11

WHITE PAPER

Bonding, grounding and earthing in a data centre

By Niek van der Pas

Summary

Earthing and bonding can be quite a complex subject. The usage of earthing is extensively prescribed in standards. Going through all these standards is very time-consuming and may be confusing. That is why Minkels decided to publish a clear white paper on this topic.

This white paper explains how to connect to the Earth (earthing) and how to connect conductors (bonding) together in a data centre. White paper 11:

• guides you through the different standards
• explains which standards to use
• explains what is the best earthing system for data centres
• explains how to handle cabinets, racks and containment

The white paper also clarifies how the mandatory usage of earthing (for safety) can seamlessly be integrated with the functional aspects of earthing – in creating an optimal environment for high speed data exchange.

The last part of the white paper offers you an overview of the colours and graphical symbols used in ISO and IEC Standards. The white paper is concluded with some hands-on best practices.

CONTENTS

Introduction

This white paper explains how to use earthing and bonding in a data centre. The usage of earthing is extensively prescribed in standards. This WP guides you through the different standards and explains which ones to use. It explains about the best earthing system for data centres and what to do for cabinets racks and containment. It clarifies how the mandatory usage of earthing for safety can seamlessly be integrated with the functional aspects of earthing in creating an optimal environment for high speed data exchange. And it is finalised with the symbols which are applicable and what colours are used for conductors.

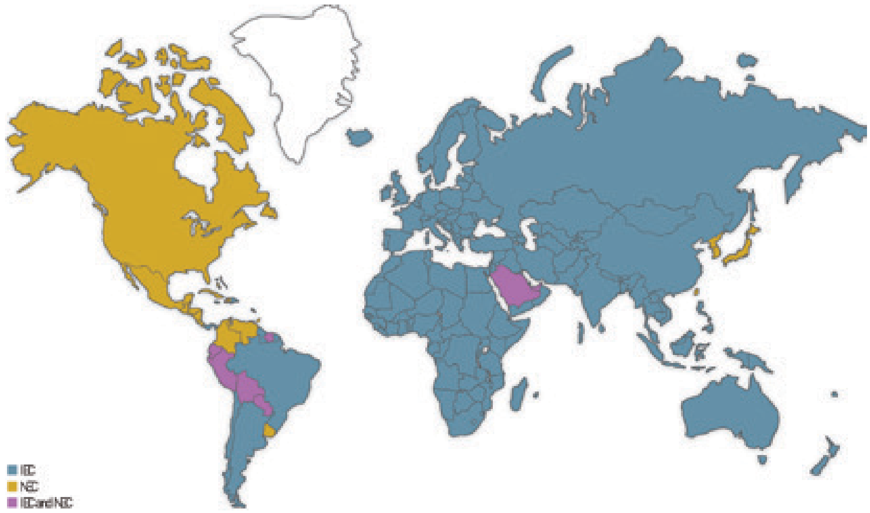
BONDING, GROUNDING AND EARTHING

In publications on the subject of this WP the terms bonding, grounding and earthing are commonly used and it is seems sometimes hard to distinguish the differences. The term *grounding* is mainly used in the American English and has the same meaning as *earthing* which is mainly used in other English-speaking countries. Earthing means connecting to the Earth. In electrical terminology a conductor is connected to the earth potential. Bonding is connecting conductors together. In the context of this paper and in referred standards, *bonding* is always related to connecting to the earth. The bonding of conductors is done to get an equipotential reference to the earth. Depending on the function of the earthing system the conductors must have certain properties.

The references in this white paper can be found on page 16

Why bonding, grounding and earthing?

It's a proven way to create safe and functional environment.



In the early days of energy distribution, the voltages were low, and the risks of personnel exposure limited. During the beginning of the 20th century the electrical industry matured, the voltages increased, and all kinds of protection measures were taken to prevent both human casualties and prevent fires. In the US the national electrical code (NEC) (NFPA, 2017) is published by the National Fire Protection Association (NFPA) which indicates the importance of fire protection by the regulation of the use of electrical systems. Earthing soon became a way to protect electrical installations. In the second half of the 20th century the International Electrotechnical Committee (IEC) standardised different earthing systems and created common terminology. International installation rules were established and put to paper in the IEC 60364 (IEC, 2005) series. The EU adopted these standards and harmonised them to the HD 60364 series. Although national varieties of the interpretation of the HD 60364 series in Europe still exist the principals behind the series are not in doubt and very uniform. The three earthing systems for electrical installations of the IEC 60364 are TN, TT and IT. In data centre systems one of the variants of the TN system, the TN-S variant, is most common and best fitted for its purpose. In some cases, an IT system can be preferred but it is critical to understand all the aspects of this system and have the correct monitoring systems to create and operate a safe and sound system. One of these cases could be in medical environments such as operating theatres in hospitals, but this is outside the scope of this white paper.

