Engineering Standard

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Grounding, Bonding, and Electrical Protection for Telecommunications Facilities

Document Responsibility: Communications Standards Committee

Contents

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1 Scope

This standard specifies the mandatory minimum requirements governing the system planning, design and installation of grounding and bonding systems for telecommunications facilities such as, but not limited to a DCO buildings, commercial buildings, remote telecommunications facilities, shelters, manholes and also, include community housing with a special requirements to comply. Also, commends the mandatory requirements for electrical protection of telecommunications facilities serving power plants, radio towers and for OSP (outside plant) cables.

2 Conflicts and Deviations

Any deviations, providing less than the mandatory requirements of this standard require written waiver approval as per Saudi Aramco Engineering Procedure SAEP-302.

3 References

Referenced standards and specifications shall be of the latest edition, revision or addendum, unless otherwise stated. Applicable references are listed below.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Waiver of a Mandatory Saudi Aramco Engineering Requirement*

Saudi Aramco Engineering Standards

SAES-P-111	*Grounding*
SAES-T-624	*Telecommunications Outside Plant - Fiber Optics*
SAES-T-629	*Telecommunications Outside Plant - Copper Cable and Wire*
SAES-T-634	*Telecommunications - Cable Testing and Acceptance*
SAES-T-911	*Telecommunication Conduit System Design*
SAES-T-916	*Communications Building Cable*
SAES-T-928	*Telecommunications - OSP Buried Plant*

Saudi Aramco Materials System Specification

09-SAMSS-106	*Epoxy Coating of Steel Reinforcing Bars*

Saudi Aramco Standard Drawings

AA-036361	*VHF/UHF Antenna Installation on Self-Supporting Towers*
AA-036391	*Communications Equipment Grounding for Telecommunication Facilities*
AA-036765	*Grounding for Remote Communication Sites*

3.2 Industry Codes and Standards

National Fire Protection Association

NFPA 70	*National Electrical Code (NEC)*
NFPA 780	*Standards for the Installation of Lightning Protection Systems*

Electronics Industries Association

J-STD-607-A	*Commercial Building Grounding and Bonding Requirements for Telecommunications*
NECA/BICSI 607-2001	*Telecommunications Bonding and Grounding Planning and installation Methods for Commercial Buildings*
ANSI/TIA 607-B	*Generic Telecommunications Bonding and Grounding for Customer Premises*

Building Industry Consulting Service International

BICSI TDMM	*Telecommunications Distribution Methods Manual (TDMM), 13th Edition*
OSP DRM	*Outside Plant Design Reference Manual*

Institute of Electrical and Electronics Engineers

IEEE 81	*Guide for Measuring Earth Resistivity, Ground Impedance and Earth Surface Potentials of a Ground System*
IEEE 487	*IEEE Recommended Practice for the Protection of Wire-Line Communication Facilities Serving Electric Supply Locations*
IEEE 998	*IEEE Guide for Direct Lighting Stroke Shielding of Substations*

Underwriters Laboratories

UL 96	*Lightning Protection Components*
UL 96A	*Installation Requirements for Lightning Protection Systems*
UL 467	*Groundings and Bonding Equipment*
UL 497	*Protectors for Paired Conductor Communication Circuits*
UL 497A	*Secondary Protectors for Communication Circuits*
UL 497B	*Protectors for Data Communication and Fire Alarm Circuits*

4 Design Requirements

4.1 Telecommunication Building Grounding Requirements

This section specifies the minimum requirements for design and installation of grounding system for Digital Central Office (DCO) and/or a building/structure for main primary purpose is for telecommunications use only where telecommunications equipment will be installed.

4.1.1 Each Telecommunications facility shall have one common grounding system, this means that all grounding electrodes system that are present at each building or structure served shall be bonded together to form a single grounding electrode system. For example, the AC power system ground, communications tower ground, lightning protection system ground, telephone system ground, exposed structural building steel, underground metallic piping, and any other existing grounding system, refer to NFPA 70 (NEC 250.50).

4.1.2 External Grounding for Telecommunication Building

This section provides requirements for establishing a grounding system outside Telecommunication (DCO) Building and within its site perimeter.

4.1.2.1 Telecommunications Grounding Electrode System

The telecommunications building grounding electrode system for grounding which is acceptable by the Saudi Aramco shall consist of either of the following:

- Ground Ring: A ground ring encircling the building or structure, in direct contact with the earth at a minimum depth of 460 mm (as per SAES-P-111) and consisting

of at least 6 m of bare copper conductor not smaller than 2/0 AWG (70 mm^2).

