



Annex E:

Requirements to be met by installation

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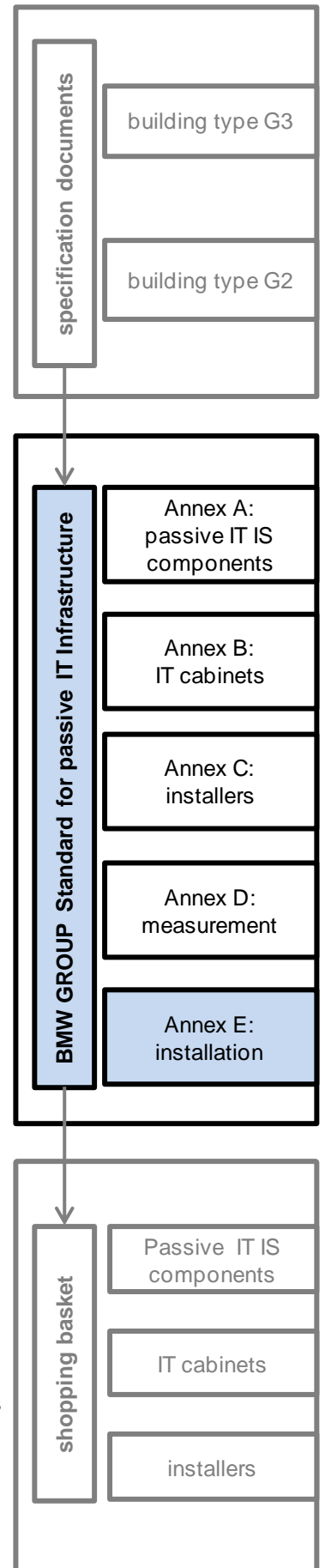




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1 Basic requirements

The installation must be implemented in conformity with DIN EN 50174-1 and DIN EN 50174-2 as amended. Furthermore, in particular the following requirements have to be taken into account in installation:

1.1 General remarks

- If smoke, dust and heat develop in areas that are equipped with sprinkler systems, fire and smoke detectors, the safety measures required must be coordinated by the contractor with the plant fire brigade or the competent authority.
- All work areas must be left in a clean condition after completion of the daily installation work.
- All installation materials must be checked for damage caused during transport and for completeness prior to assembly.
- Dust protection walls or covering must be used during assembly in office environments and in particular in manufacturing facilities.
- If it is not clear where to fit/install the installation material, the mechanics must contact the contract awarder or the technical planner in charge.
- The instructions for installation and processing provided by the manufacturers of the devices, products and materials must be strictly observed.
- Any packaging/safety guards removed for the purposes of visual inspection or measurement-based tests must be replaced in order to restore the requisite protection against environmental impact and the physical damage of components.
- If protective caps or similar items are used for the protection of components, these must only be removed if required and must be restored without delay or, if required, must be replaced until the installation has been completed.
- The installer has to ensure that all installation tools required are available in perfect condition.

1.2 Passive IT IS components

- The installer is obliged to obtain instructions from the manufacturer as regards the IT IS components to be installed, which includes:
 - o Environmental compatibility (storage, installation, and operation)
 - o Minimum bending radius for cables and stranded elements (during installation, in operation - static - and, if relevant, in operation - dynamic)
 - o Cable tensile force
 - o Cable transverse compression strength

and must effect installation according to these specifications.

- Prior to and during the laying process, cables must be checked for
 - o visible damage to the overall sheath;
 - o missing labelling/designation

and, if required, must be excluded from installation.

- Dents on the cable sheath or on the stranded elements (for example caused by inappropriate fastening or cross-overs) must be avoided.
- Sharp bending (kinking) that may impair the transmission characteristics of the cables are not permitted.



Figure 1: Bending of cables without causing impairment

- When copper and fibre optic data cables are placed in metal pipes, the ends of said metal pipes must be provided with suitable edge guards made of plastic.
- The ends of stored cables must be sealed to protect them against the ingress of soiling and moisture.
- Cables must not be exposed to moisture values or to temperatures outside the limits specified by the manufacturer, which includes local effects such as the ones caused by fan heaters or gas burners.
- When connection components are installed in hollow walls or in furniture, use must be made of hollow wall outlets according to DIN VDE 0606 part 1 with a constructional depth of at least 54.5 mm as well as of suitable connection components and termination panels. The hollow-wall outlets used for the terminal connections to be installed must offer sufficient depth to prevent the cabling from kinking. If system-specific outlets are offered or recommended by the manufacturer of the cabling components, these must be used.
- The assembly instructions provided by the supplier for the connection of cabling to the connecting hardware must be observed.

- All RJ45 connection components are to be connected to four wire pairs (=8 wires) in each case according to assignment type **TIA/EIA-568-A**. **Cable sharing is not permitted.**

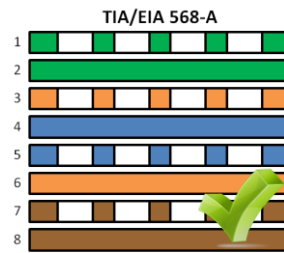


Figure 2: Type of assignment applicable to RJ45 connectivity

- When feeding outdoor cables from the outside into a property, care must be taken to ensure proper sealing against the ingress of water and moisture (for example Hauff, Raychem systems).
- The area in which the fibre-optic cables of a single production batch are installed must be documented by recording the installation pathways precisely. A combination of various production batches along a single cable route is only permissible if the various batches feature the same mechanical and optical parameter characteristics.
- When cables are installed in vertical cable routes (for example, risers), cables must be lowered into position. It is not allowed to pull up the cables within the cable chamber.
- When routing cables via cable ladders in the building backbone (cf. Figure 23), please exclusively use adequately sized angle brackets (clamps) and the matching plastic shims (fastened finger-tight) for attaching copper and fibre optic data cables to the cable clamp rails (C profiles) of the cable ladder.

Only velcro tapes may be used to bundle and to secure the copper and fibre optic data cables in position outside the cable clamp rails (C profile).

IMPORTANT NOTICE:

The use of cable ties for bundling and securing cables is prohibited!

- Cable ties used in copper patch panels, RJ45 connecting hardware, strain relief for fibre optic cables at fibre optic splice boxes are the only exception and must remain in place.
- It is not permitted to install power cords and IT cabling in one and the same installation conduit.
- All copper and fibre optic data cables are to be installed in an end-to-end fashion, i.e. in one piece and without any intermediate connectors / link splices.
- On leaving the building backbone, fibre optic data cables must be routed in adequate protective conduits, taking their permissible bending into account.
- Any lines to be dismantled must be removed without causing damage to the remaining installation and building services.
- The mechanics must allow for a cabling reserve installed in accordance with good professional practice at every laying end of the data cables:
 - o Floor box: 3.0 m
 - o Window and furniture raceway covers: 1.0 m
 - o Patch panel: 1.0 m, however, the cabling reserve must be provided along the link and **not** in the IT cabinet

It is not permitted to install excessively large cable reserves.

1.3 IT cabinets

- IT cabinets and the relevant fixtures must be connected to the meshed bonding network in accordance with the instructions laid down in chapter 3.2.
- Please use adequately sized angle brackets (clamps) and plastic shims (fastened finger-tight) for fastening copper and fibre optic data cabling to the cable clamp rails (C profiles). Alternatively, data cables may also be supported by cascading cables in several layers.
- Please make sure that this rating is complied with by means of small, flat cable entry glands (no bundling) for routing any data and power cabling.