In this paper we presume that a TN-S system is used to supply the data centre. TN-S stands for Terra, Neutral and Separated. A point in the power supply, generally the transformer neutral, is earthed. The exposed conductive parts of the installation are connected to the same point by a protective conductor PE and are separate from the Neutral. This earthing setup is most frequently used and provides a good starting point for a well-designed earthing system. In a three phase TN-S system, five conductors are provided, the three phases L1, L2, L3 the neutral N and the protective earth PE conductor. The primary electrical power distribution units are connected to the Main Earthing Terminal (MET). This MET is an essential part in a good earthing design. The primary goal of earthing in electrical installation design is to protect people and livestock against an unsafe environment, but protection against power supply interruption a secondary target.

Main Earthing Terminal in a switchgear assembly

Furthermore, earthing is an essential part of a lightning-resilient design. The demands regarding earthing and lightning in a data centre are easy to combine as they are based on the same principals.

The data networks based on structured cabling installation practices also require a coherent and well-planned setup. These are the main subject of this paper.

STANDARDS

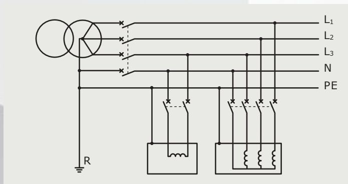
Reviewing the various existing standards is a good way to understand the different needs for earthing in a data centre. Standards can be seen as an accumulation of rules and best practices in their different fields of application. However, this is also the starting point for a lot of confusion. For this reason, it is very useful to understand the source of a certain rule or best practice. Take the connection of a 19" cabinet door to the cabinet frame using a yellow/green cable. What is the reason for these connection choices? Is it safety? Is it functionality, to have good data connections? Is it to avoid equipment damage due to Electrostatic Discharge? Is it to create a faraday cage-effect within the cabinet?

These are the questions that will be described here to give reference to the chosen solutions.

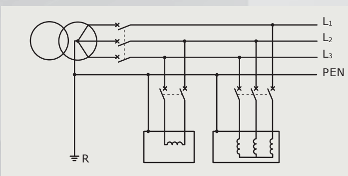
The standards describing earthing have their origin in various fields.

IEC 60364 Low-voltage electrical installations

This standard is the basis for most of the installation rules in the world. In Europe it is mandatory in the form of national implementations of the HD 60364, in France the NF C 15-100, in the UK the BS 7671, in Germany the DIN-VDE 0100, In Belgium the AREI/RGIE and in the Netherlands the NEN 1010.



TN-S



TN-C

The way earthing is arranged in installations as described in this standard depends on the type of system earthing. As the cost of the conductor (and mostly its copper components) is often a very important factor in the choice of a type of system earthing, systems with combined functions for neutral, phase or the earth as earthing conductor are the most common choice. There is also a lot legacy in the choice of earthing systems which has to do with things like differences in soil/underground conditions and common practices in different countries. If the protective earthing system of the electrical installation of a data centre is used in conjunction with the data network bonding then the earthing system shall be a TN-S system . In this system the neutral is separate from the protective earth and if the protective earthing system is integrated with the earthing of the data network then the neutral currents won't be influential as they can be in for example a TN-C system . In a TN-C (Terra Neutral Combined) system the Protective Earth conductor is combined with the Neutral conductor forming a PEN conductor. If the load in a three-phase system is not evenly distributed over the different phases this will result in asymmetrical load. If a distributing busbar is part of this system with a combined earth and neutral, the resulting neutral current can cause trouble in the earthing system. If this earthing system is combined with the data network earthing system, unpredicted behaviour can be the result. The earth conductor is the return path in an electrical system in case of an earth fault in an attached appliance. If due to an isolation fault, a conductive part becomes connected to the earthing system and is energised, a short circuit current will be initiated. If this short circuit current is high enough the protective device will switch off the supply and the earthing system performed its function correctly. The earthing system provided a return path, so the circuit breaker or fuse went off and the dangerous citation was mitigated, all as intended. But the short circuit and the operation of the protective devices will also result in a fast change of the current in the supply and return earth path and will result in an induced electromagnetic field. The short circuit behaviour in the earth path has our special interest. It is best to isolate this path as much as possible from the data carrying devices and paths. This will avoid high potential differences in the data channel.

Protective earthing must always follow local installation rules but bear in mind that a lot of choices can be made in designing this system. In a data centres, simply complying with the local standard and implementing the most cost-effective design is not the best way of designing the earthing system. IEC 60364-1 (IEC, 2005) clause 312.2 Types of system earthing gives an overview of the different earthing systems.