- Rod Electrodes: Rod electrodes shall not be less than 2.44 m (8 ft) in length, spacing between multiple rods should be not less than 1.8 m (6 ft). Additional characteristic of ground rods shall comply with requirements stated in SAES-P-111.

- Plate Electrodes: As per NEC Section 250.52 (A) (7) Plate Electrodes: Each plate electrode shall expose not less than 0.186 m^2 (2 ft^2) of surface to exterior soil. Electrodes of bare or conductively coated iron or steel plates shall be at least 6.4 mm (¼ in) in thickness. Solid, uncoated electrodes of nonferrous metal shall be at least 1.5 mm (0.06 in) in thickness.

  Commentary Note:

  Plates Electrodes shall only permitted in Telecommunications shelters (not include buildings) that is sited on a rocky areas and the surrounding areas are all rocks that is mostly encountered.

4.1.2.2 Saudi Aramco Standard SAES-P-111 and the NFPA 70 (NEC 250) code requirements shall be complied with Electrical (AC) grounding and grounding electrode systems for Telecommunications facilities.

4.1.2.3 The design of the grounding electrode system, calculations of the earth resistance, and the grounding methods and measurements shall be according to SAES-P-111.

4.1.2.4 Grounding electrodes and ground rings shall be constructed, bonded and shall provide a minimum of one (1) test point or access point for connections to resistance measurements as per SAES-P-111.

4.1.2.5 Chemical treatments of the earth around ground electrodes shall not be used. Marl or concrete could be used to assist in maintaining moisture content around ground electrodes.

4.1.2.6 The required grounding resistance of the grounding electrode system shall not exceed, as follows:

Required Resistance (ohms)	Telecommunications Facilities
2 ohms	With a Telecommunications Tower (this include microwave antenna/remote repeater site)
3 ohms	With Electronic Switching, PABX, and Telecom Transmission Systems
25 ohms	Telecommunications Shelters, OSP outdoor cabinets/pedestals/manholes

4.1.2.7 Other Attachment to the External Grounding System

a) AC Power System Grounding

- AC Power services shall be grounded according to Saudi Aramco grounding standard SAES-P-111 and NFPA 70 (NEC 250) minimum requirements.
- AC outlets grounding installed on telecommunications equipment rack shall be isolated from equipment chassis.
- AC-powered equipment, such as rectifiers and inverters and racks that they are mounted on, shall be isolated from the DC equipment racks, cable trays, and DC grounding.

b) Bonding to Structural Steel of Building

- All non-coated building structural steel and rebar shall be bonded to the building external grounding system in accordance with SAES-P-111.

Commentary Note:

Coated rebar specified in this standard should be the epoxy-coated steel rebar as specified in 09-SAMSS-106.

4.1.4 Internal Grounding for Telecommunication Building

This section provides guidelines and requirements for establishing an internal grounding system inside a Telecommunication Digital Central Office Building.

4.1.4.1 Single-point Ground Systems (SPG)

Telecommunications building grounding shall have a

Single-point Ground (SPG) System also known as TMGB (Telecommunications Master Grounding Bus bar), refer to Standard Drawing AA-036391.

4.1.4.2 Grounding System Components

The Major Components are as follows:

- Telecommunications Master Grounding Busbar (TMGB)
- Grounding Conductor (GC)
- Telecommunications Grounding Busbar (TGB)
- Computer Flooring Grounding
- MDF/Entrance Cable Protector Ground Bar (ECPGB)
- Cable Shield/Cable Vault Ground Bar (CVGB)
- Waveguide Entrance Ground Bar (WEGB)

4.1.4.3 Telecommunications Master Grounding Busbar (TMGB)

a) The TMGB shall;

- Be a predrilled copper busbar (electro tin plated) with holes use with a standard 2-holes sized lugs.
- Have a minimum dimension of 6 mm (thick) X 100 mm wide X 500 mm (length) or a variable length to meet application requirements and with consideration of future growth, also refer to J-STD-607-A for additional requirements.
- Be insulated from its support and maintain a minimum of 50 mm (2 in) separation from the wall allow access to the rear of the busbar.

b) The TMGB shall be bonded to the building grounding electrode system through a two buried leads from opposite sides (refer to SASD AA-036391). The leads shall be equal to size of the building grounding grid and a minimum of 2/0 AWG (70 mm²) bare tinned-copper conductors as per SAES-P-111 requirement. The two leads shall be run inside a PVC conduit that is resistant to ultraviolet rays when it is exposed to sunlight.

