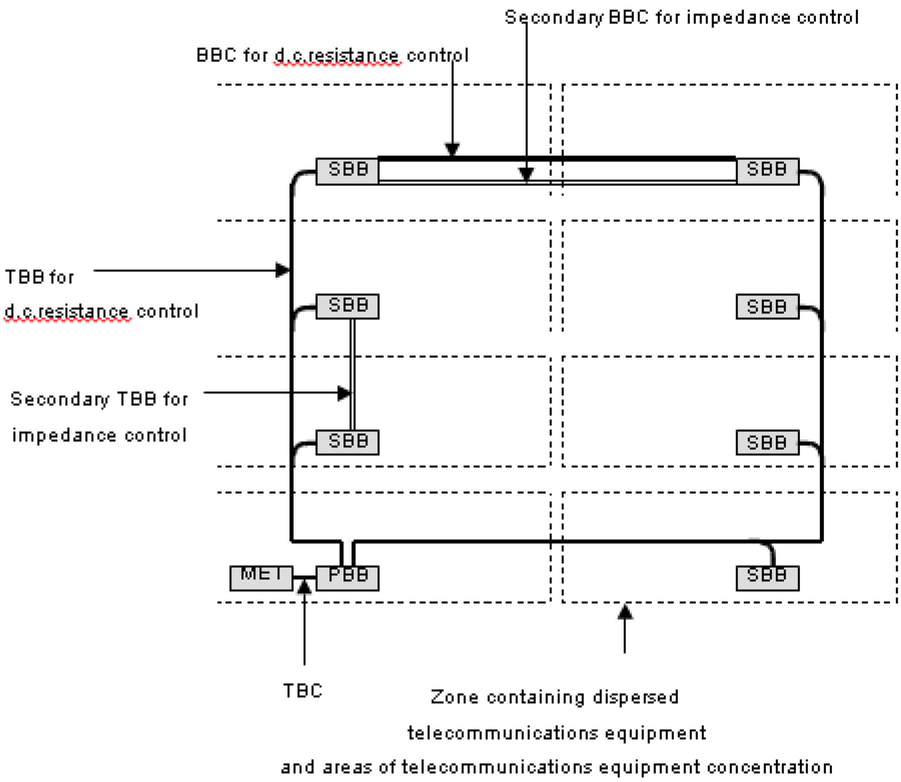


Figure 6 – Illustrative example of a large building

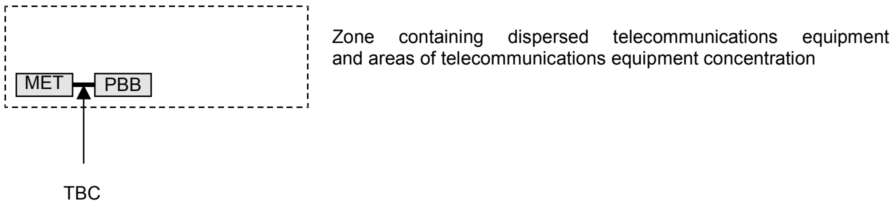


Figure 7 – Illustrative example of a smaller building

8.2 Components

8.2.1 Primary bonding busbar (PBB)

In the absence of national or local regulations, the PBB shall

a) be a busbar provided with holes for use with correctly matched bonding connections and fastening hardware in accordance with 7.4,

b) be made of copper, or copper alloys, in accordance with 7.4,

c) be 6,35 mm (minimum) thick and 100 mm (minimum) wide,

d) either be of a length to provide an adequate number of holes or be designed to be modular, allowing extension by means of fittings in accordance with manufacturer's instructions,

e) be designed to enable and maintain a bond contact resistance in accordance with 7.4.

Figure 8 shows a generalized schematic of a PBB.

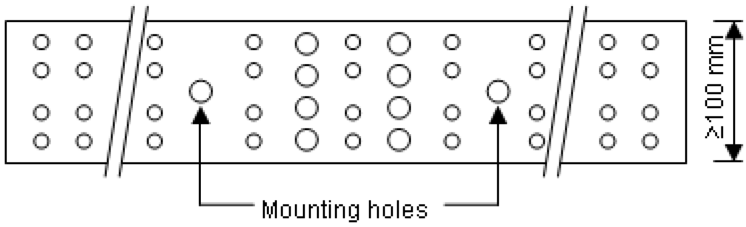


Figure 8 – Schematic of PBB

8.2.2 Secondary bonding busbar (SBB)

In the absence of national or local regulations, the SBB shall

a) be a busbar provided with holes for use with correctly matched bonding connections and fastening hardware in accordance with 7.4,

b) be made of copper, or copper alloys, in accordance with 7.4,

c) be 6,35 mm (minimum) thick and 50 mm (minimum) wide,

d) either be of a length to provide an adequate number of holes or be designed to be modular, allowing extension by means of fittings in accordance with the manufacturer’s instructions,

e) be designed to enable and maintain a bond contact resistance in accordance with 7.4.

Figure 9 shows a generalized schematic of an SBB.

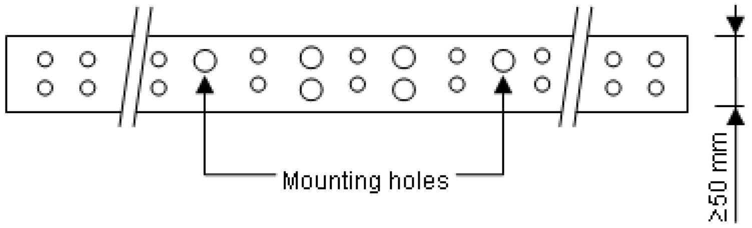


Figure 9 – Schematic of SBB

8.2.3 Bonding conductors for d.c. resistance control

8.2.3.1 Telecommunications bonding conductor (TBC)

The TBC shall be, as a minimum, the same size as the largest TBB (see 8.3.2.2).

8.2.3.2 Telecommunications bonding backbone (TBB)

8.2.3.2.1 Requirements

The TBB shall be constructed from conductors of minimum cross-sectional area of 16 mm^2 (see Table 6).

Where the TBB is constructed from conductors of differing diameters, the diameters shall increase as the TBB approaches the PBB.

8.2.3.2.2 Recommendations

To provide optimum d.c. resistance control the TBB should be constructed from conductors in accordance with Table 6.

Table 6 – TBB conductor sizing

Maximum PBB-SBB length *l* **m**	**Nominal conductor cross-sectional area** **mm^2**
$l \le 4$	16
$4 < l \le 6$	25
$6 < l \le 8$	35
$8 < l \le 10$	35
$10 < l \le 13$	50
$13 < l \le 16$	60
$16 < l \le 20$	70
$20 < l \le 26$	95
$26 < l \le 32$	120
$32 < l \le 38$	150
$38 < l \le 46$	150
$46 < l \le 53$	185
$53 < l \le 76$	250
$76 < l \le 91$	300
For lengths in excess of those shown above, the conductor cross-sectional area should be calculated as 3,3 mm^2 per meter	

8.2.3.3 Backbone bonding conductor (BBC)

The BBC shall be, as a minimum, the same size as the largest TBB (see 8.3.2.2) to which it is attached.

