2022 PEG Webinar Series - Session 1: Practical Bonding Practices

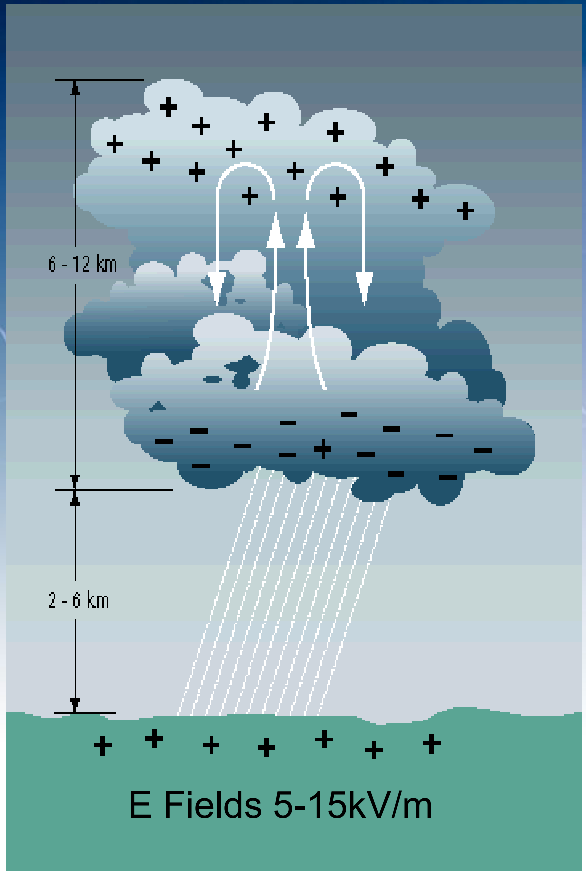
Rohit Narayan

Learning Objectives

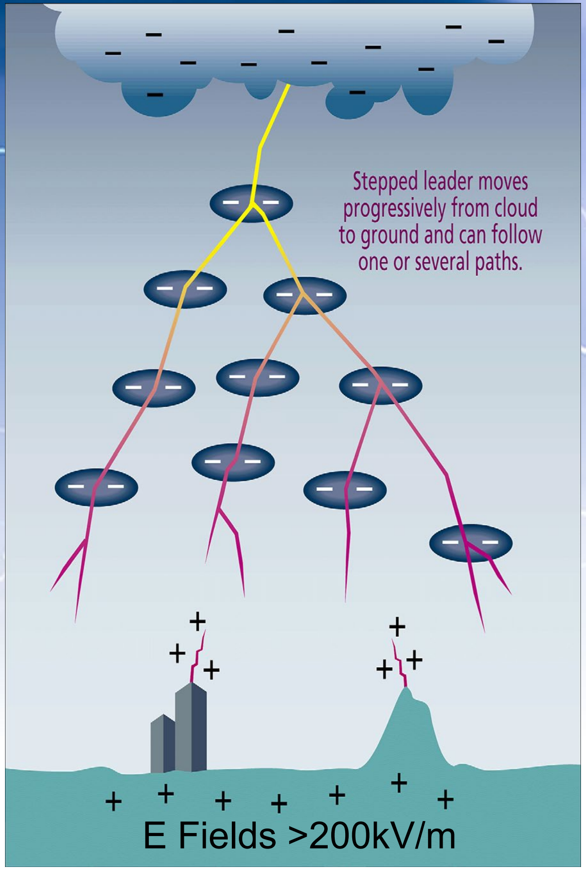
Learning objectives for this training:

- An understanding of how lightning can enter feeders on towers
- Risks of Lightning Damage
- Methods of Tower Bonding as per Industry Practices. Motorola R56, AT&T, Verizon and K.56 Standards
- Methods of practical bonding of equipment on tower

Storm Cloud Electric Fields



Cloud electrification – charge particle separation, quasi static E Field est. between cloud & ground

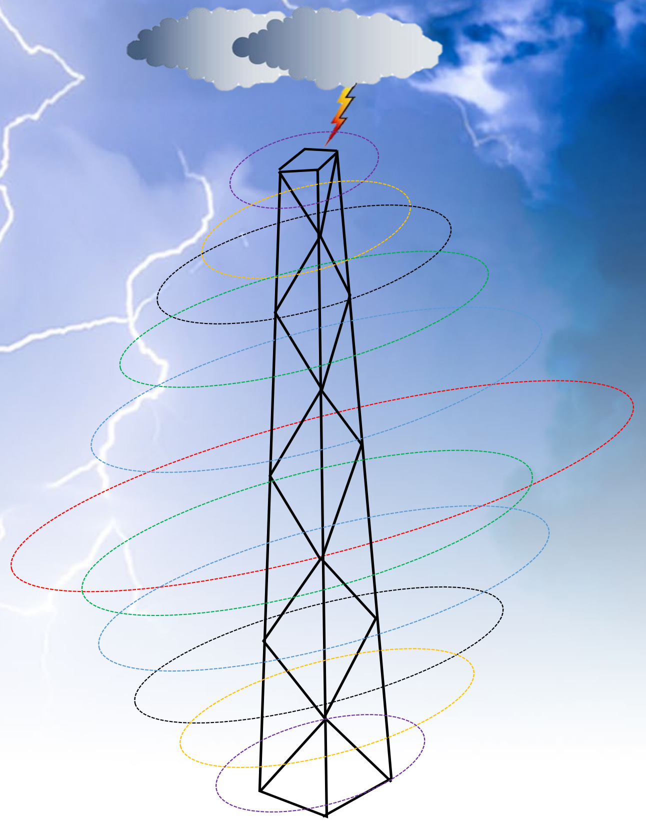


Down-leader approaches, E Field increases to point of initiation of upward streamers

Upward leader propagates toward down leader to complete ionised path between cloud & ground

How Lightning Enters Feeders on Towers – Magnetic Fields

- When the lightning current travels down the body of the tower or via and dedicated down-conductors a rapid rise and fall of magnetic field occurs around the tower. This field moves in intensity from the top of the tower to the bottom. It is well understood that when wires or electrical equipment are placed in rapidly changing magnetic fields, this causes electrical currents to flow.
- In the case of a telecommunications tower, these electrical currents take the form of surge currents in telecommunications and power feeders.
- As it is a common practice to have radio feeders, power of ethernet and ethernet cable and power cables screened, a large portion of this current flows in the screens of this feeders.

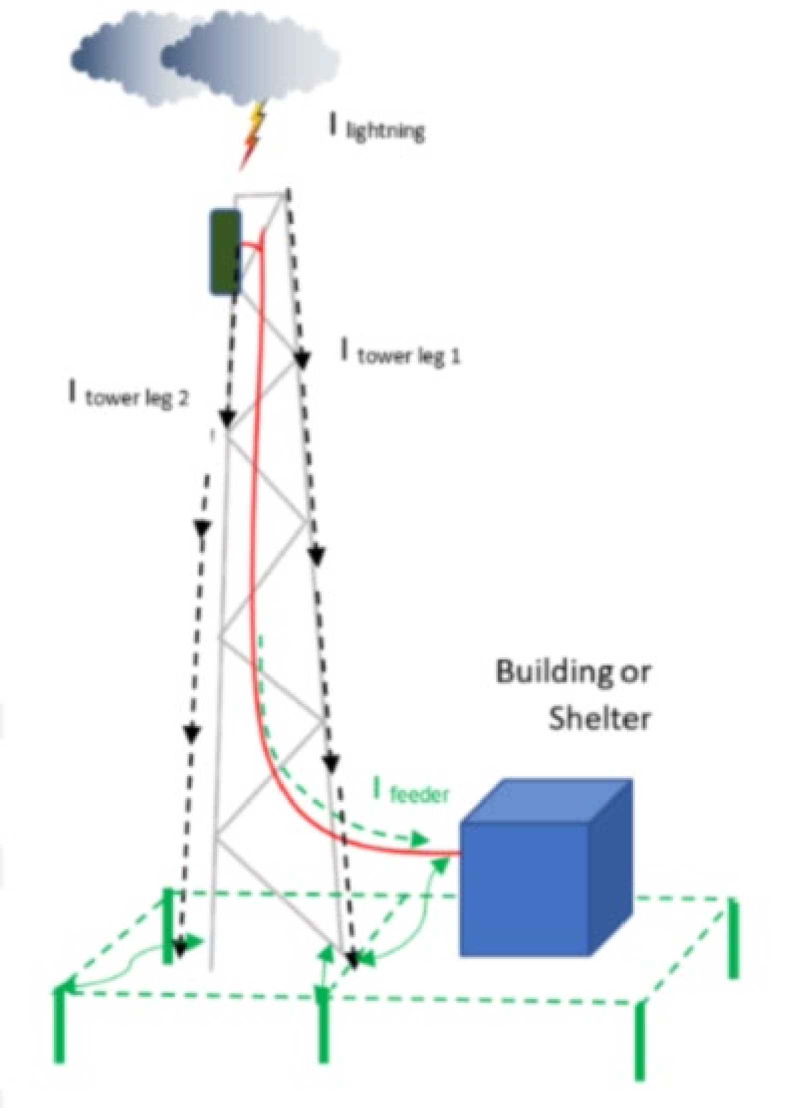


Magnetic Field on a Tower During at one moment during a lightning conduction

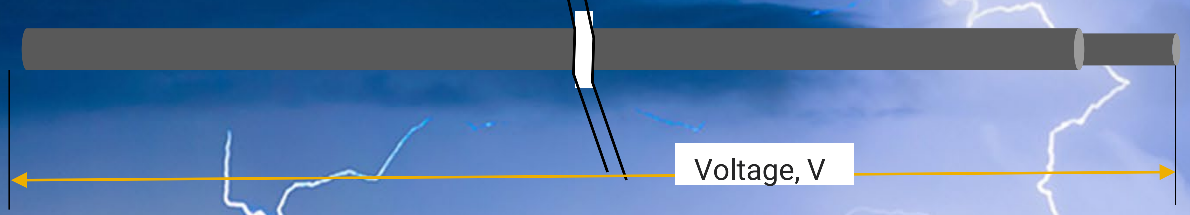
- Magnetic Field Cause Currents to Enter Feeders

How Lightning Enters Feeders on Towers – Shared Paths

- Consider a telecommunications tower that has had a lightning strike. Ideally one would like the tower or a dedicated conductor for lightning protection to conduct all of this lightning currents.
- In reality this currents primarily flows in the tower, however shared paths of this currents happen to be the feeder trays, radio feeders, d.c. feeder and ethernet or power of ethernet cables feeders.
- The currents can enter these other feeders via a range of methods. It can enter via the feeder screens that are grounded at the top of the tower, via surge protective devices within or external to tower mounted electronics, via side flashing to exposed connection points and other electrical mechanisms.



