CONNECT AND PROTECT

Datacenter Protection Solutions

Grounding and Lightning Protection

nVent ERICO

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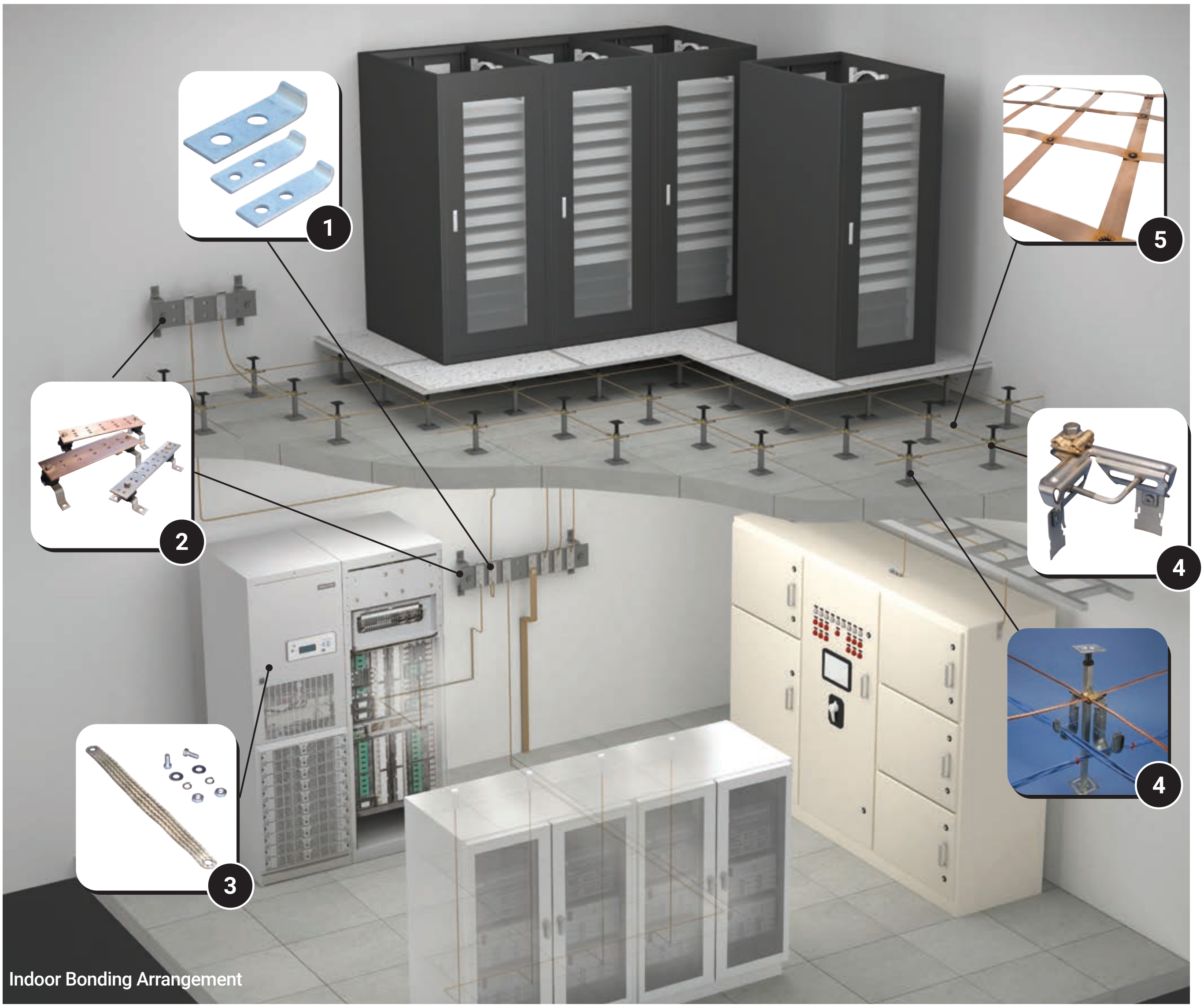
Indoor Bonding Arrangement

The datacenter indoor grounding can be done using one of 3 methods. These are, Mesh Isolated Bonded Network or Mesh-IBN, Mesh Bonded Network or Mesh-BN or Star Isolated Bonded System or Star-IBN.

In the diagram below the Mesh-IBN is depicted on the 2nd floor and the Star-IBN is depicted in the first floor. A mesh-IBN is a mesh-topology bonding network that has a Single point connection, SPC to either the Common Bonded Network, CBN or another Isolated bonded network IBN. This SPC or the IBN then forms a single connection to the external ground electrode system. A Mesh-BN is similar to a Mesh-IBN, but instead of terminating at a SPC, it will terminate at multiple point around the datacenter either to building reinforcement steel or to the dedicated ground electrode system external to the building. A Star-IBN System is depicted in the bottom floor consists of ground wires running along cable trays either above equipment or under the raised floor picking up ground connection to all the racks and termination and termination at the SPC, which has a single connection to the external ground electrode system.

The mesh system in Mesh-IBN and Mesh-BN is constructed using these methods below the raised floor.

1. Signal Reference Grid, SRG consisting of flat conductors, the mesh-BN should be prefabricated of minimum 0.4 mm (0.0159 in; 26 gauge) x 50 mm (2 in) wide copper strips with all crossings and joints sections properly welded.
2. SRG consisting of wire mesh that is typically fabricated from solid copper or copper clad steel wire, ranging from 6 AWG to 12 AWG or 10 to 16 mm^2 either welded or mechanically connected at joints and to pedestals.
3. The spacing between conductors ranging is typically up to 1.2 m (4 ft).
4. All equipment, pedestals and other metallic objects are connected to the mesh via a short connection.



1 Bonding Lugs
2 Equipotential Ground Bar
3 Ground Bonding Braids
4 Mechanical Mesh Bonding
5 Signal Reference Grid

Figure 1: Typical Indoor Grounding System

Indoor Bonding Arrangement

The MBN or the IBN forms the large part of the indoor grounding arrangement. The indoor grounding system has to mitigate surges, transients and noise after it has already entered the equipment room and hence these system are critical to the operation of the equipment. Incorrect routing or diversion of electrical disturbances will result in damage to electronic equipment or excessive noise levels.

Mesh bonding networks have historically been critical in the operation of datacenters. These grounding networks equalized the voltage at all parts of the computer room so that the differential mode noise in between equipment is negligible and hence digital data does not get corrupted. Modern communication protocols in data communication like packet switching, transmit data in no particular time order and have better inbuilt methods for correcting for bit error rates arising from high noise level. This improved noise immunity on data transmission and better noise immunity on equipment in modern computer rooms perhaps slightly diminished the reliance of datacenters on a signal reference grid, SRG created by a MBN. However, having a MBN will greatly improve the error rates in transmission of data within the data center and provide excellent transient and surge control.

Star-IBN have historically used in Telecommunication DC rooms and they are as important today as they were historically and these days they may be utilized in smaller datacenters. Facility owners of large mission critical datacenters invariably desire a mesh bonded network.

STANDARDS AND CODES

There is generally a strong consistency in the approach to telecommunication indoor grounding amongst standards and codes. The following standards & codes will be discussed and referenced in this this paper:

- Standard ITU K27 Bonding Configuration and Earthing Inside a Telecommunications Building
- Standard TIA 607 B/C Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
- Standard NECA/BICSI 607 2011 Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
- Telcordia GR295 Mesh and Isolated Bonding Networks
- IEC 30129 and AS 30129 Information technology, Telecommunications bonding networks for buildings and other structures

ITU K27

The ITU K series of guidelines deal with protection against interference. The Guideline ITU K27 is Titled "Bonding Configurations and Earthing Inside a Telecommunications Building." The three methods commonly used in telecommunications & data centre facilities, that is Star-IBN, Mesh-IBN and Mesh-BN are described in ITU-K27.

The Star-IBN is the most common method observed in telecommunications equipment room including central offices, transmission sites and cellular radio sites, that are powered by −48VDC and −24VDC power systems.

The Mesh-IBN and MESH-BN is more common in data centres generally AC UPS (and more recently High Voltage DC) powered as opposed to traditional telecommunication equipment room which are extra low voltage DC powered.

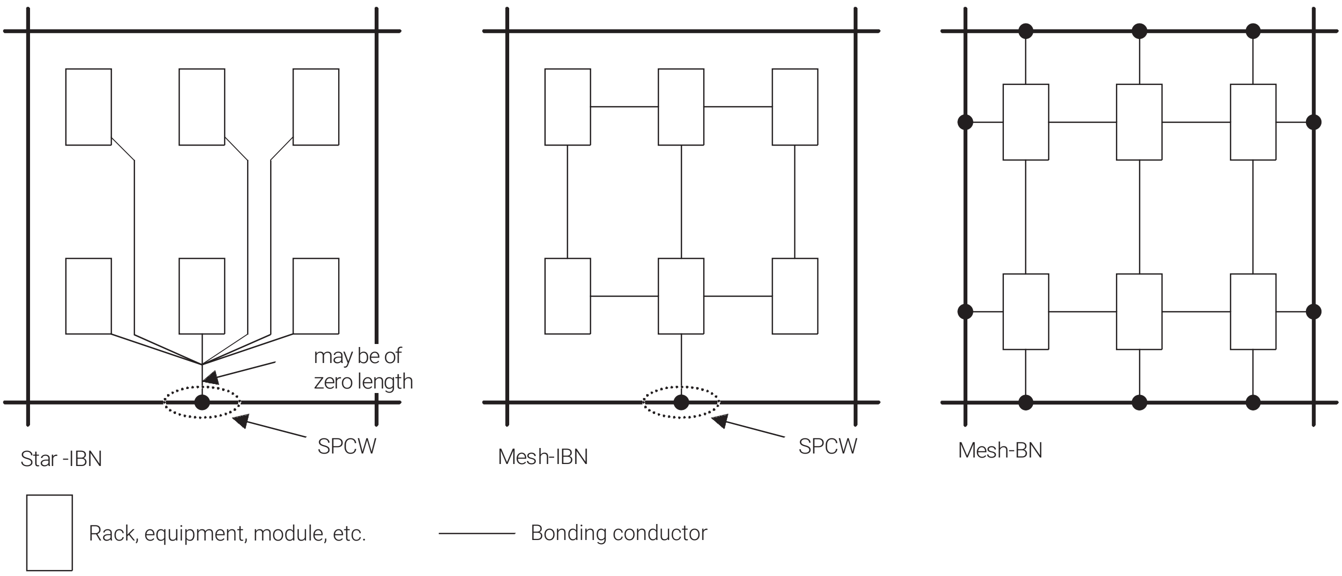


Figure 2: Methods as depicted in ITU K.27

Indoor Bonding Arrangement

Figure 3 below shows a typical single point connection for Star IBN and Mesh IBN system. Please note that double holes lugs are more common in telecommunication and data center applications in telecommunications but single-hole lugs are also used in some countries. Figure 4 shows a typical MBN, mesh bonded network or a signal reference grid.

In the Star-IBN System there is a single point connection window or SPCW via which the indoor grounding system is connected to the ground electrode system.

In the MESH-IBN the components inside the telecommunication facility (e.g. equipment frames) are interconnected to form a mesh-like structure & there is only one SPCW via which the MESH-IBN connects to the external ground electrode system.

In MESH-BN but there is a clear attempt not have isolation but rather deliberate multiple points of connection around the mesh to a Common Bonding Network, or a CBN. The CBN maybe a part of the steel re-inforcement system or an installed ground electrode system forming a ring around the building.

Figure 4 shows a typical MBN, mesh bonded network or a signal reference grid.