8.2.4 Bonding conductors for impedance control

8.2.4.1 Telecommunications bonding backbone (TBB)

8.2.4.1.1 Requirements

In addition to the requirements of 8.2.3.2.1, *n* additional bonding conductors of minimum cross-sectional area of 4 mm^2 shall be installed if the distance, *l*, between zones exceeds 6 m, where n = ROUNDUP(l/6) − 1.

8.2.4.1.2 Recommendations

In addition to the requirements of 8.2.4.1.1, *n* additional bonding conductors of minimum cross-sectional area of 4 mm^2 should be installed if the distance, *l*, between zones exceeds 3 m, where n = ROUNDUP(l/3) − 1.

8.2.4.2 Backbone bonding conductor (BBC)

8.2.4.2.1 Requirements

See 8.2.4.1.1.

8.2.4.2.2 Recommendations

See 8.2.4.1.2.

8.3 Implementation

8.3.1 Primary bonding busbar (PBB)

8.3.1.1 General

There shall be one PBB associated with each MET in a building which shall be installed either in the TEF (if an electrical distribution panel for telecommunications equipment is present) or in the space which accommodates a generic cabling building distributor and the associated telecommunications equipment.

The PBB acts as a SBB for telecommunications equipment, cabinets, racks or frames in the space within which the PBB is located.

The PBB shall be located to simplify the routing of the connections (taking into account the need to minimize both conductor length and the number of bends) to be made to it. The PBB shall be mounted with adequate clearances (50 mm minimum recommended) to allow access during attachment of bonding conductors. Where it is anticipated that testing of the telecommunications bonding network is required, the PBB shall be insulated from its surroundings.

If installed in the TEF, the PBB should be installed as close as practicable to the electrical distribution panel.

The PBB should serve telecommunications equipment that is located within the same room or space. The PBB is intended to be the location for connecting bonding busbars incorporated in telecommunications equipment located in the TEF. Extensions of the PBB (i.e. other telecommunications busbars in other telecommunications spaces) shall be SBBs.

8.3.1.2 Bonding to the PBB

The PBB provides a connection point for

a) the TBC (where the PBB comprises multiple busbars accommodated in the same space, connections between them shall be made with conductors that meet the d.c. resistance specification of the TBC),

b) TBB conductors,

c) TEBC(s) to RBC(s) in the space served by the PBB, see Clause 10,

d) TEBC(s) to any supplementary bonding grids (SBG) as described in Clause 11 in the space served by the PBB, see Clause 10,

e) RBC(s) in the space served by the PBB, see Clause 10,

f) bonds to continuous conductive telecommunications pathway systems serving the space accommodating the SBB which are not otherwise connected to the protective or telecommunications bonding networks (see 8.3.6),

g) bonds to appropriate structural metal (see 8.3.7),

h) the protective bonding connection (or the enclosure) of any electrical distribution panel serving the space accommodating the PBB,

i) surge protection devices (where required by manufacturer's instructions) associated with external telecommunications cabling entering the building.

These connections shall employ either exothermic welding, compression two-hole connectors or two-hole exothermic connectors or another method providing equivalent mechanical resistance to long-term environmental influences including vibration.

The busbar shall be cleaned and, where necessary, a conductive anti-oxidant applied prior to fastening connectors to the busbar.

To avoid induced currents associated with bonding conductors to surge protection devices, the bonding conductors to surge protection devices shall be located as far as is practicable from telecommunications and power supply cables.

8.3.2 Secondary bonding busbar (SBB)

8.3.2.1 General

Each area of telecommunications equipment concentration (see Figure 2) not directly served by a PBB shall contain at least one SBB.

The SBBs shall be located

a) as close as practicable to any electrical distribution panel which serves the space,

b) to simplify the routing of the connections (taking into account the need to minimize both conductor length and the number of bends) to be made to it.

The SBB shall be mounted with adequate clearances (50 mm minimum recommended) to allow access during attachment of bonding conductors. Where it is anticipated that testing of the telecommunications bonding network is required, the PBB shall be insulated from its surroundings.

8.3.2.2 Bonding to the secondary bonding busbar

The SBB provides a connection point for

a) TBB conductor(s) (where multiple SBBs are accommodated in the same space, connections between them shall be made with conductors that meet the d.c. resistance specification of the TBB),

b) BBCs,

c) TEBC(s) to RBB(s), see Clause 10,

d) TEBC(s) to supplementary bonding grids, see Clause 10,

e) RBC(s) in the space served by the SBB, see Clause 10,

f) continuous conductive telecommunications pathway systems serving the space accommodating the SBB which are not otherwise connected to the protective or telecommunications bonding networks (see 8.3.6),

g) bonds to appropriate structural metal (see 8.3.7),

h) the protective bonding connection (or the enclosure) of any electrical distribution panel serving the space accommodating the SBB,

i) local surge protection devices (where required by manufacturer’s instructions).

When secondary protection is provided, the secondary protector bonding conductor shall be connected to the nearest PBB or SBB using the shortest bonding conductor practical.

These connections shall employ either exothermic welding, compression two-hole connectors or two-hole exothermic connectors or another method providing equivalent mechanical resistance to long-term environmental influences including vibration.

The busbar shall be cleaned and, where necessary, a conductive anti-oxidant applied prior to fastening connectors to the busbar.

8.3.3 Telecommunications bonding conductor (TBC)

A PBB shall be bonded to the associated MET using a TBC is accordance with 8.2.3.1.

The routing of the TBC shall take into account the need to minimize both conductor length and the number of bends.

The conductors shall be labelled at both ends and the label shall state the specific function of the conductor and the need for care when disconnecting.

8.3.4 Telecommunications bonding backbone (TBB)

The type of building construction, building size, general telecommunications requirements, and the configuration of the telecommunications pathways and spaces should be considered when designing the TBB. Specifically, the design of a TBB shall

a) be consistent with the design of the telecommunications backbone cabling system (e.g. follow the backbone pathways),

b) permit multiple TBBs as necessary (e.g. multiple distributors per floor, see Figure 5),

c) minimize, to the extent practical, the lengths of the TBB(s).

TBB conductors shall be protected from physical and mechanical damage. The TBB conductors should be installed without splices, however, where splices are unavoidable, there should be a minimum number of splices. Splices shall be accessible and located in telecommunications spaces.

Segments of a TBB shall be joined by means of an exothermic weld, irreversible compression-type connectors, or equivalent. All joints shall be adequately supported and protected from damage on both sides of the joint.

8.3.5 Backbone bonding conductor (BBC)

Where it is intended to connect telecommunications equipment using metallic cabling between zones served by separate TBBs, the SBBs within the zones shall be bonded at intervals using a BBC.

Within multi-floor buildings, the TBBs shall be bonded together via their respective SBBs with a BBC on the top floor and at a minimum of every third floor (see Figure 5). Within buildings of horizontal extent, the bonding between TBBs shall be undertaken on an equivalent basis.