Why is Tower Bonding Important



- Will require more complex modelling but in simple terms Voltage, V = L di/dt smaller resistive drop – capacitive effects in coax cable reduce this voltage
- di/dt is in the order of 1000V/m hence large voltage can develop over distance and expect this to be the dominant effect
- When this voltage exceeds the insulation rating damage can occur
- Bonding screen regularly over the length decreases this voltage
- Bonding decreases the currents going into the building/shelter/cabinet (currents find alternative path via screen ground to tower to the ground)
- In sites with high resistance bonding become even more important because the currents in feeders may be higher in magnitude

- Bonding Reduced Currents in Feeders

International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

K.56

(01/2010)

SERIES K: PROTECTION AGAINST INTERFERENCE

Protection of radio base stations against lightning discharges

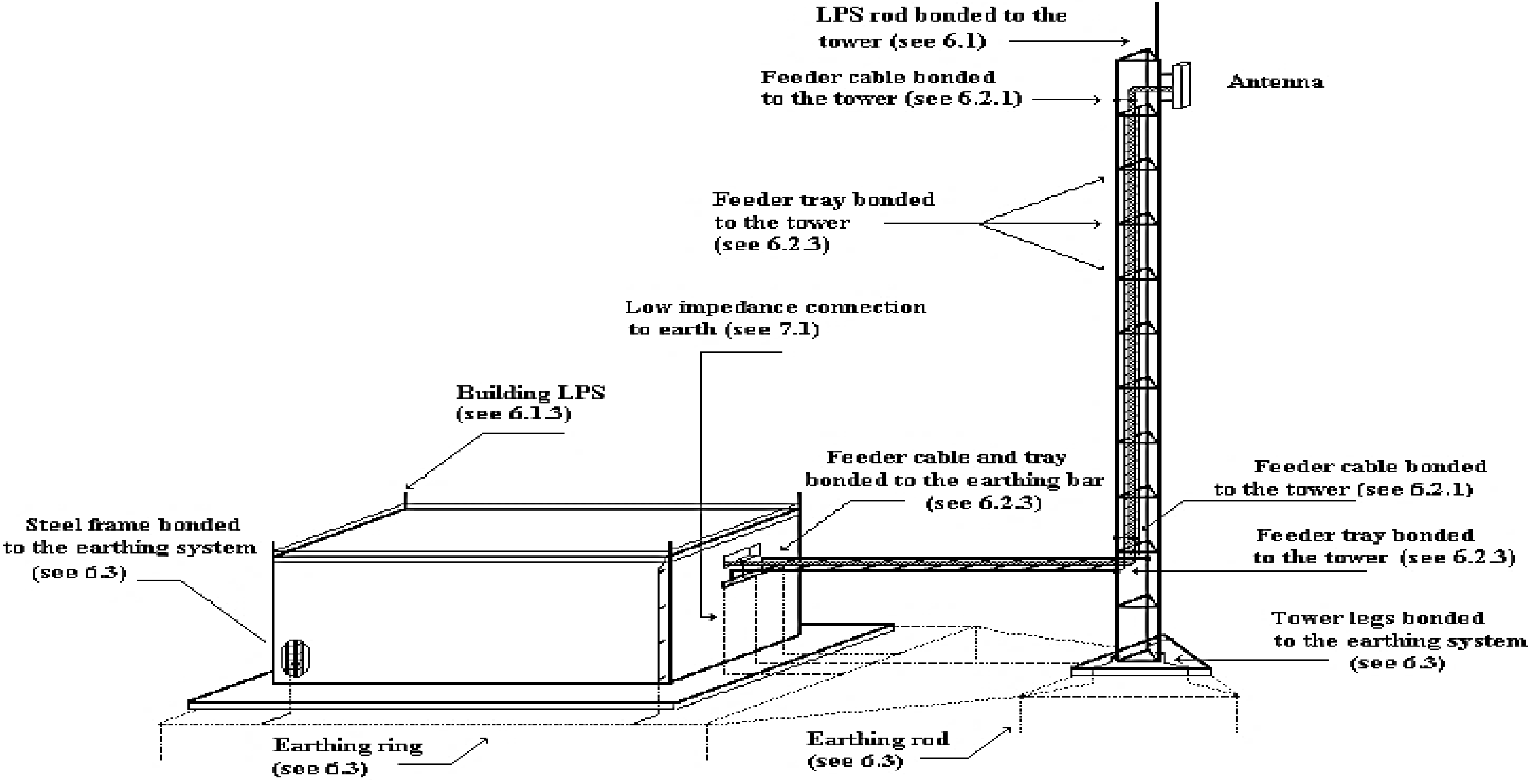


Figure 1 – General view of earthing and bonding procedures in the external area

ITU K56 APPENDIX 1 and BARBOSA PAPER

- A study referenced in ITU K.56 [5]Appendix 1 is contained in a paper, Barbosa et al. 2007 [4]. A test site with rocket-triggered lightning in Cachoeira Paulista (Brazil) was active from 2000-2007.

- This test site had the participation of several institutions with different research interests, including the protection of telecommunication installations against lightning.

- In this experiment the currents in radio feeders was measured during the incidence of a rocket triggered lightning.

- The paper concluded that when a metallic telecommunication tower is struck by lightning, most of the return stroke current flows through the tower's metallic elements (legs and cross-arms), and a fraction of the current flows through the feeder cables.

- In the experiments carried out with a standard radio base station complying with ITU-T Rec.56 about 2% of the return stroke current flowed through each feeder cable.

- To put a magnitude on this, the average lightning strike has 30kA current and an extreme lightning strike has 200kA current. In which case the feeders would be expected to have 0.6-4kA of the full lightning current.

ITU K56 APPENDIX and BARBOSA PAPER

CURRENT DISTRIBUTION IN A TELECOMMUNICATION TOWER STRUCK BY ROCKET-TRIGGERED LIGHTNING

C.F. Barbosa, F.E. Nallin
CPqD Telecom & IT Solutions
grcelio@cpqd.com.br

S. Person, A. Zeddam
France Télécom R&D
ahmed.zeddam@orange-ftgroup.com

SP-340, km 118 - Campinas - SP - Brazil

Fig.3 - Tower top with rocket platform

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Fig.4 - Flash triggered at 4th Feb. 2005

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6 CONCLUSION

When a metallic telecommunication tower is struck by lightning, most of the return stroke current flows through the tower's metallic elements (legs and cross-arms), and only a small fraction of the current flows through the feeder cables. In the experiments carried out with a standard radio base station complying with ITU-T Rec.56 [4], about 2% of the return stroke current flowed through each feeder cable. This value is in agreement with the theoretical value predicted by Rec.K.56, indicating that the current distribution is governed by the inductances of the conductors, instead of the resistances. The wave shape of the feeder current is influenced by the front time of the return stroke current, as a short front time (relative to the tower's transit time) leads to a pronounced peak on the feeder current, and this peak is almost absent in the case of a long front time. Apparently, the variation of the

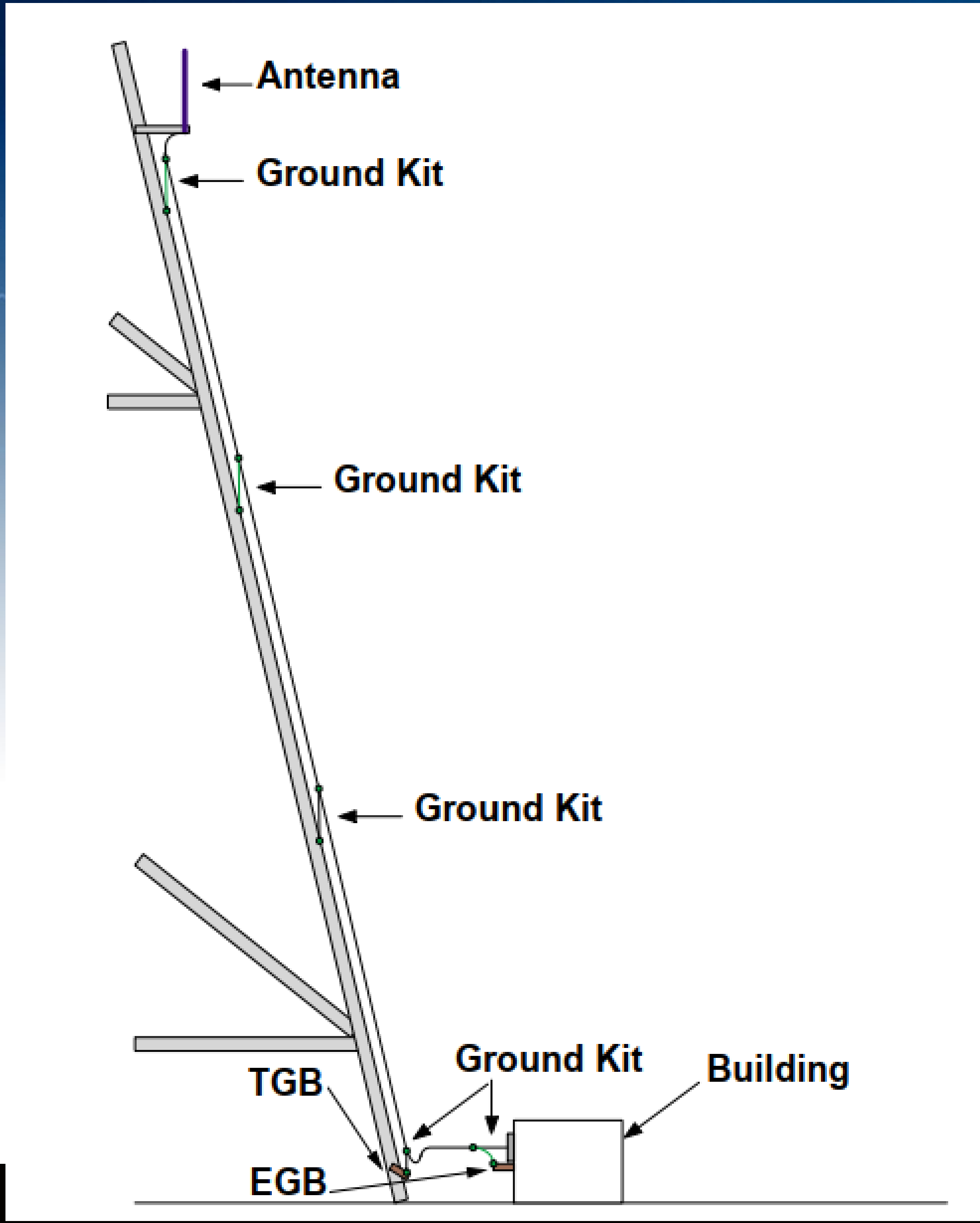
ITU K56 & BARBOSA EXPERIMENT

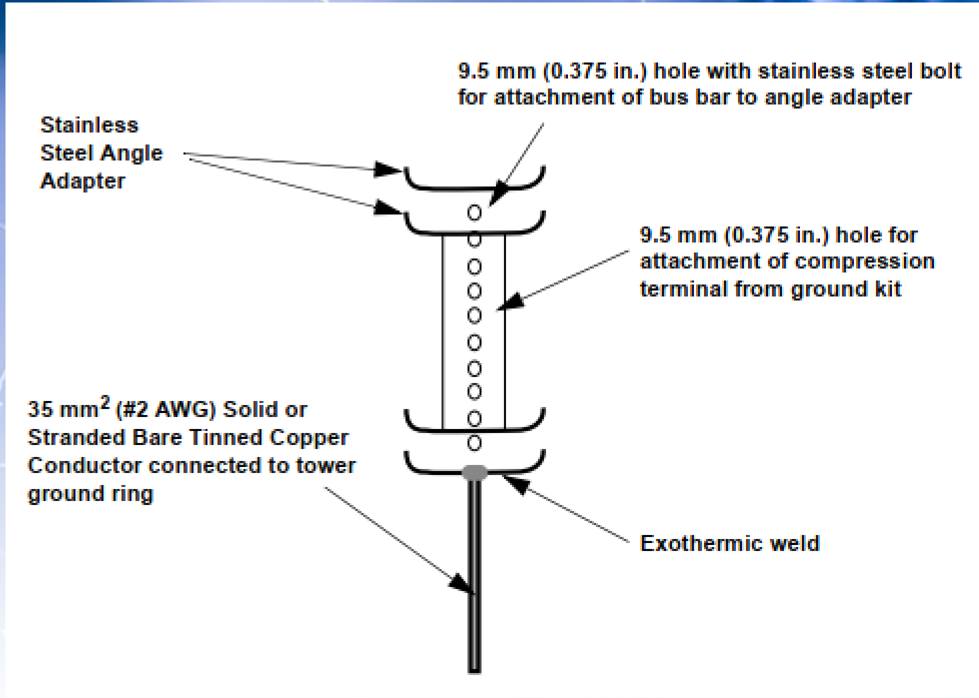
If the worst case lightning discharge under IEC62305 was 200kA at PL 1

EXPERIMENTALLY

And 2% of this could flow on feeders on cable ladders then the expected surge on the DC Feeds would be 4 kA (experiment Used 3 Feeders no DC Cables)

Motorola R56





Feeder Cable Grounding

Feeder cables

- The feeders including the wave-guide, the external conductor of coaxial cables, shields on d.c. & hybrid cables and shield on miscellaneous communications like PoE, Cat6, etc. shall be bonded to the metallic tower (or to the feeder tray) via grounding bar, grounding stand-off or direct connections near the antenna.