Commentary Note:

When TMGB is connecting to building grounding electrode systems, the grounding electrode conductor that is the sole

connection to the grounding electrode system shall not be required to be larger than the conductor used for the building ground ring.

c) There shall be only be one (1) TMGB for every telecommunication building and if used to extend as a supplementary grounding bus then it shall have a two connection points. Also, the location of the TMGB must be identified on building drawings and equipment layout plans.

d) A direct bonding of telecommunications equipment to the building grounding system shall not permitted. The TMGB is the Single Point Ground of grounding connection for the telecommunications equipment, as well with the DC power connectivity.

Commentary Note:

The electrical (AC) master ground busbar shall not be direct connected to the TMGB, refer to Figure 3.

e) The TMGB shall be divided to the following zones (Figure 4).

P surge producers (such as interior radio equipment including cable trays that are connected to radio equipment, Cable Shield/Cable Vault Ground Bar and MDF/Entrance Cable Protector Ground Bar)

A surge absorbers (both ground leads coming from the opposite sides of the ground grid)

N non-isolated equipment (DC Power system positive return bus, computer floor, communication racks and cable trays)

I isolated equipment (electronic switching equipment and transmission systems and terminal Equipment)

These zones shall be permanently labeled on the TMGB and on the building drawings.

Commentary Notes:

1. *The isolated equipment zone must be placed as far away as possible from the surge producer zone.*
2. *The used of PANI zoning was intended for administrative purposes for easy identifications*

4.1.4.4 Grounding Conductor

a) Conductor shall be an insulated copper and with a GREEN and YELLOW color. It shall be permanently marked at the TMGB as well as at all other ground bus bars. Connections to ground bus bars shall be only of 2 holes connector type.

b) Conductor shall be run either in non-metallic conduit only or not in conduit at all, and run only through non-metallic sleeves in ceilings, floors, and walls. The use of metallic conduit for running conductor is not permitted.

c) Conductor shall maintain 300 mm separation from DC power, switchboards and high frequency cables or power cables.

d) Conductors cable bend shall be kept to a minimum and the acceptable bend radius shall be:

Minimum Bend Radius (mm)	Conductor Size (AWG)
150 mm	sizes up to #6 AWG (16 mm²)
300 mm	sizes more than #6 AWG (16 mm²) and up to #4/0 AWG (120 mm²)
600 mm	sizes more than #4/0 AWG (120 mm²) and up to No. 500 MCM (250 mm²)
900 mm	sizes greater than No. 500 MCM (250 mm²)

d) Bonding connection requirements shall comply with Section 4.2.3 "Telecommunications Bonding Connection", of this standard.

4.1.4.5 Other Attachment to the TMGB

4.1.4.5.1 Computer Flooring Grounding - N zone

- When computer flooring is used, form a loop around the perimeter of the floor area using a minimum of #6 AWG (16 mm²) copper conductor and splice its ends together with a single splice. Bond the loop to the computer flooring metal support in intervals along the loop not to exceed 6 meters. Exposed connections shall be taped.

- Bond the loop to the nearest TMGB using a minimum of #2/0 AWG (70 mm²) insulated copper conductor.
- Additional grounding and bonding of computer floors shall be applied according to the computer-flooring manufacturer's instructions.

4.1.4.5.2 Main Distribution Frame (MDF) Ground Bar / ECPGR - P zone

- MDF shall have an Entrance Cable Protector Ground Bar (ECPGB) is a copper bar that is attached horizontally across the top or bottom of the Main Distribution Frame (MDF) or the Protector Distribution Frame (PDF).
- The ECPGB shall be grounded to the TMGB/TGB using a minimum of #1/0 AWG (50 mm²) PVC insulated copper conductor at maximum intervals of 5 meters, so that no protector vertical is more than 2.5 meters from a ground lead to the TMGB/TGB.
- The protectors (connectors) on each MDF or PDF vertical shall be interconnected (Interconnector Ground Strap) using a minimum of #6 AWG (16 mm²) insulated copper conductors and then connected to the ECPGB (Long Ground Strap) using a minimum of #6 AWG (16 mm²) insulated copper conductor (Figure 1).