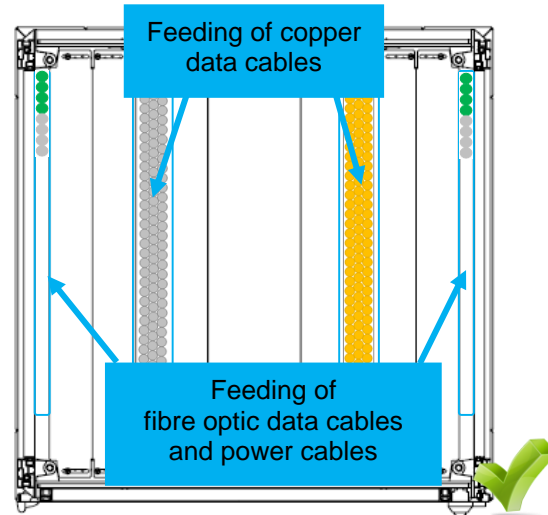


Figure 3: Feeding of data and power cables

- In addition, when feeding shielded power cables to the "IT cabinet EMC for BD room", they must be terminated at the **EMC PG gland** as follows:

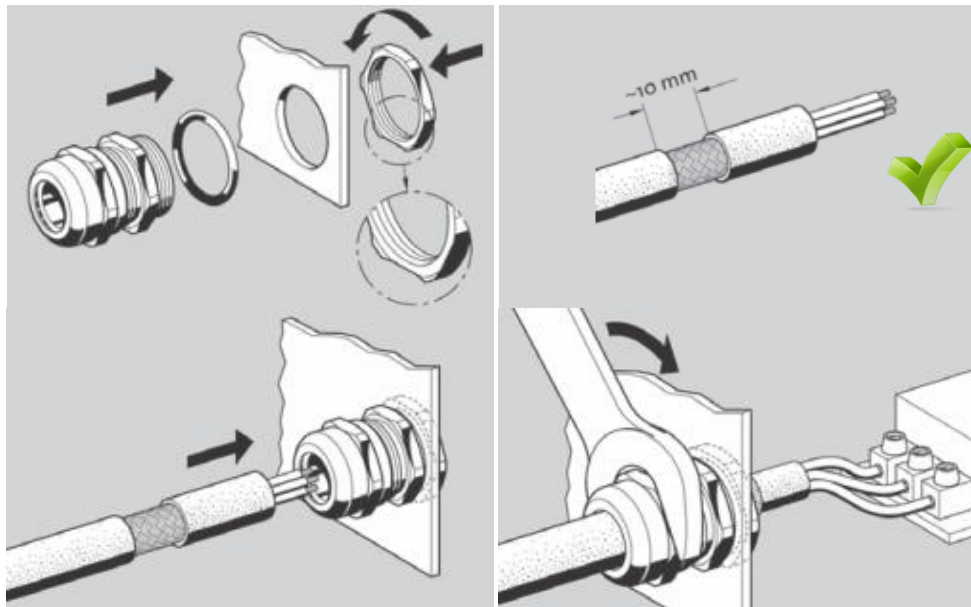


Figure 4: Assembly instructions pertaining to the EMC PG gland

- Please ideally use panel modules with integrated brush strips for cable entry both from the top and from the bottom.
- Data cabling must be protected from any increased transverse pressure loads when routed through the base of IT cabinets.
- The following picture demonstrate how to lay data cabling within IT cabinets.



Figure 5: **How to install and feed cabling from the side within an IT cabinet**

- It is essential to provide an adequately sized patch cable management system (horizontal and vertical) in the IT cabinets.
- The potentials of the patch cable management in place should be made use of for the routing of the patch cables. Patch cable management has to be well-coordinated, and the mechanical patch cable specifications laid down (for example, transverse compression strength, minimum bending radius) must not be exceeded.
- Active IT IS components must allow for fitting patch cables at both sides (right- and left-hand side).
- System carriers for mounting cable trays must be provided on IT cabinets for routing copper and fibre optic patch cables across cabinets. An adequately sized cable tray must be installed on these system carriers.
- Copper and fibre optic patch cables must be routed in separate cable trays. Adequate system elements for limiting the permissible bending radii must be installed for branches into IT cabinets.

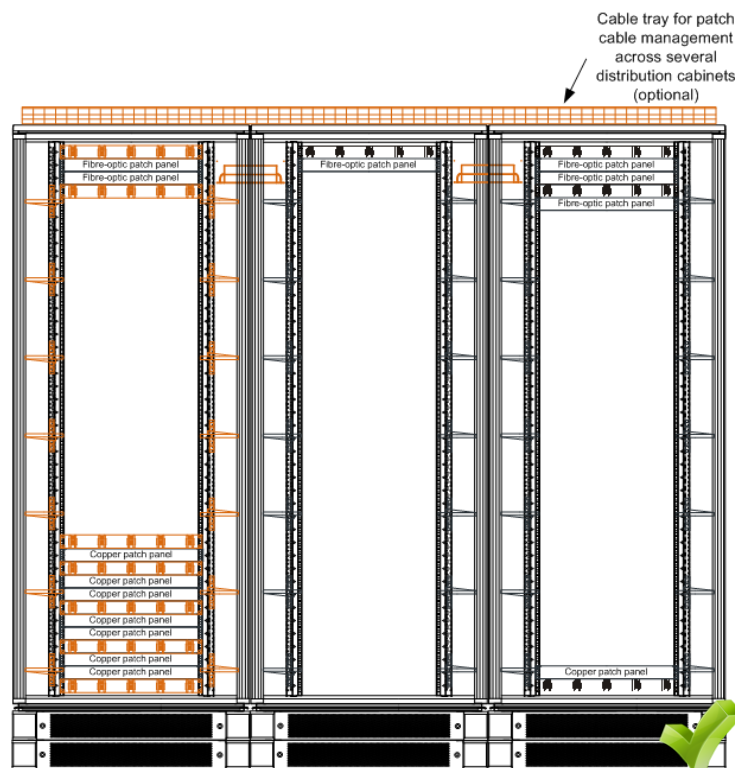


Figure 6: Coordinated patch cable management

- When an IT cabinet is positioned in the production area, the customer must clearly identify the floor area by the said area being marked with adhesive tape on the floor or with easily recognisable barriers. The floor area so marked may be changed only upon coordination with the customer.
 - IT cabinets that are installed in production environments must be equipped with an adequately sized collision guard all around.
 - IT cabinets must be cleaned carefully and handed over in a pristine condition.
 - Fibre optic patch panels must be installed in the top section of both active and passive IT cabinets.
 - Copper patch panels are fitted from the bottom upwards in IT cabinets.
 - The panels must be installed without leaving any gap but in one continuous sequence, without separating any logical areas from each other. (for example by not starting an area with a new patch panel).
 - IT cabinets that are positioned next to each other must be connected and aligned flush with alignment brackets.
 - **All IT cabinets must** be secured against tipping in particular since there is pull-out shelving and they must be suitable for accommodating heavy-duty rails to secure heavy components, such as cooling units (for example, by anchoring them to the floor properly).
- In addition, the binding instructions provided by the IT cabinet manufacturer as to how to secure IT cabinets must be taken into account:

- o In general, floors must be suitable for securing cabinets and offer sufficient carrying capacity.
- o Suitable anchoring hardware must be used depending on the quality and type of floors. (Not included in the scope of delivery)
- o All four cabinet corners must be anchored to the floor.
- o The anchoring hardware must ensure that the cabinet is positioned vertically.
- o For safety reasons, the cabinet must be anchored to the floor before the cooling unit is fitted on the cabinet.