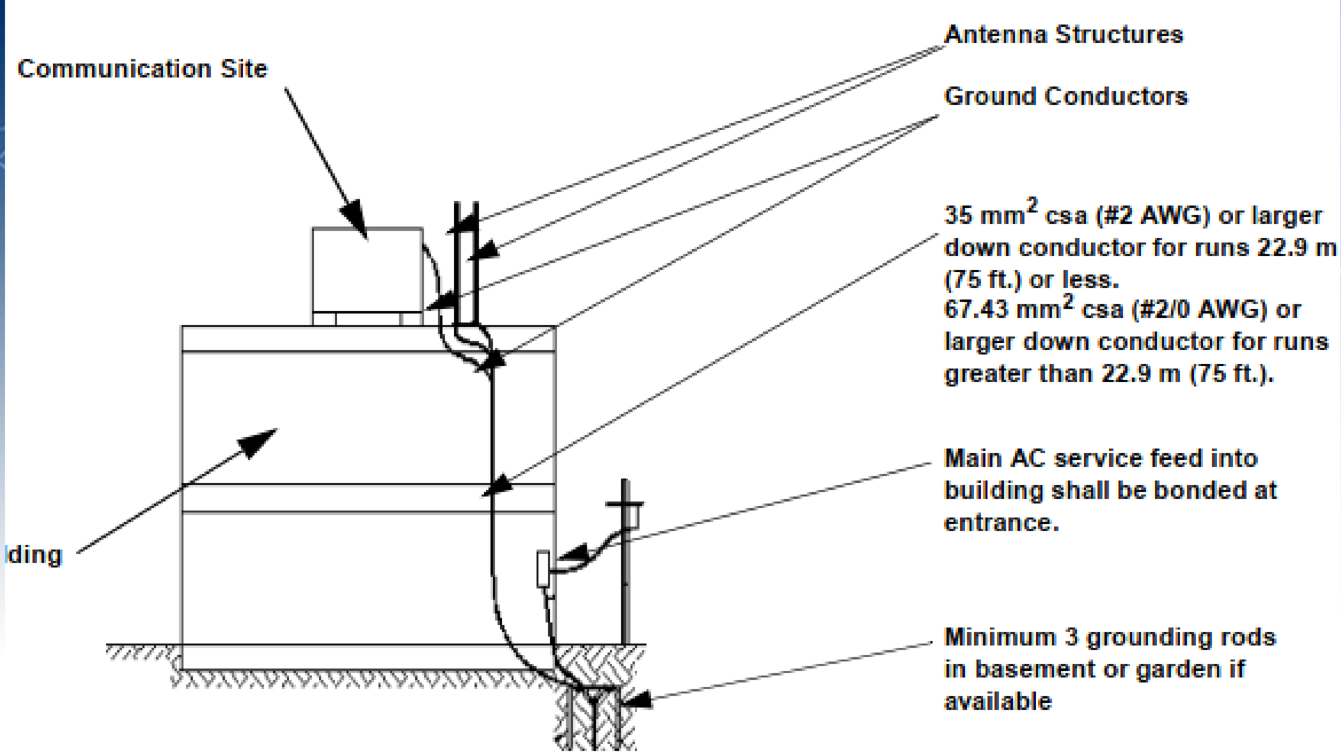
- A weatherproof connector shall make the connection to the feeder cable in order to avoid corrosion, and the connection to the tower (or feeder tray) structure shall also be protected to avoid ingression of moisture. Usually, the cable manufacturers provide appropriated earthing kits for these connections.

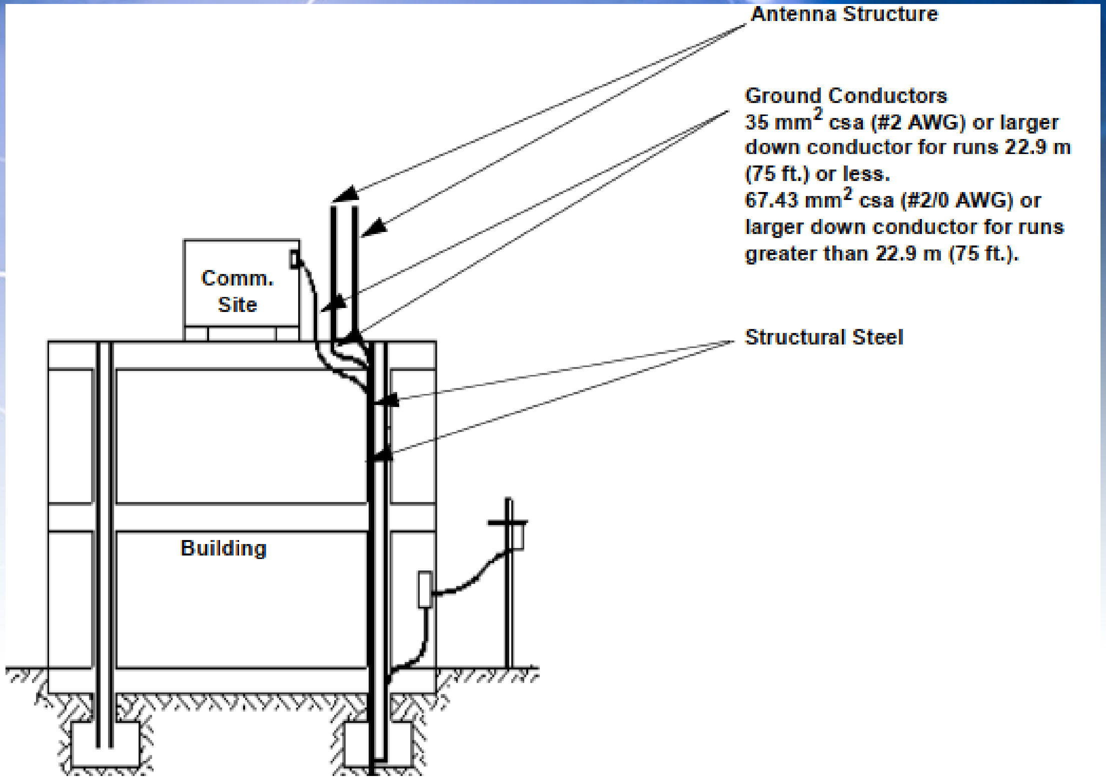
- The earthing kits shall have a connector to be attached on the bare outer surface of the feeder (the feeder plastic outer jacket shall be removed), another connector to be attached to the tower structure (paint shall be removed) and a conductor bonding the two connectors. The earthing kit shall also contain protective coatings to be applied on the connections.

- Some types of antenna are inherently connected to the tower by design. In this case, it is not necessary to use an earthing kit to bond the feeder to the tower (or feeder tray), as it is already bonded through the antenna structure.