The requirements of 7.1 shall be met where TBBs are connected to multiple PBBs.

8.3.6 Bonds to continuous conductive pathway systems

Continuous conductive telecommunications pathway systems serving the spaces accommodating a PBB or SBB which are not otherwise connected to the protective or telecommunications bonding networks shall be bonded to the PBB (see 8.3.1.2) or SBB (see 8.3.2.2) respectively.

A bonding conductor of minimum cross-sectional area of 16 mm^2 (see Table 6) shall be used.

8.3.7 Bonds to structural metal

The PBB (see 8.3.1.2) and SBB (see 8.3.2.2) shall be bonded to readily accessible structural metal if it has been determined that the structural metal will improve the performance of the telecommunications bonding network.

A bonding conductor of minimum cross-sectional area of 16 mm^2 (see Table 6) shall be used.

Structural metal that is bonded to the MET may be used in place of a TBB or a BBC. Before utilizing structural metal in place of a TBB or a BBC, building plans (including as-built drawings as applicable) and specifications shall be reviewed to ensure the structural metal is electrically continuous or can be made so.

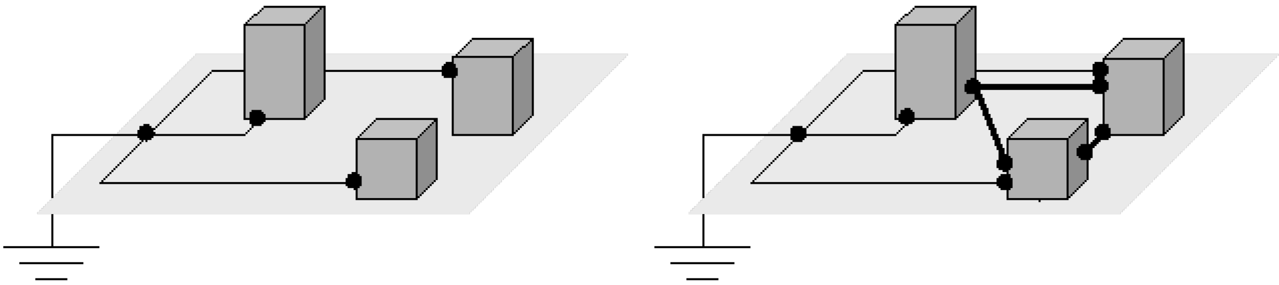
Additionally, the two-point continuity test described in 6.3.3 should be performed from floor-to-floor on the structural metal, thereby ensuring electrical continuity through the entire structure. Concrete reinforcing steel shall not be used as a TBB or a BBC unless all appropriate connections between the elements have been welded in order to provide the required contact resistance.

9 Local telecommunications bonding networks in conjunction with protective bonding networks

9.1 Bonding for local distribution

9.1.1 Star protective bonding networks

In this configuration, each item of telecommunications equipment is connected to the primary protective bonding point by its own primary bonding network conductor (PBNC) as shown in Figure 10a).



a) – Star local protective bonding network **b) – Supplementary telecommunications bonding network**

Figure 10 – Star protective bonding and supplementary telecommunications bonding

Where the telecommunications equipment served by the star protective bonding network is interconnected, the following problems may result where the PBNCs are long or the items of equipment are some distance from each other

a) a high common impedance between equipment particularly at high frequencies (see Figure 11),

b) large ground loops (see Figure 11).

This configuration makes electronic equipment more vulnerable to electromagnetic disturbances.

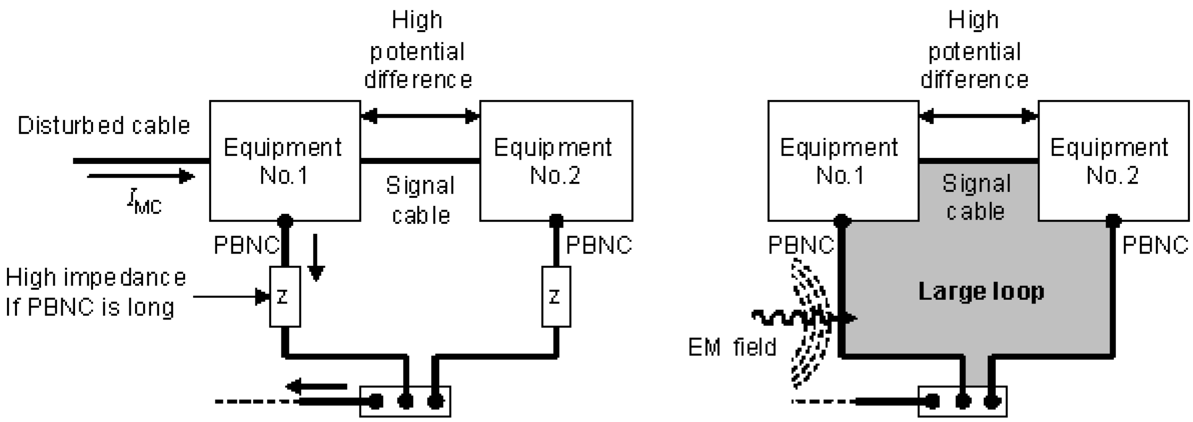


Figure 11 – Example of high common impedance and large loop

Additional bonding conductors shall be connected between the telecommunications equipment in order to reduce both the common impedance and the size, and the resulting effect of the relevant ground loop (see reduced ground loop shown by the shaded area in Figure 12). The supplementary telecommunications bonding network is shown in Figure 10b).

The bonding conductors to be used are specified in 9.2.