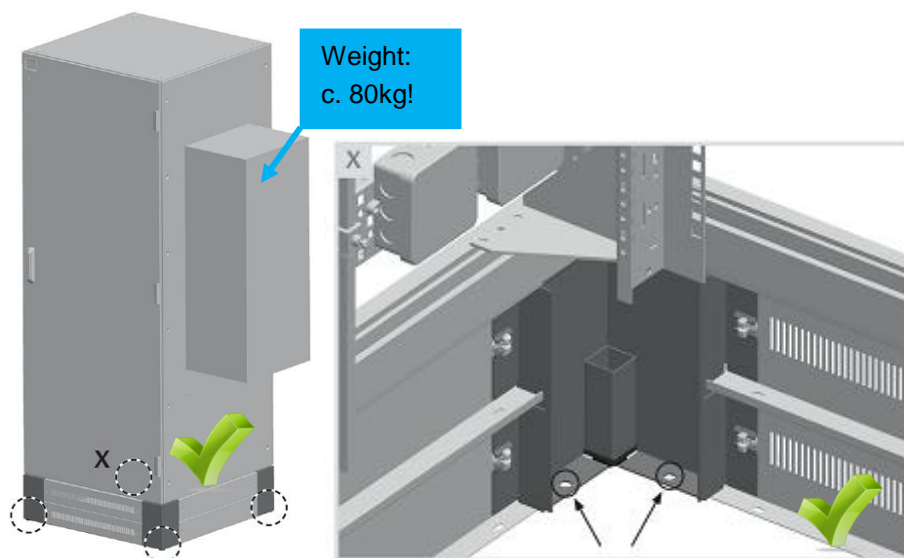


Figure 7: How to anchor IT cabinets to the floor correctly



1.4 Raised floor installation

- Raised floor installation is not required for IT IS rooms (FD - floor distributor, and BD - building distributor) but is permissible if this is necessary on account of the environment or the design of the IT IS room.
- Open areas in raised floors must be cordoned off in a clearly visible fashion (for example with traffic cones or barricade tape).
- If it is necessary to remove raised floor panels, only the requisite minimum number of panels may be removed and will have to be fitted back in place correctly immediately upon completion of the task. The stability of the raised floor must not be impaired by the process, and full personal and material protection must be ensured at all times.
- For reasons of stability, it is not permitted to open entire "strips" of raised floor panels at the same time; a maximum of three adjacent panels may be opened at any given time. Nor is it permitted to open several separate groups of raised floor panels.
- In rooms in which air-conditioning is effected through the raised floor (pressurized air floor), it is not permitted to open more than five floor panels at the same time.
- The raised floor is to be adequately protected during the installation phase. The rooms must be accessible during the process.
- The floor panels have to be ready-cut in accordance with the grid size. They must be fitted loosely so that they can easily be removed individually.
- The locations at which the fire alarm systems are installed out of sight in the false floor are to be marked with red dots (diameter of 50 - 100mm) according to the specifications of the relevant fire protection authority. Floor panels under which automatic fire alarm systems are installed are to be secured permanently by means of a chain in order to prevent the accidental exchange of panels.
- **Media lines** (such as for water, heating, waste water, energy supply, air-conditioning, BOS equipment (public-security authorities and organisations) and other plant equipment) **that are not required for the operation of ICT equipment or its components must not be routed through IT IS rooms.**
If need be, IT IS rooms and their facilities must be protected by adequate structural measures (for instance, troughs, ramps, etc.).

1.5 Floor box

- Depending on the floor box system fitted, suitable adapters must be available for floor box installation so as to ensure professional installation in compliance with any cable- and connection-specific requirements.
- The centre part for accommodating passive IT IS components must be compatible with the switch range.
- Floor boxes made of metal must be integrated in the equipotential bonding system for the purpose of protecting people.
- Passive IT IS components must be installed so as to ensure that the patch cable can be unlocked without any problems, as shown in Figure 8 (left).

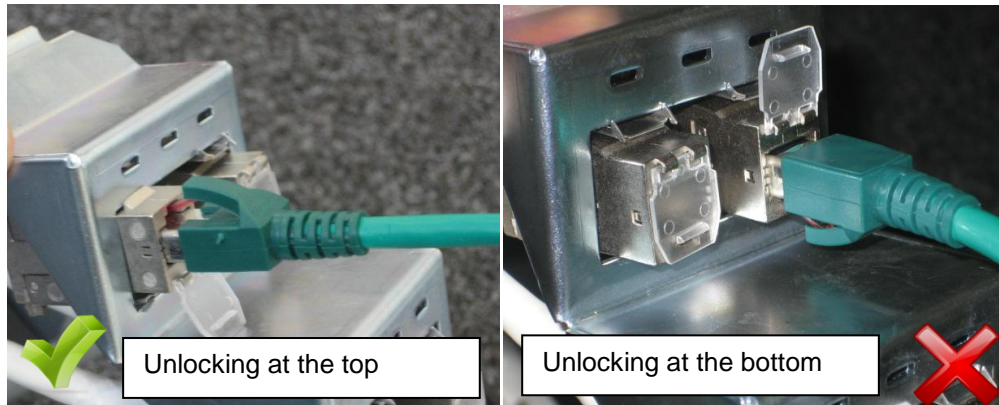


Figure 8: Arrangement of passive IT IS components in the floor box

- The height calculated for the raised floor must ensure that the data cabling in the floor box is not subjected to any unnecessary mechanical loads (reduction of bending radiuses).

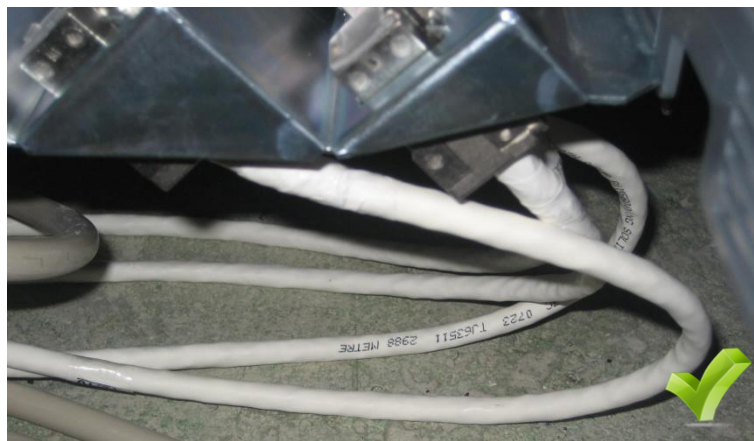


Figure 9: Arrangement with sufficient distance to the floor

2 Routing and cable management

2.1 Redundancy

Depending on the availability requirements, the breakdown of connections or the failure to set up connections within communications or energy facilities may impair operations significantly. Since the typical working environment in the meantime has also come to cover the industrial environment to an ever-increasing extent due to IP, the breakdown of connections may lead to a situation in which important data and information can no longer be exchanged. This may result in the loss of working hours and in production downtime, which may cause substantial follow-up costs. Therefore it makes sense to provide redundant cabling routes for different connections (depending on their protection requirements).

The term technical redundancy of cabling routes refers to the intentional installation of additional lines, which actually however are unnecessary for standard operations. The necessity for these extra cabling routes to be installed results from the stringent availability requirements to be met by the connected facilities, such as building distributors, network distributors, or data processing centres. Technical redundancy has to ensure the operation of these facilities even if one of the two connected routes fails or is destroyed.