4.1.4.5.3 Cable Vaults Ground Bar (CVGB) - P zone

- Cable vaults shall have a copper Cable Vault Ground Bar (CVGB) which shall be bonded to the TMGB using a minimum of #1/0 AWG (50 mm²) insulated copper conductor #6 AWG insulated copper conductor or equivalent copper strap shall be used to bond cable shields to the (CVGB). The minimum size shall be 6 mm x 51 mm x 150 mm.
- The metallic members of OSP cables such as cables shield which includes metallic armor and metallic central strength member entering a

telecommunications facilities shall be bonded with a copper bonding ribbon of minimum 1.6 mm x 10 mm or a minimum of #6 AWG (16 mm^2) insulated copper. The bonding ribbon or the copper conductor shall be terminated and grounded on the cable vault ground bar (CVGB).

4.1.4.5.4 DC Power System Grounding - N zone

- The DC Power system positive return bus shall be isolated from the framework and locate the return bus in or above the:
  - Power control and distribution units
  - Batteries and chargers/rectifiers
- The positive return bus in the power distribution unit frame shall be connected to the nearest TMGB or TGB on the same floor using an insulated copper conductor. The size of this conductor shall be a minimum of #2/0 AWG (70 mm^2), or designed to carry the maximum office drain current (whichever is larger).
- Cable color codes:
  - Solid BLACK for DC positive return cables.
  - Solid RED for DC negative supply cables.
  - Solid GREEN for chassis ground cables.

4.1.4.5.5 Telecommunications Grounding Busbar (TGB)

Refer to Section 4.2.1.3 of this standard.

4.1.4.5.6 Waveguide Entrance Ground Bar (WEGB)

Refer to Section 4.5.3.3 bullet #2 of this standard.

4.1.4.6 Lightning Protection Systems

Lightning protection system design and installation shall be based on:

- NFPA 780, UL 96A, IEEE 998 and shall comply with requirements stated in SAES-P-111 section 13, Lightning Protection.

4.1.4.7 Electronic Switching Equipment Grounding

a) Each electronic switching equipment frame shall be bonded to the grounding system through the TMGB/TGB.

b) Run ground lead from TMGB/TGB (I) zone along the main aisle, perpendicular to the equipment frame line-ups using a minimum of #2/0 AWG (70 mm²) insulated copper conductor. Install a lead down each aisle of electronic equipment, using a minimum of #2 AWG (35 mm²) insulated copper conductor, and bond it to the primary ground lead. Bond each equipment frame to the aisle ground lead using a minimum of #6 AWG (16 mm²) insulated copper conductor (Figure 2).

Commentary Note:

(I) zone applies only to very sensitive types of electronic equipment or by manufacturer recommendation.

4.1.4.8 Grounding Requirements for Telecommunications Transmission Systems

a) All transmission systems, equipment, and terminal equipment shall be grounded using a Single-point Ground system bonded to the TMGB/TGB.

b) The DC power cabling (feeder and distribution) to transmission system and terminal equipment shall be parallel paired conductors of equal size. The return buses of the Disconnect Switch Unit Frames and Power Distribution Unit Frames serving transmission equipment shall be insulated from the frames. All transmission equipment frames and the superstructure shall be grounded to the TMGB/TGB.

c) Single-point ground powered transmission frames shall not share a common remote power distribution unit frame or fuse panel bay. On transmission bays supported by a power distribution unit frame, connect the power distribution unit frame metal directly to the TMGB/TGB using insulated copper conductor.

d) If the largest fuse used at the Disconnect Switch Unit Frame or the fuse panel bay feeding transmission equipment bay is less than:

Amperes Rating	Wire Size (AWG/mm²)
250 amperes	use #2/0 AWG (70 mm²)
400 amperes	use 250 MCM (125 mm²)
600 amperes	use 500 MCM (250 mm²) conductor
1000 amperes	use 750 MCM (400 mm²) conductor

e) Each individual transmission equipment frame shall be grounded using a ground lead from the TMGB with #2/0 AWG (70 mm²) insulated copper. The ground lead shall run along the equipment bay and connect to the individual equipment, using branch leads of #6 AWG (16 mm²) insulated copper of no more than 1 meter in length.

f) Interior radio and microwave equipment (including cabinets and cable trays that are connected to the equipment) shall be connected directly to the TMGB with #2/0 AWG (70 mm²) insulated copper conductors. The ground lead shall run along the equipment bay and connect to the individual equipment, using branch leads of #6 AWG (16 mm²) insulated copper.