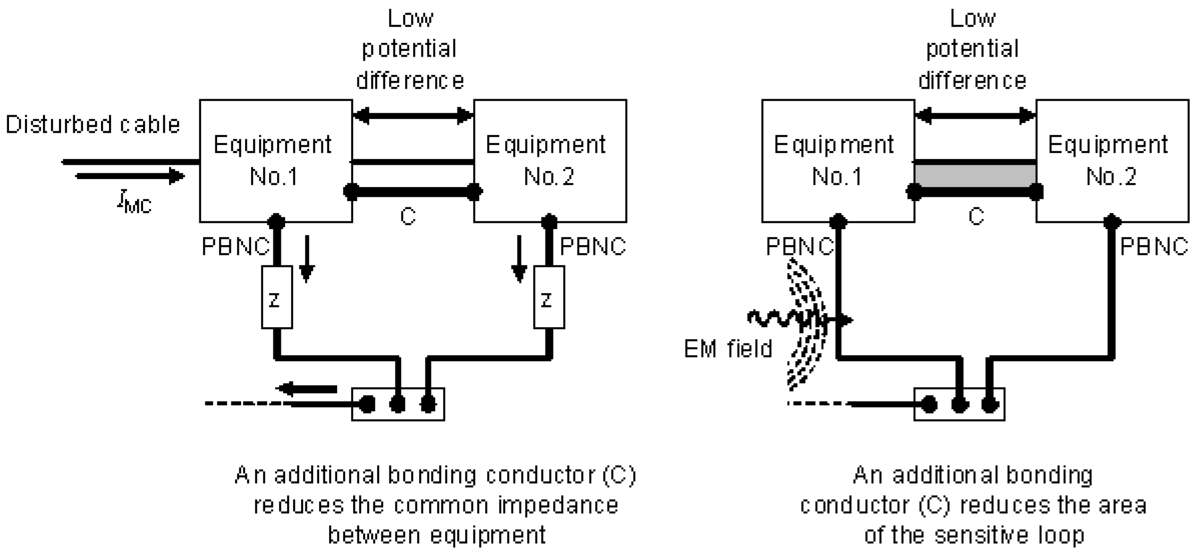
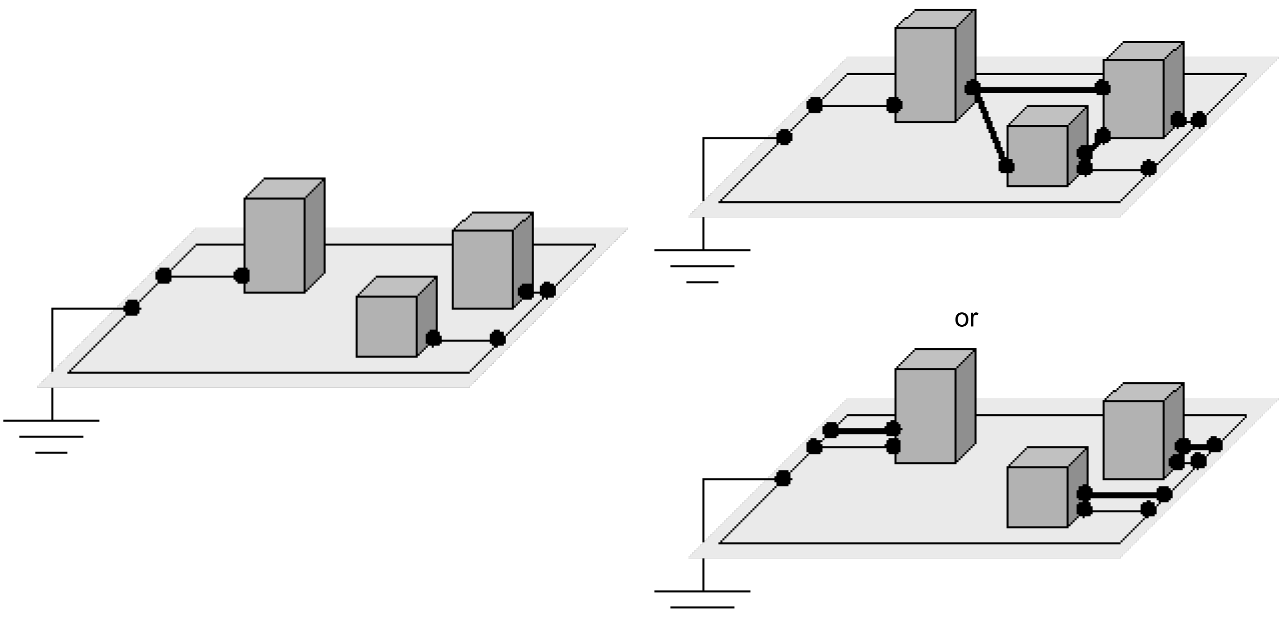


Figure 12 – Example of low common impedance and small loop

9.1.2 Ring protective bonding networks

In this configuration, each item of telecommunications equipment shall be connected to the bonding ring conductor by its own bonding conductor as shown in Figure 13a).



a) Ring local protective bonding network **b) Supplementary telecommunications bonding network**

Figure 13 – Ring protective bonding and supplementary telecommunications bonding

Additional bonding conductors shall be connected between the telecommunications equipment or between the telecommunications equipment and the bonding ring conductor. The supplementary telecommunications bonding network is shown in Figure 13b).

In addition, it is recommended that bonding conductors should be connected between conductive cable management systems and the bonding ring conductor.

The bonding conductors to be used are specified in 9.2.

9.2 Telecommunications bonding conductors

9.2.1 Bonding conductors for d.c. resistance control

9.2.1.1 Requirements

Bonding conductors shall be of minimum cross-sectional of 4 mm^2.

Where the conductor is used as part of a d.c. return path it shall comply with the requirements of HD 60364-4-44.

9.2.1.2 Recommendations

Multiple bonds, including those using building structures, should be used rather than a single bond since this reduces the impedance (inductance) of the resulting bond (see Figure 14). Examples of mesh bonding networks which provide multiple bonds are discussed in Clause 11.

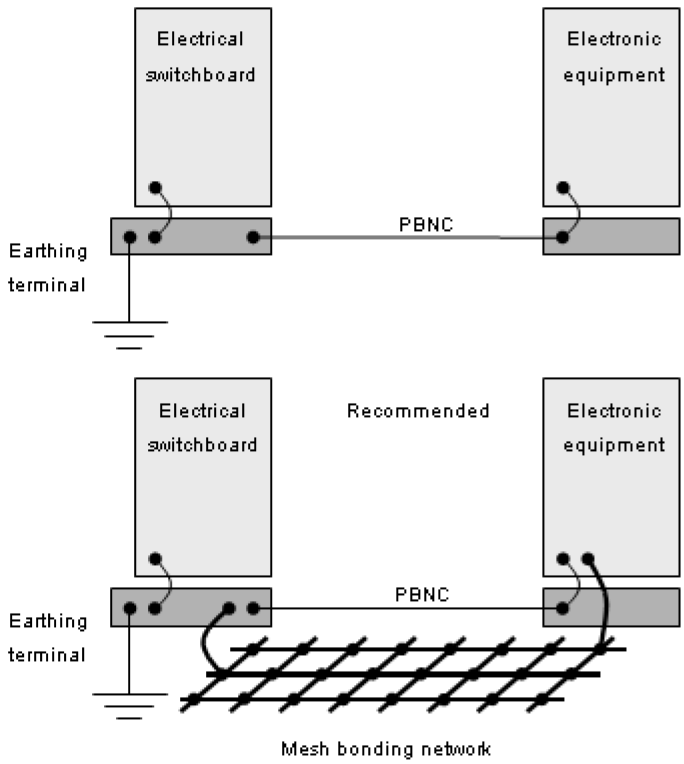


Figure 14 – MESH-BN example

9.2.2 Bonding conductors for impedance control

9.2.2.1 Requirements

In addition to the requirements of 9.2.1.1, *n* additional bonding conductors (independent of cross-sectional area or shape) shall be installed if the length, *l*, of the bonding conductor exceeds 6 m, where n = ROUNDUP(l/6) − 1.

9.2.2.2 Recommendations

In addition to the requirements of 9.2.1.1, *n* additional bonding conductors (independent of cross-sectional area or shape) should be installed if the length, *l*, of the bonding conductor exceeds 3 m, where n = ROUNDUP(l/3) − 1.