Redundancy is based on the consistent avoidance of what is generally referred to as "single points of failure" (SPOF). This means that the facility is designed such as to avoid shared cabling routes, shared cable inlets at the same position within a building, shared distributor sites, etc. as far as possible. (cf. Figure 10 or Figure 11)

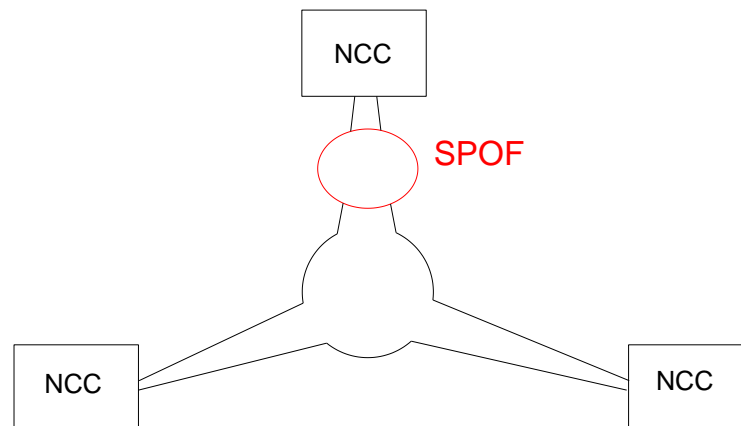


Figure 10: Avoiding shared points of entry into the building

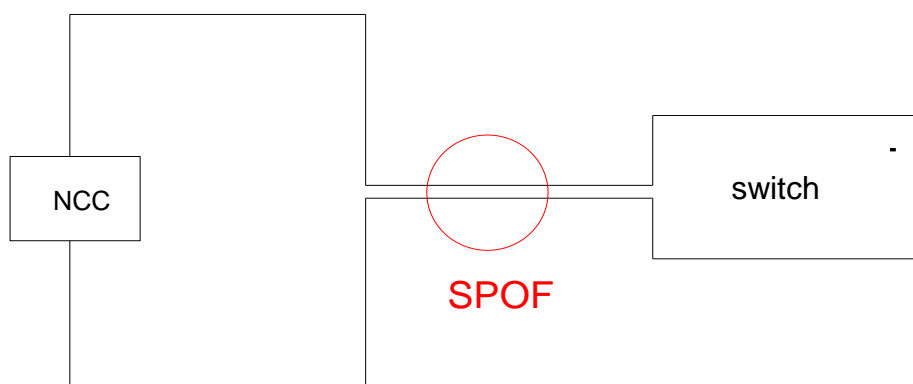


Figure 11: Avoiding parallel cable routing

Technical (physical) redundancy is not to be confused with so-called logical redundancy structures, such as ring structures, since the end parts of the two rings may potentially enter the building through the same inlet, thereby creating a "single point of failure" (SPOF). To ensure true redundancy, the corresponding provider network also has to be checked for SPOFs.

In selecting the sites suitable for physically redundant facilities, engineers also have to take into account the fact that specific physical effects may even affect a large physical area. Lightning strokes, for example, may even create significant magnetic fields within a radius of several hundred meters, thus impacting "redundant" sites that are physically close. The same applies to fires.

In addition to network cabling, the technically redundant design of facilities also has to cover other supply media, such as power supply or air-conditioning.

Campus and building backbone cabling must be planned redundantly. Moreover, separate cable routes must be used for campus backbone cabling. Depending on the availability requirements, separate cable routes must be provided for building backbone cabling.

2.2 Separation of cables according to their categories

- All line categories connected to a system (plant, equipment room, computer centre, etc.):
 - o IT cabling
 - o measuring lines
 - o auxiliary lines
 - o power lines

are to be laid in parallel along the same main routes, if possible, however, separately in different trays or chambers. (See Figure 12).

- The combination of various cable categories within the same tray or chamber of a cable duct or cable platform is to be avoided. If it is not possible to separate cables by keeping an adequate distance between the various cable categories (cf. chapter 3.1), metal partitions are to be used within the cable duct or cable platform. (See Figure 12).

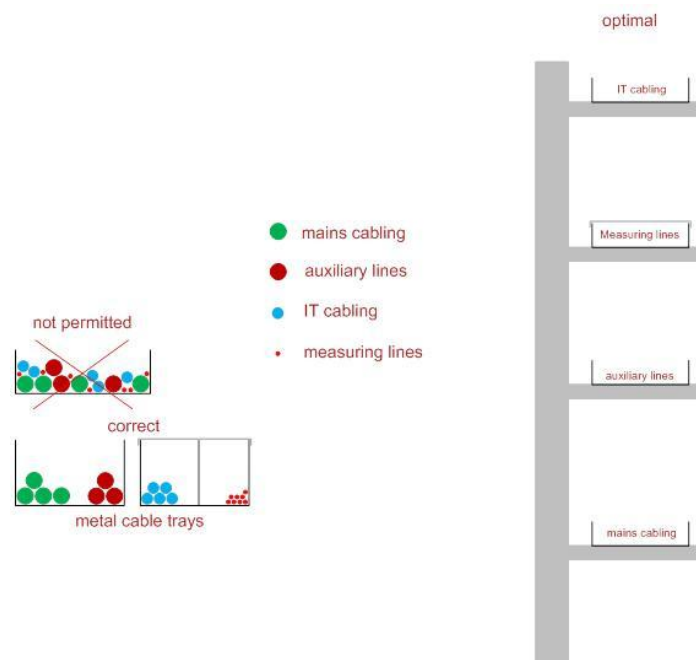


Figure 12: Cable tray without/with separation of cables according to their categories

- The separation distance between communication cables or lines on the one hand and fluorescent lamps, neon lamps, mercury vapour lamps or high-performance gas discharge lamps on the other, must be at least 130 mm.
- Cables of different categories must not be routed in the same cable bundle. (For example, by bundling them with the use of velcro tapes)
- The tray system must be placed so as to:
 - o observe a distance of ≥ 25 mm between the floor and the lowermost tray for floor mounting.
 - o ensure that ≥ 150 mm space is available for installation above the tray system.
 - o not fall short of the minimum bending radius of the cable.
 - o prevent any damage to the cabling installed therein.

2.3 Cable routes and systems

- **The inter-building installation of balanced copper data cabling (for example LAN connection) is not allowed.**
- **Only fibre optics must be used for campus backbone cabling.**
- In order to facilitate subsequent retrofits, the usable space within the selected cable route system must be designed twice as large as is required for accommodating the original volume of cables.
- Use must be made of cable route systems that are suited for routing the cabling used.
- All cable or line bundles must be routed preferably in metal cable trays; mesh cable trays should be used in isolated cases. It is absolutely essential to adhere to the respective bending radii for any T-pieces installed in these cable route systems!
- Cable routes or, as the case may be, cable route systems must be selected such as to ensure adequate protection against physical damage (for example, bending radii, edge protection) and against climatic conditions both during installation and during operation.
- Cable route systems must be selected so as to ensure that neither water nor any other (contaminating) liquids may accumulate in the system.
- The installations of other trades, such as water, heating, air-conditioning or sprinkler facilities must neither be used as a cable route nor for installing cable route systems.
- The system elements recommended by the system suppliers must be used for changing the direction in the cable route system.
- The cutting edges of the cable route systems must be provided with edge protection.
- Access to the cable routes, including pulling equipment, must:
 - o be clear and must not be concealed by any other fixed building installation;
 - o allow for installation, repair and maintenance without any risk for staff or equipment;
 - o provide for sufficient space for all devices that are required for installation purposes (including cable drums and unreel devices).
- Cable routes inside buildings that are designed for use with cable ducts or conduits for electrical installations must be accessible at intervals of ≤ 12 m in order to facilitate the use of pull boxes.
- The pull boxes must be large enough to ensure the installation of IT cabling in line with their minimum bending radii. If various cable types are used, the largest minimum bending radius must be selected.