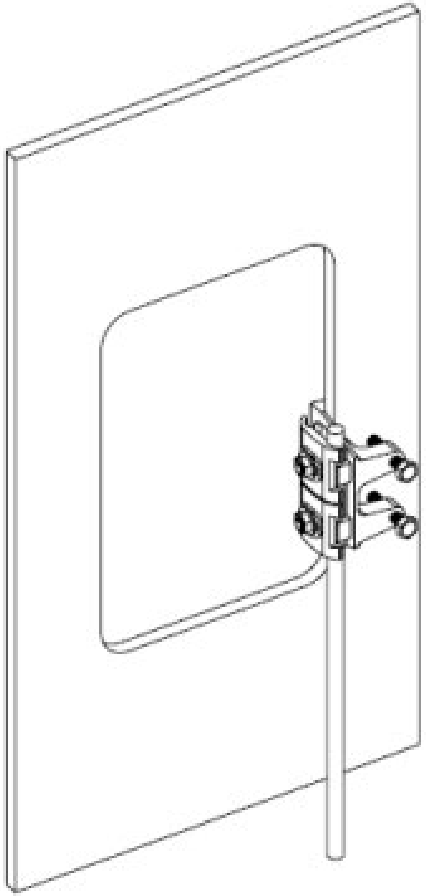
Motorola R56

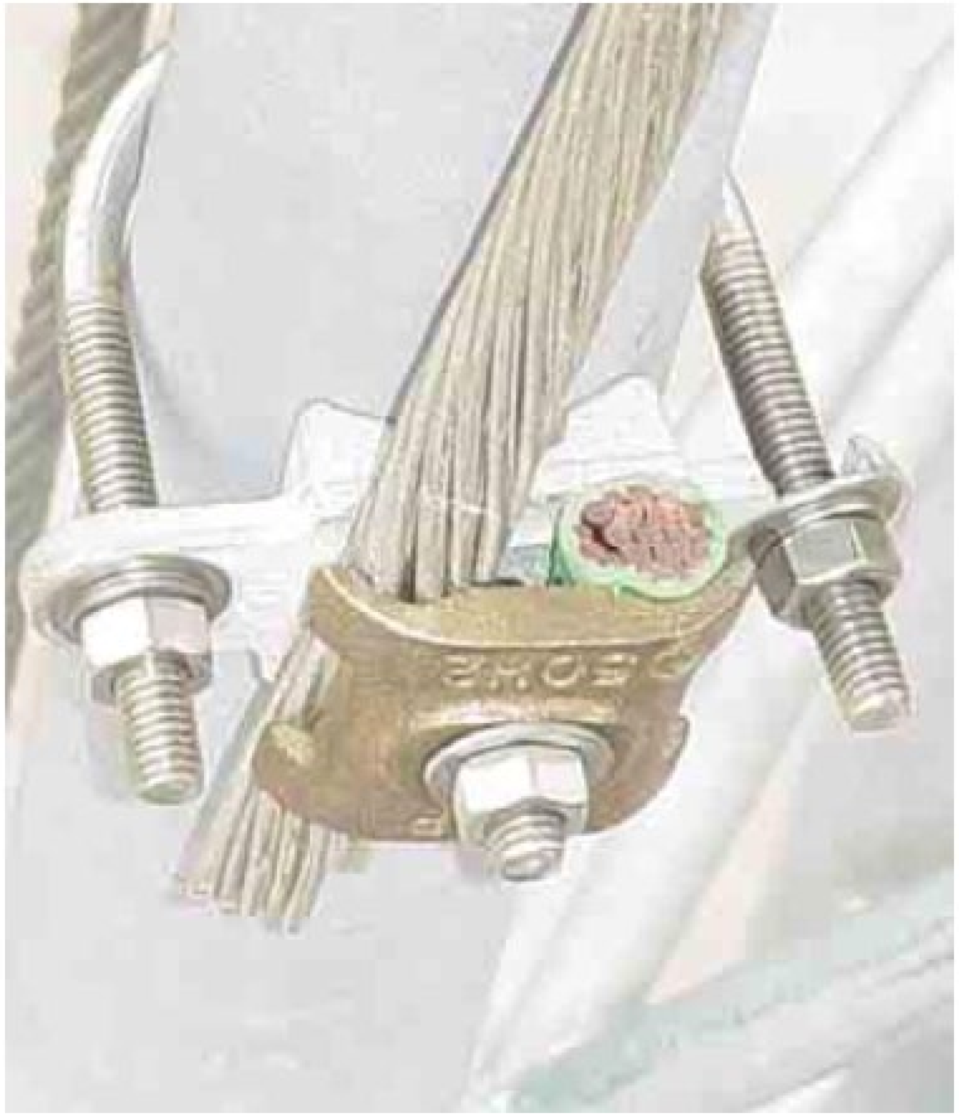
Motorola R56



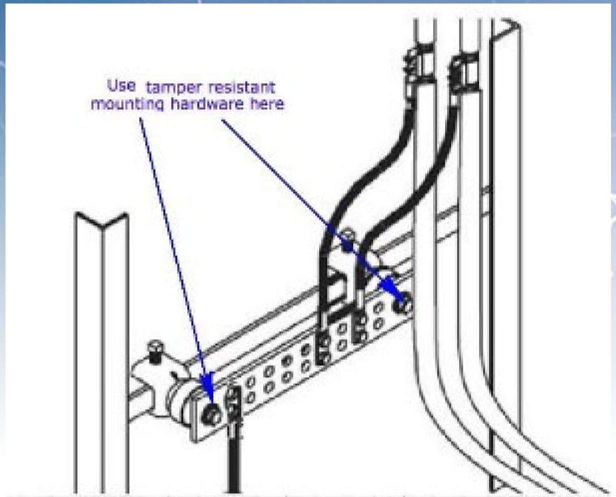


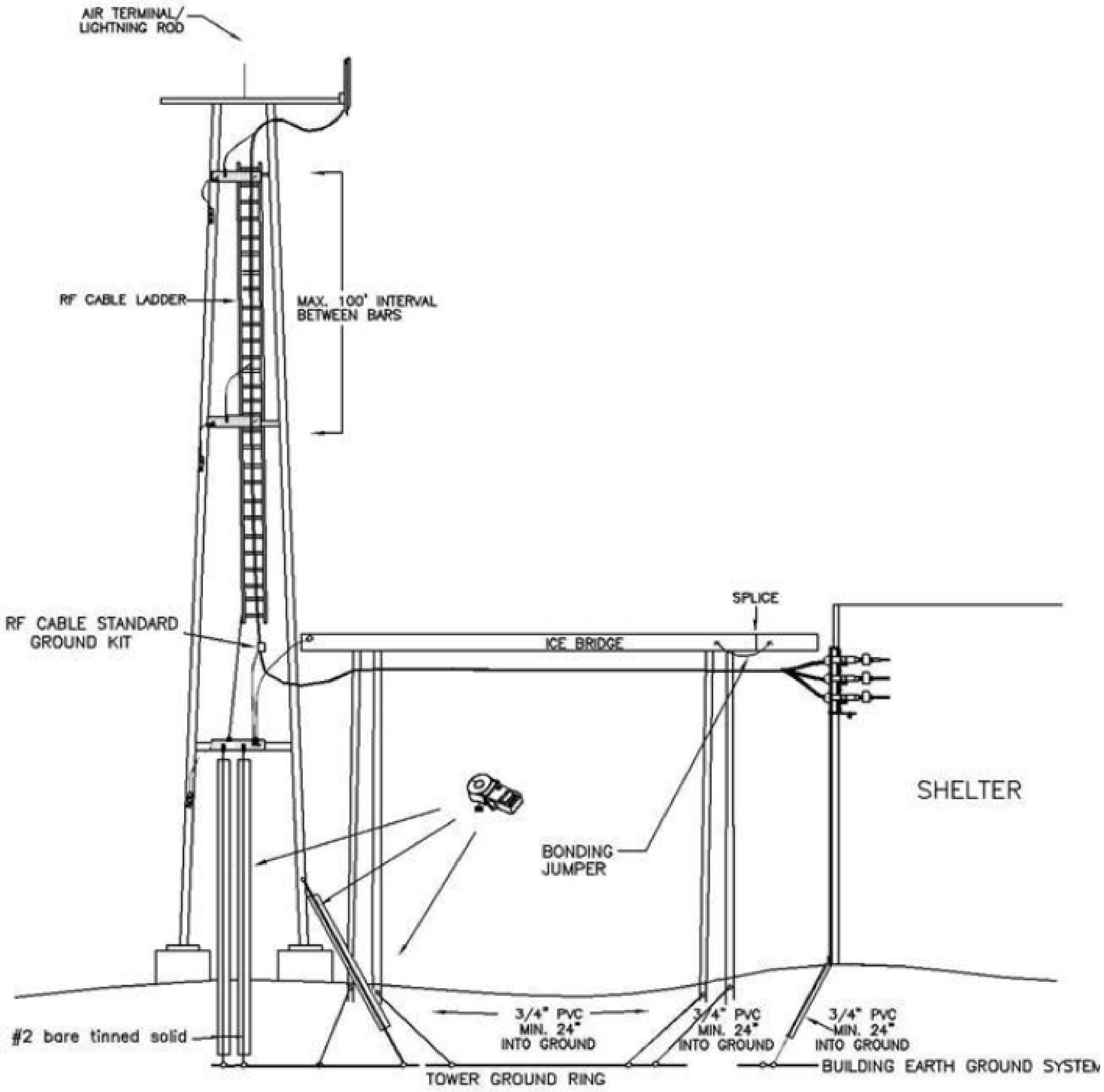
VERIZON NSTD46 – Tower Bonding





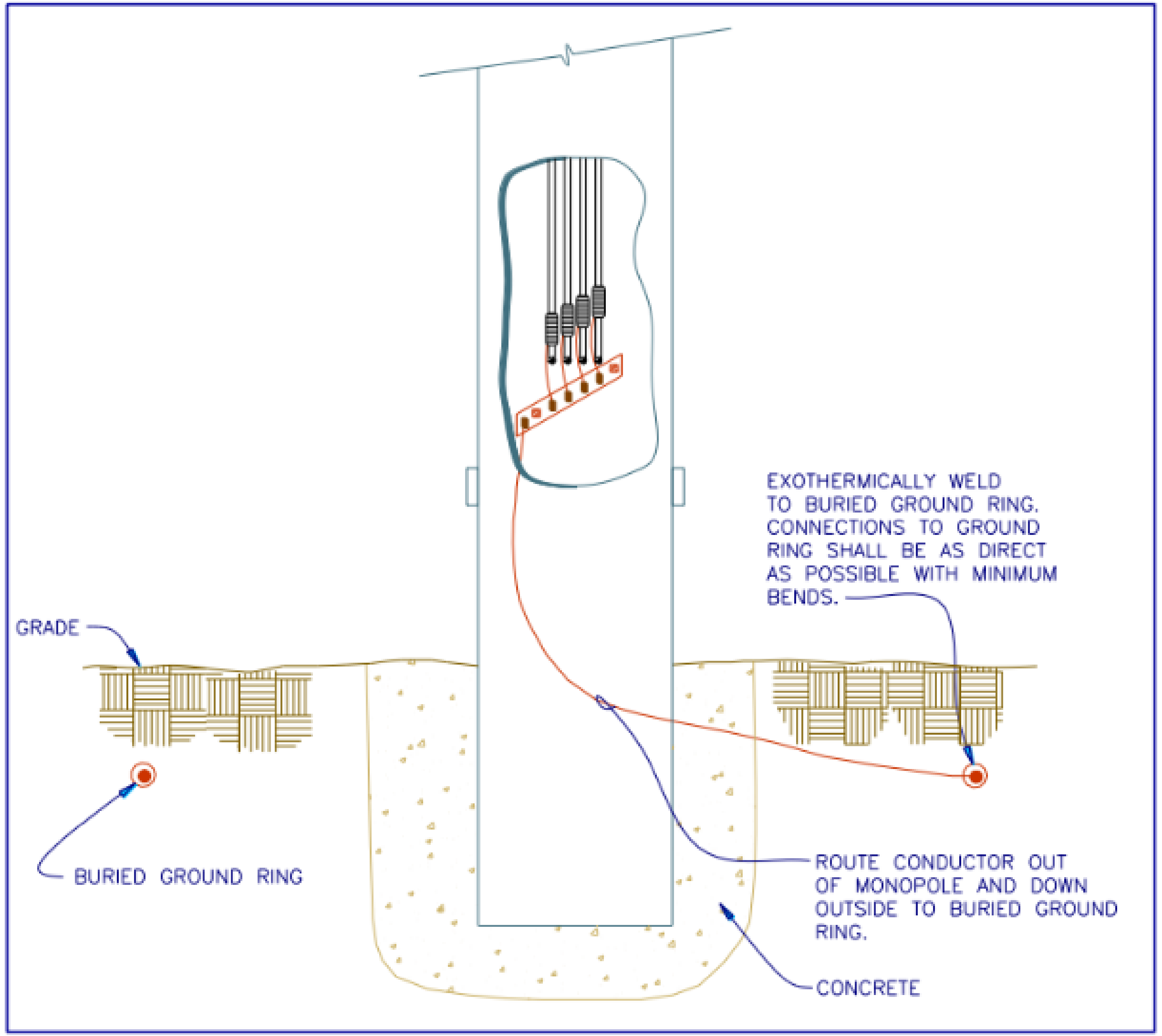
VERIZON NSTD46 – Tower Bonding

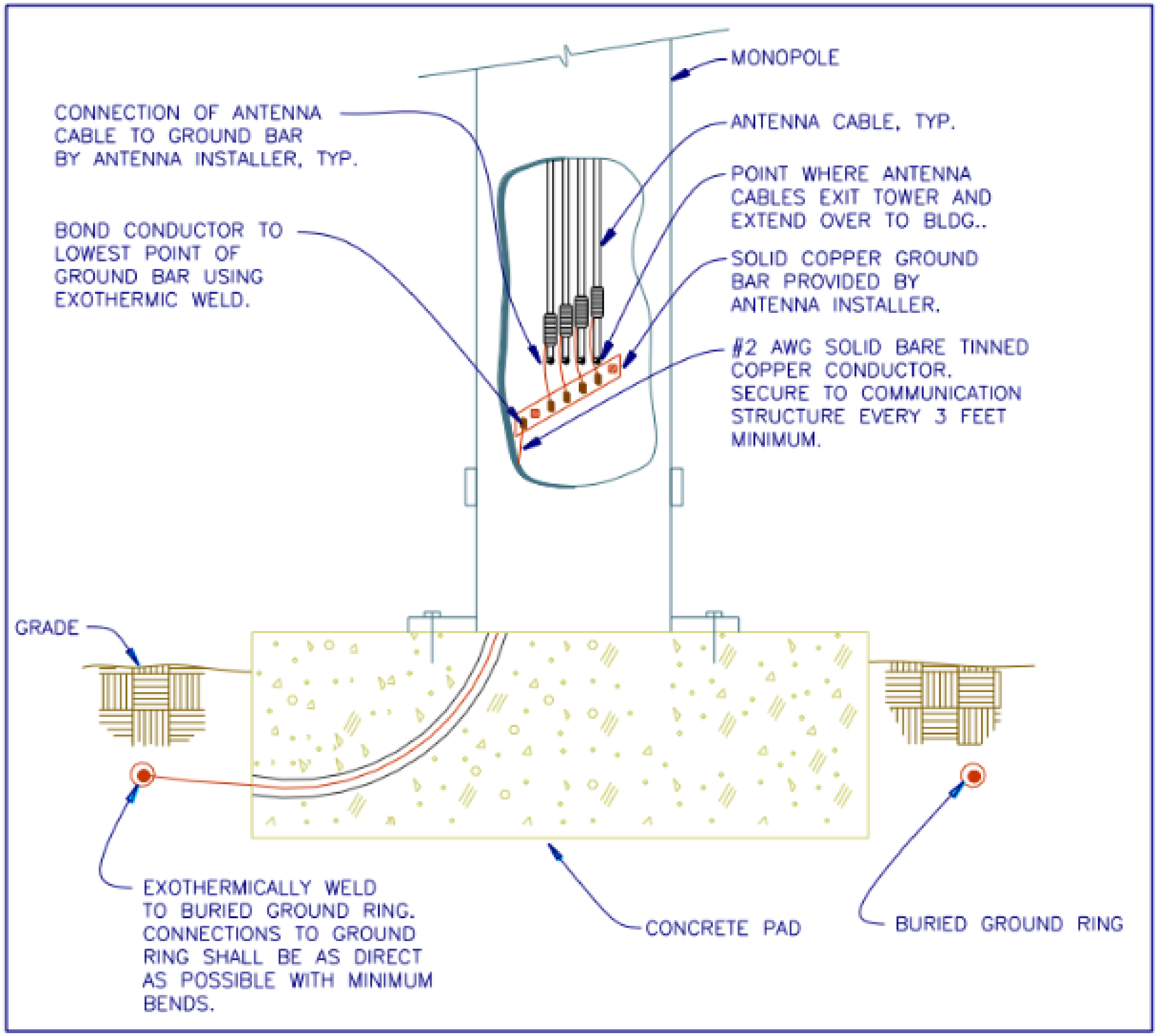




VERIZON NSTD46 – Tower Bonding - Alternative Method