9.3 Bonding for areas of telecommunications equipment concentration

In each area of equipment concentration, a minimum of one busbar shall be provided. The busbar shall be fitted with a disconnection point.

Each busbar serving that area shall be connected to the protective bonding network with a bonding conductor of minimum cross-sectional area of 25 mm^2 (see Table 6).

The RBC of each cabinet, rack or frame shall be connected to the busbar.

The internal connections of the cabinet, rack or frame shall be in accordance with 7.5.

10 Local telecommunications bonding networks in conjunction with dedicated telecommunications bonding networks

10.1 Bonding for areas of telecommunications equipment concentration

10.1.1 Requirements

Each area of telecommunications equipment concentration shall contain a SBB (or PBB when specified in the design).

10.1.2 Recommendations

Spaces with high densities of telecommunications equipment and/or cabinets, frames and racks accommodating telecommunications equipment (e.g. computer room spaces within data centres) should feature mesh bonding networks of the form described in Clause 11.

A mesh bonding network may also provide for electromagnetic shielding in varying degrees based upon its design and installation.

10.1.3 Cabinets, frames and racks

Cabinets, frames and racks (and other enclosures) containing, or intended to contain, information technology equipment or metallic information technology cable shall either be bonded

a) directly to the local SBB (or PBB) using RBCs or to the mesh bonding network using conductors in accordance with 7.5.2,

b) to the local SBB (or PBB) or the mesh bonding network via a telecommunications equipment bonding conductor (TEBC) in accordance with 10.2.1.

10.2 Telecommunications equipment bonding conductors (TEBC)

10.2.1 TEBC for d.c. resistance control

The TEBC shall be a continuous conductor with a bonding conductor of either minimum cross-sectional area of 16 mm^2 (see Table 6)or that of the largest size equipment protective earth conductor in the a.c. power supply cabling serving the group of cabinets, frames and racks served by the TEBC.

NOTE Cable shields do not satisfy the requirements for a TEBC.

10.2.2 TEBC for impedance control

10.2.2.1 Requirements

In addition to the requirements of 10.2.1, *n* additional bonding conductors (independent of cross-sectional area or shape) shall be installed if the length, *l*, of the TEBC exceeds 6 m, where n = ROUNDUP(l/6) − 1.

10.2.2.2 Recommendations

In addition to the requirements of 10.2.1, *n* additional bonding conductors (independent of cross-sectional area or shape) should be installed if the length, *l*, of the TEBC exceeds 3 m, where n = ROUNDUP(l/3) − 1.

10.2.3 Implementation

The TEBC shall be connected to the cabinets/equipment racks, to a RBC or to a vertical/horizontal RBB.

Connections to the TEBC shall be made with irreversible compression connectors and with the rack bonding conductors (RBCs) routed toward the PBB/SBB, see Figure 15.

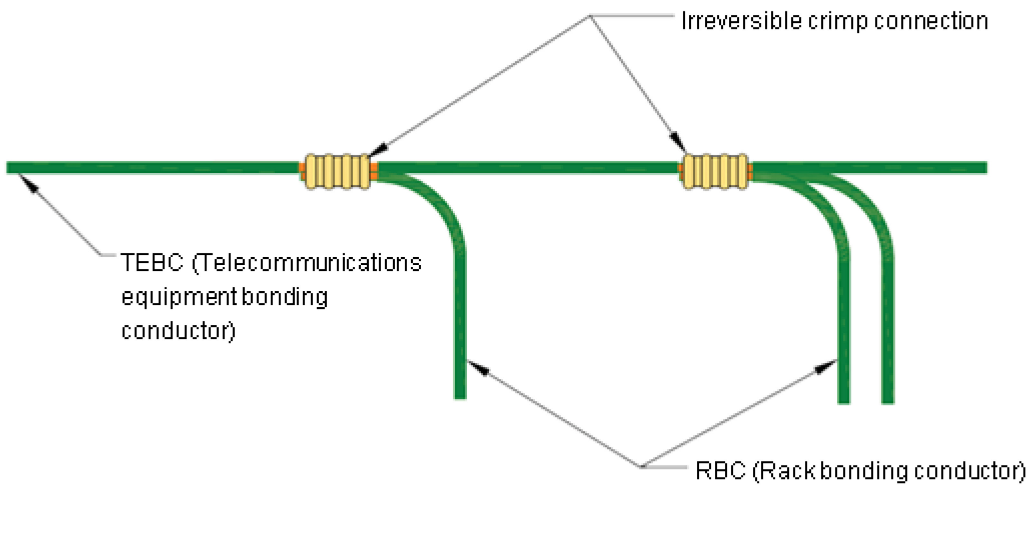


Figure 15 – Example TEBC to rack bonding conductor connection

The TEBCs may be routed within cable trays, on the outside of ladder rack, tray supported at no greater than 0,9 m intervals, or along equipment platforms. Examples of acceptable means of supporting the TEBCs include the use of lay-in connectors, cable brackets, and other brackets designed for this purpose.

An alternative method to running TEBCs overhead is to route them under an access floor. All requirements set forth for running the bonding conductors specified in this standard shall apply.

11 Mesh bonded networks

11.1 General

The mesh bonded networks provide enhanced immunity to EMI compared to that provided by the bonding networks specified in Clauses 8, 9 and 10. This enhanced performance mitigates issues resulting from steady-state and transient voltages and currents generated by lightning, power systems, power circuit earth faults and EMI.

Mesh bonding networks shall be bonded to the protective bonding network within the building.

Mesh bonding networks (also known as supplementary bonding networks) are described in detail in ITU-T K.27 and identified for telecommunications equipment as the primary topologies described below.

a) MESH-BN – generally, the default topology as most telecommunications equipment has intra/inter intentional and unintentional metallic interconnections. A MESH-BN augments the protective bonding network by increasing the local density of conductors and functions by attempting to diversify and limit the radio frequency capture-loop area of the current paths such that the current density on any conductor or conductive loop is reduced to an acceptable level. Typically, the telecommunications equipment, cabinets, racks and frames are arranged into a holistic (single system block) MESH-BN by manufacturer’s equipment design, user deployment guidelines, or both. The holistic MESH-BN is a recommended practice since it simplifies installation procedures, most telecommunications equipment is powered by a.c. branch circuits, and most ITE employed for a computer room is suitable for placement directly into the protective bonding network. However, under certain circumstances such as a manufacturer’s requirement or access provider recommendations, the telecommunications equipment may also be arranged into certain segregated “functional system blocks” of either MESH-BN, MESH-IBN or other form of bonding network within the same room.

b) MESH-IBN – generally can be described as a MESH-BN functional system block that is arranged into a single point bonding entity that is isolated from the protective bonding network except for at one controlled location (a single point connection (SPC) window). The IBN topology is known to provide high robustness to building lightning and power fault currents. The star topology is amenable to “current mapping” for troubleshooting within the IBN. The IBN topology functions by attempting to block extraneous currents (such as lightning) from flowing within the protective bonding network and then entering and traversing through the IBN. This topology is especially robust to transients occurring in the protective bonding network.

c) Star IBN – an IBN deployed into a star network instead of a mesh network.