- Cable routes must allow the fastening of the selected cable route systems and their subsequent filling, taking into account:
 - o the installation method used;
 - o the weight of the planned cable quantity;
 - o the possibility of filling the routes with other services or by third parties.
- Cable route systems must:
 - o feature smooth surfaces and be free of burrs, sharp edges or noses that might damage the cables.
 - o be free from pressure points that might impair the transmission properties of the installed cabling.
 - o facilitate the installation and removal of cables without causing damage to the remaining installation and building services.
 - o be implemented in an end-to-end fashion without any joints, if possible.
- If permanent installations may have an impact on cabling installed, one or several of the following actions must be taken to ensure protection against damage:
 - o the mechanical properties of the cable route system;
 - o the place selected;
 - o additional local or general mechanical protection.
- When cable routes are chosen, sources of heat, moisture or vibrations that might increase the risk of damage to the cabling or might lead to reduced performance must be avoided.
- If hidden cable routes are required, they must be aligned either horizontally or vertically.
- Cables that are provided as redundant links must be installed in separate cable routes.
- The cable route systems selected must allow the installation of bulkheads.
- When cable route systems are selected, one has to take into account that these possibly transmit noise. If required, acoustic decoupling must be provided in order to avoid/reduce noise transmission through cable route systems.
- Separate cable routes must be chosen both for fibre-optic and for power cabling in the building backbone and campus backbone areas.
- In the plant area and in buildings in which several building distributors are installed, the building distributors must be connected preferably by outside cable routes.

3 EMC aspects

- The cables and lines to be installed must be classified in categories in line with their interference potential.
- The various cable categories have to be routed so as to ensure minimum interconnection between these categories.
- The routing must be chosen so as to
 - o minimise induction loop areas, for example between mains cables and horizontal cables or signal lines; (See Figure 13).
 - o make sure that cables, lines and metal pipes do not enter buildings at an unnecessarily large number of entry points;
 - o minimise the number of transitions from one interference protection zone into another one.
- Cabling support systems must be directly connected to the meshed bonding network at low impedance.
- Individual parts of the cabling support systems must be connected at low impedance.

Example: Reduction of induction effects due to IT and electrical distribution units that are located close to each other.

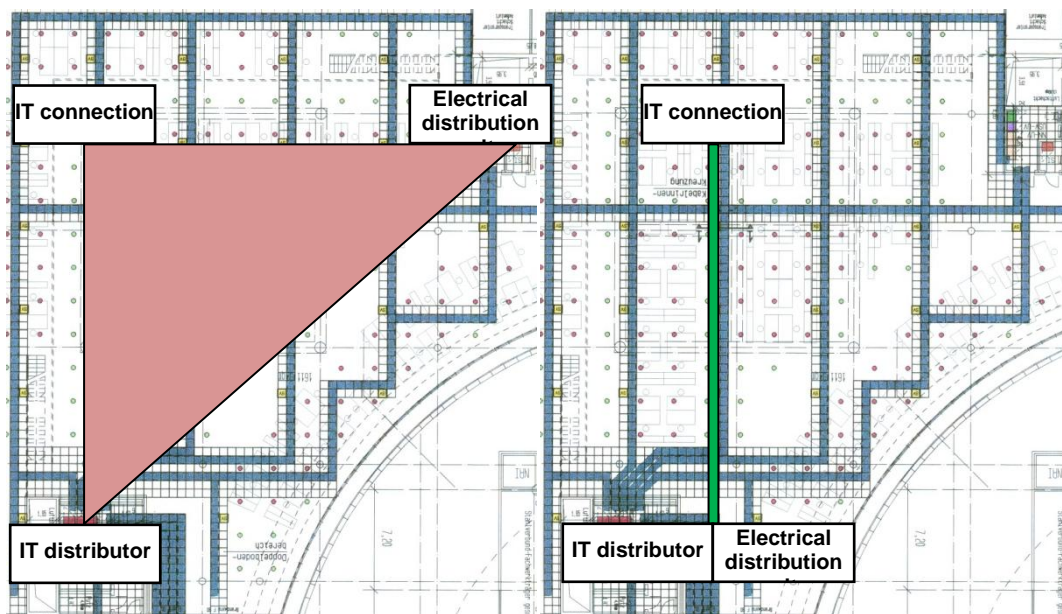


Figure 13: Example of how to reduce induction effects

Left-hand figure: Large loop area with strong induction effects that result from the large distance between the IT and the electrical distributor units.

Right-hand figure: Considerably reduced loop area with weaker induction effects that result from the short distance between the IT and the electrical distributor units.



3.1 Separation distance for the joint installation of power and horizontal cabling

In order to ensure minimum interconnection between faulty power cabling and horizontal cabling that is susceptible to disruptions, spatial separation must be provided. Excessively large distances between the power and horizontal cabling of a system, however, go against the requirements of effective LEMP protection for minimum loop areas.

A compromise must be found between these opposing requirements, with distances of approximately 10 to 20 cm having proven effective in practice.

Power and horizontal cabling must be preferably installed in separate trays (= cable separation according to categories, cf. chapter 2.2). If this cannot be implemented at the construction site, the separation distance specified in DIN EN 50174-2 must be observed.

The following aspects must be taken into account in calculating separation distance:

- **Separation class**,
which is classified on the basis of the coupling and screening attenuation of the cable ¹
- **Minimum separation distance S**
for the cable management system selected (cf. Table 1)
- **Factor P for power supply** cabling (cf. Table 2)

Depending on the abovementioned parameters, the following tables can be used to calculate separation distance A in accordance with the formula **A = S * P**.

A sample calculation is shown on the following page.

When applied to the IT cabling approved by the BMW Group, the following minimum separation distances S apply:

Separation class	Separation without any electromagnetic barriers	Cable ducts used for IT cabling or power supply cabling		
		Open metal cable duct	Perforated plate cable duct	Solid metal cable duct
D	10 mm	8 mm	5 mm	0 mm

Table 1: Minimum separation distances S according to DIN EN 50174-2

To calculate the separation distance, the factor "P" for power supply cabling in accordance with Table 2 must be taken into account in addition to the minimum separation distance "S".

¹ All category 7 data cabling approved by BMW Group feature a coupling attenuation of ≥ 80 dB and thus correspond to separation class "d".

Type of electrical circuit ^{a, b, c}	Number of circuits	Factor for power supply cabling P
20 A, 230 V, single-phase	1 to 3	0.2
	4 to 6	0.4
	7 to 9	0.6
	10 to 12	0.8
	13 to 15	1.0
	16 to 30	2
	31 to 45	3
	46 to 60	4
	61 to 75	5
	> 75	6
^a Three-phase cables must be treated as three individual single-phase cables. ^b More than 20 A must be treated as a multiple of 20 A. ^c Power supply cables for lower alternating or direct voltage must be treated on the basis of their current intensity, i.e. a 100 A/50 V dc cable corresponds to 5 x 20-A cables (P = 0.4).		