ATT-TP-76416 - Grounding and Bonding Requirements for Network Facilities





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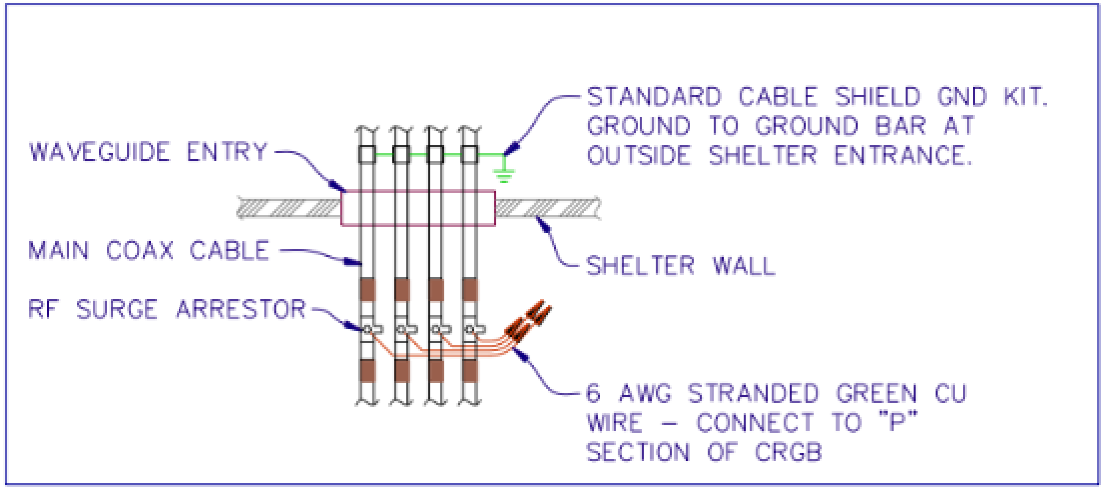
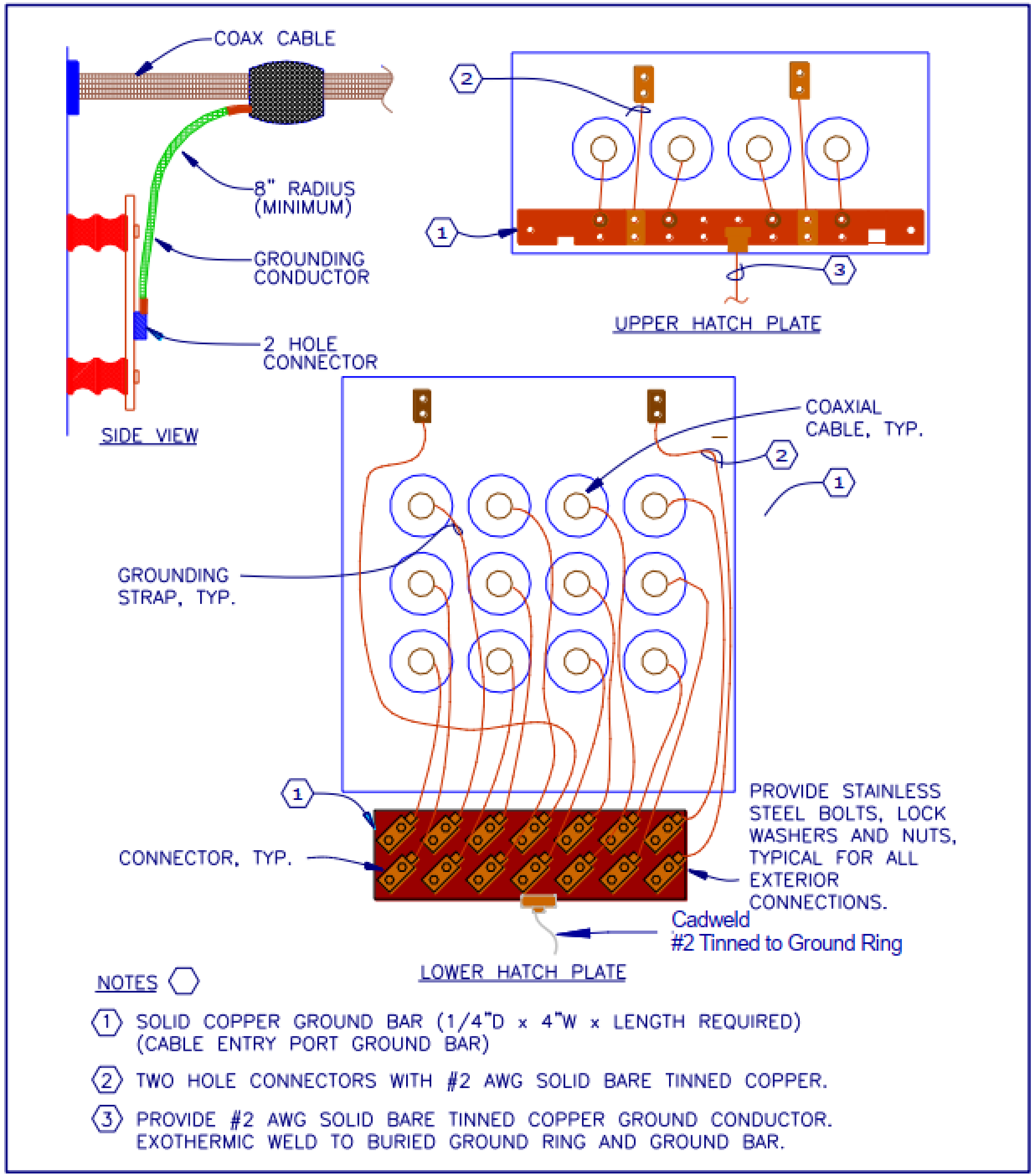


Figure 7-18 RF Surge Arrestor Detail

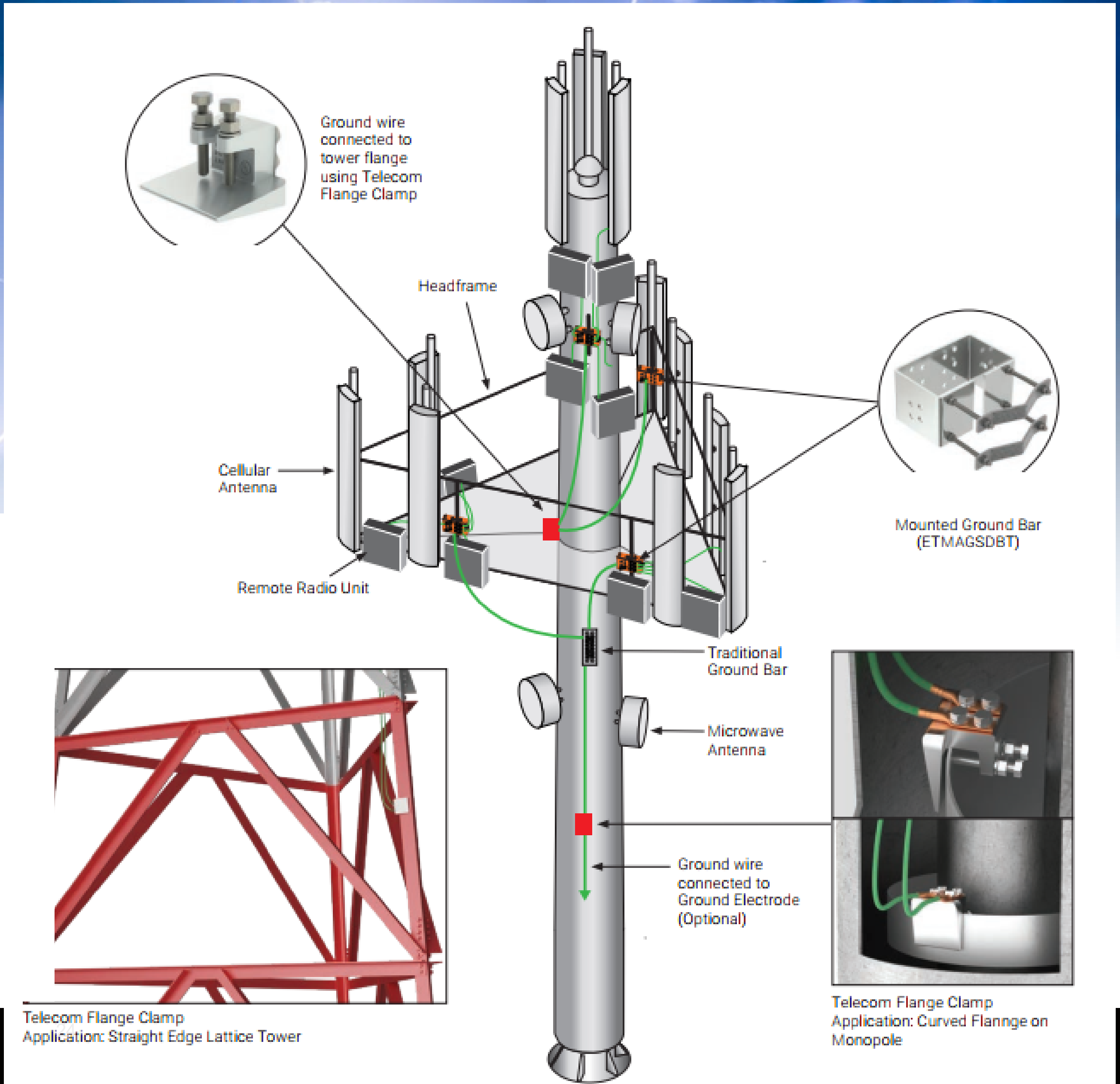


Motorola R56

Vertical Mount

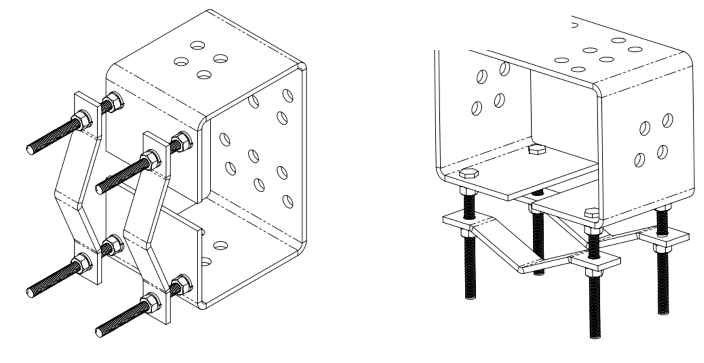
Horizontal Mount

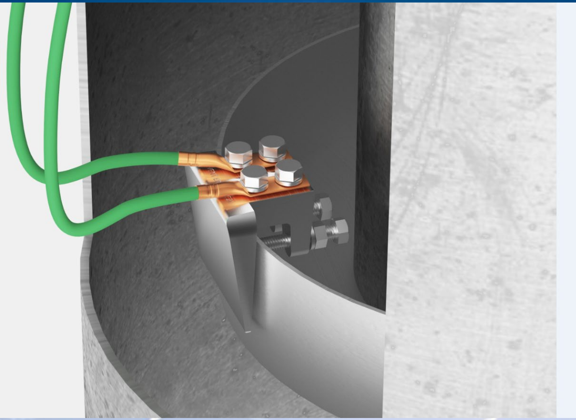
EXAMPLE - Monopole Tower Bonding Accessories