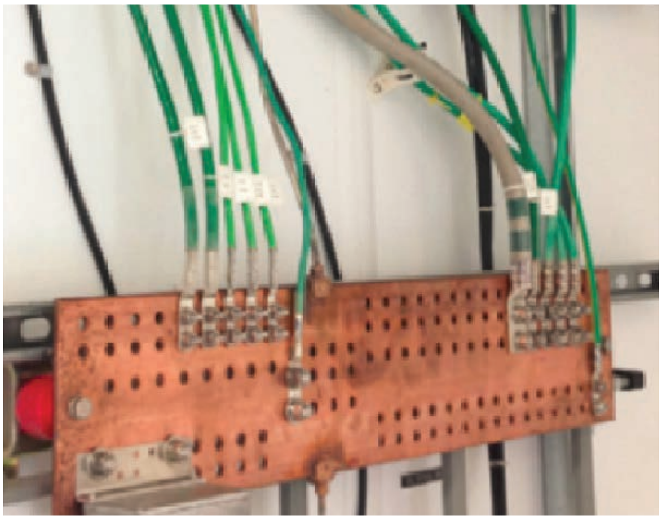


Figure 3: Typical Single Point Connection Window

Figure 4: Examples of Bonding Mat or Signal Reference Grids

Indoor Bonding Arrangement

TIA 607 Generic Telecommunications Bonding and Grounding for Customer Premises

The purpose of this Standard is to enable and encourage the planning, design, and installation of generic telecommunications bonding and grounding systems within premises with or without prior knowledge of the telecommunications systems that will subsequently be installed.

While primarily intended to provide direction for the design of new buildings, this Standard may be used for existing building renovations or retrofit treatment. This standard is for customer premises grounding and bonding and not a for a telecommunication carrier. It is generally used for the grounding and bonding of computer and data rooms and large data centres outside of a carrier network. They may be used by carriers in some datacentre and other applications. Figure 3 below is taken from TIA607-C Standard. This arrangement is almost like the Star-IBN system in ITU K27 with a few modifications.

Primary bonding bar, PBB is the single point connection window and usually at the basement of a building. The PBB serves as the dedicated extension of the building grounding electrode system for the telecommunications infrastructure.

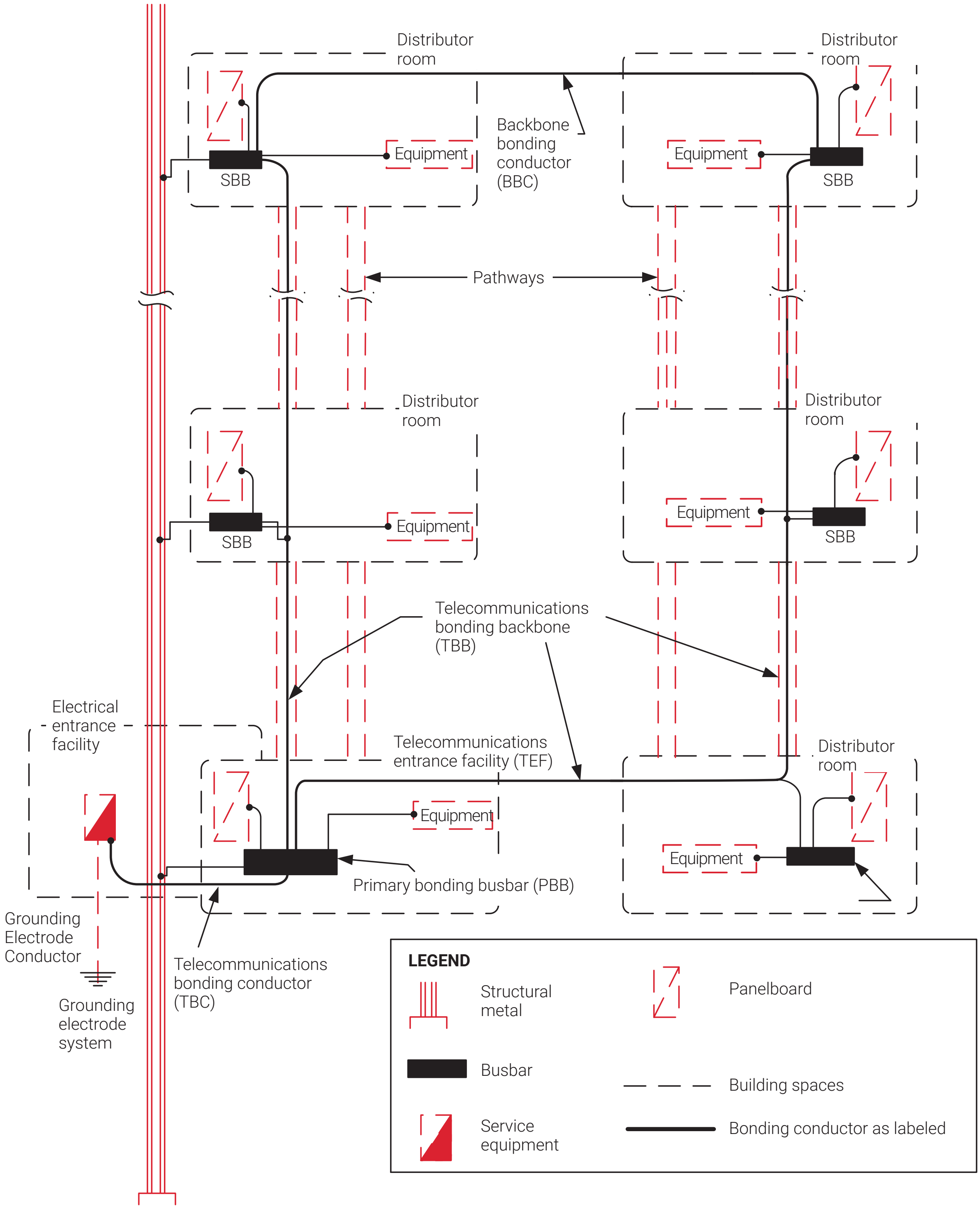


Figure 5: General Arrangement in TIA 607C

Indoor Bonding Arrangement

The PBB also serves as the central attachment point for the Telecommunication bonding backbone TBB, Secondary bonding bars, SBB and equipment. Telecommunications bonding conductor (TBC) bonds the PBB to the service equipment (power) ground.

Telecommunications bonding backbone (TBB) is a conductor that interconnects all Secondary bonding busbars SBB s with the PBB. The intended function of a TBB is to reduce or equalize potential differences. A TBB is not intended to serve as the only conductor providing a ground fault current return path. The TBB originates at the PBB and extends throughout the building using the telecommunications backbone pathways, and connects to the SBBs in distributors.

SBB is the grounding connection point for telecommunications systems and equipment in the area served by a distributor.

Each computer room shall contain a SBB (or PBB when specified in the design) and should also contain a supplementary bonding network. that is MESH BONDED NETWORK)that is bonded and thus becomes grounded to the SBB or PBB. This is similar to MESH-IBN in ITU K27.

If the mesh is constructed from flat conductors, the mesh should be prefabricated of minimum of 0.4 mm (0.0159 in; 26 gauge) x 50.8 mm (2 in) wide copper strips with all crossings and joined sections properly welded.

Where the mesh is constructed from standard, bare round wire, the conductors shall be a minimum sized conductor of No. 6 AWG stranded copper conductors joined together via proper welding, brazing, listed compression connectors, or listed grounding clamps at each of the crossing points.

If the mesh is constructed using the access-floor pedestals, the flooring system must be electrically continuous and must be bonded together every 4 to 6 pedestals in each direction using a minimum sized conductor of No. 6 AWG stranded copper conductors and listed pedestal grounding clamps.

The spacing for the SRG pattern is between 0.61 m to 1.22 m (2 ft to 4 ft) and was historically stated in Guideline on Electrical Power for ADP Installations, 1983 (USA Federal Information Processing Standards Publications - FIPS PUBS 94) to aid in reducing the effect of resonance on ac branch circuit equipment grounding conductors.

BICSI 607

BICSI 607 Contains local code requirements shall be followed. Always review the local code requirements with the local authority having jurisdiction (AHJ) before proceeding with the installation. BICSI 607 has strong consistency with TIA 607C in methods and terminology used. It has added clauses to signify that publication is intended to conform to the National Electrical Safety Code® and National Electrical Code® of USA.

We all understand that the best design can be undone by poor implementation, As such, the majority of NECA/BICSI 607 details installation methods and practices to minimize potential grounding system failure.

A. Telcordia Generic Requirements GR-295

Telcordia GR 295 is Titled "Mesh and Isolated Bonding Networks" This document is very comprehensive and gets into significant detail of how to construct a Star-IBN, Mesh-IBN and MESH-BN system. There is consistency in methodology recommended in ITU-K27 and Telcordia GR295.

B. IEC 30129

The IEC 30129 is a recent standard. It applies the 3 methods in ITU K27 to data and telecommunications facilities. The requirements of this International Standard are applicable to the buildings and other structures within premises including residential, office, industrial and data centers.

The example below in Figure 6 shows the layout of the Star-IBN system in a large building. It must be noted that as a contrast to TIA 607, the bonds from the star-IBN to the building is not shown and this is a more strict implementation of the Star-IBN system as per ITU K27.

This standard recognizes that, where the telecommunications equipment served by the Star-IBN the following problems may result where the cables lengths are long or the items of equipment are some distance from each other:

a) a high common impedance between equipment particularly at high frequencies

b) potential large ground loops

In addition to the Star-IBN the IEC30129 also allows the use of additional bonding and localized MESH-BN, compliment the star-IBN in order to reduce the above problems. The use of localized MESH-BN can also be used for AC UPS powered data equipment inside the telecommunications equipment room where local jurisdiction or carrier standards only allow Star-IBN for the DC grounding system. For example in Australia, Standard AS3015 prescribes the Star-IBN system for DC Power systems.