4.1.4.9 Grounding Requirements for Remote Areas that Provide Communications Service utilizing a Copper Cables

These refer to a small telecommunications installation such us remote repeater/terminal site, microwave radio repeater, a radio/multiplexer, terminal, or a combination with or without telephone switches. The ground resistance of the grounding electrodes at the TMGB shall not exceed:

Required Resistance	Remote Areas provides Electronic Services
2 ohms	For radio sites with hut
3 ohms	For a pad-mount over a total of 600 lines and for huts (enclosed walk-in structure that includes a vault with a controlled environment) without radio sites.
5 ohms	For telecommunication sites that are part of other non-communication facilities or buildings without radio sites. For pad-mount radio sites.
25 ohms	For pad-mount up to 600 total lines

4.2 Commercial Building Grounding and Bonding Requirements

This section specifies the minimum requirements telecommunications grounding and bonding arrangement that shall be followed within commercial buildings of differing design or structure where telecommunications equipment will be installed. Commercial building is a building that is design and intended for office use, this includes even a portion of a building intended for office usage.

The following standards shall be apply:

(1) *ANSI/JSTD-607-B*: Commercial Building Grounding and Bonding Requirements for Telecommunications

(2) NECA/BICSI 607-2001 Telecommunications Bonding and Grounding Planning and Installation Methods for Commercial Buildings.

(3) *BICSI* Guidelines (latest edition)

(4) *National Electrical Code* (NFPA 70 NEC)

In the events of conflicting requirements, the most restrictive requirements shall prevail and the conflict shall be resolved with the Communications Standards Committee Chairman.

4.2.1 Commercial Building Grounding and Bonding System Infrastructure

The grounding system infrastructure originates at the electrical (AC) power grounding system thru the TMGB and extends through to each ground busbar known as TGB located throughout building. It includes the following major components:

1) Grounding Electrode System and Electrode Conductor
2) Telecommunications Master Grounding Bus bar (TMGB)
3) Telecommunications Grounding Bus bar (TGB)
4) Telecommunications Bonding Backbone (TBB)
5) Grounding Equalizer (GE)

4.2.1.1 Grounding Electrode System and Grounding Electrode Conductor Selections

The telecommunications grounding system shall be bonded to the electrical (AC) power grounding system thru the TMGB at either of the following, as described in ANSI/J-STD-607-A;

a) Service (AC) Panel Ground Busbar

OR

b) Electrical (AC) Grounding Electrodes (located outside the building or structure).

The Grounding (AC) Electrode Conductor sizing requirement shall be follow as stated in Table 250.102 (C)(1) of NEC 2014.

Commentary Note:

Additional requirements for TMGB as stated in Section 4.1.3.3 of this standard shall be follow. And

Exception:

The electrical service grounding conductor is critical to the safety of the electrical power system. Do not remove, modify, or disconnect without the direct participation and approval of the building design engineer or the utilities/maintenance engineer (proponent, POD, etc.) in the case of existing structures.

4.2.1.2 Telecommunications Master Grounding Bus bar (TMGB)

a) The TMGB serves as the dedicated extension of the building grounding electrodes system for the telecommunications infrastructure. And, serve as the central attachment point for telecommunications bonding backbone (TBB), telecommunications grounding busbar TGB) and its equipment that shall be installed and located within the same room or spaces.

b) TMGB should be located in the entrance facility; however, it should be located to minimize the length on the bonding electrode conductor. The extension of TMGB to other telecommunications room or spaces shall be known as TGBs.

c) Refer to above *Section 4.2.1.1*, for the right choices of Grounding Electrode System and Grounding Electrode Conductor.

Commentary Note:

If TMGB is directly connected to the Electrical (AC) grounding electrode system thru the Service (AC) Panel Ground Busbar or panelboard then it should not be longer than 900 mm (30 ft), refer to BICSI Manual Chapter 8, 13th Edition.

4.2.1.3 Telecommunications Grounding Busbar (TGB)

a) The TGB shall;

- Be a predrilled copper busbar (electro tin plated) with holes use with a standard 2-holes sized lugs.
- Have a minimum dimension of 6 mm (thick) X 50 mm (wide) X variable length to meet the application required and with consideration of future growth, also refer to J-STD-607-A standard.

b) It shall be located nearest to the Service (AC) Panel Ground Busbar or panelboard and bonded to equalize potential voltage between them. Also, it shall be bonded to the nearest structural steel and all metallic parts that is present in the location.

c) Additional requirements of TGB shall satisfy the requirements stated in J-STD-607-A standards, see also Section 4.2 of this standard for other standards list.