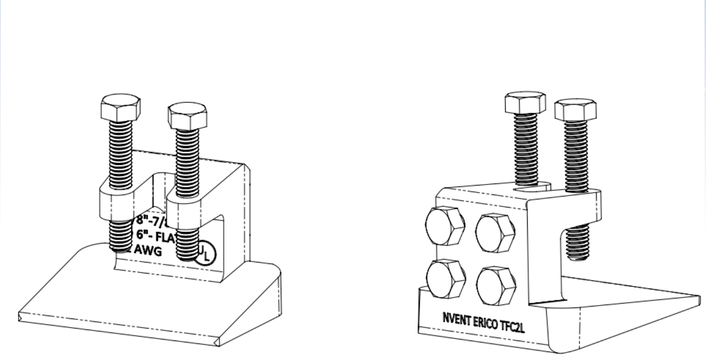


Example - Monopole Tower

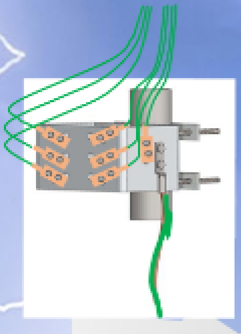
nVent EF
ETMAGS

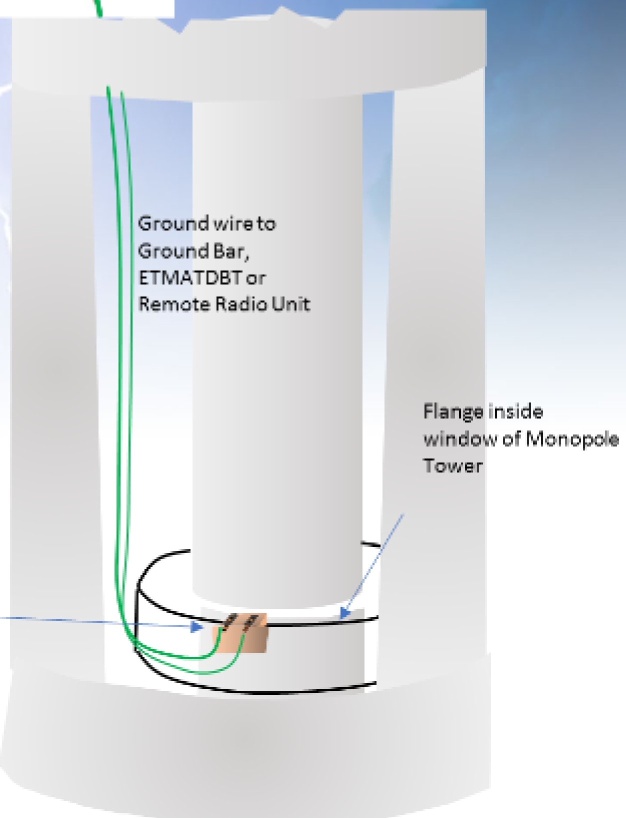






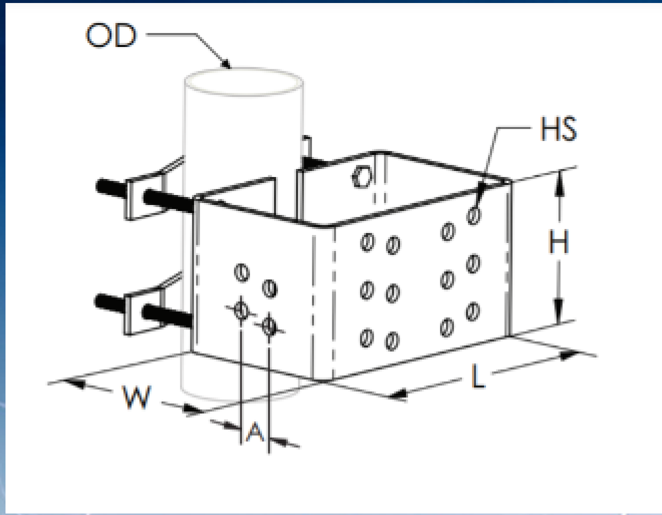
MOUNTED ON RADIO HEADFRAME

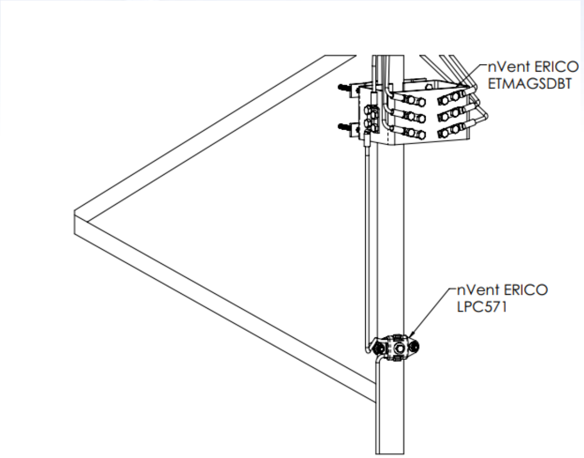


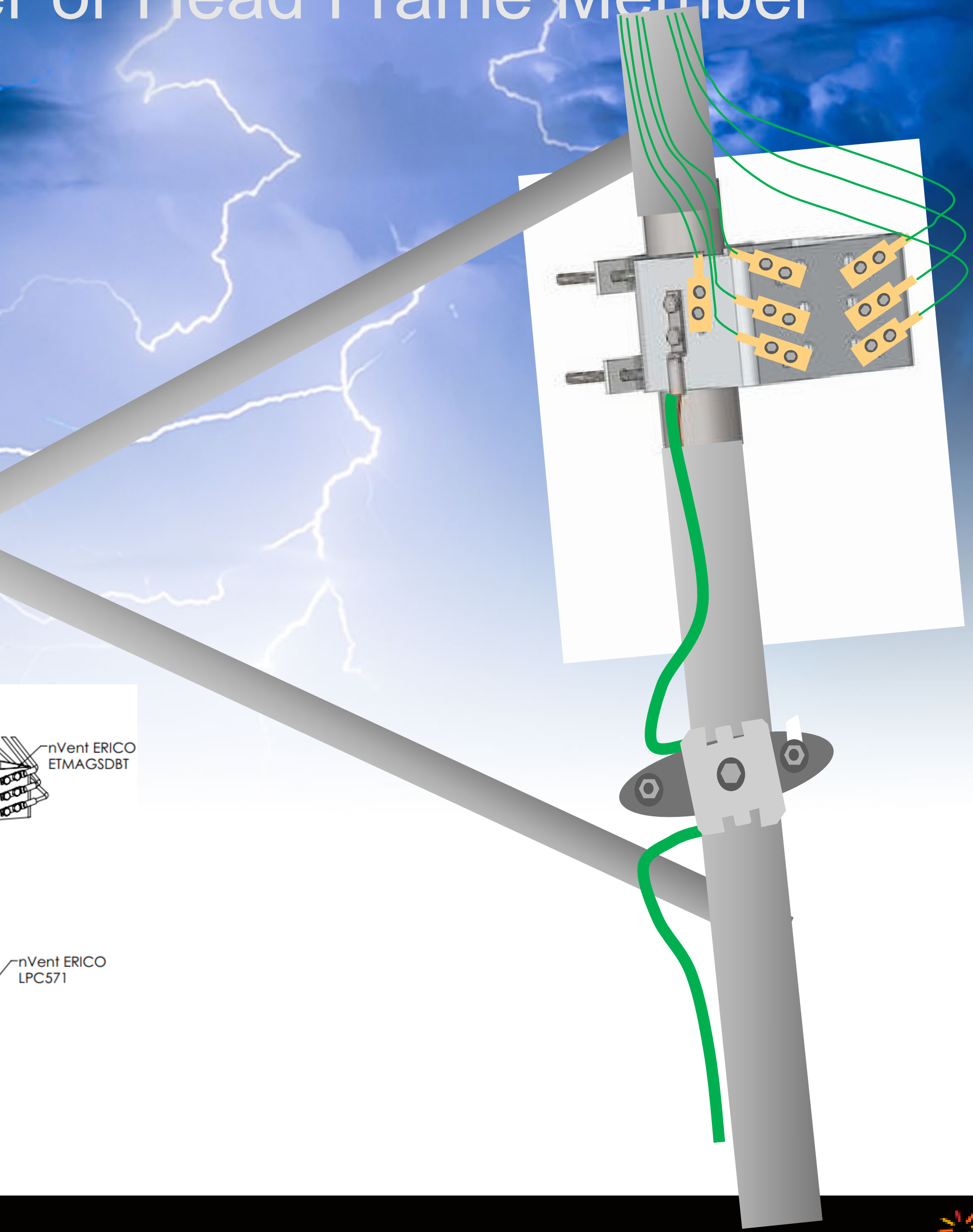


Tower
Clamp

Example Tower Bonding - Round Tower or Head Frame Member

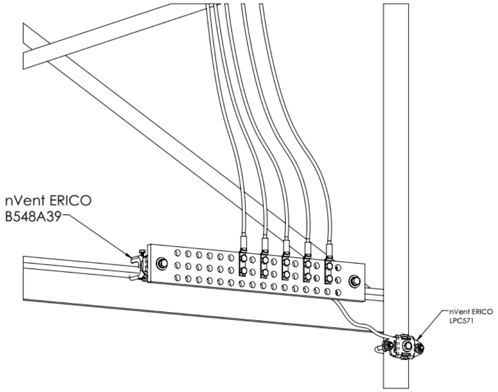




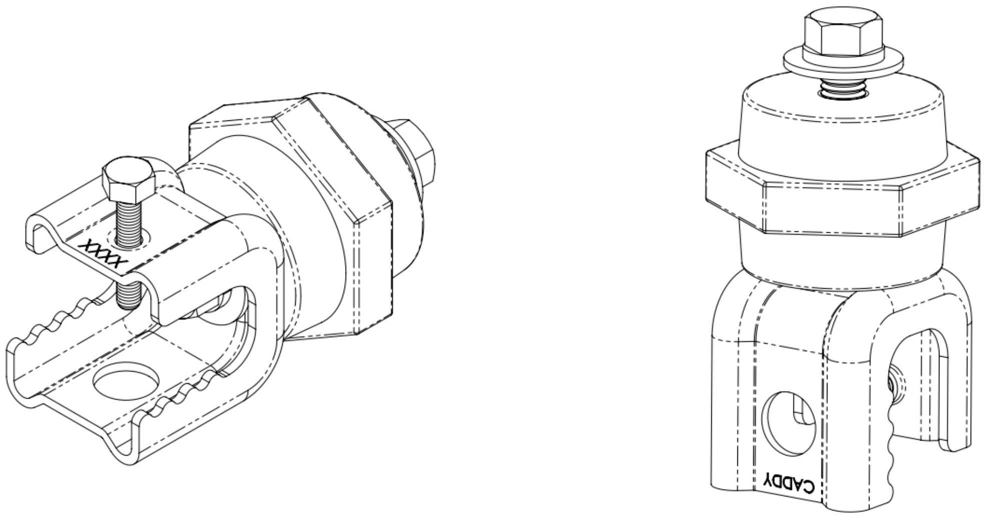


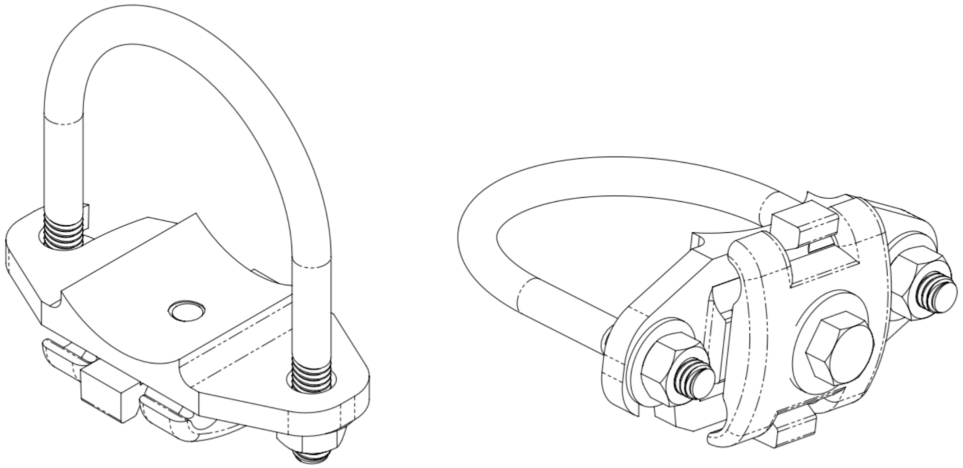
Tower with Angle Line Members

Tower Bonding – Ground Bar & Clamp Details
Round Tower Member

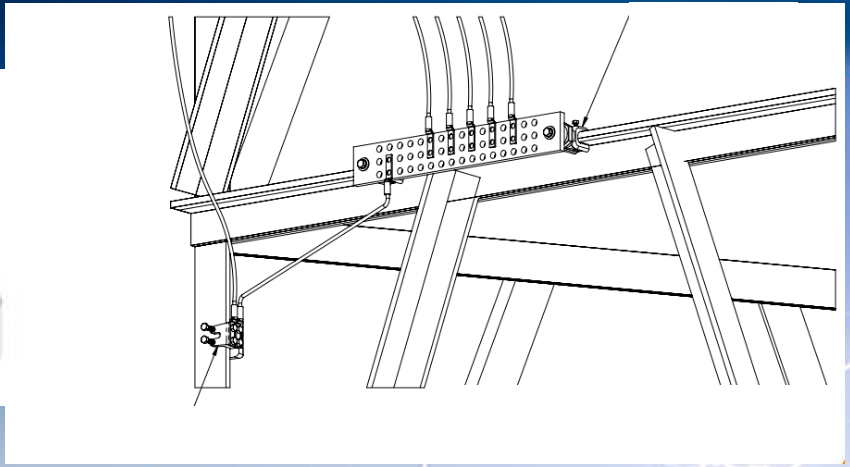


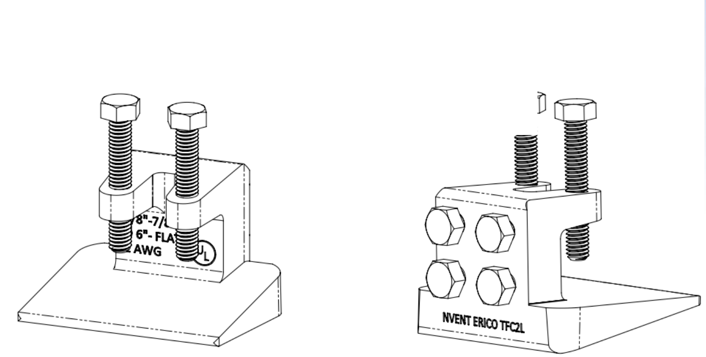
Example - Tower Mounting & Bonding Accessories

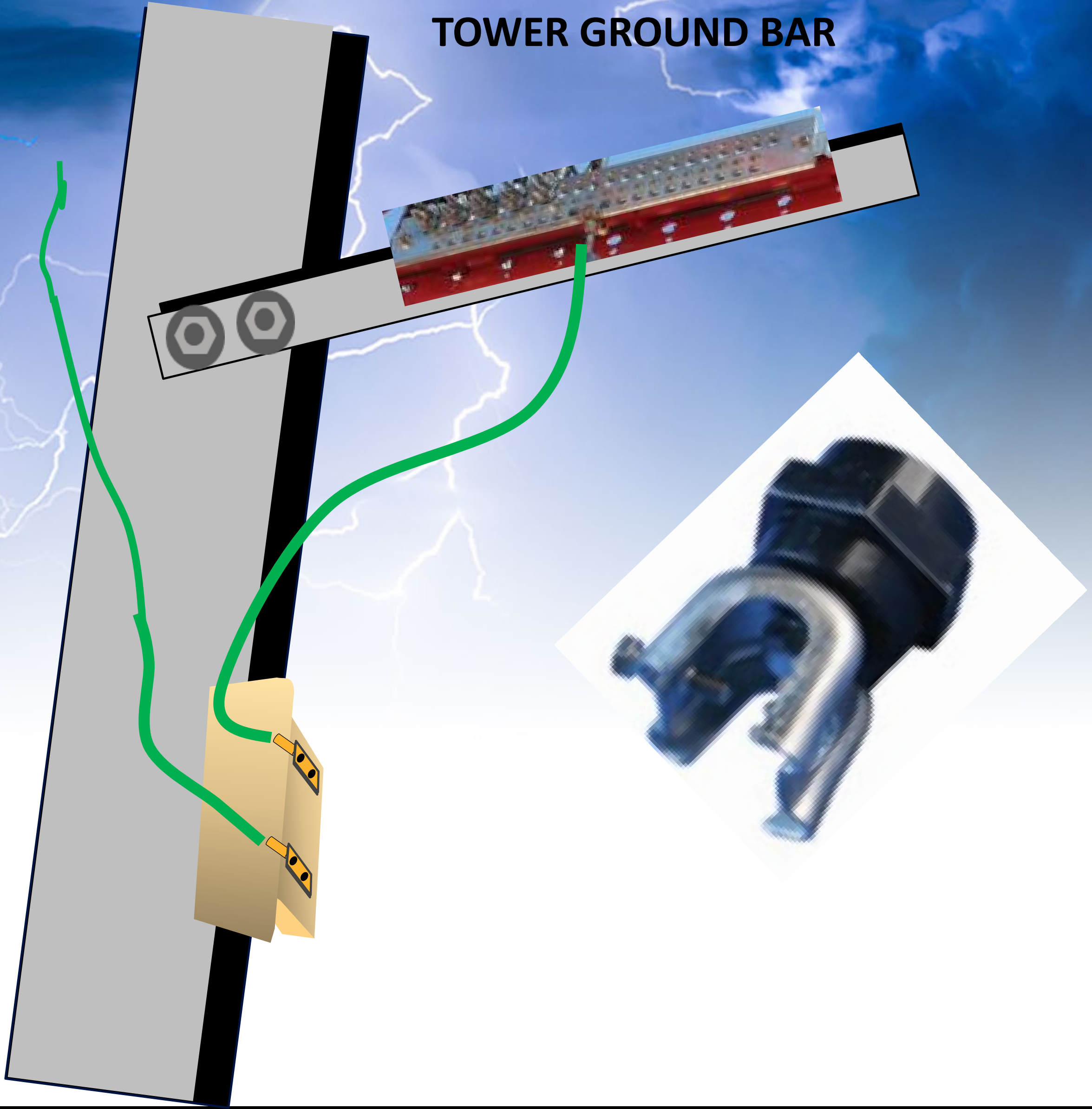




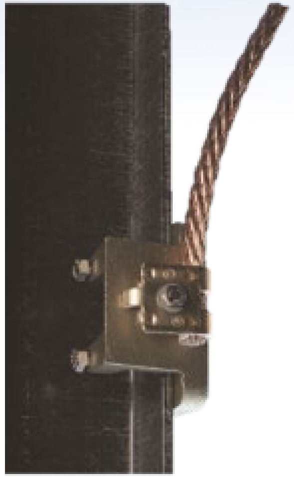
Example Tower Bonding – Ground Bar & TFC2L Details
Angle Line Tower Member







Example OTHER TOWER MOUNTED GROUNDING STANDOFFS



Obstruction and Warning Lights

Cable supplying power to the tower lights

- The cable used for supplying power to the lights of the tower shall be screened and the screen earthed to the tower to protect from the lightning current by one of the options described in this clause. This cable shall be earthed at the bottom of the tower and to the Feeder Earth Bar before it enters the building. Bonding Surge protection on this cable is recommended at the point of exit from the shelter or building.

Shielded & Unshielded Cables

Un-Shielded cable