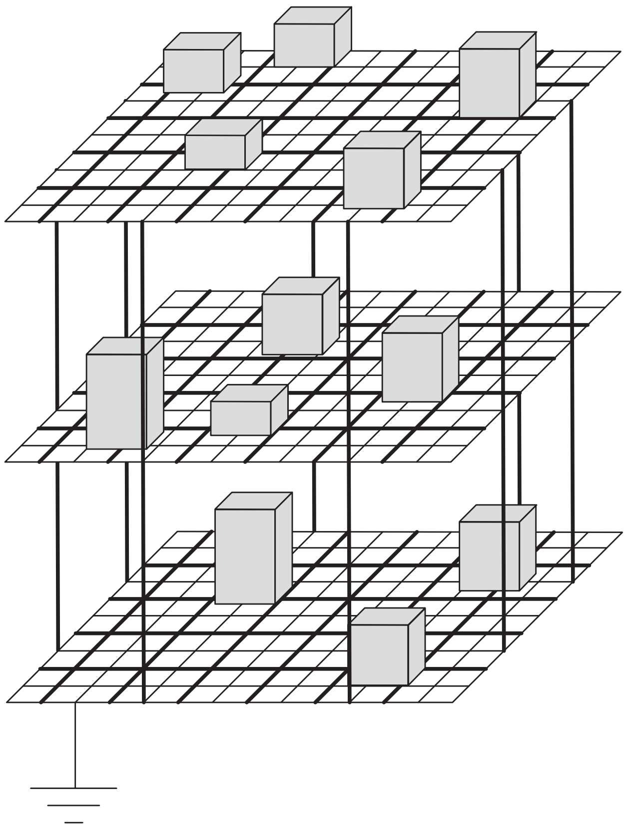


Figure 6: Mesh Bonded Network TIA 607 C

Indoor Bonding Arrangement

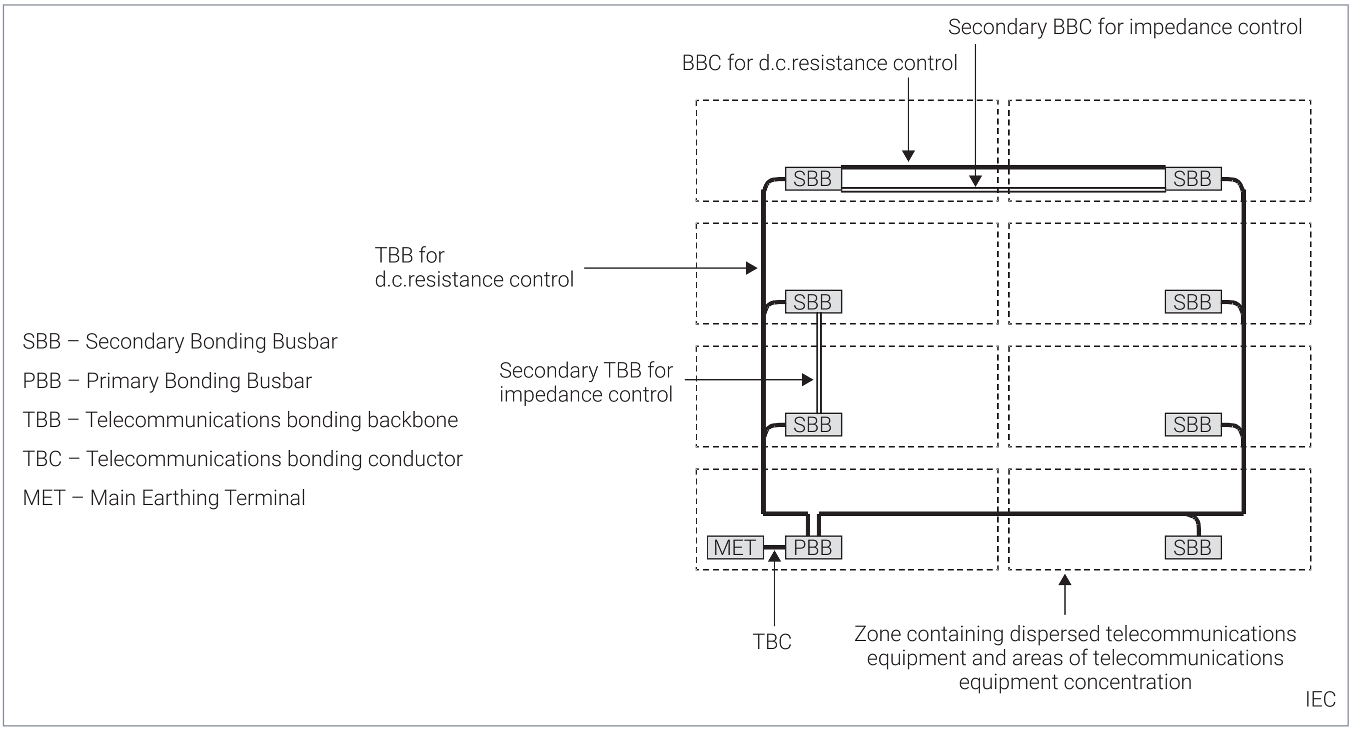


Figure 7: Star-IBN in Large Building IEC30129

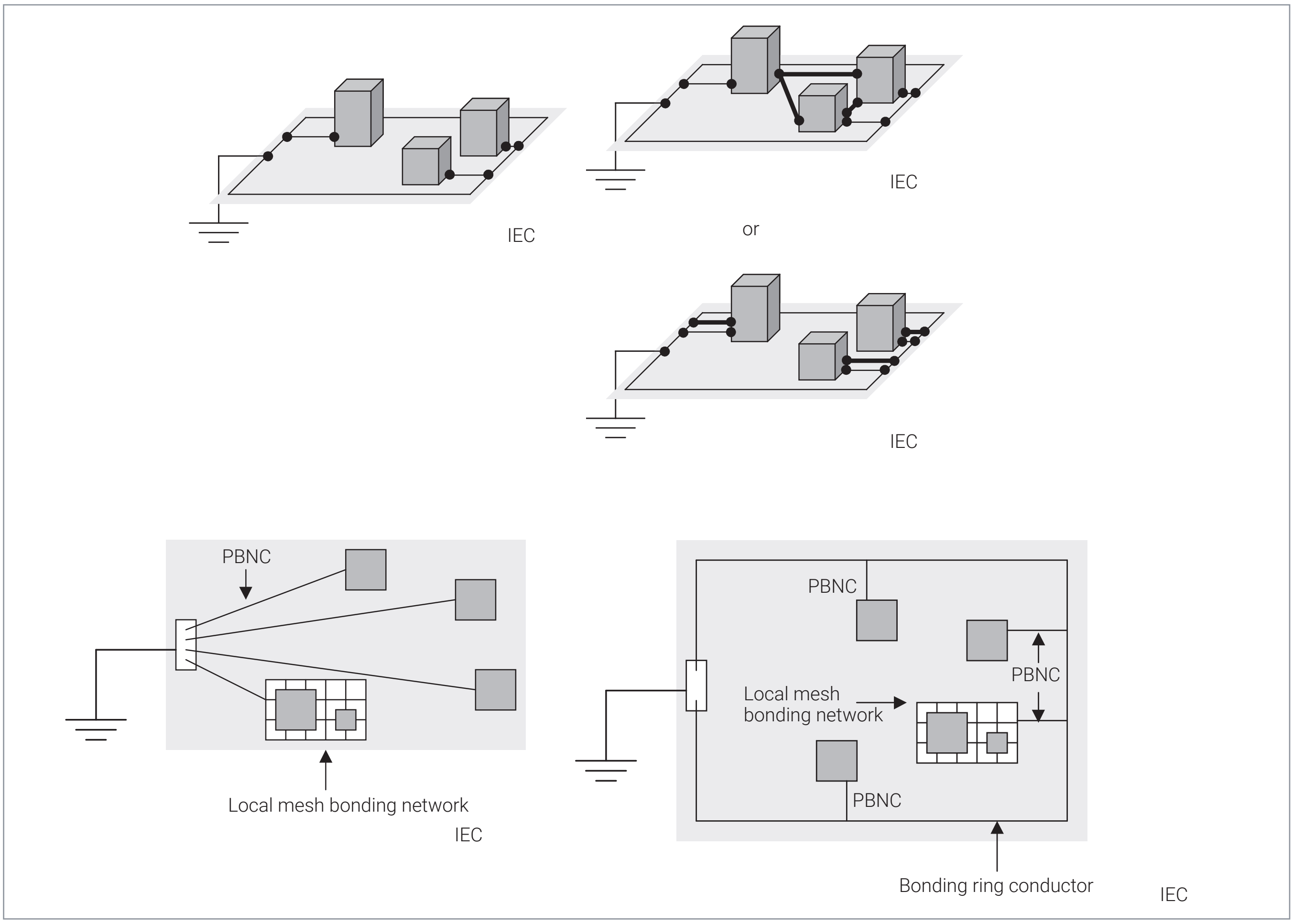


Figure 8: Additional Bonding and Localized Mesh Networks IEC30129

The use of MESH-IBN may still possible for AC Data Equipment provides these are located in one part of the room. This is an important point on the application of these systems and still complying to local codes.

Local codes and jurisdiction must be checked and complied with in addition to or in lieu of standards that are discussed in this paper.

Indoor Bonding Arrangement

BONDING OF CABINETS AND CABLE TRAYS

The equipment and the cabinets shall be connected to the indoor grounding system via the Telecommunication Equipment Bonding Conductor (TEBC) using one of the three methods shown in Figure 8. This methods is identical in TIA607C and IEC 30129.

The TEBC shall be run on cable trays as shown below. All joint of cable trays shall be bonded across with a short wire as shown.

All connections shall be irreversible crimp conductor.

The typical arrangement of cable tray bonding and TEBC connections is shown in Figure 9.

The bend radius on the TEBC shall not be less than 200 mm. The angle bend of any grounding conductors shall not be less than 90 degrees.

Smaller bends radius may be permitted on grounding wires at cabinet level. However sharp bends shall be avoided where possible.