Table 2: Factor for power supply cabling P in accordance with DIN EN 50174-2

Example:

- (1) Screened IT cable with a coupling attenuation of > 80 dB
 → Separation class "d"
- (2) Perforated plate cable duct for IT cabling or power supply cabling
 → Minimum separation distance "S" = 5 mm
- (3) Power supply cabling run in parallel:
 5 current circuits (2 x single-phase, 230V, 16A; 1 x three-phase, 230/400V, 32A)
 → 8 "20A circuits"
 → Factor "P" = 0.6

Minimum separation distance $A = S * P = 5 \text{ mm} * 0.6 = \underline{3 \text{ mm}}$

3.2 Shielding and equipotential bonding

- Interference coupled into the structured ICT cabling and electromagnetic emission must be avoided permanently and safely in all relevant frequency ranges by establishing adequate connections between the cabling and the meshed bonding network.

The following components must be taken into account:

- o IT cabinets
 - o passive IT IS components of structured IT cabling
 - o shielded telecommunication cables
 - o shielded cables and lines that are part of the outside or campus backbone cabling
 - o etc.
- All equipment slots must be protected by the covers specified by the manufacturer.
 - All structured IT cabling connections to the meshed bonding network must be permanent, electrically safe and must ensure a low level of impedance in the relevant frequency range. For reasons of corrosion prevention, the galvanic series of metals needs to be taken into consideration.
 - Any connections to the meshed bonding network may be released with the use of tools only.
 - **Equipotential bonding bars must in general be installed at a height of c. 30 cm above the floor, or as the case may be, raised floor, in the visible area on walls or pillars. (See Figure 14).**

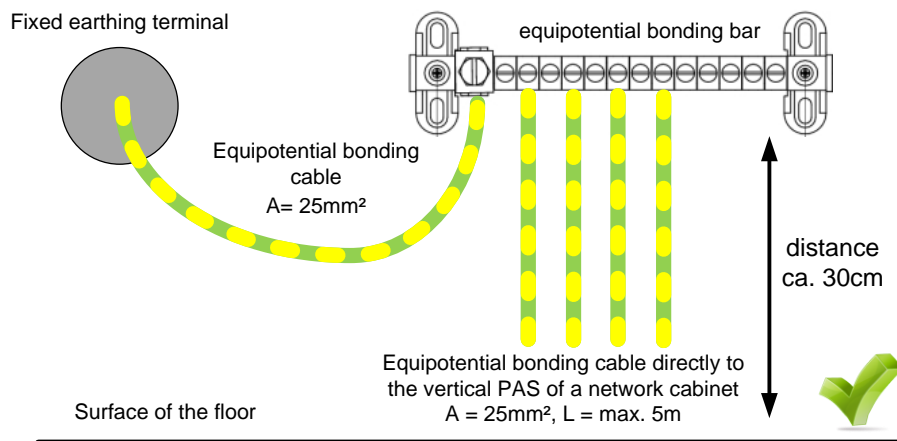


Figure 14: Fixed earthing terminal and equipotential bonding bar (PAS) (schematic diagram)

- If round steel or a steel strip is available for connection to the equipotential bonding bar instead of a fixed earthing terminal, then follow the same procedure as shown in Figure 14. In this case, care must be taken to ensure that the equipotential bonding bar is fastened properly due to potential "voltage" relating to the round steel or steel strip.

3.2.1 IT cabinets

- Earthing bars must be positioned in the vicinity of IT cabinets.
- The vertical earthing bar of the IT cabinets must be connected directly and over as short a distance as possible (**$L \leq 5.0 \text{ m}$**) to the meshed bonding network with stranded copper conductors or earthing strips (minimum area **$A_{\min} = 25 \text{ mm}^2$** , stranded wire design according to IEC 60228: at least fine-strand wire, class 5) at low impedance (**$Z < 1.0 \Omega$ at 2 kHz**). (See Figure 14 and Figure 15)

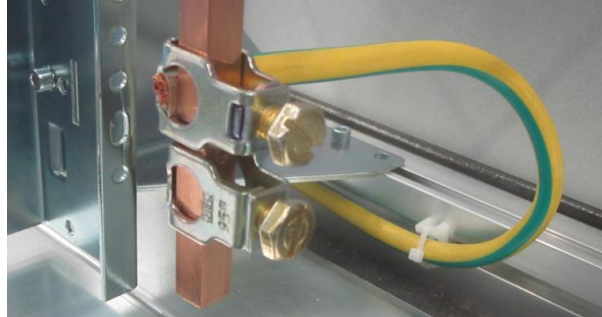


Figure 15: Connecting the active IT IS component to equipotential bonding

- A vertical equipotential busbar that extends over the entire height of the 19" frame must be installed in the IT cabinet.
- Any IT IS components (passive and active) installed in IT cabinets must be connected to the vertical equipotential busbar over as short a distance as possible (**max. 10-15 cm**) with stranded copper conductors or earthing strips (**$A_{\min} = 6 \text{ mm}^2$** , stranded wire design according to IEC 60228: at least fine-strand wire, class 5) at low impedance (**$Z < 1.0 \Omega$ at 2 kHz**). (See Figure 16 and Figure 17).

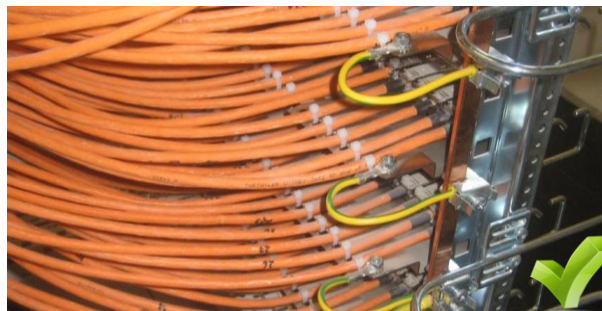


Figure 16: Connecting copper patch panels to equipotential bonding



Figure 17: Connecting active components to equipotential bonding

- The protection earthing of all other metal cabinet components may be implemented through the vertical earthing bar according to the relevant regulations.
- The vertical earthing bar is to be fitted right next to the connection point of the patch panels or active components installed.

3.2.2 Handling of cable shields

- The assembly instructions provided by the manufacturer for the connection of cabling to the connecting hardware must be observed. If the manufacturer specifies several assembly versions, the version that offers higher technical performance must always be applied.
- Unless otherwise specified by the manufacturer in his installation instructions, both the braided overall shield and the overall foil shield of SF/UTP cables must be connected to the RJ45 jack modules over a large area. The shielding termination of the data cables must ensure full contact with metallic housings (360°).

3.2.3 Telecommunications cables

- Multi-unit telecommunications cables are to be connected at both ends to the meshed equipotential bonding system.
- If the premises are equipped with analogue telecommunications systems, only single-ended earthing (close to the system) must be implemented. The remote shielding end will be earthed via an air gap. (= indirect potential equalisation)

3.2.4 Cable support systems

- The cable management systems must be directly connected to the closest meshed bonding network at the start, at the end, and at a distance of approximately 15m to 20m pursuant to IEC 60364-5-54 and DIN EN 50310.
- Individual segments of metallic cable management systems must be connected with system elements in an electrically conductive manner (see Figure 18 and Figure 19 in the following section). Interrupted sections that cannot be bridged with system elements on account of a large distance must be connected with at least two conductors each with a minimum cross-section of 25mm². (Stranded wire design in accordance with IEC 60228: at least fine-strand wire, class 5).