4.2.1.4 Telecommunications Bonding Backbone (TBB)

a) The TBB connects the TMGB to the telecommunications grounding busbars (TGB) to each floor. It shall be a continuous insulated copper conductors that should be sized at 2 kcmil per linear foot of conductor length, not less than 6 AWG to a maximum size of 3/0 AWG, refer to J-STD-607-A.

b) TBB sizing of copper conductor (insulated) shall comply the requirements stated in J-STD-607-A, Table for Sizing of the TBB.

SIZING OF THE TBB (Telecommunications Bonding Backbone)		
#	**TBB length linear (m)/(ft)**	**TBB Size (AWG)**
1	Less than 4 / (13)	6
2	4 – 6 / (14 – 20)	4
3	6 – 8 / (21 – 26)	3
4	8 – 10 / (27 – 33)	2
5	10 – 13 / (34 – 41)	1
6	13 – 16 / (42 – 52)	1/0
7	16 – 20 / (53 – 66)	2/0
8	Greater than 20	3/0
Note: *Taken from J-STD-607-A, Table 5.4.4.1 - Sizing of the TBB*		

c) Additional requirements of TBB shall comply the requirements stated on J-STD-607-A standards, see also Section 4.2 of this standard for other standards list.

4.2.1.5 Ground Equalizer (GE)

a) The GE is typically employed in a multistory building to interconnect multiple TBB. The TBB shall be bonded together with GE at the top floor and at a minimum of every 3rd floor in between to the lowest floor level of the building, refer to Figure 5.

b) The GE shall be size according to Table- Sizing of TBB of this standard as stated in Section 4.2.1.4.

4.2.2 Telecommunications Grounding Practices and Installation Requirements

Telecommunications sites with exposed Outside Plant cables within Saudi Aramco is classified as "Exposed" and telecommunication grounding system shall always be required in the following locations:

4.2.2.1 Telecommunications Entrance Facility (TEF)

TEF is recommended location of the TMGB and it shall be near as possible to the telecommunications cable Entrance Facility, see BICSI Manual Chapter 8, 13th Edition for additional requirements to comply and precise placement of TMGB.

4.2.2.2 Telecommunications Equipment Room (TER)

TER is recommended location of the TGB and serve as the connection point for telecommunications infrastructure system such as cabling, pathways and telecommunications equipment that to be install in the TER, see BICSI Manual Chapter 8, 13th Edition for additional requirements to comply and precise placement of TGB.

4.2.2.3 Telecommunications Room (TR) or closet

Like the TER, the grounding and bonding infrastructure for the TR will depend on the referencing of TGG and shall follow the same design and installation guidelines specified in the TER section.

4.2.2.4 Ground Rods Specification and Installation Requirements

SAES-P-111 requirements shall be complied.

4.2.2.5 Physical Protection

Physical protection shall be provided for grounding conductors when there is a possibility that it will be subjected to damage from surrounding activities or vehicular traffic.

If a metallic conduit or raceway is used to provide mechanical protection for ground conductors, it shall be bonded at both ends to the ground conductor.

A #6 AWG size conductor is the minimum sized conductor that shall be run in metallic conduit or race way.

4.2.3 Telecommunications Bonding Connection

4.2.3.1 Each telecommunications facilities the bonding conductor shall be identified and labeled. The label shall be located on the conductor as close as possible to the termination point. Labels should be non-metallic and depict the following information:

Exception:

If this connector or cable is loose or must be removed, contact Saudi Aramco Communication Operations representative.

4.2.3.2 Splice in the bonding conductor be permitted for only approved and shall be listed and may consist of the following:

- Mechanical clamps or lugs. (Do not use for direct buried applications)
- Compression type fittings. (Do not use for direct buried applications)
- Exothermic welding

Commentary Notes:

1. *Exothermic welding usually is used in areas subject to corrosion, systems that carry high current, receive little or no maintenance, and within a direct buried ground electrode system.*
2. *Connectors shall be listed for the application and environment in which they are to be placed.*

4.2.3.3 Additional requirements for bonding connectivity shall follow the requirement as per J-STD-607-A and BICSI Manual Chapter 8, 13th Edition.