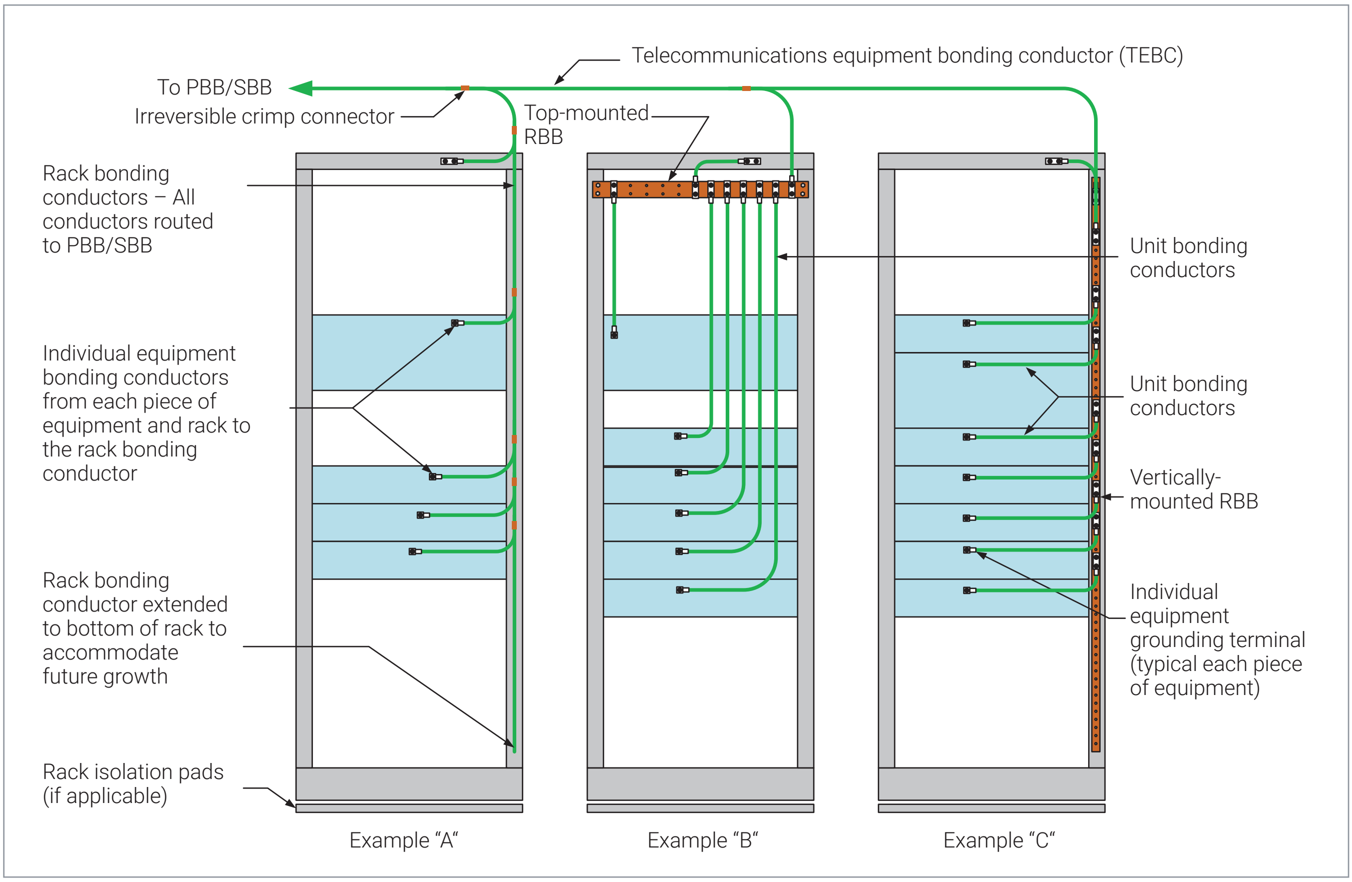


Figure 9: Equipment & Cabinet Bonding

Indoor Bonding Arrangement

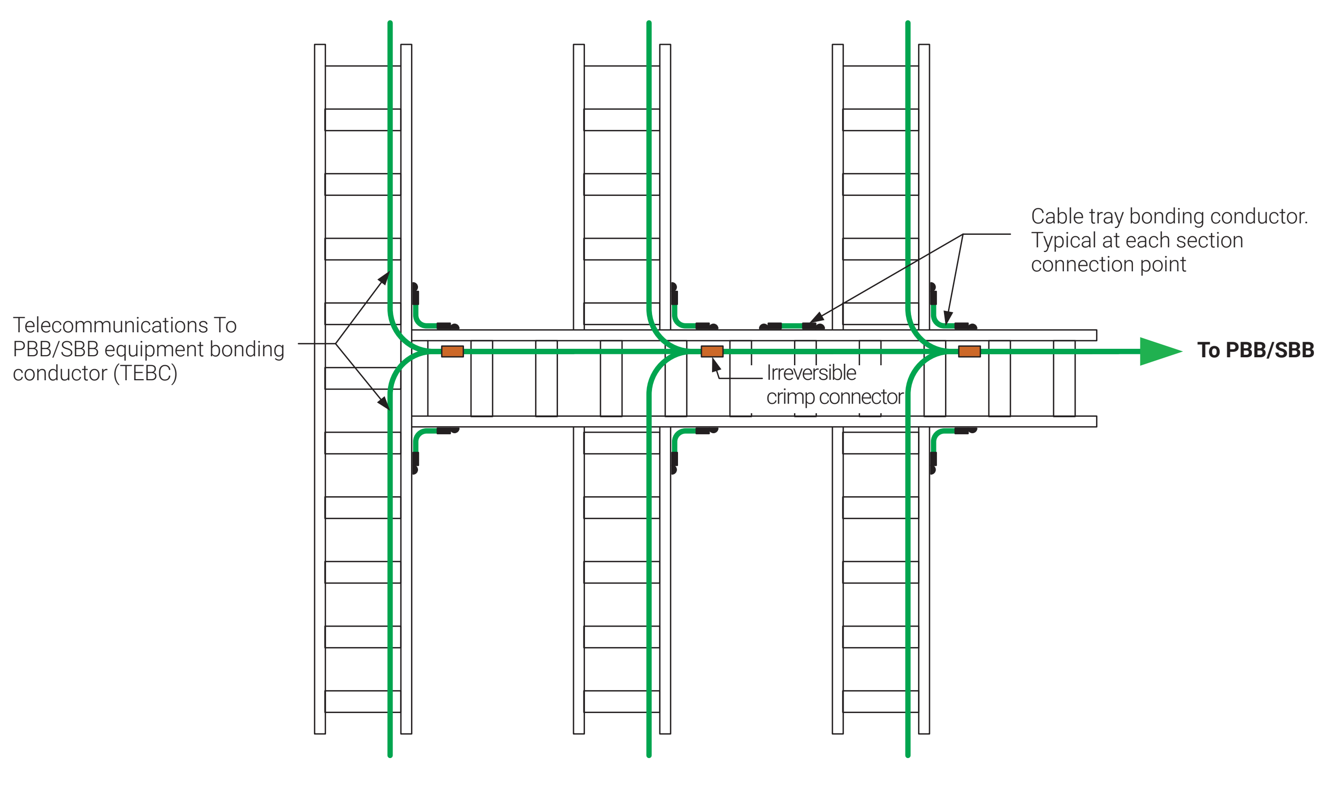


Figure 10: Typical Arrangement of Cable Tray Bonding and TEBC connections

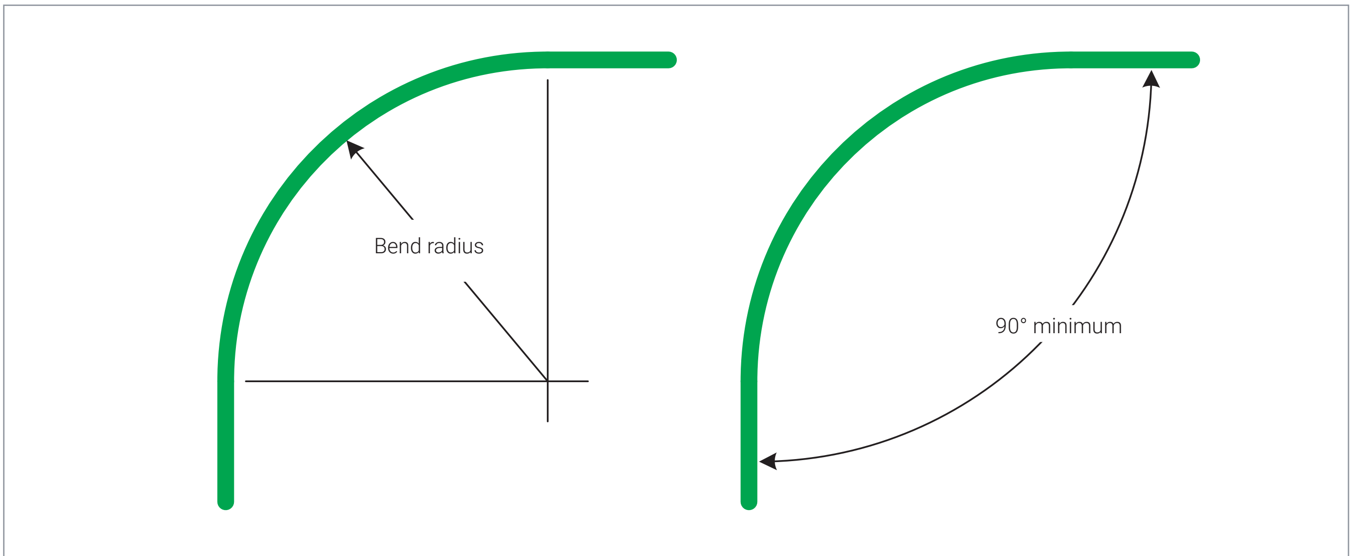


Figure 11: Bend Radius on TEBC Conductor

Outdoor Grounding Arrangement

The design philosophy for outdoor grounding for sites with any of the power system will be the same. There are 3 options provided depending of the amount of land available to install the grounding system. The existing standards do not elaborate deeply into the design of the outdoor grounding system, however TIA 607C contains information of outdoor grounding in it's APPENDIX.

The design philosophy for outdoor grounding for sites with any power system will be the same. There are 3 options provided depending of the amount of land available to install the grounding system.

OPTION 1 – GROUND RING. PREFERRED OPTION

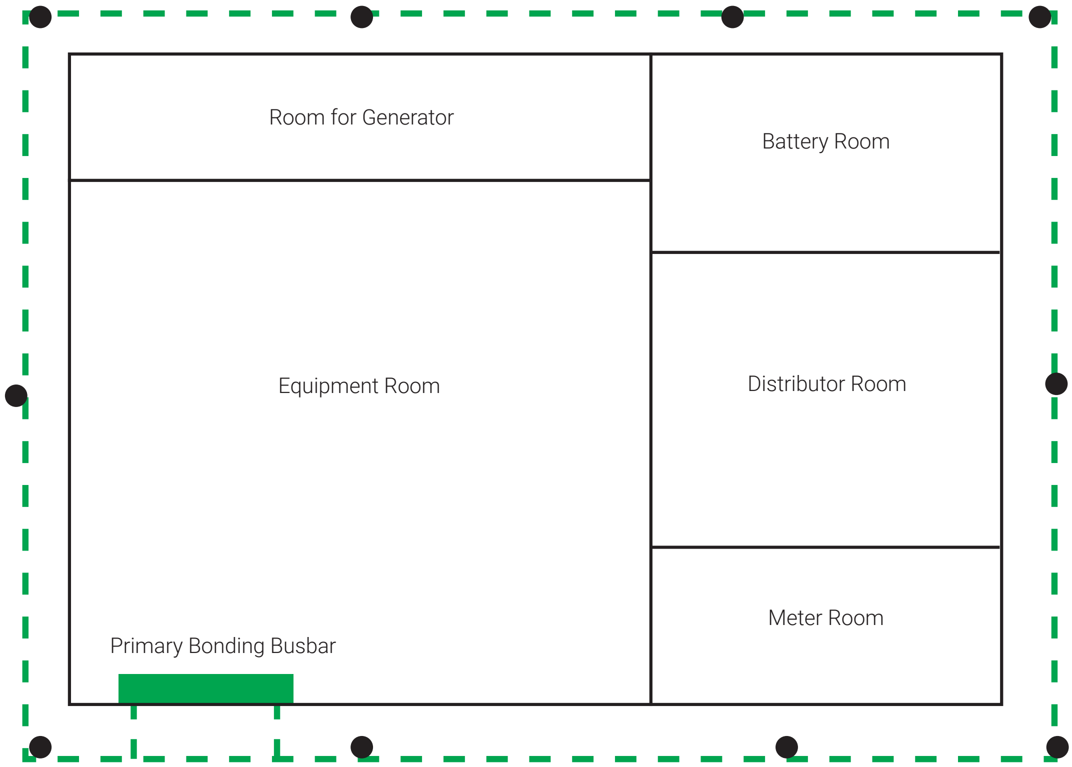
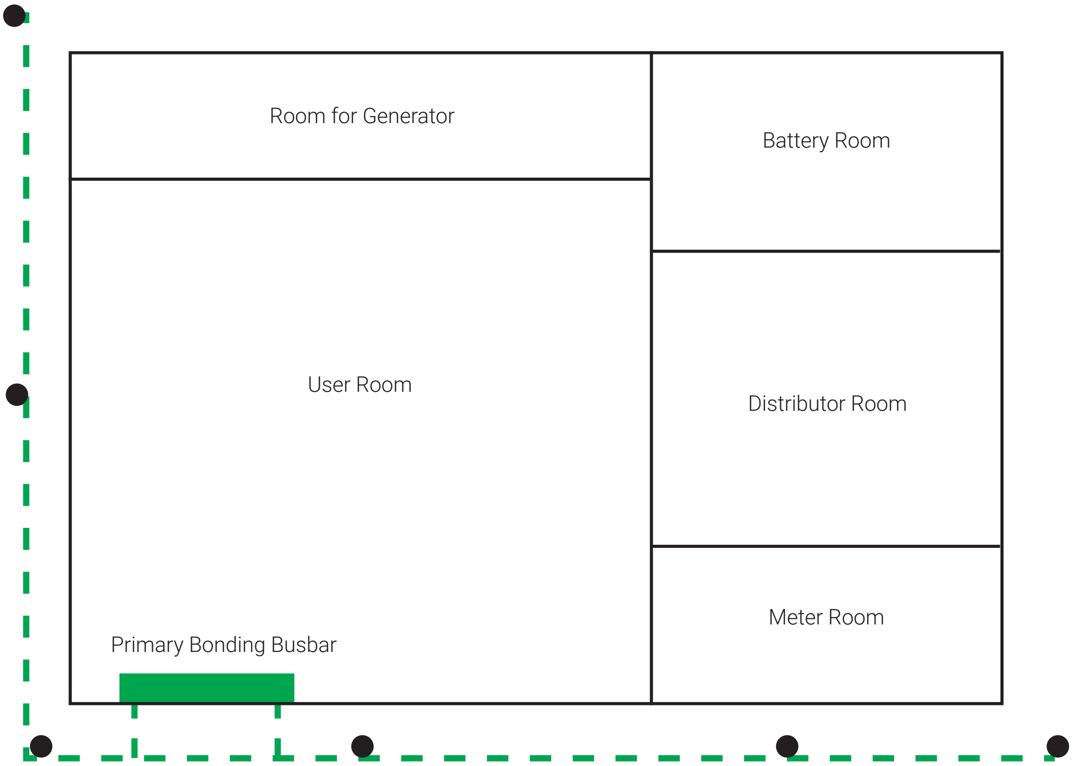


Figure12: Ground Electrode Using Ring

Outdoor Grounding Arrangement

OPTION 2 – LINEAR EARTHING (WHERE AVAILABLE LAND IS LIMITED)

This method can be used when land around the building is not available for installing a ring earth electrode



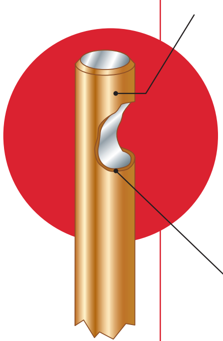
GEM25A

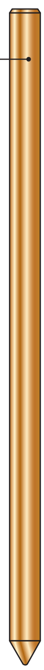
Copper-Bonded Ground Rod

- **Cost-effective long service life**

Copper-bonded coating:

- Permanent molecular bond
- Low resistance performance
- High fault current capacity (IEEE® Std 80)
  - Will not slip or tear when driven
  - Will not crack if rod is bent
  - Copper coating may vary to meet required standards
  - 10 mil (254 micron) minimum coating on rods listed to UL®467





Carbon steel core and tip*:

- Greater tensile strength
- Deep driving capability

Figure 13: Ground Electrode Linear Electrodes

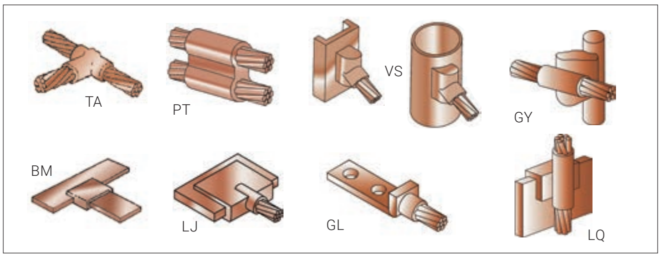
● Ground Rod, ERICO Copper Bonded Steel, Minimum Depth 5/8" x 8 ft (15 mm x 2400 mm)

– – Horizontal Conductor, #2AWG Solid Copper, 50-70 mm² bare copper, 25 x 3 mm Copper Tape or nVent ERICO Copper Bonded Steel Conductor, dia. 10 mm, CBSC10, 18" (500 mm) below ground.