60364-4-41 (IEC, 2017-2018) Protection for safety

Protection against electric shock, gives extensive requirements for the properties of the earthing system to create a protective system. In Clause 411.3.1 Protective earthing and protective equipotential bonding the general earthing and bonding requirements for the installation are defined, in Clause 411.4 this is further elaborated for TN systems. Maximum circuit impedance is one of the properties dealt with.

IEC 60364-5-54 Earthing arrangements and protective conductors

IEC 60364-5-54 Earthing arrangements and protective conductors gives extensive requirements for the conductors used in the earthing system, shows how to arrange the system, and explains about earth electrodes as well as elaborating on the main earthing terminal and on minimum cross-sectional areas of protective conductors.

The Legrand Power guide series can give useful support in dimensioning the earthing system to fulfil the installation rules. Book 03 Electrical energy supply and Book 04 Sizing conductors and selecting protection devices can be of great help but 'do keep in mind that these resources should be used together with the other standards.

IEC 61439 Low-voltage Switchgear and controlgear assemblies

The IEC 61439 series of standards are applicable to, as the title denotes, switchgear assemblies. This implies that for a data centre only 19" cabinets which are used for the distribution of power with internal copper busbars etc. are within the scope. But it is not for a 19" cabinet with a rack PDU with an earthed power cord that houses IT equipment.

In the IEC 61439-1 (IEC, 2011) "General rules" earthing is covered and Clause 8.4.3.2.2 states that If apparatus with a voltage exceeding the limits of extra-low voltage are attached to lids, doors, or cover plates additional measures shall be taken to ensure earth continuity. So above ELV (50 V AC or 120 V DC see: IEC 61140 (IEC, 2016)) earthing might be necessarily and can be done either by conductivity in designed components like hinges or with an attached protective conductor, see Table 3. When a 10 mm2 green/yellow conductor is used the maximum current demand is met and all the applications can be used. If structural elements of the cabinet like the frame are used for providing the fault current path, then these elements have to be rated for the occurring maximum fault current.

QUOTE FROM IEC 61439-1

Clause 4.8 8.4.3.2.2

If apparatus with a voltage exceeding the limits of extra-low voltage are attached to lids, doors, or cover plates additional measures shall be taken to ensure earth continuity. These parts shall be fitted with a protective conductor (PE) whose cross-sectional area is in accordance with Table 3 depending on the highest rated operational current I_e of the apparatus attached or, if the rated operational current of the attached apparatus is less than or equal to 16 A, an equivalent electrical connection especially designed and verified for this purpose (sliding contact, hinges protected against corrosion).

Exposed conductive parts of a device that cannot be connected to the protective circuit by the fixing means of the device shall be connected to the protective circuit of the assembly by a conductor whose cross-sectional area is chosen according to table 3.

Certain exposed conductive parts of an assembly that do not constitute a danger
- either because they cannot be touched on large surfaces or grasped with the hand
- or because they are of small size (approximately 50 mm by 50 mm) or so located as to exclude any contact with live parts.

need no be connected to a protective conductor. This applies to screws, rivets and nameplates. It also applies to electromagnets of contactors or relay, magnetic cores of transformers, certain parts of releases, or similar, irrespective of their size.

When removable parts are equipped with a metal supporting surface, these surfaces shall be considered sufficient for ensuring earth continuity of protective circuits provided that the pressure exerted on them is sufficiently high.

QUOTE FROM IEC 61439-1 TABLE 3

Table 3 – Cross-sectional area of a copper protective conductor (8.4.3.2.2)

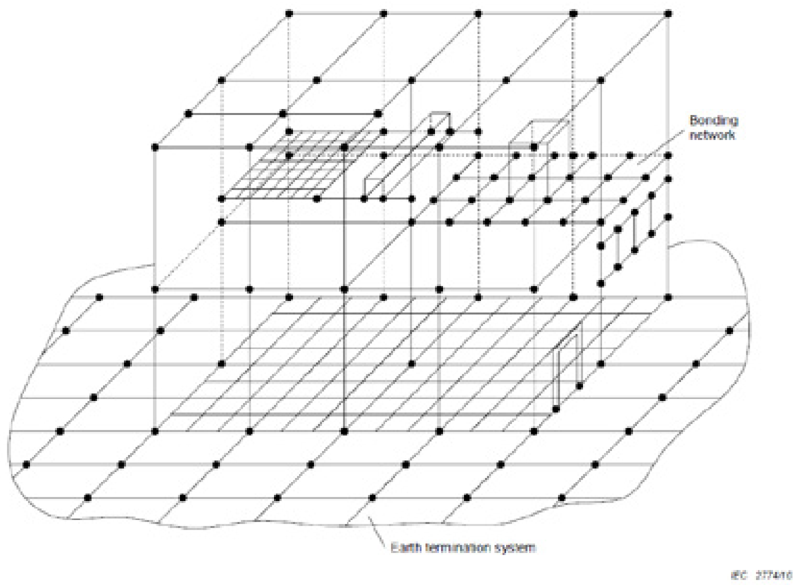
Rated operational current I_e A	Minimum cross-sectional area of a protective conductor mm²
$I_e \leq 20$	S^a
$20 < I_e \leq 25$	2,5
$25 < I_e \leq 32$	4
$32 < I_e \leq 63$	6
$63 < I_e$	10

[a] S is the cross-sectional area of the phase conductor (mm²).