4.2.4 Equipment Rack Grounding and Bonding

4.2.4.1 There are three (3) methods that are acceptable to achieved grounding and bonding for equipment rack as per BICSI Manual Chapter 8, 13th Edition, see Figure 6.

Commentary Note:

The figure shows the use of irreversible compression connections along the length of a conductor that is run to the telecommunications equipment rack, also refer to ANSI/TIA 607-B for irreversible crimp connection.

a) Method A: A grounding conductor is run from a listed or approved grounding lugs on the back of the equipment connection points.

Commentary Note:

This method of bonding equipment is established in a single rack environment.

b) Method B: Telecommunications rack grounding busbar (RGB) situated along the top of the rack/cabinet. Individual grounding conductor are run from a grounding lug on the back of the equipment busbar.

c) Method C: Telecommunications rack grounding busbar mounted vertically along the racks/cabinet's structure. Individual grounding conductor are run from a grounding lug on the back of the equipment busbar.

4.3 Telecommunications Electrical Protection - Outside Plant Cables

4.3.1 Outside Plant Protection

The following list of standards are integral part of this section are the following:

1) BICSI OSP DRM, and BICSI TDMM
2) NEC Articles 800, 500, and 250.

Mandatory items and modifications are listed herein.

4.3.1.1 All metallic loops in Saudi Aramco are considered exposed to lightning, except any on premises extensions that are:

a) Not exposed to 300 volts or more and
b) Not extended to a separate building located more than

43 m (140 ft).

Commentary Note:

The 43 m (140 ft) is the zone of protection and it is the physical wall-to-wall distance between buildings.

4.3.1.2 All exposed telecommunication cable conductors that enter buildings shall be protected with UL-listed with fail safe solid state protectors. The Outside Plant Engineer must specify the type of protection required on the design and construction drawing.

4.3.1.3 Sharing of a vault, pull box, or maintenance holes with a power system of any voltage is not permitted. Also, trench sharing with power cable having a phase-to-ground voltage of more than 20 kV is not permitted.

4.3.2 OSP Cables Entering Telecommunication Facilities

4.3.2.1 The termination of Outside plant cables (OSP) on distribution frames shall be fail safe solid state protectors, refer to Section 4.3.3.10 of this standard.

4.3.2.2 OSP cables entering telecommunication buildings/facilities, either directly or in vaults, shall have fuse cables installed according to Table 1.

Table 1 - Fuse Cables Installation Types

Gauge of Entrance Cable*	Gauge of Fuse Cable*	Gauge of Tip Cable*
19 or 22	24	22
19 or 22	26	24 or 22
24	None	22
24	26	24
26	None	24 or 22

** Gauge Cable = AWG*

4.3.2.3 Telecommunications Equipment's Protection Types

a) All OSP cables type entering telecommunication facilities including the metallic members such as shields and armor shall be bonded to each other and connected to the grounding system (Cable Entrance Ground Bar).

b) All cables entering the telecommunications facilities with a metallic members (shields, strand, etc.) shall be grounded, but not to exceeding 15 m (50 ft) from the entrance point. Refer to NEC Articles 800-47 and 48.

c) All outside plant metallic twisted cable pairs entering telecommunications facilities and other telecommunication equipment buildings (includes radio and microwave buildings) shall be protected with fail safe solid state protectors.

d) Telecommunication facilities or DCO shall not be located where:

- The maximum Ground Potential Rise (GPR) exceeds 300 V peak.
- The Electromagnetic field originated by a fault in the power system would impose more than 3.33 Joules within the telecommunication facility.

4.3.3 OSP Cables at Cable Entrances Grounding Requirements

When OSP cables entering telecommunication buildings that contains a metallic shield, armor and/or strength members shall be grounded and bonded:

a) To each other and metallic conduits (entrance, riser, tie, and station), shall be bonded together and grounded to the grounding busbar (TMGB/TGB).

b) Shall not be more than 150 mm (50 ft) from the point of entrance, refer to Figure 7.

c) OSP Cables Entering User Buildings Grounding Requirements

i) Station Terminal Equipment is represented by such items as telephones, answering sets, PBX's, data and alarm circuits, modems, computers, computer terminals, or other electronic type installations.

ii) Telephone service, power service, and CATV shall be provided with a common ground system to protect against differences in ground potential between the systems.