Minimum ground rod spacing > 1-2 x ground length.

There shall be only one connection between the indoor and outdoor earthhing system. This connection shall be between the earth ring and the Primary Bonding Bar, PBB.

All underground Connections shall be Exothermically Cadwelded.



Outdoor Grounding Arrangement

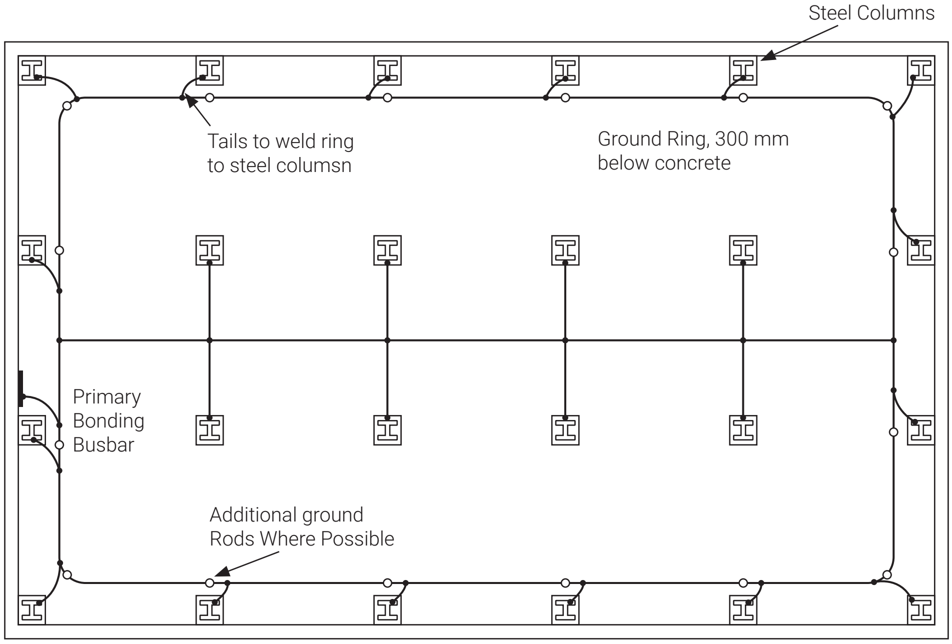
OPTION 3 – STEEL COLUMNS, WHERE NO LAND IS AVAILABLE

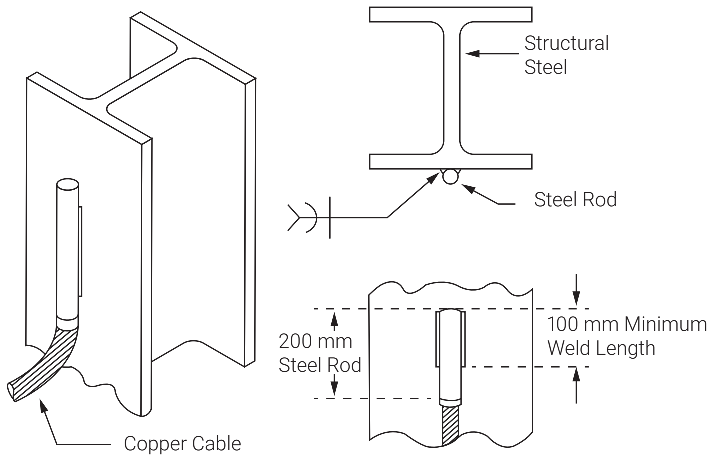
There may be situations where the data centre is installed at an existing or a new building where there is no land available for the installation of the grounding system.

In these applications the steel in the footing of columns may be used as part of the ground electrode system.

A ring (#2AWG Solid Copper, 50-70 mm^2 copper of nVent ERICO Copper Bonded Steel, 10 mm) shall be run in a ring formation internal to the columns, possible in the basement of the building. Short tails shall be welded between this conductor and column steel.

Additional columns in the middle of the basement shall be picked up as part of the earth electrode system, where practical.





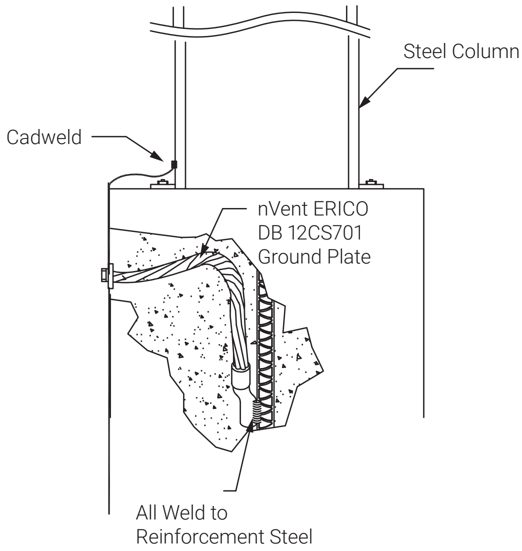


Figure 14: Ground Electrode- Building with Basement

Surge Protection

The surge protection scheme will vary around the world but the two main approaches available will be that described in IEC62305-4 and IEEE Trilogy C62.4.1, C62.4.2 and C62.45.

Voltage transients or surges can couple on to power lines due to lightning strikes near power lines or other power system disturbances like switching. Lightning can couple to power lines via a direct strike to the power line, or capacitive and magnetic coupling from nearby strikes. In addition to IEC and IEEE standards above UL1449-Edition 4 defines the "requirements cover Surge Protective Devices (SPDs) designed for repeated limiting of transient voltage surges" and is standard for safety testing of SPD's.

In this section of the paper we will briefly discuss the operation of SPD's, some common topologies & some key performance criteria for the selection of SPD's.

OPERATION OF SURGE PROTECTIVE DEVICES

The most common topology for a SPD is the shunt connection. There are various types of SPD's including Metal Oxide Varistors or MOVS, Silicone Avalance Diodes or SADs, Gas Arrestors, Spark Gaps. No one device type is not superior to other device types. It is more the case, that all of these have advantages and disadvantages and they need to be chosen correctly for the application.

In a shunt application a SPD is installed between the phase and the neutral and between neutral and earth. SPD's are normally open circuit but turn on, when a higher voltage is applied across the terminals during a transient or a surge. They momentarily create a short circuit to ground to allow the surge energy to divert to the ground instead of going to the load. In doing this the SPD also limits the voltage seen by the load.

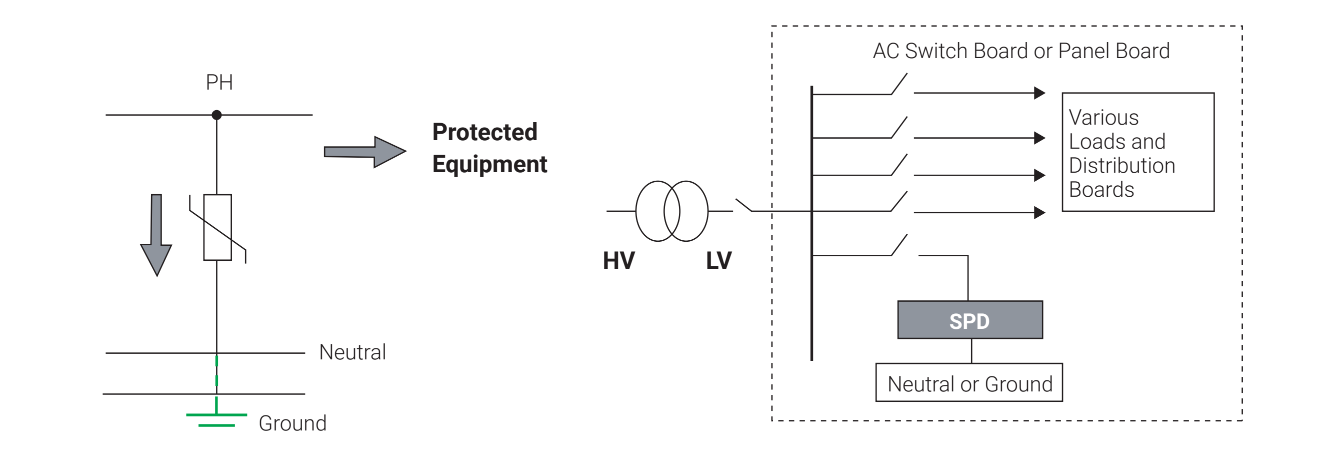


Figure 15: Surge Protection Device Location

Examples of AC Surge Protection Devices

TDX100M 3 phase Imax = 100kA
Typical Application:
Main Switch Board
Modular Data Center

TDX200M 3 phase Imax = 100kA
Typical Application:
Main Switch Board
Modular Data Center

TDX50C 3 & 1 phase
Imax = 50kA
Typical Application:
Distribution Boards
Modular Data Center

TDX100C 3 and 1 phase
Imax = 50kA
Typical Application:
Distribution Boards
Modular Data Center

DT1M – 3 Phase & 1 phase
Iimp = 25kA
Typical Application: Main Switch Board, Modular Data Center

DT2 – 3 Phase and 1 Phase
Imax = 50 kA
Typical Application: Distribution boards

Figure 16: Typical nVent Surge Protection Products for Data Centers

Surge Protection

SURGE REDUCTION FILTERS

Lightning surges and other power system transients are very fast (durations of few tens of microseconds) and can have very high amplitudes (many thousands of volts). Therefore to be effective, SPD's need to switch on quickly and handle large amounts of energy in a short time. Normally, upstream circuit breakers or fuses do not even get time to trip in the event of the SPD activating because of the reaction time of CB's and fuses is much slower. Figure 15 below shows a SPD connected in a shunt configuration between a phase & neutral. Depending on the power system, this connection may be between phase and ground and sometimes between ground and neutral.

A useful and extremely effective but less common topology, for an SPD is series connected incorporating a low pass filter.

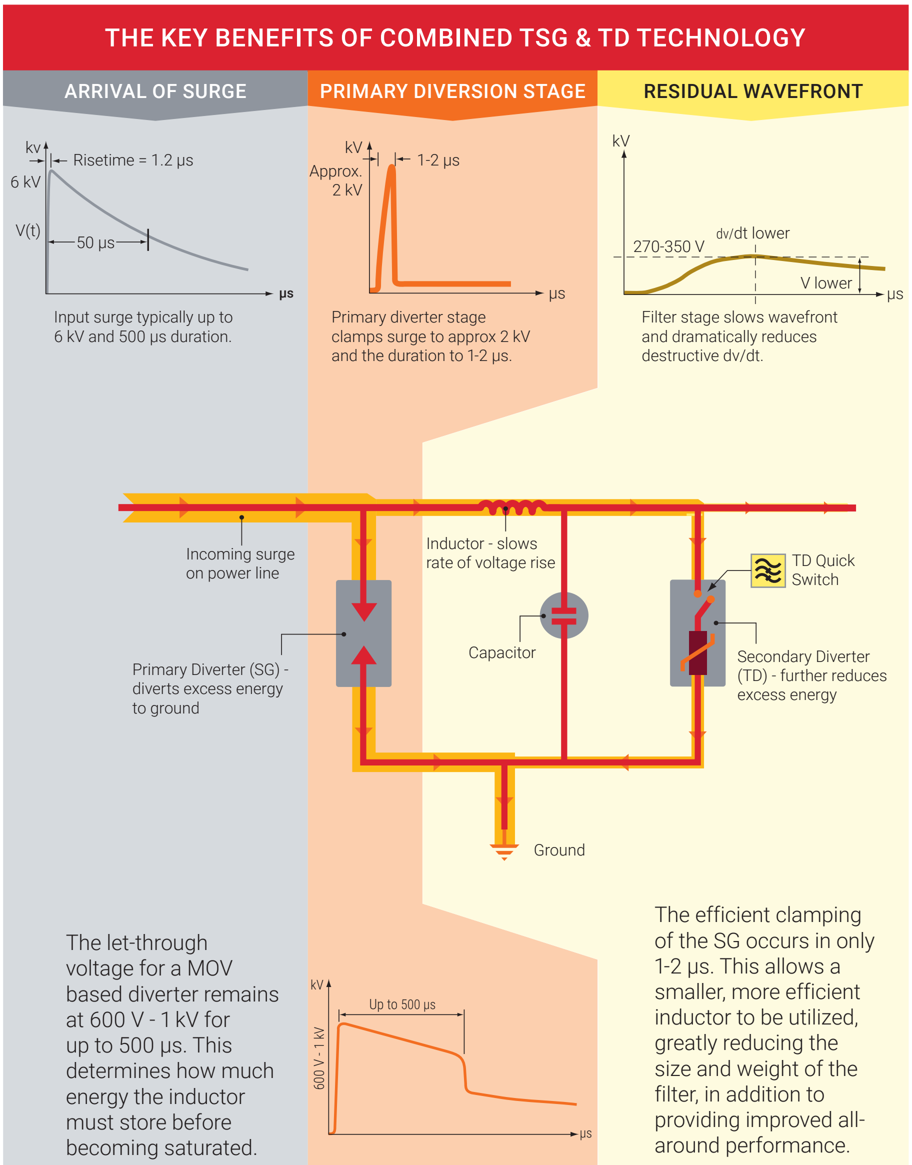


Figure 16: Operation of a Surge Reduction Filter, SRF

Surge Protection

Generally series connected SPD have the ability to produce lower voltages at the output. Series connected SPD, that have a low pass filter suitable for filtering lightning frequencies can in addition product lower voltage rise time or dv/dt and ever lower output voltages. Hence their performance is often superior to shunt connected SPD,s. Series connected devices inevitably have an inductor which is load current dependent which is one reason these are not used on a widespread basis. Generally series connected SPD's with low pass filtering are suitable to for mission critical applications or in high lightning event zones of the world. Figure 15 shows the typical operation of a series connected SPD with low pass filtering, normally referred to as Surge Reduction Filters or SRF