Figure 18: Contacting between adjacent support segments



Figure 19: Interruption of metal cable management systems at fire wall

3.2.5 Outside cables and campus backbone cables

- **The inter-building installation of balanced copper data cabling (for example LAN connection) is not allowed. Only fibre optics must be used for campus backbone cabling.**
- Any copper telecommunication cabling (WAN) entering the building from outside must be equipped with a shield that is capable of carrying lightning current. The cable shield must be connected to the meshed bonding network directly at the point of entry into the building (inside). If the operating mode or service requires single-ended grounding, the shielding must always be earthed via an air gap (indirect potential equalisation).
- The conductors of the copper telecommunication cabling must be connected to surge protection devices at the point of entry into the building.

3.3 Cable or line management

- All cable or line bundles must be routed in metal cable trays
- **Mesh cable trays are not allowed**
- It is absolutely essential to adhere to the respective bending radii for any T-pieces installed in these cable route systems!
- Cables in cable route systems must be routed at least 10 mm below the upper edge of the side walls. (cf. Figure 20)

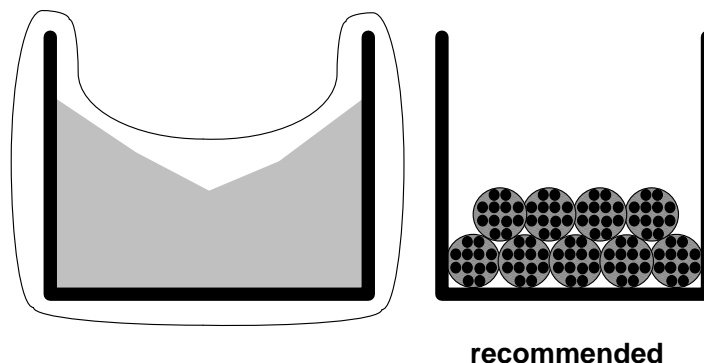


Figure 20: Laying of cables in cable route systems

- Use direct line routing in order to avoid unnecessary cable or line lengths.
- Power and IT cables are to be separated as shown in Figure 21 in raceway covers. (separation by way of keeping a specific distance in accordance with chapter 3.1)
- Adhere to a 90° curve when laying cables or lines at cross-connect points. (See Figure 22).
- A cross-over of various cable categories must be avoided. If this is not feasible, cross-overs must be implemented along the shortest possible route and adhere to a 90° bend. (See Figure 22).

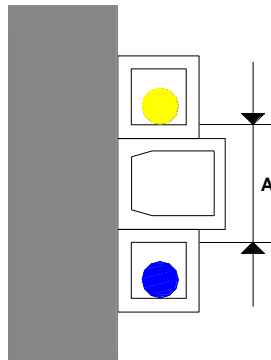


Figure 21: Minimum separation distance A in connection with raceway covers

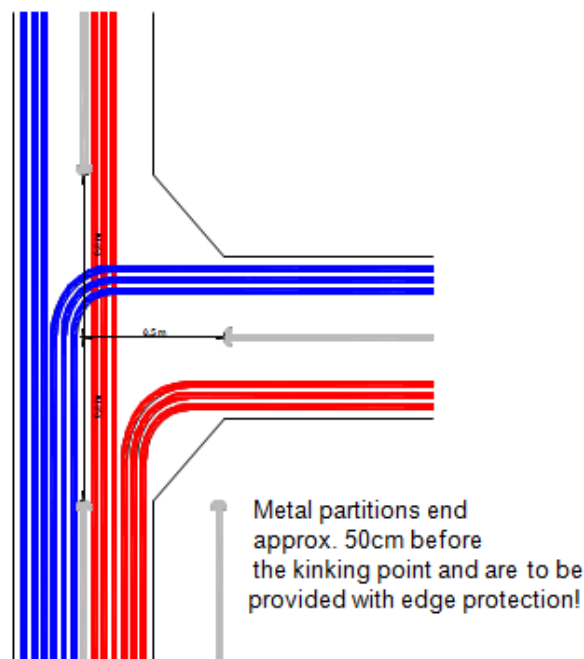


Figure 22: Cable installation in cross-connect points and cross-over areas

3.3.1 Main risers

The individual elements of the riser must be connected at both ends at low impedance and hooked up to the next earth electrode terminal or, as the case may be, the next equipotential busbar. (See Figure 23).

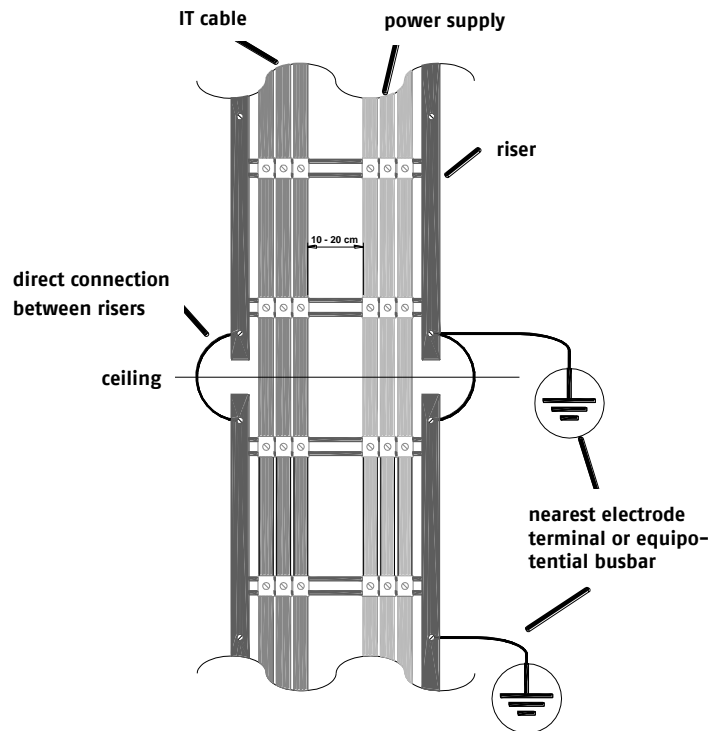


Figure 23: Equipotential bonding in the riser area

3.3.2 Above-ground routes

Lines routed through areas that are subject to the risk of being hit by lightning strikes must be laid in enclosed cable routes which are to be connected to the equipotential bonding system at several positions.

3.3.3 Underground routes

- Routes (buried cables/conduits) must be fitted with one or more protection rope conductor(s), depending on the route width. The material recommended for the protection rope conductor is stainless steel, material number 1.4571 (V4A) without coating. The round wire variant must have a diameter of at least 10 mm, whilst the flat steel variant must feature a minimum cross-section of 100 mm² and a minimum thickness of 3 mm.
- Protection rope conductors must be placed at a distance of 0.5 m above the routes in contact with earth (see Figure 24). If several rope conductors are required on account of the route width, these are to be laid next to each other at the same level and at a distance of approximately 0.5 m.
- Protection rope conductors must be connected to the earthing system directly at the point of entry into the building (in front of or after said point).
- If the structural design of the building to be supplied by the route does not allow a connection close to the point of entry, the protection rope conductors should be left to end approximately 5.0 m in front of the building. (As soon as the earthing system has been upgraded, the protection rope conductor can be connected.)

- Other electrically conductive connections between protection rope conductors, cable sheaths and fittings along the link between buildings are not allowed.
- Adhere to an installation distance of 0.5 m in the area around sleeves.
- Join protection rope conductors by having the individual sections overlap along a length of approximately 15–20 cm and by fitting screw-type terminals.
- In order to avoid constraints for cable assembly work in cable ducts, the protection rope conductor is not routed through the cable duct but is bypassed around the duct in a curved shape at one side at a distance of c.30 cm. The opposite side of the duct shaft is protected by another curved section of the protection rope conductor. Said section is to be connected to the continuous protection rope conductor at both sides of the shaft by means of screw-type terminals. (cf. Figure 25)
- Fault-tolerant lines may require installation in enclosed steel pipes depending on the individual situation. Whether or not this is necessary, must be clarified with **BMW Group IT IS Function Datacenter Technology (Rechenzentrumstechnik)** on a case-by-case basis.