IEC 62305 and EN 62305 Protection against lightning

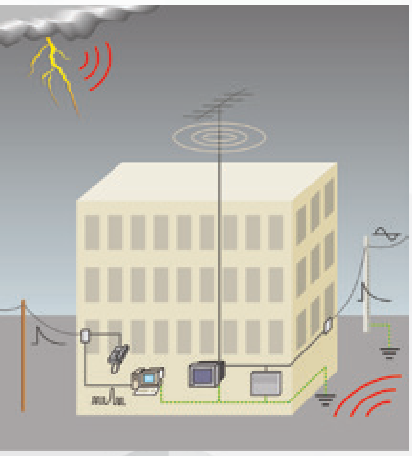
These two standards series are identical and are effectively used in many countries but might have a different numbering/naming in a particular country. In Germany part one of the standard is known as the VDE 0185-305-1 (VDE, 2011), and in France as the C17-100-1PR (AFNOR , 2017) but in the UK and the Netherlands as in many other countries the IEC numbering is used. Although part 1 *General principals* (IEC, 2012) and part 2 *Risk management* (IEC, 2010) are essential for a good analysis, part 4 *Electrical and electronic systems within structures* is of most interest in relation to data centres. In Clause 5 the earthing and bonding system is discussed and the requirements for a suitable design are laid out (see figure 5). However, in order to come to a complete overview, part 3 *Physical damage to structures and life hazard* (IEC, 2010) must also be taken into account.. A type B earthing arrangement with a ring structure or equivalent is recommended.

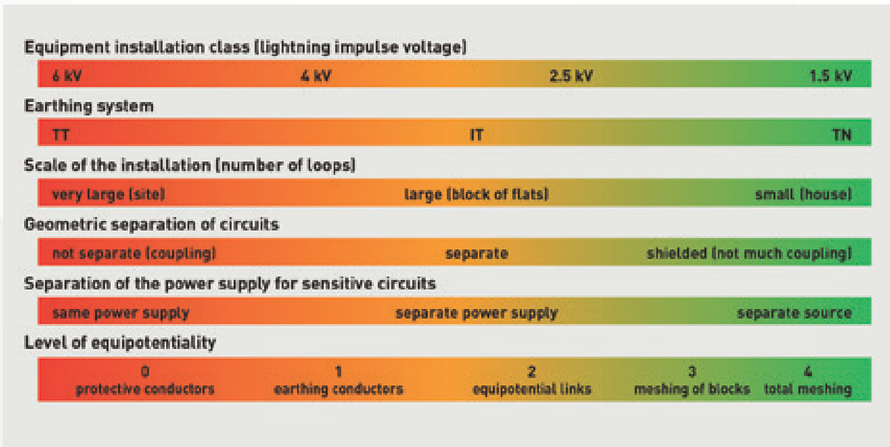
QUOTE FROM IEC 62305-3 2010



NOTE All drawn conductors are either bonded structural metal elements or bonding conductors. Some of them may also serve to intercept, conduct and disperse the lightning current into the earth.

Figure 5 – Example of a three-dimensional earthing system consisting of the bonding network interconnected with the earth-termination system





Protection against the effects of lightning: structure and setup of the installation according IEC 62305-4. See Legrand Power Guide Book 07
Protection against lightning effects (Legrand, 2009) for background reading.

EN 50310 (Cenelec, 2016) and ISO/IEC 30129 (ISO/IEC, 2015) Telecommunications bonding networks for buildings and other structures

These two standards are almost identical and are the latest reflection on how proceed in a data centre. They are respectively part of the EN 50600/50173/50174 and the ISO/IEC 11801 series. The standard are also in line with the ITU-T K.27 *Bonding configurations and earthing inside a telecommunication building and the ANSI/TIA-607-B Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises* (ANSI/TIA, 2011).

It is an absolute must to take either one of these two EN, ISO/IEC) standards into account during the design process of any earthing network in a data centre.. The standard starts with the selection of the telecommunications bonding network approach and continues with the assessment of the impact of the telecommunications bonding network on the interconnection of telecommunications equipment. For selecting the best earthing network, a zoning concept for the data centre is provided.