The construction of the nVent ERICO srf n-series true INDUCTOR-CAPACITOR (lc filter)

In order to provide the excellent filtering performance, the filters are constructed with separate inductor and capacitor elements

Figure 17: Example of a Surge Reduction Filter, SRF

KEY PERFORMANCE PARAMETERS OF A SPD

There are various performance measurements that are written down in the specification sheets or nameplates of SPD's. This section will discuss and explain the some of the key performance yardsticks that one can use, in making the appropriate selection of SPD's. Some of these are detailed in the IEC, IEEE and UL standards referred to in this paper.

These are:

- Maximum Discharge Current, or Imax
- Nominal Discharge Current or In
- Maximum Impulse Current, or Iimp
- Voltage Protection Level, or Up or Vp
- Maximum Continuous Operating Voltage, or Uc
- Temporary Overvoltage, TOV

Maximum Discharge Current, or Imax - The Imax gives an indication of the amount of surge energy the SPDwill be able to handle without getting damaged. The Imax, is often equated to maximum single shot current, the SPD can handle. Recent standards have focused rating more on the next two rating values than on Imax.

Nominal Discharge Current or In - In is an indication of the nominal current that the device will need to conduct in its lifetime. The IEC standards require SPD's tested for common power system applications or Class II applications, to withstand 15 impulses at In followed by 10%, 25%, 50%, 75% and 100% of Imax followed by another In. Cooling between the application of the test wave-shapes is allowed in accordance with IEC61643 Standards.

Maximum Impulse Current, Iimp - Iimp rating is called upon in IEC standards for what it calls Class I devices. Iimp is similar to Imax but the testing occurs using the 10/350μs test waveshape. This wave shape has a larger area under the curve and hence a lot more energy. A device with a certain Imax rating will have a lot lower Iimp rating. This rating, Iimp shape is not used in IEEE and UL standards.

Surge Protection

Voltage Protection Level, Vpr or Up - The Up characterizes the performance of a SPD in limiting the voltage. The Up indicates how well the SPD, clamps an applied surge and hence a SPD with a lower Up, is a better device in terms of limiting the voltage across an equipment. Under IEC standard Up is measure with current In applied. IEEE and UL standards have a Vpr rating which is similar to Up, however when Vpr is tested, the applied current in 3kA instead of the declared In.

Maximum Continuous Operating Voltage, or Uc - SPD's are voltage-limiting devices and it is important to select a SPD that will not attempt to clamp slight over voltages at 50-60 Hz. Uc is a guide to the continuous operating voltage that the SPD will work at without clamping. If the SPD attempts to clamps the voltage continuously, then this can either result in damage to the SPD.

Temporary Overvoltage. TOV – For 230-340V SPD's IEC standards required the SPD device to be subjected to 442V for a period of 2 hours. The SPD must either fail safely at this voltage or withstand the voltage and continue operating.

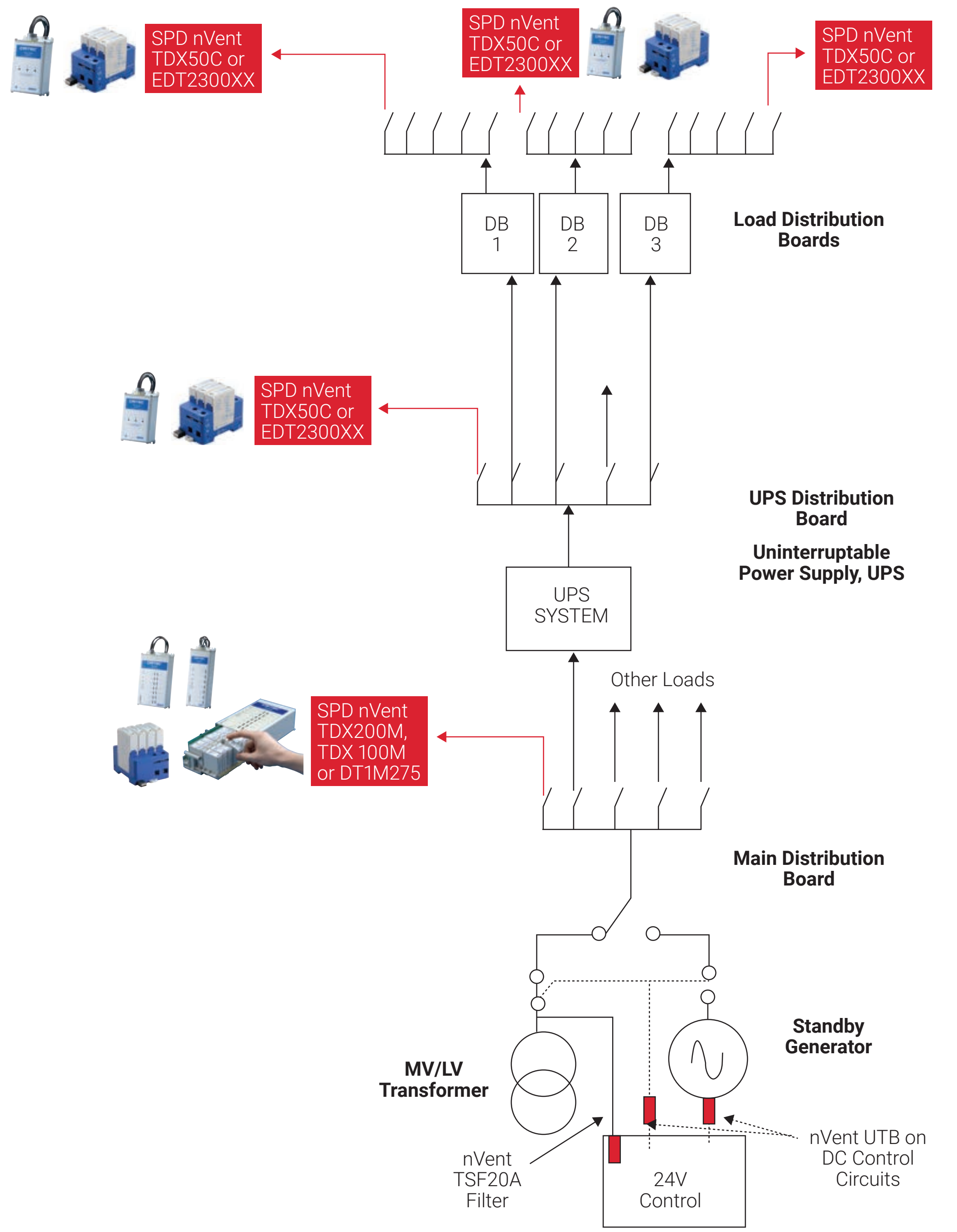


Figure 18: Surge Protection Scheme at a Data Center - Line Diagram

Surge Protection

TYPICAL SCHEME OF SURGE PROTECTION AT A DATA CENTER

The surge protection scheme shown in Figure 18 is a typical scheme which would fit most standards globally. It follows the principle of point of entry protection at the main switchboard and secondary protection at each downstream distribution boards. Protection should also be provided on generator controls on AC input and DC control side. As an alternative to this scheme Surge Reduction Filters or SRF can be installed on load distribution boards to provide ultimate protection at critical sites,

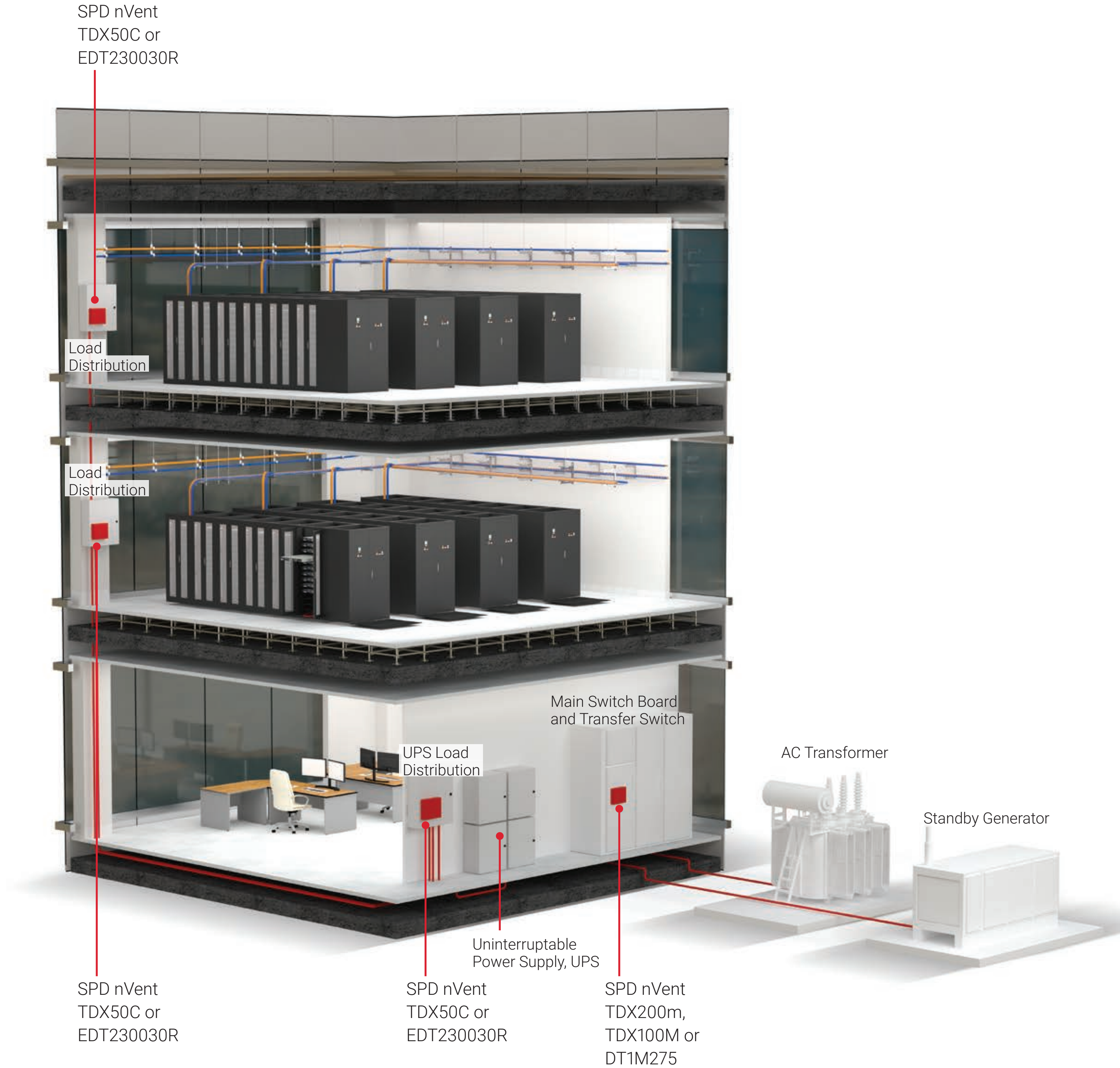


Figure 19: Surge Protection Scheme at Data Center

Lightning Protection

If the datacenter is a standalone building a direct strike lightning protection system, LPS will inevitably be required for the facility. If the Datacenter is part of an existing high rise building of adequate height a lightning protection system for the building may already be installed.