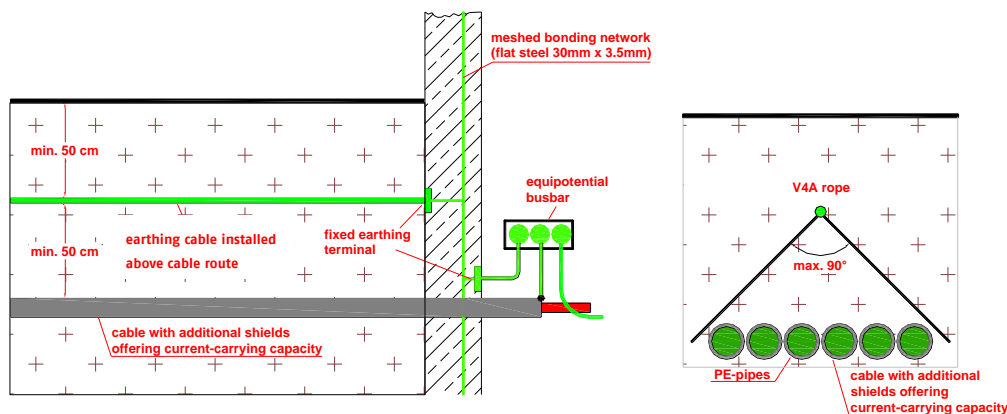


Figure 24: Basic principle of protecting routes with earthing cable/protection rope conductor

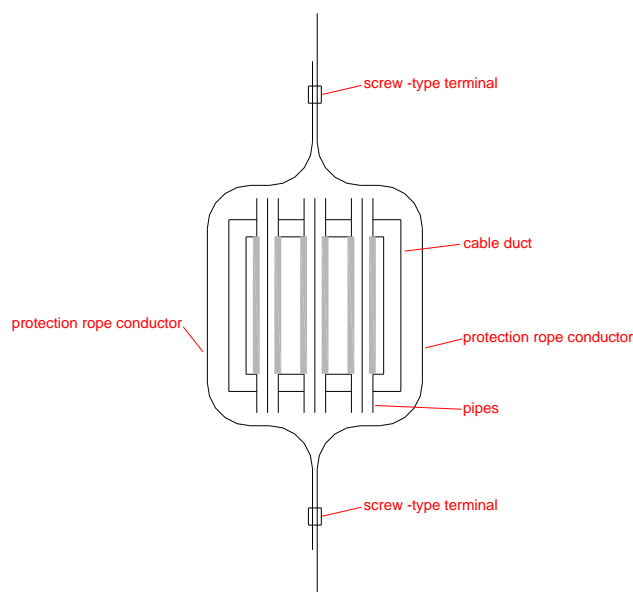


Figure 25: Routing of the protection rope conductor around a cable duct



4 Documentation for acceptance

The following documentation must be created by the installation service provider both in electronic and in printed form and must be stored in BMW's own documentation system COMMAND as full, consistent and correct documentation:

- drawings and sketches
 - o floor plans
 - o type of cables and campus terminations (fibre optic backbone, copper cabling)
 - o cabinet overview
- measuring records
 - o copper cabling
 - o fibre-optic cabling
 - o (telephone cabling)

Labels must be used in order to clearly mark structured cabling installations and components. Labelling must be completed by the installer and must meet the following requirements:

- Labels must be printed.
- Labels must be affixed to the relevant object permanently.
- Labels must withstand the environmental conditions prevailing at the installation site (such as air humidity, heat or UV radiation) and must be designed for a service life corresponding to the labelled component.

4.1 Labelling of IT cabinets

- Every IT cabinet is to be labelled separately and in coordination.
- The labels must be placed at the front of the IT cabinets permanently and must be clearly visible from outside. (for example VT-12345). White formica (resopal) signs sized 40mm x 150mm with black typeface (font size: ≥ 25 mm) must be used for this purpose.
- The IT cabinets including their fixtures must be documented in the COMMAND documentation system.

4.2 Labelling of connections to equipotential bonding

- Equipotential busbars must be generally indicated by white formica (resopal) signs sized 40 mm x 100 mm with "equipotential bonding system connection" printed in black (font size: ≥ 25 mm) approximately 30 cm above the floor or raised floor in the visible area on walls or pillars.

4.3 Labelling of passive IT IS components

- IDENT labels (to be provided by the specialist site manager) must be used to label both ends of every RJ45 cabling link at its connection components and must be documented in the COMMAND documentation system.
- Campus and building backbone cabling must be identified with a cabling designation sign in every cable chamber, every cross-over, in front of and behind wall breakthroughs, and every 25 m.
- The fibre-optic patch panels also have to be labelled in coordination and must be documented according to the specifications laid down in the COMMAND documentation system.

Example:

IDENT-No. 12AB

→ IT cabinet: VT-12345
→ Patch panel: 1
→ Port: C

Plant: 1.2
Building: 17.0
Room/Coordinate: 0815

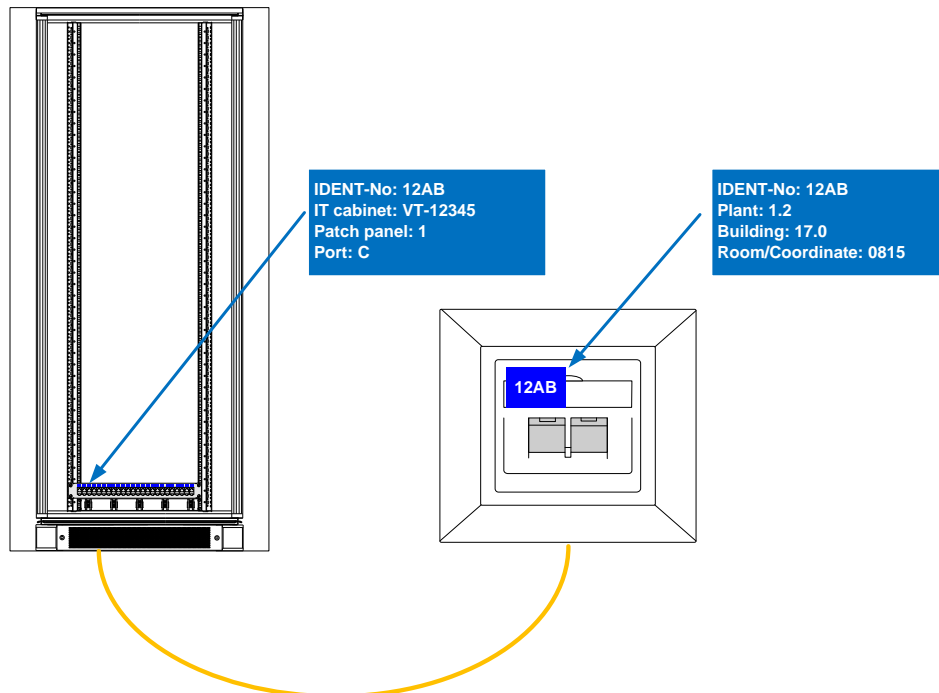


Figure 26: Specifications for labelling a copper link