QUOTE FROM EN 50310 (Cenelec, 2016) and ISO/IEC 30129 (ISO/IEC, 2015)

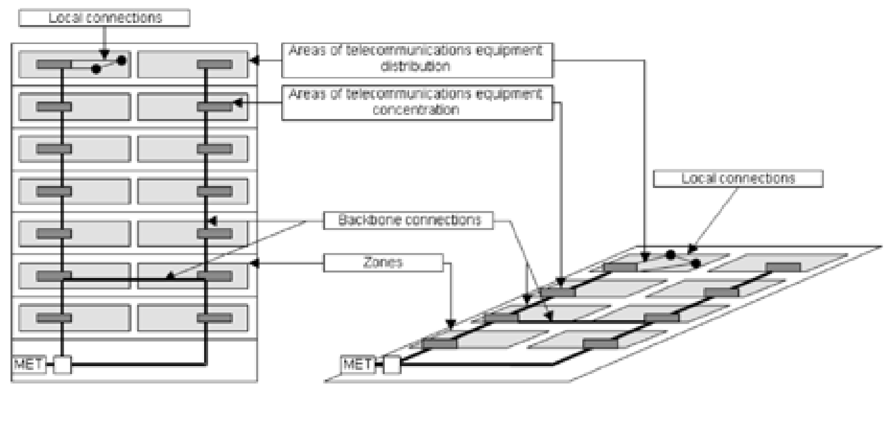


Figure 2 – Schematic of telecommunications equipment distribution

The appropriate choice depends on the type of network applied in the data centre. In the paragraph on data centres the selection process is further discussed.

EN 50600 and ISO/IEC 22237 Information technology - Data centre facilities and infrastructures

This standard is becoming the most important European and Global standard for data centres. Availability is a core design parameter within this standard. In Annex A of Part 1 General concepts, it is explained that the implementation of the meshed bonding concept as dealt with in EN 50310(ISO/IEC 30129), the EN 50174-2 and the IEC 62305 is crucial in order to minimise Electromagnetic interference as part of the EMC conceptual design.

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

Sensitivity of cabling media to bonding network performance

DATA CENTRES

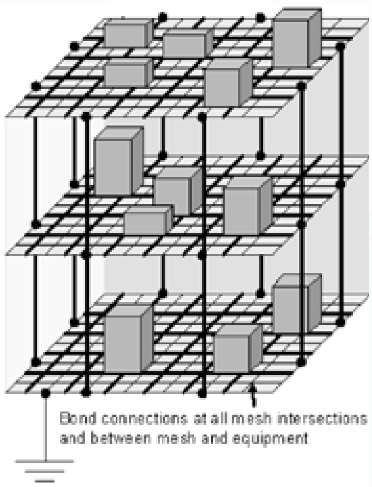
As mentioned before, the EN 50310 and ISO/IEC 30129 are our main guidelines in selecting the appropriate earthing network. The main denominator as presented in Table 2 is the cabling medium used. If all the data communication within the data centre would be provided solely by an optical fibre network the earthing demands would only be governed by the protective network but as this is hardly ever the case, we have to follow the principles set out in this standard to create a reliable and predictive network. Through an understanding the governing physical principals, the right choices can be made. If the copper network transports low frequencies and uses symmetric balanced unscreened cabling, the bonding network has a limited effect on the performance of the connection channel. As the frequencies on structured cabling went up from 100 MHz for Category 5 to the current 2000 MHz for Category 8 cabling, the requirements for shielding also went up. If you are now designing a structured cabling network for 10 and 40 GBit/s it is only possible to use shielded cable. This cable has to be bonded and earthed and if you follow the methods of the above-mentioned standards a meshed network shall be used.

Generally, three types of mesh bonded networks are distinguished:

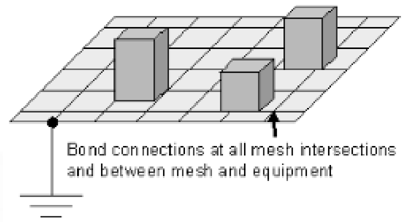
a) MESH Bonding network (MESH-BN) - The Generic bonding network with a fine maze of bonding conductors,

b) MESH-IBN MESH Isolated Bonding Network - Only the single point of bonding of the mesh is connected with the protective bonding,