There are two type of lightning protection that can be provided

SYSTEM 2000

System 2000 is a nVent brand name for what is referred to in the industry as conventional lightning protection. These are covered by IEC62305 standard and NFPA780 standard in USA. In addition to these many countries have their own lightning protection standard.

These system will consist of air termination network, a down-conductor network, a ground electrode system, comprehensive bonding system and surge protection system.

Typical materials used for the air termination and down-conductor network are copper, tinned copper, aluminum and copper bonded steel. The conductors may be tape, or solid or stranded cables.

The preferred grounding system is either copper or copper bonded steel, aluminum or a combination of these as this provides a long life expectancy of 40 years which is required for such installations. Galvanized steel based grounding system may be justified in other applications but not recommended for data centers

This Illustration is not drawn to scale, nor does it portray an actual or typical application. It is designed to illustrate some of the major components of the nVent ERICO System 2000 Lightning Protection System and their relationship with one another.

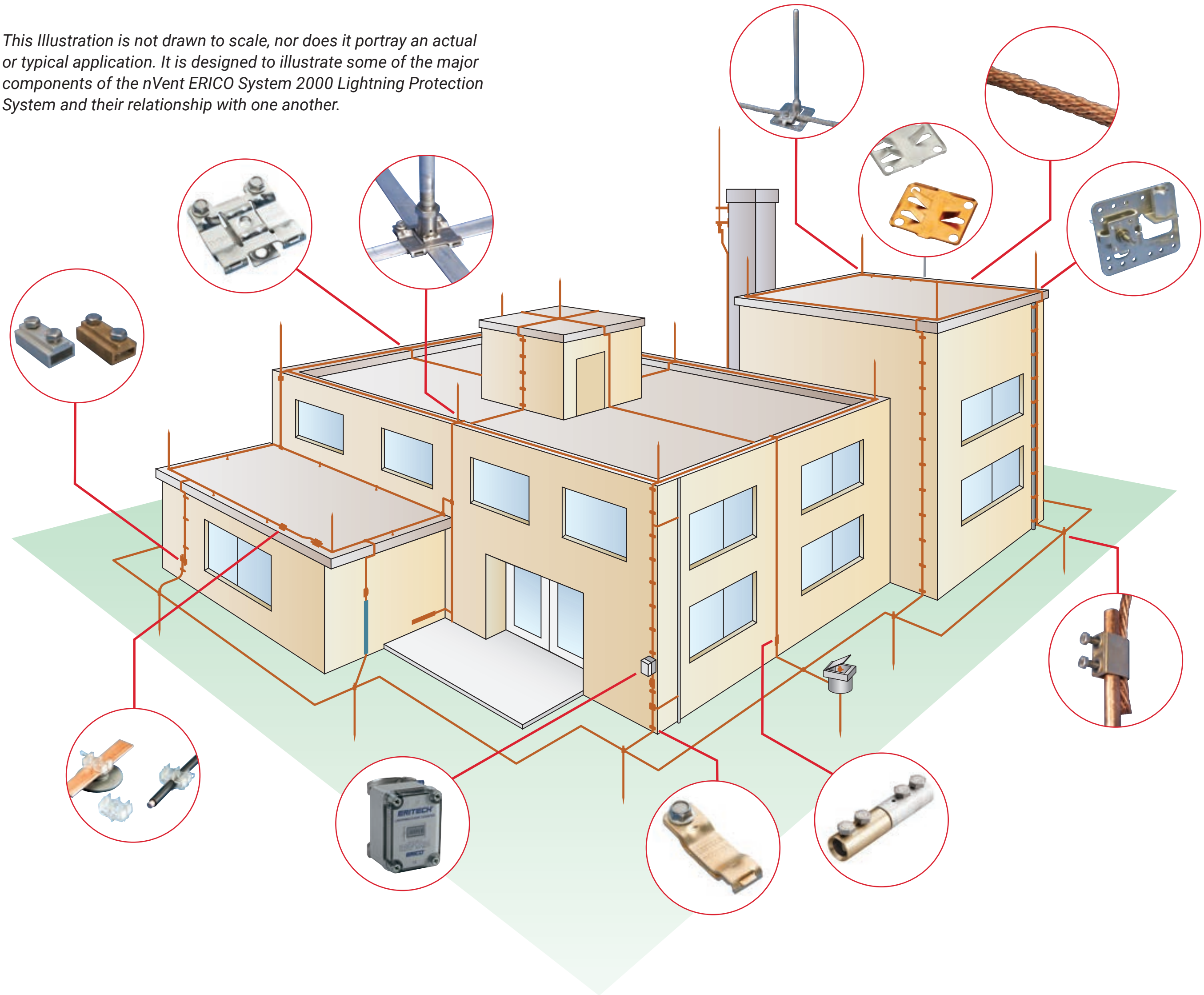


Figure 20: nVent ERICO System 2000 or Conventional Lightning Protection System

Lightning Protection

SYSTEM 3000

nVent ERICO System is an advanced lightning protection system that ensures that the lightning energy is contained withing the capture air terminal and the downconductor system of the LPS. This avoid lightning current flowing within building structure. This feature make the nVent System 3000 and attractive option for stand alone data centers.

The System 3000 is a technically advanced lightning protection system.
The unique features of this system allow the achievement of reliable lightning capture and control.

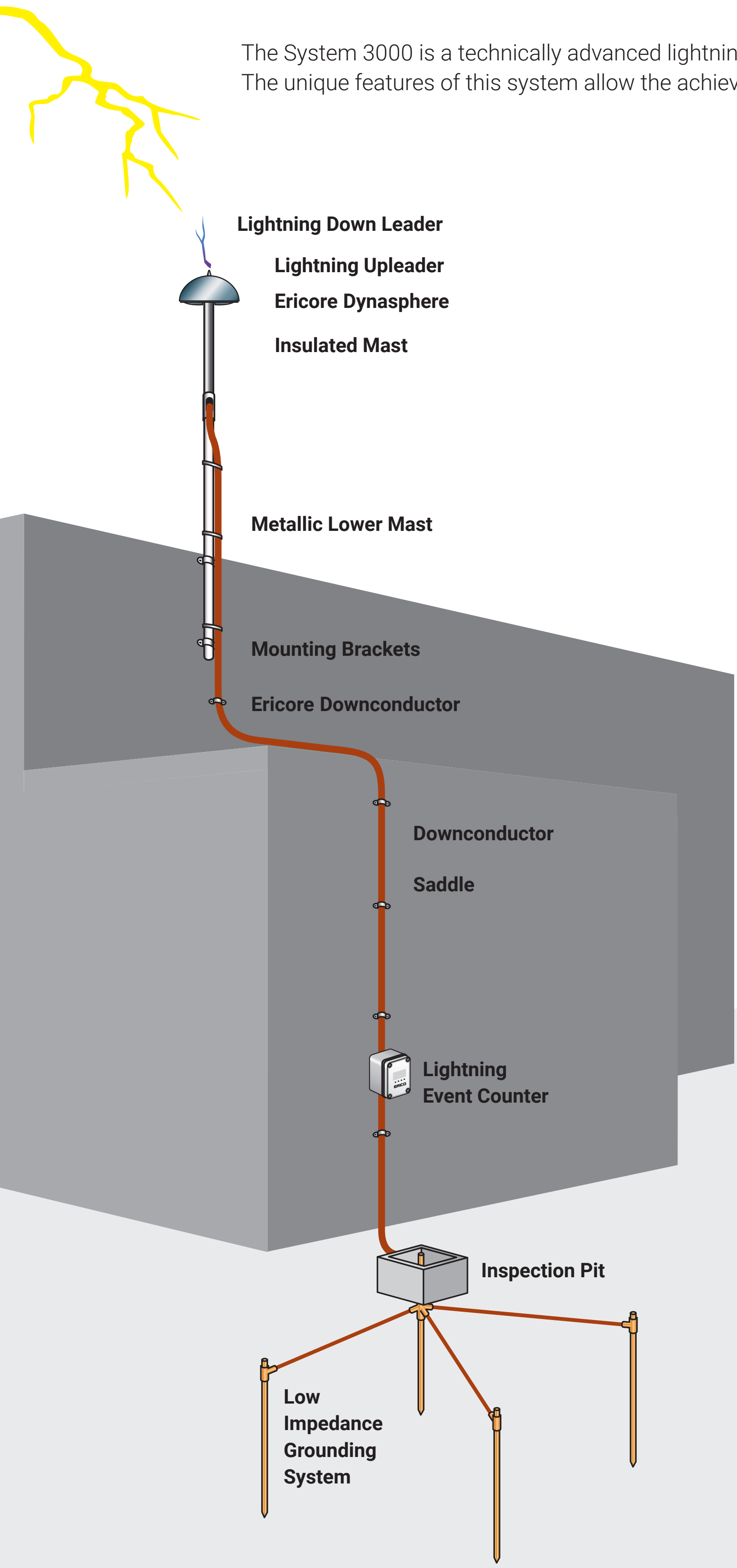


Figure 21: nVent ERICO System 3000 Lightning Protection System

1. Dynasphere The Air Terminal

The primary function of an air terminal, or air termination system, is to capture the lightning strike to a preferred point, so that the discharge current can be directed via the down-conductor(s) to the grounding system. The Dynasphere air terminal provides optimal lightning capture.

2. Ericore The Downconductor

The function of a downconductor is to provide a low impedance path from the air termination to the ground system so that the lightning current can be conducted to earth, without the development of excessively large voltages that could lead to flash over of the lightning energy to the structure or equipment to be protected.

A purpose designed, insulated down conductor, acts to eliminate side flashing of the lightning energy to the structure or nearby equipment ensuring its safe conduction to earth. A low impedance designed insulated down conductor ensures the lightning energy can be safely contained within the conductor over greater lengths.

3. The nVent ERICO Advantage Grounding System

The grounding system must have a low impedance to disperse the energy of the lightning strike. Because the lightning discharge consists of high frequency components, we are particularly concerned with the frequency-dependent electrical parameter of a grounding system – impedance – as well as low resistance grounding.

Grounding systems are highly variable from site to site due to geographical considerations. The grounding grid should minimize the ground voltage potential rise and minimize the risk of injury to personnel or damage to equipment.

nVent ERICO Expertise

The nVent ERICO advantage is our approach to the complete Facility Electrical Protection Solution. Well designed and high quality Surge Protection is critical to a facility equipment's reliable operation, however it is only part of the solution.

nVent ERICO therefore offers the complete range and expertise in grounding, bonding, surge and lightning protection, providing the complete solution worldwide and across applications including Commercial, Industrial, Telecom, Utility and Railway. Our service and expertise encompasses more than just the product.

PRODUCT TESTING

To effectively meet market requirements and ensure our products are designed and tested to the highest of performance standards, nVent ERICO has invested in state of the art testing equipment that is able to:

- Support application testing for clients – to ensure your equipment is adequately protected.
- Participate in the UL Client Test Data Program.
- Support competitive product testing.
- Test and evaluate to a range of mechanical, electrical and environmental requirements.