NOTE Other topological versions of IBNs (such as “star” and “sparse-mesh”) are described in ITU-T K.27.

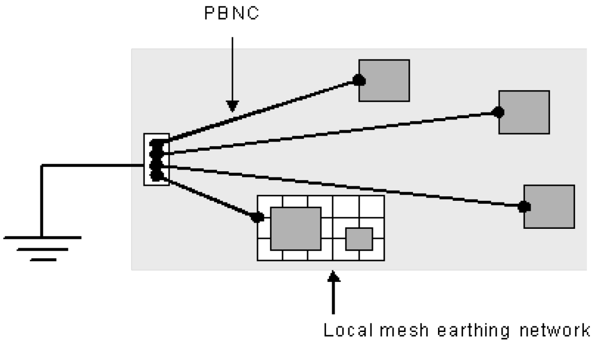
11.2 Mesh bonding alternatives

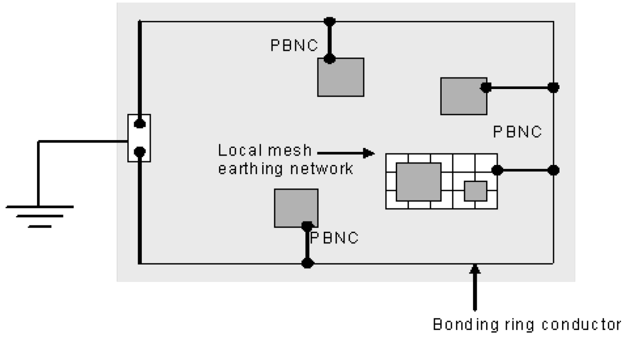
11.2.1 Local mesh bonding (MESH-IBN) networks

11.2.1.1 General

Figure 16 shows a local mesh network installed within both star and ring protective bonding networks. Such networks constitute local mesh isolated bonding networks (MESH-IBN).

The MESH-IBN is typically limited to a restricted area within a building such as in areas of concentration of IT equipment. The MESH-IBN is not typical (but can be utilized) for a commercial environment but is recognized and sometimes utilized in areas of concentration of IT equipment in access provider premises.





a) MESH-IBN via a star protective bonding network

b) MESH-IBN via a ring protective bonding network

Figure 16 – Local mesh bonding network

The MESH-IBN components such as associated equipment cabinets, frames, racks and cabling pathways are insulated from the protective bonding network except for one controlled single point of connection (SPC) location, as shown in Figure 17, and the MESH-IBN is said to be "insulated or isolated" from the protective bonding network.

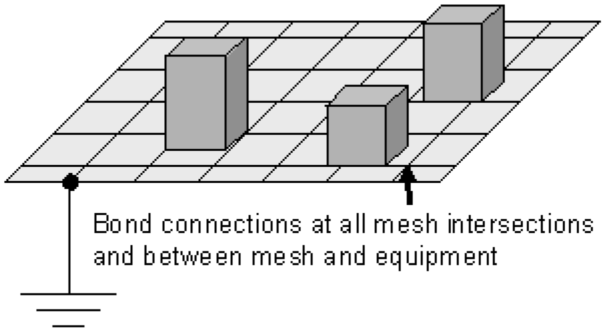


Figure 17 – A MESH-IBN having a single point of connection (SPC)

The instructions of equipment suppliers in conjunction with the identified electromagnetic environment may require specific areas within buildings to be subject to more stringent requirements and may require the local mesh network to be improved using one of the following

a) the recommendations of 11.3.2,

b) a supplementary bonding grid (SBG) of 11.5,

c) a system reference potential plane (SRPP) as described in 11.6.

11.2.1.2 Requirements

A local mesh requires all metallic parts in a restricted area within a building to be bonded to provide an electrically continuous network with low impedance and shall include

a) cabinets, frames and racks,

b) conductive pathway systems,

c) cable screens (the treatment of telecommunications cabling screens is specified in EN 50174-2),

d) bonding mats, where appropriate.

This shall be achieved by a combination of the following:

1) the installation of additional bonding conductors,

2) the improvement of finishing and fastening methods for existing bonding conductors.

There shall be a connection between the local MESH-IBN and the protective bonding network. The SPC location applies to all bonding conductors (including power circuits) entering or exiting the MESH-IBN.

The pathways of metallic telecommunications cables within and between local mesh networks shall be routed along the elements of the protective bonding network.

11.2.1.3 Recommendations

The telecommunications cabling at entry points to a local mesh network should be located in close proximity.

There should be multiple connections between the local mesh network and the protective bonding network.

11.2.2 MESH-BN

11.2.2.1 General

A MESH-BN installed in a multi-floor building is shown in Figure 18.

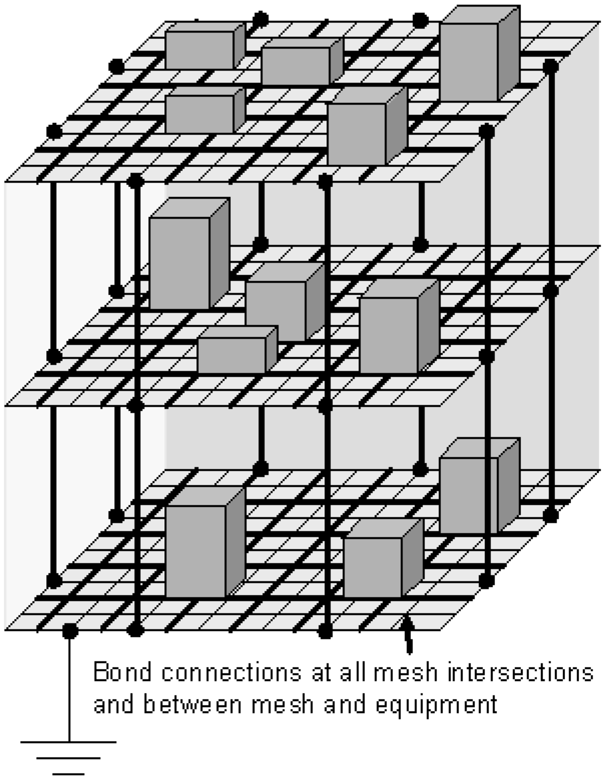


Figure 18 – A MESH-BN with equipment cabinets, frames, racks and CBN bonded together

11.2.2.2 Requirements

A merged MESH-BN and protective bonding network in buildings shall include the interconnections to the following installations, if present

a) “integrated lightning protection system” according to EN 62305-4,

b) bonding measures of antenna installations (including satellite receiving equipment under private property) and cable networks according to series EN 50083 and EN 60728,

c) bonding measures of information technology cabling according to EN 50174-2,

d) bonding in hazardous areas, e.g. according to EN 60079-14.