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

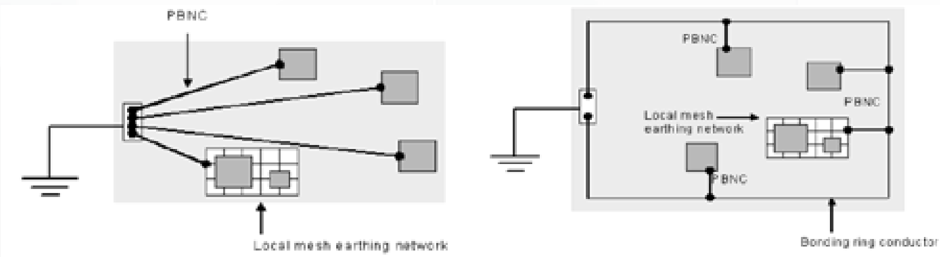


ure 18 – A MESH-BN with equipment cabinets, fr racks and CBN bonded together



7 – A MESH-IBN having a single point of connectic

QUOTES FROM EN 50310 (Cenelec, 2016) and ISO/IEC 30129 (ISO/IEC, 2015)



a) MESH-IBN via a star protective bonding network

b) MESH-IBN via a ring protective bonding network

Figure 16 – Local mesh bonding network

In the end, it is important to understand that all the earthing networks are connected together. The protective earthing system, the telecommunications Mesh bonding network and the lightning equipotential bonding system are all connected.

Coordinating the design of these different earthing systems is crucial to achieve a well-preforming and cost-effective result.

When a microdata centre like the EMDC is deployed, all the different considerations can easily be included in the design.

In every EMDC (ENGIE Mobile Data Center – powered by Legrand) you will find as a minimum all the basic components that are needed for your data centre applications:

- An integrated design
- Protective and completely insulated enclosure
- Cooling installation specifically designed to cool your precious IT equipment
- High-end racks perfectly fit to build in all your equipment
- Redundant power supply in the equipment-racks, including a UPS system

CABINETS

One of the standards not yet mentioned is the IEC 60950-1 Information Technology Equipment – Safety – General Requirements or the equivalent EN 60950-1 (IEC, 2013) and CSA/UL 60950. This is because it is actually not applicable for data centre infrastructure components such as cabinets if they are used as general purpose 19" server or network cabinets. The standard is often referred to in specification of 19" cabinets but as an empty cabinet does not contain equipment it cannot be compliant. The scope explicitly states:

QUOTE FROM IEC 60950-1

> 1.1.3 exclusions – devices requiring no electric power.

If a cabinet is an integral part of a designated "Information Technology Equipment" it could be as a whole assessed according the 60950-1. In most cases the equipment placed inside the 19" cabinets are designed according the 60950-1 but this cannot be done for a general-purpose cabinet.

The 19" cabinet does need earthing facilities but this is mainly managed by the EN 50310 and ISO/IEC 30129. This standard requires in 7.4.2 Telecommunications bonding network connections:

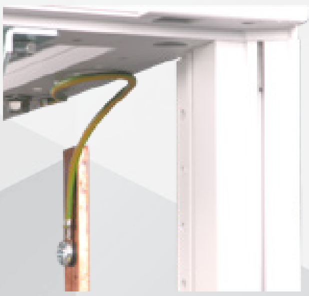
QUOTE FROM EN 50310 and ISO/IEC 30129

> "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 electrochemical potential of ≤ 300 mV (with reference to EN 60950-1). See A.3.1 for additional requirements and information."

QUOTE FROM EN 50310 and ISO/IEC 30129

And According 7.5 Cabinets, frames and racks:

> Each cabinet, frame and rack shall have a connection point to which the rack bonding conductor (RBC) can be terminated.
>
> ....
>
> 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 mm2 for a cabinet, frame or rack of ≤ 21 U,
>
> b) of minimum cross-sectional area of 16 mm2 (see Table 6) for a cabinet, frame or rack of > 21 U.



Earth rail (RBC)
MER0106 / MER0107

The standard requires the bonding of all installed equipment containing metallic parts to the telecommunications bonding network according the manufacturer's instructions with unit bonding conductors with a minimum cross-sectional area of 4 mm^2