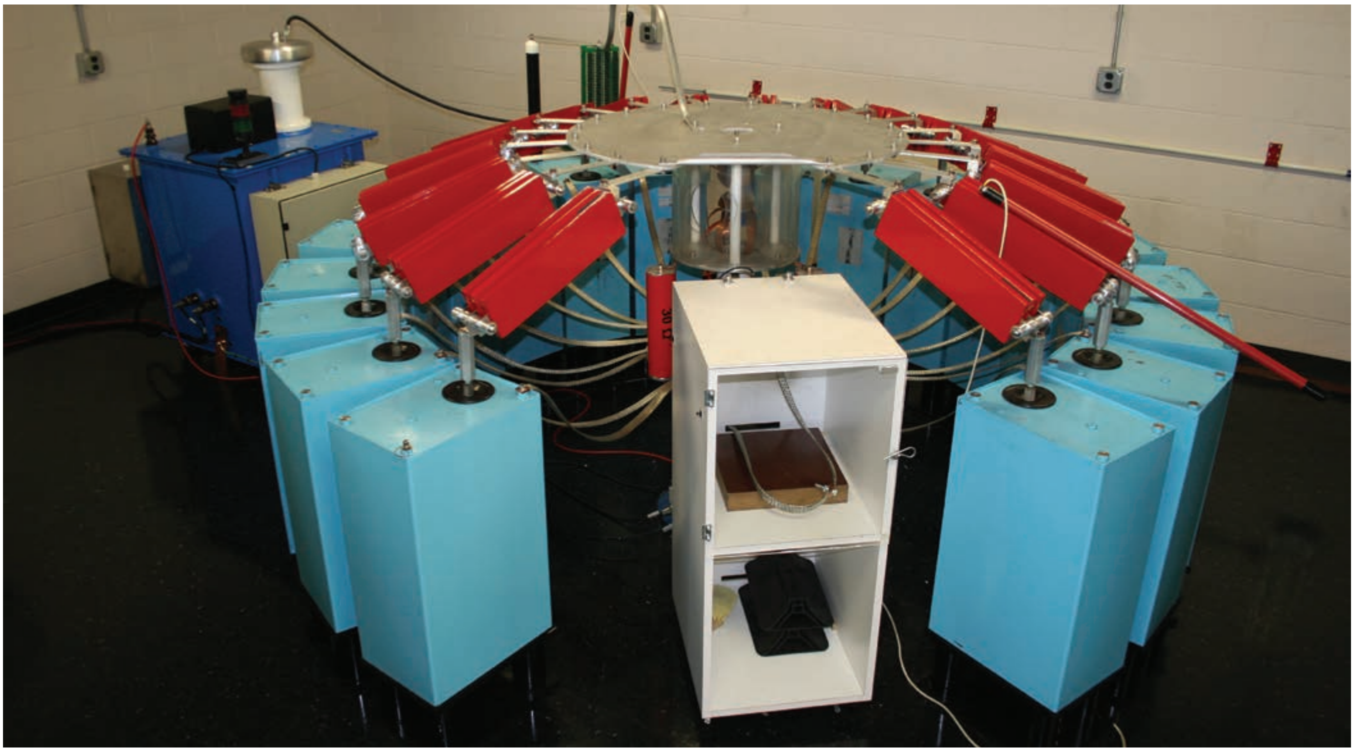
HISTORY

nVent ERICO engineers have been developing earthing & surge solutions for over 100 years. In 1903, the Electric Railway Improvement Company (ERICO®) was created to supply power bonds, signal bonds and related welding equipment to railroads, mining and street railway industries.

They are experts in designing products to achieve a variety of global certifications including, but not limited to, UL 1449 Ed. 4 and IEC 61643-11. In addition to this, nVent ERICO engineers have designed unique, innovative surge technologies like Transient Discriminating (TD) Technology and high-performance surge filters. Our engineers have developed surge products and technologies protecting a variety of industry-specific needs with some examples being: rail signaling, photovoltaics, telecommunications, LED lighting, and wind turbines.

SEMINARS AND SITE AUDITS

Each year nVent ERICO conducts hundreds of seminars in numerous countries around the world, educating specifiers, engineers, and installers on Facility Electrical Protection.



nVent Training

With more than 100 years of industry experience, nVent ERICO is dedicated to providing extensive training for the specification, installation and maintenance of electrical protection systems to ensure optimal performance and compliance.

nVent ERICO is an RCEP national, live instruction technical education provider, approved to issue PDHs for educational activities.

nVent ERICO Telecommunications Training Courses teaches participants about the theoretical and practical understanding of telecommunications protection designs and best practices for grounding, bonding, surge and lightning protection. Taking a holistic approach to grounding, bonding, surge and lightning protection designs is critical to ensure a complete electrical protection system for a telecommunications facility.

Course Reference	Course Title	Course Description	Course Length
TEL-001	**Telecommunication Network Architecture and Trends in Site Deployment**	This course reviews typical telecommunication architecture, including 3G, 4G and 5G cellular radio networks and fixed and transport networks, including fiber and cable networks. We also look at trends in the telecommunication industry including deployment of street mounted equipment, densification and applications modern telecom networks will facilitate.	1 hr
TEL-002	**nVent ERICO Six Point Plan of Protection**	In this course, we will review the nVent ERICO Six Point Plan of Protection: a holistic approach to protecting of facilities, consisting of direct lightning strike protection, grounding, bonding and surge protection.	1 hr
TEL-003	**Indoor Grounding System Design at a Telecommunications Facility – Codes and Carrier Standards**	In this course, we look at the methods of indoor grounding including Star-IBN, Mesh-IBN and Mesh-BN. We will look at codes, standards and carrier practices for the best indoor grounding system design. Using case studies we will demonstrate the benefit of Star-IBN system in telecommunications facilities.	1 hr
TEL-004	**Outdoor Grounding System Design for Telecommunications**	In this course, we will look at the typical layout of the outdoor grounding system at a telecommunication site, as well as the codes, standards and carrier practices of best outdoor grounding system design.	1 hr
TEL-005	**Outdoor Grounding System Electrode Design for Telecommunications**	In this course, we will look at the sheath theory of grounding and how this impacts the design for deep driven, horizontal and multiple electrodes. We will look at methods for testing and measuring soil resistivity and ground resistance. We will learn how to calculate resistance of single and multiple vertical ground electrodes using manual calculations and nomograms.	1 hr
TEL-006	**Grounding Components for Outdoor Grounding Systems**	The selection of grounding materials is critical and can impact the performance and longevity of the grounding system over its expected service life. In this course, we will look at the available options for grounding materials and how to choose the best options when constructing a grounding system for telecommunications facilities.	1 hr
TEL-007	**Ground Enhancement Materials for Telecommunications**	Achieving the target ground resistance in difficult soil conditions is challenging. In this course, we will look at methods for improving ground resistance using ground enhancement materials and other design techniques.	1 hr
TEL-008	**AC Surge Protection Fundamentals for Telecommunications**	In this course, we look at the fundamentals of surge protection including the purpose of proper surge protection, available devices and components and the advantages and disadvantages of each options. We will look at a few installation tips and cover applicable standards, including both IEC and UL standards.	1 hr
TEL-009	**AC Surge Protection Applications for Telecommunications**	In this course, we will examine the line of nVent ERICO surge protective devices including nVent ERICO TDX, DT and EDT series of products. In particular, we look at nVent ERICO Transient Discriminating (TD) Technology and other features and benefits, including high temporary overvoltage withstand in telecommunication applications.	1 hr
TEL-010	**Surge Reduction Filters for Telecommunications**	Surge reduction filters are the premium surge protection option that provides significantly lower let-through voltages and voltage rise times when compared to other, more common, types of surge protective devices (SPDs) wired in shunt. In this course, we will look at the operation and performance of the surge reduction filter in telecommunication applications.	1 hr
TEL-011	**DC Surge Protection for Remote Radio Units**	DC power feed to remote radio heads has recently become a common and well established method of powering radio systems. In the case of a direct lightning strike to the tower, surges can enter the DC feeds via magnetic and inductive effects. This course, will look at proper protection design for DC power systems from these events. We will investigate the best location to mount DC surge protective devices and look at typical design examples.	1 hr
TEL-012	**Isolated Lightning Protection Systems for Telecommunications**	In this course, we will look at isolated lightning protection using nVent ERICO ISOnV and nVent ERICO ISODC systems. We will look at practical examples of nVent ERICO System 3000 lightning protection system and conventional lightning protection systems for common telecommunication structures.	1 hr
TEL-013	**Theft Deterrent Telecommunications Grounding**	Copper theft in telecommunication grounding systems has become a common occurrence across the industry. In this course, we will look at nVent ERICO Cu-Bond Composite systems and nVent ERICO Cu-Bond Solid systems for telecommunication grounding. We will also review a case study and examples of how these systems have been implemented in the USA, Australia and Indonesia.	1 hr
TEL-014	**ITU Standards Relevant to Telecommunication Grounding and Protection**	In this course, we will look at the set of K series of the ITU standards that are relevant to grounding, bonding and protection of telecommunication facilities. We will discuss key design recommendations based on these standards.	1 hr

nVent Training

Course Reference	Course Title	Course Description	Course Length
TEL-015	**nVent ERICO Cadweld 101: How to Select**	In this course we will look at the selection of nVent ERICO CADWELD molds for telecommunications and data center applications and review common Cadweld accessories	1 hr
TEL-016	**nVent ERICO Cadweld 101: Inspection Guide**	In this course we will look at inspection of nVent ERICO CADWELD connections	1 hr
TEL-017	**nVent ERICO Cadweld 101: How to Install nVent ERICO Cadweld**	In this course, we will review the steps involved in preparing to make an nVent ERICO Cadweld connection, carrying out the installation and proper care for molds and tools.	1 hr
TEL-018	**Case Study: Application of Surge Protection Devices in Telecommunication Sites**	In this case study course, we will look at ten examples of nVent ERICO surge protective devices, specific to different customer applications.	1 hr
TEL-019	**Case Study: How 2 Ohms Resistance Was Achieved at a Central Office Site**	In this case study course, we will look at how a grounding system with a resistance of less than 2 ohms was designed, calculated, installed and measured at a new mobile switching center (MSC) and a central office (CO) with the help of nVent ERICO.	1 hr
TEL-020	**nVent ERICO System 2000 and 3000 for Buildings**	This course looks at protection of common structures with conventional lightning protection systems and isolated lightning protection systems.	1 hr
TEL-021	**Grounding Requirements and Methods for Armored Optical Fiber**	In this course, participants will learn the technical and codes requirements for grounding of armored fiber optic cable. Questions still surround the need to ground metallic screen or armored fiber cable in the industry in the USA and globally, especially when the practices for doing so seem to be based around copper cable grounding.	1 hr
TEL-022	**Powering and Grounding Challenges in Deployment of 5G Small Cells**	In this course, participants will learn about the considerations for powering and grounding of 5G small cells. Many operators are already planning hyperdense 4G networks and they expect the trend to intensify with the migration to 5G. The attractiveness of this technology from a data network availability point of view is obvious. However, considerations for powering and grounding of these small cells continue to be a challenge for the industry.	1 hr
TEL-023	**Case Studies of Successful Installation of nVent ERICO Products in Telecommunications**	In this case study course, we will look at where nVent ERICO products have been successfully installed around the world. Installation examples will include the USA, Mexico, Africa, Asia and Australia.	1 hr
TEL-024	**Grounding and Protection of AC and HVDC Powered Datacenters**	In this course, we will examine the design of indoor grounding systems at datacenters that need to comply with TIA607C, IEC30129 and other relevant standards. We will also consider options for outdoor grounding system and AC surge protection of critical power systems supplying datacenters.	1 hr

References

1. ETSI EN 300 253 “Environmental Engineering (EE); Earthing and Bonding Configuration Inside Telecommunications Centres”
2. ITU K27 Protection Against Interference - Bonding Configurations and Earthing Inside a Telecommunications Building.
3. Telcordia Generic Requirements GR 295 is Titled “Mesh and Isolated Bonding Networks
4. IEEE Emerald Book IEEE Recommended Practice for Powering and Grounding Electronic Equipment”
5. Motorola R56, Standards and guidelines for Communications Sites
6. Rohit Narayan Method for the Design of Lightning Protection, Noise Control And Grounding System at a Telecom Facility INTELEC 2014,Copyright IEEE
7. STANDARD TIA 607 B/C B/C Generic Telecommunications Bonding and Grounding (Earthing) for Customer Premises
8. Standard NECA/BICSI 607 2011 Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings
9. AT&T: ATT-TP-76416 Grounding and Bonding Requirements for Network Facilities
10. IEC & AS 30129 Information technology — Telecommunications bonding networks for buildings and other structure
11. Rohit Narayan, Mesh Bonded vs Isolated Bonded Earthing Network for Indoor Grounding, INTELEC 2017,Copyright IEEE
12. IEC 62305-4:2010 Protection against lightning - Part 4: Electrical and electronic systems within structures IEEE
13. UL1449-Edition 4 Surge Protective Devices
14. NFPA780 Standard for the Installation of Lightning Protection System
15. IEEE C62.41.1 IEEE Guide on the Surge Environment on Low-Voltage AC Power Circuits
16. IEEE C62.41.2, “Recommended Practice on characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits”
17. IEEE C62.45, “Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits”

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