11.3 Bonding conductors of a mesh bonding network

11.3.1 Requirements

The mesh bonding network shall be constructed from bonding conductors of minimum cross-sectional area of 16 mm^2 (see Table 6) which may be used in conjunction with access-floor pedestals and stringers.

Where the mesh bonding network is constructed from bonding conductors of minimum cross-sectional area of 16 mm^2 (see Table 6), they shall be jointed with exothermic weld, irreversible compression-type connectors, or equivalent. All joints shall be adequately supported and protected from damage on both sides of the joint.

In addition, *n* additional bonding conductors (independent of cross-sectional area or shape) shall be installed if the length, *l*, of the mesh connection exceeds 6 m, where $n = \text{ROUNDUP}(l/6) - 1$.

If the mesh bonding network is constructed using the access-floor pedestals and stringers, the flooring system shall be electrically continuous and shall be bonded together at intervals no greater than every six pedestals in each direction using a stranded bonding conductor of minimum cross-sectional area ≥ 13 mm^2 and pedestal bonding clamps.

A mesh bonding network may be constructed from flat conductors using prefabricated copper strips (minimum 0,4 mm thick × 50 mm wide). All crossings and jointed sections shall employ either exothermic welding, compression two-hole connectors or two-hole exothermic connectors or another method providing equivalent mechanical resistance to long-term environmental influences including vibration.

11.3.2 Recommendations

EMI from a mesh earthing network decreases significantly as the mesh size is reduced. Specific areas within buildings may be subject to more stringent requirements that require the mesh to be improved either as follows or by providing an SRPP (see 11.6).

In addition to the requirements of 11.3.1, *n* additional bonding conductors (independent of cross-sectional area or shape) should be installed if the length, *l*, of the mesh connection exceeds 3 m, where $n = \text{ROUNDUP}(l/3) - 1$.

11.4 Bonding conductors to the mesh bonding network

The mesh bonding network shall have the following connections in the areas served in addition to those specified in Clauses 9 and 10:

a) bonding conductors of minimum cross-sectional area of 50 mm^2 (see Table 6) to the PBB, SBB or equivalent element;

b) bonding conductors of minimum cross-sectional area of 16 mm^2 (see Table 6) to heating, ventilating, and air-conditioning equipment (which shall not be bonded to the bonding mat/grid serially, each shall have its own connection to the MESH-BN);

c) bonding conductors of minimum cross-sectional area of 25 mm^2 (see Table 6) to each structural metal column;

d) bonding conductors of minimum cross-sectional area of 16 mm^2 (see Table 6) to each metallic cable tray and cable runway in the room, which may be bonded in series;

e) bonding conductors of minimum cross-sectional area of 16 mm^2 (see Table 6) to each metallic conduit, water pipe, metallic air duct in the room, which may be bonded in series.

Bonding conductors shall

1) be installed using the shortest practicable route,

2) be secured at no greater than 0,9 m intervals,

3) not be routed where it creates a tripping hazard, impairs access to equipment, nor attached with staples or other methods that could damage the conductors,

4) where bare conductors are deployed, they shall be supported by standoff insulators at intervals no greater than 0,6 m or be contained in non-metallic conduit (bare bonding conductors shall not make incidental contact with metallic surfaces that are not part of the telecommunications bonding system),

5) be installed using low-emission exothermic welds, where exothermic welds are specified and allowed within a space containing electronics.

11.5 Supplementary bonding grid (SBG)

A recommended augmentation to a mesh bonding network is a supplementary bonding grid (SBG).

For a MESH-IBN, located under an access-floor, the SBG is typically only directly connected to the serving PBB or SBB in order to not violate the insulation requirements for the MESH-IBN. An “above cabinet/frame/rack” SBG is more easily incorporated where desirable into the MESH-IBN by means of insulating devices between the bonding grid and any nearby protective bonding network components.

Upon installation and connection of the SBG to the BN (primary components are cabinets, racks and frames), the SBG becomes part of the overall BN. The SBG typically covers the room containing areas of concentration of IT equipment or a local area within a room.

The historical spacing for the SBG pattern is between 0,61 m to 1,22 m to aid in reducing the effect of resonance on a.c. branch circuit equipment bonding conductors.

The minimum density of the SBG shall be either on 3 m centres or one that corresponds to the grid defined by the cabinets, frames or racks in the areas of concentration of IT equipment.

11.6 System reference potential plane (SRPP)

11.6.1 General

Where a complex installation is required, a reliable signal reference shall be provided by an SRPP dedicated at least to a functional unit or a system block.

NOTE 1 Signal reference to the SRPP does not imply signal return via the SRPP.

The SRPP shall provide sufficiently low impedance up to the highest frequency considered in the design of the equipment in order to

a) avoid undue functional distortion or risk of component failure,

b) enable efficient connection of filters, cabinets and cable screens.

The frequency band to be covered shall include the spectral components of transients caused by switching, short circuits and atmospheric discharges.

NOTE 2 Requirements for the protection against overvoltages and (or) atmospheric discharge are outside the scope of this European Standard.

The design of the SRPP shall address the discharge of electrostatic energy. Requirements and recommendations are contained in EN 50174-2.

An SRPP is typically constructed using a metal plane or a mesh configuration having adequate mesh dimensions, e.g. a bonding mat.

11.6.2 Access floors

11.6.2.1 Requirements

The shielding effect provided above an access floor is a combination of the equipotential performance of the designs of the frame bonding grid and the access floor.

If there is no contact between the flooring panels/tiles (panels with anti-static vibration isolating and air flow rubber seals), or if the contact through support stringers is not guaranteed (pollution, corrosion, moisture, etc., or stringerless flooring system), a frame bonding grid shall be added by providing bonding to the metal uprights, as shown in Figure 19.

The frame bonding grid shall be installed with a maximum cell size of 2 m in each horizontal direction. The minimum cross-sectional area of the conductors that create the frame bonding grid shall be 10 mm^2. The bonding connector used for attaching the metal rights to the frame bonding grid shall comply with the resistance requirements as detailed in 6.3.2.

If the access floor is installed with a surface that is intended to provide protection against electrostatic discharge, the d.c. resistance between the upper surface of the access floor and the protective bonding grid shall be in the range 1 MΩ to 10 MΩ. The location and values of any d.c. resistance measurements made shall be recorded for comparison with future measurements following any maintenance or repair activity undertaken on the floor.