QUOTE FROM EN 50310 and ISO/IEC 30129

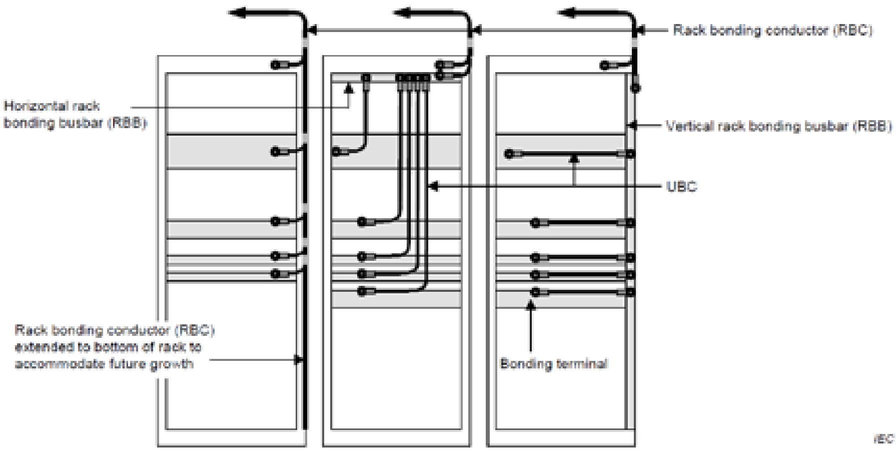


Figure 3 – Example of three methods of equipment and rack bonding

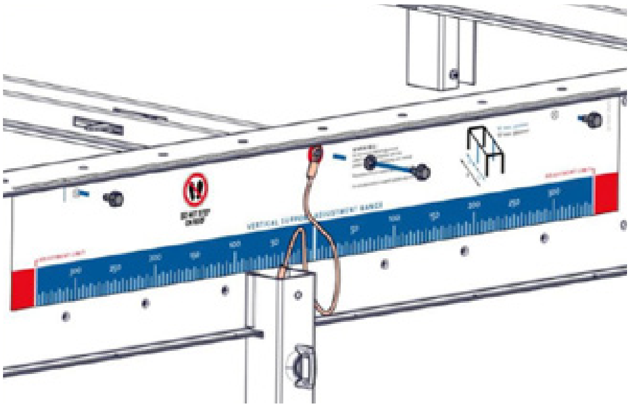
According to the standard, the same must be done for doors and panels. The conductors shall be easily visible and quick connect to facilitate their detachment and reattachment. The aluminium frames as used in the Minkels cabinets are welded and partly bolted together. These bolted connections are conductive and comply with the requirements of this standard. If the cabinet is not factory assembled but build up from i.e. a flatpack delivery, the components shall be assembled according to the instructions. It is very important in particular for the requested torque levels to be applied.

COLOUR CODING OF THE EARTH CONDUCTOR IN A 19" CABINET

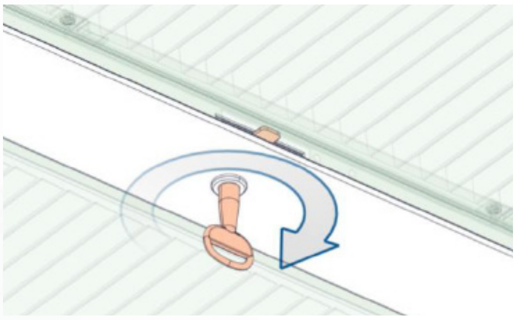
The bonding conductor in 19" cabinets are very often yellow/green coloured. As this colour is intended for the use as a protective conductor this might give confusion. If yellow/green is used, the installer responsible for the placing of equipment inside the cabinet should verify the current carrying demands for the installed equipment and assure that the requirements are met as demanded by the installation rules or i.e. the IEC 61439 if the cabinet is used as a *"Power switchgear and controlgear assemblies"*. If this is not the case, it might be better to use transparent or no insulation on the cables.

CONTAINMENT

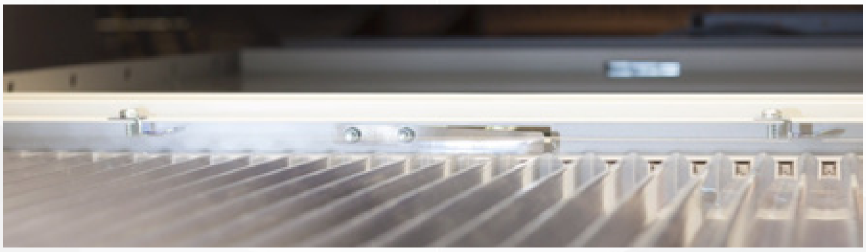
As previously explained, the best performing data centre will be one with a Mesh bonding network. Therefore, it is best to connect all larger metallic parts within the data centre with the bonding network. All the conductive components of the containment systems of Minkels provide provisions to incorporate them in such a network. On this pages two examples are shown The adjustable metal supporting poles of the freestanding corridor are attached with a cable for earthing and the drop-away panels have provisions for bonding.



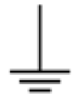
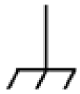
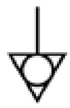
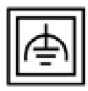
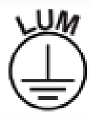
Free Standing Corridor support post