- An unshielded cable should be installed inside a metallic duct and this duct shall be electrically continuous for its entire length. The duct shall be bonded to the tower at least at its upper end. The length of cable that may run outside the metallic duct shall be as short as possible. Preferably, the cable should run inside the metallic duct up to the lighting hardware. The metallic duct can be made of galvanized steel and shall have a cross-section area not less than 16 mm2. The openings in the duct shall be adequately sealed in order to prevent the ingression of moisture. The metallic duct shall also be bonded to the earthing bar installed near the feed-through window.

- The use of unshielded cable installed without a metallic duct requires the installation of adequate SPDs close to the lighting hardware and connected between the conductors and the tower structure. Another set of SPDs is also required at the point where the lighting conductors enters the building and these SPDs shall be bonded to the earthing bar installed below the feed-through window.

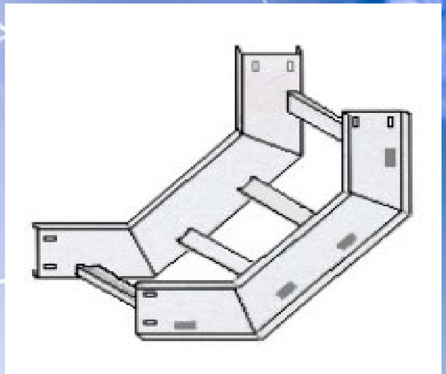
Shielded cable

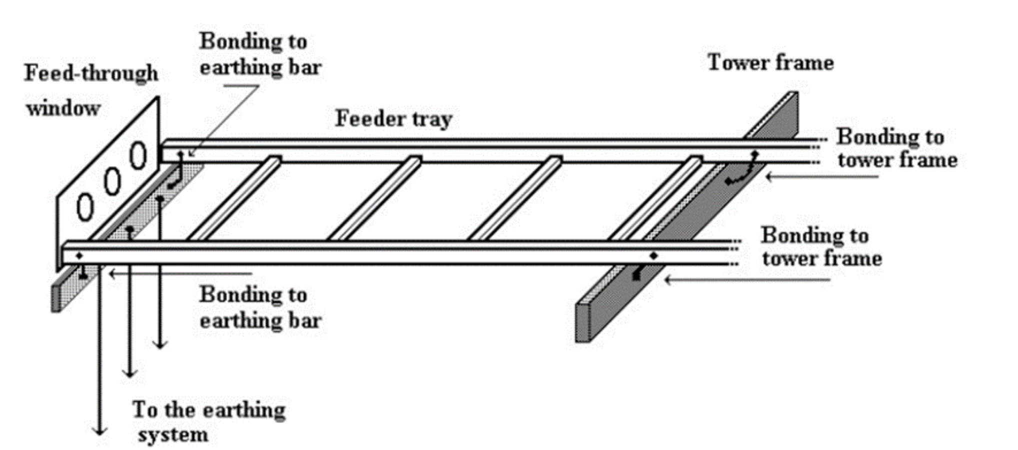
A shielded cable can be installed directly along the tower, i.e., without a metallic duct. The shield of the cable shall be electrically continuous for its entire length and shall be bonded to the tower at its upper end. The shield shall be terminated as close as possible to the lighting hardware and shall be bonded to the earthing bar installed near the feed-through window.