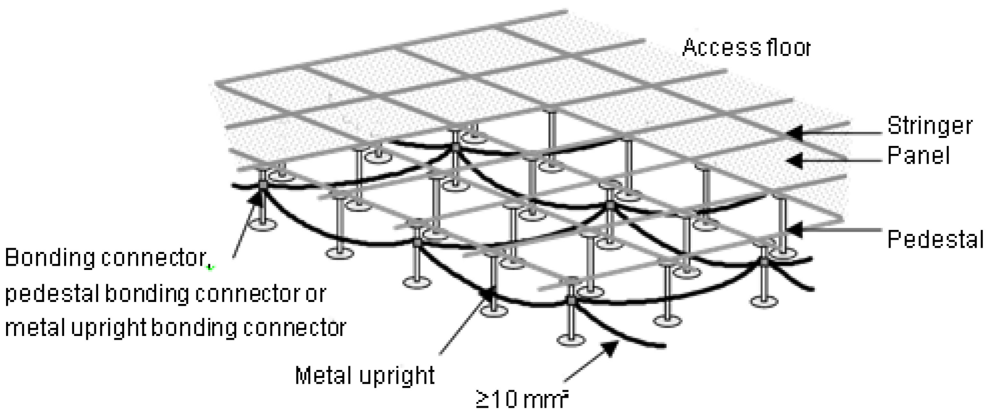


Figure 19 – Example of access floor

11.6.2.2 Recommendations

The frame bonding grid should be installed with a maximum cell size of 1,5 m in each horizontal direction.

Where the SRPP forms part of the mesh bonding network, the frame bonding grid should be connected to the protective bonding network at multiple points.

For a floor designed to provide shielding performance, periodic maintenance should be applied to ensure that its design performance is maintained following changes in the operating environment (e.g. levels of pollution, corrosion, moisture, etc.) or following damage to the contact provided by the support brackets.

For a floor designed to provide protection against electrostatic discharge, periodic maintenance with proper cleaning, appropriate chemicals (no wax) should be used to ensure that

a) the d.c. resistance measurements already obtained and recorded as detailed in 11.6.2.1 are maintained,

b) any measurements at new locations are within the range detailed in 11.6.2.1.

11.6.3 Transient suppression plate (TSP)

The TSP is used as a potential reference on which all EMI suppression components are bonded (filters, voltage suppressors, screens of screened cables, etc.). For example, as shown in Figure 20, a metal plate of 1 m × 1 m (minimum) is intended to divert noise current to the reinforcing steel in the concrete of the sub-floor under the access floor.

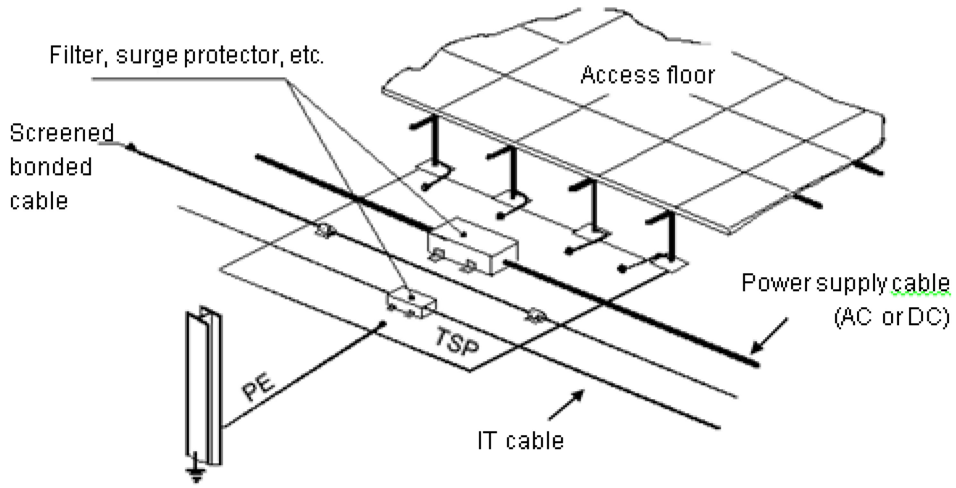


Figure 20 – Example of installation details for an under floor transient suppression plate

Annex A
(normative)

Maintenance of telecommunications bonding network performance

A.1 General

This annex addresses the monitoring of the effective performance of a telecommunications bonding network during operation of the building or structure.

A.2 Periodic activity

A.2.1 Schedule

Subclause 6.3.3 describes the measurement of d.c. resistance of telecommunications bonding networks where the telecommunications equipment is installed. In order to maintain an effective bonding system the owner (or equivalent) of the building or structure should implement a regime for periodic inspection, measurement and assessment in accordance with this annex.

The schedule, i.e. periodicity, of the inspection and measurement procedure should reflect the periodicity of other electrical inspections but should also consider the climatic and physical environmental conditions and the rate of installation of electrical equipment accommodated by the building or structure.

A.2.2 Implementation

A.2.2.1 Protective bonding network

All connections to the busbar in each area of equipment concentration shall be visually inspected for an adequate mechanical connection and for possible corrosion.

Current clamp measurement shall be undertaken on the bonding conductor(s) connecting the busbar to the protective bonding network.

A.2.2.2 Dedicated bonding network

All connections to PBB, SBB and their connection to the MET shall be visually inspected for adequate mechanical connection and for possible corrosion.

A current clamp measurement shall be carried out on the relevant bonding conductor connected to each individual PBB, SBB and their connection to the MET.

A.2.2.3 Assessment of results

The measured results for each location shall be recorded and compared over time in order to identify possible disconnects or high d.c. resistance connections. The causes of changes that are considered to be significant in comparable results shall be investigated. A non-exhaustive list of possible causes is included in A.3.

A.3 Causes of performance deterioration

A.3.1 Galvanic corrosion

When surfaces of metals with different electro-chemical properties are connected together there will be a galvanic potential between these surfaces. The rate of corrosion depends on this electro-chemical potential between the two metals and the conditions under which contact is made. It is also necessary to take into consideration the humidity and other environmental parameters in the vicinity of the connection.

A.3.2 Requirements

EN 60950-1 contains a table that states the electro-chemical potentials for a variety of metals. Electro-chemical potentials of 300 mV (maximum) maintain a low galvanic effect in a moderately corrosive environment. However, lower potential differences are recommended in order ensure a low impedance contact and a reliable electrical contact.

When interconnecting metal conductors, electro-chemically compatible metals shall be used to minimize corrosion effects that may otherwise increase the impedance of the connection above its design value. To minimize dissimilar metal corrosion, the following preventive measures shall be used:

a) select metals which form a compatible couple (e.g. use nickel, not naval brass, in contact with silver);

b) interpose a metal which reduces the potential difference between the two metals (e.g. tin plate brass to be used next to aluminium or use a tin or cadmium plated washer between a steel screw in contact with aluminium);

c) design the metal contact such that the relative area of the cathodic (more noble) metal is smaller than that of the anodic metal (e.g. stainless steel screws in aluminium chassis);

d) apply corrosion inhibitor such as zinc chromate primer or paste (e.g. use zinc chromate inhibitor when assembling steel screws in aluminium).

When filters are used, care shall be paid to corrosion problems. The metallic filter cases shall have a non-corroding surface in order to ensure a low contact resistance (approximately 100 µΩ) of the case to the interface with the victim apparatus throughout an extensive period of time.

The information technology cable termination on insulation transformers, surge protective devices or systems shall be protected from corrosion, particularly if installed outside of a controlled environment. Corroded contacts or cable termination affect the installed protection arrangements and increase the impedance of the mechanical joint/connection to the building earthing arrangements.

Protection of any contact surfaces within any protection device installed in an outside environment shall be ensured.

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