Bonding of drop away panels



CABLE COLOURS AND GRAPHICAL SYMBOLS USED IN ISO AND IEC STANDARDS

Standard	Title	Description	
IEC 60417-5017	Earth; ground	To identify an earth (ground) terminal in cases where neither the symbol 5018 nor 5019 is explicitly required.	
IEC 60417-5018	Functional earthing; functional grounding (US)	To identify a functional earthing (grounding) terminal, for example, of a specially designed earthing (grounding) system to avoid causing malfunction of the equipment.	
IEC 60417-5019	Protective earth; protective ground	To identify any terminal which is intended for connection to an external conductor for protection against electric shock in case of a fault, or the terminal of a protective earth (ground) electrode.	
IEC 60417-5020	Frame or chassis	To identify the frame or chassis terminal	
IEC 60417-5021	Equipotentiality	To identify the terminals which, when connected together, bring the various parts of an equipment or of a system to the same potential, not necessarily being the earth (ground) potential, e.g. for local bonding.	
IEC 60417-6092	Class II equipment with functional earthing; Class II equipment with functional grounding (US)	To identify class II equipment with functional earthing (grounding).	
IEC 60417-6173	Connection, protective conductor (PE)	[To provide instruction that the protective conductor (PE) should be connected first to main protective earthing terminal before connecting the line and neutral to avoid shock hazard, and that a PE connection to the main PE terminal is essential before connecting the mains to avoid electric shock. In the application of this symbol, IEC 60417-6042 and IEC 60417-5019 shall be used in conjunction with this symbol.]	
IEC 60417-6296	LUM connection; luminaire connection	To identify the terminal for earth connection with luminaire light source terminal block and to provide information for preventing connection with other electrical equipment.	
ISO 7010-M005	Connect an earth terminal to the ground	To signify that an earth terminal must be connected. Remark: Mandatory action	

QUOTE FROM IEC 60445 Edition 6.0 2017

Table A.1 – Colours, alphanumeric notations and graphical symbols used for identification of conductors and terminals

Designated conductors/terminals		Identification of conductors / terminals by			
		Alphanumeric notations [a]		Colours	Graphical symbols [b]
		Conductors	Terminals		
AC conductors		AC	AC	-	
	Line 1	L1	U	BK [d] or	~
	Line 2	L2 [c]	V	BR [d] or	
	Line 3	L3 [c]	W	GR [d]	
	Mid-point conductor	M	M	BU [e]	No recommendation
	Neutral conductor	N	N		
DC conductors		DC	DC	-	⎓
	Positive	L+	+	RD	+
	Negative	L-	-	WH	–
	Mid-point conductor	M	M	BU [e]	No recommendation
	Neutral conductor	N	N		
Protective conductor		PE	PE	GNYE	⏚
	PEN conductor	PEN	PEN	GNYE [f] BU [f]	No recommendation
	PEL conductor	PEL	PEL		
	PEM conductor	PEM	PEM		
Protective bonding conductor [g]		PB	PB	GNYE	⏚
	– earthed	PBE	PBE		No recommendation
	– unearthed	PBU	PBU		
Functional earthing conductor [h]		FE	FE	PK	⏚
Functional bonding conductor		FB	FB	No recommendation	⏚

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g A protective bonding conductor will in most cases be a protective bonding conductor earthed. It is not necessary to designate it with PBE. In those cases where a distinction between a protective bonding conductor earthed and a protective bonding conductor unearthed is used, a clear distinction between them shall be made (for example, within electro-medical installations) and the designations PBE and PBU should be applied.

h Neither the designation FE nor the graphical symbol 5018 of IEC 60417 shall be applied for conductors or terminals having a protective function. Bi-colour insulation GREEN-AND-YELLOW cannot be used for conductors that do not have a protective function (i.e. for conductors other than PE, PEN, PEL, PEM, PB, PBE, PBU). See Clause 5.

Conclusion / best practices

- Use the EN 50310 or ISO/IEC 30129 as your starting point to gain an understanding of earthing in a data centre .

- Coordinate the demands for earthing and bonding with the three main specialists on installation rules, lightning protection and network design.

- Understand that creating a reliable highly available data centre without downtime is well achievable when applying the requirements of the cited standards.

- Note that surge protective devices, as well as different active monitoring systems can support earthing systems. While outside of the scope of the current white paper, these devices are a useful addition to the topic here discussed and will be/may be elaborated on in the future/in a future white paper.

About the White paper author

The author of this white paper - Niek van der Pas - contributed to the EU Code of Conduct, a Europe-wide best practices directive for energy-efficient data centre development. He is also active in ISO/IEC JTC 1/SC39 'Sustainability for and by Information Technology', where the new standard for Power Usage Effectiveness (PUE) has been established. As a representative of the NEN - the Dutch standardisation institute - the European Standard for Data Centres (EN 50600) has its full attention. Van der Pas is also chairman of the Dutch Standard Committee NEN 381039 'Computer Rooms and Data Centres' and represents NEN in IEC TC 48D where standards for 19" cabinets and containments are developed.

CONTACT US

For questions, feedback and comments about the content of this white paper, don't hesitate to contact us:

T. +31 (0)413 311 100
E. info@minkels.com

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CONTACT US

For feedback and comments about the content of this white paper:
T. +31 (0)413 311 100
E. info@minkels.com

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