Feeder Tray

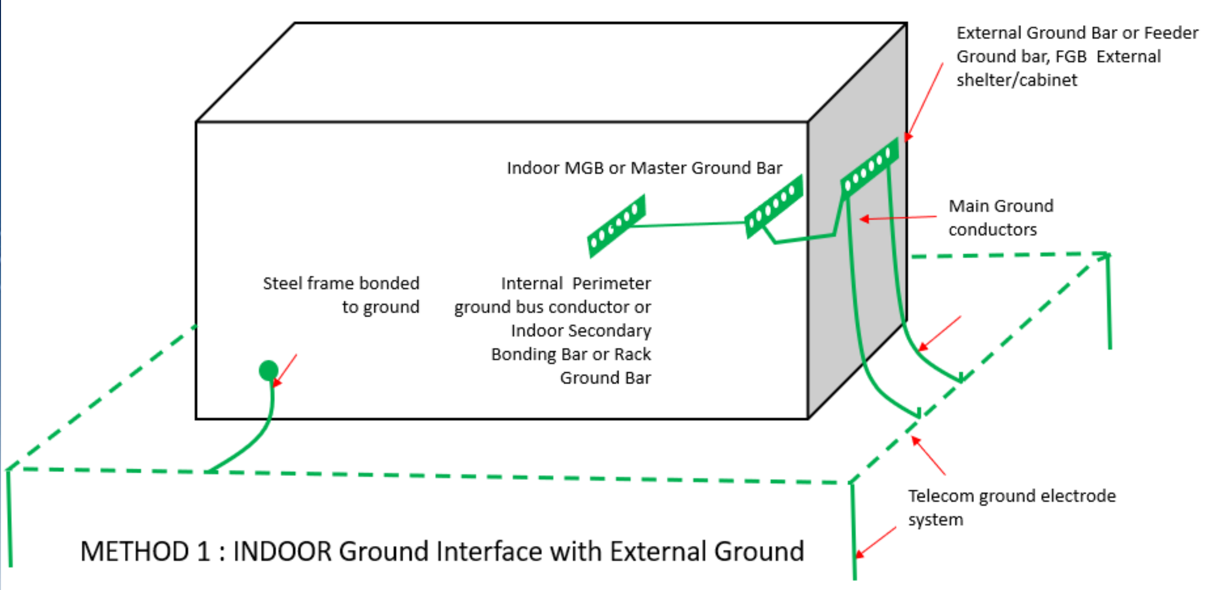
Feeder tray

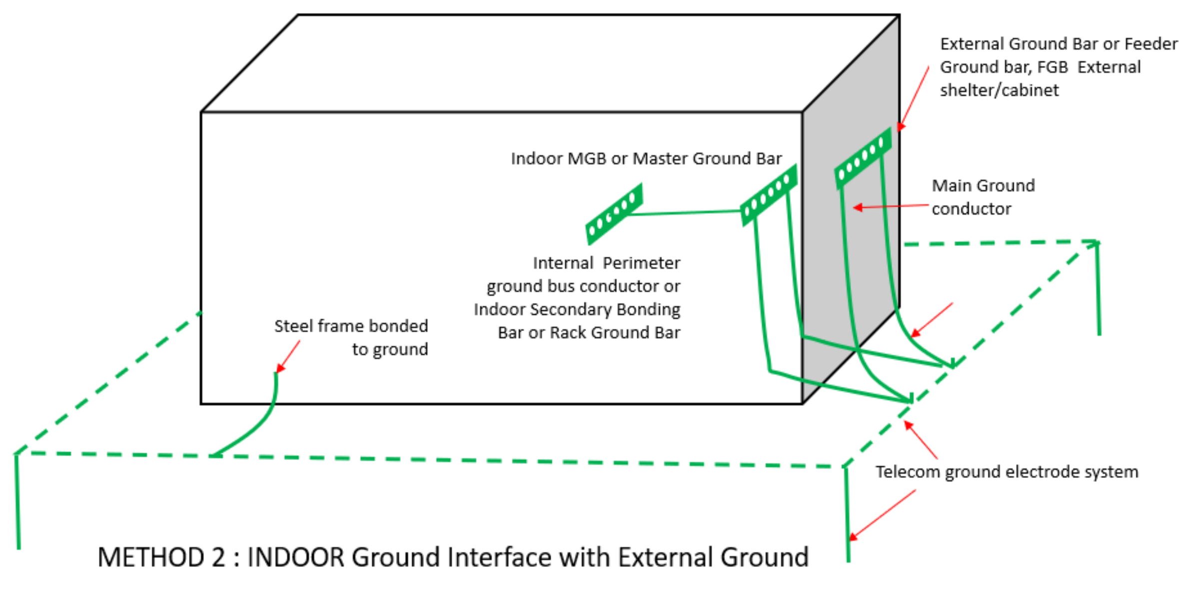
- The feeder cables are supported by a metallic structure, here designated as a feeder tray. The feeder tray shall be kept continuous in its trajectory along the tower and it shall be bonded to the tower by its supporting hardware (i.e., screws, clamps or welding). In the upper side of the tower, the feeders shall leave the feeder tray as close as possible to the antennas. The feeder tray shall be continuous when it leaves the tower towards the building, preferably using a curved section. In the trajectory between the building and the tower, the feeder tray shall be continuous and bonded to the tower and to the earthing bar located near the feed-through window of the building. The objective of this bonding is to provide a path to the lightning current in parallel to the feeders, which reduces significantly the current carried by the feeders. The bonding shall be made at least in the two sides of the tray, as shown in Figure 8. On the tower side, the bonding between the feeder and the tower frame is normally achieved by mounting clamps or bolts. On the building side, it is necessary to install bonding conductors between the feeder tray and the earthing bar.

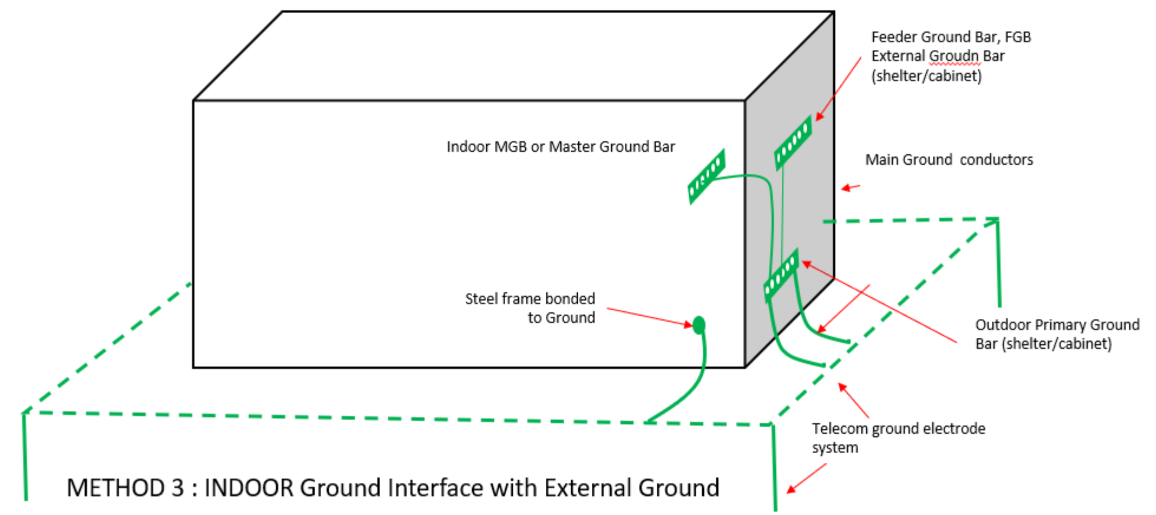




Feeder Ground Bar Bonding Methods to Internal Ground

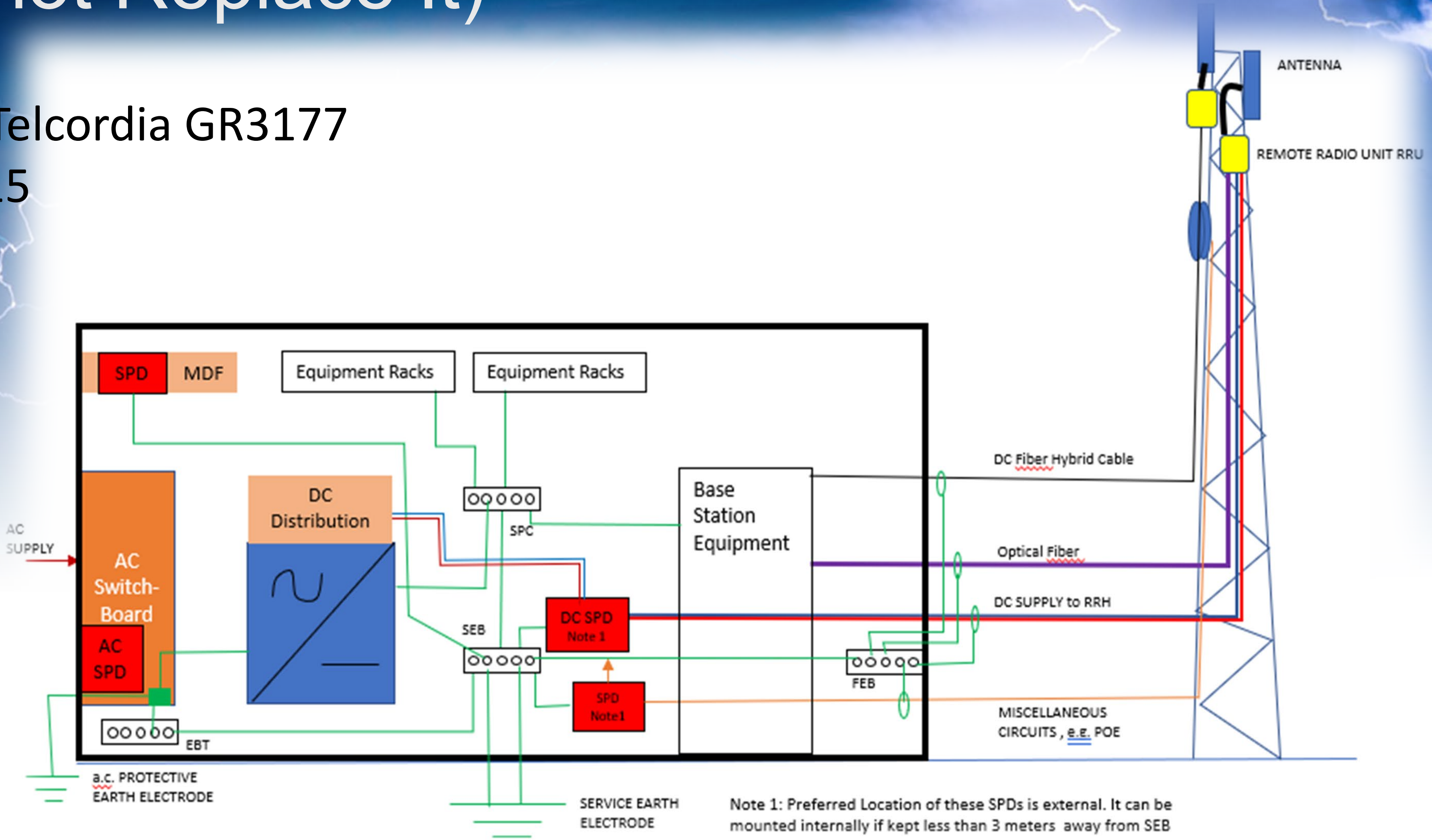






Surge Protection Scheme Compliments Tower Bonding (Does not Replace It)

Based on Telcordia GR3177 and AS3015



Note 1: Preferred Location of these SPDs is external. It can be mounted internally if kept less than 3 meters away from SEB

References

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2. Rohit Narayan, nVent, 2019 - Course Notes - TRAINING ON TELECOMMUNICATIONS GROUNDING & PROTECTION
3. Dr Al Martin, Power Feeds to Remote Radio Unit, ATIS Protection Engineers Conference , 2015
4. CURRENT DISTRIBUTION IN A TELECOMMUNICATION TOWER STRUCK BY ROCKET-TRIGGERED LIGHTNING C.F. Barbosa, F.E. Nallin S. Person, A. Zeddam CPqD Telecom & IT Solutions France Télécom R&D grcelio@cpqd.com.br ahmed.zeddam@orange-ftgroup.com, IX International Symposium on Lightning Protection 26th-30th November 2007 – Foz do Iguaçu, Brazil
5. ITU K.56 Protection of radio base stations against lightning discharges, 2001
6. ITU K.112 Lightning protection, earthing and bonding: Practical procedures for radio base stations
7. Telcordia GR3177 , Generic Requirements for Remote Radio Head Protection Used in Fiber to the Antenna (FTTA) Systems
8. AS3015 Electrical installations—Extra-low voltage d.c. power supplies and service earthing within public telecommunications networks
9. ITU K.97 Lightning protection of distributed base station
10. VERIZON NSTD46 Cell Site and Microwave Radio Station Protection – Engineering Considerations
11. ATT-TP-76416 Grounding and Bonding Requirements for Network Facilities
12. Motorola R56