4.3.4 OSP Cables Grounding and Bonding Installation Requirements

This section is to insure that the electrical protection system is well

maintained and safety hazards are highlighted and corrected. When an existing electrical protection device (bond and grounding connection and conductor, station protector) is found to be missing, defective or damaged, a report identifying (maintenance holes, pedestal, terminal no., and location) each item is to be issued promptly. The report is to be forwarded to the responsible maintenance and operations agency so that immediate action can be taken to make repairs of the electrical protection system.

Exception:

The exception to this is when a project job order specifically calls for the repair of the electrical protection system in the scope of work and construction drawing.

4.3.4.1 Aerial Strand Grounding and Bonding

a) When power lines with voltages in excess of 300 volts (but not over 20 kV phase to phase) cross over telecommunication cables on a common pole and a power ground is present, bond the cable strand to the power ground. If separate poles are used, bond the cable strand to the power ground or a 25 ohms maximum man made ground electrode at the first pole on each side of the crossing.

b) If an electrical (AC) power ground is not present, bond the cable strand to a grounding electrode system with a resistance of less than of 25 ohms on each side of the crossing.

c) Cable shields and armors, if present, shall be bonded to the vertical power ground conductor within the telecommunication space on joint-use poles.

d) Separate OPS cables on the same supporting structures and shall be bonded together at least every 610 m (2,000 ft). Where two cables are supported on the same cable suspension bolt, the bolt does not function as the necessary bond.

4.3.4.2 Fuse Cable Protection

Fuse cable shall be placed at the junction of aerial cable with buried or underground cable according to the matrix as shown in Table 2.

Table 2 - Fuse Cable Requirement at Aerial-Buried or Underground Cable Junctions

Aerial Cable Gauge*	Buried or Underground Cable Gauge*	Fusing Required		Fuse Cable Gauge*
		Yes	No	
26	Any		x	
24	26		x	
24	24, 22, 19		x (1)	
22	26, 24		x	
22	22, 19	x		24
19	26, 24		x	
19	22, 19	x		24

**** Cable Gage = AWG***

Note: (1) If 24 or heavier gauge cable extends to the central office, not fusing at this junction will require fusing at the central office unless 22 gauge tip cable is used.

4.3.4.3 Underground Polyethylene Sheath Copper Cable

a) A maintenance holes/pull box shall have a grounding electrode system as follows;

- With a rod grounding electrode system is preferred and having a 25-ohm resistance or less and be bonded to existing ground system nearby, refer to Section 4.1.3.

b) Bonding the polyethylene sheath cable at intermediate maintenance holes or pull-through where there's no opening was made in the polyethylene jacket is not required. However, ensure that the distance to a bonded and grounded point is not more than 305 m (1,000 ft).

c) When cables run through metallic conduits, bond the cable metallic shield (and armor if present) to each end of the conduit. Refer to SAES-T-629 for additional details.

d) The steel armor in wire or tape-armored cables shall be bonded to its underlying metallic shields on each side of all splices (in pedestals, direct buried or in maintenance holes) junctions and terminations. If wire or tape-armored cable is spliced to a standard underground Polyethylene-Insulated Cable (PIC) or to a submarine cable, both ends of the tapes or wires shall be bonded to the cable shields on both sides of the splice. Armor wires shall be bonded to the cable shield(s) at the end of the submarine cable. All bonds shall

then be grounded to grounding electrode system with a minimum of #6 AWG copper ground wire. This shall apply to all types of cable including standard feeder and distribution outside plant copper conductor cables, fiber optic cables (with or without interstitial copper pairs), and pulse code modulation (PCM) cables.

4.3.4.4 Buried Polyethylene Sheath Copper Cable

a) Buried cable shields and armors shall be grounded at points not more than 610 m (2,000 ft) from a ground of 25 ohms or less.

b) When a telephone cable is buried beside or beneath aerial grounded power lines, bond the telephone cable shield to the power ground at the beginning of the exposure, at the end of the exposure, and at points not more than 305 m (1,000 ft) from a ground point.

c) When a telephone cable is buried besides or beneath aerial ungrounded (delta) power lines, establish 25 ohm or less man made grounds. Bond the telephone cable shield to the man-made grounds at the beginning of the exposure, at the end of the exposure and at points not more than 305 m (1,000 ft) from a ground point.

d) Where a terminal housing/pedestal is located within 3 m (10 ft) of an electrical supply terminal or transformer housing (grounded system), a #6 AWG copper wire shall be used to bond the telecommunication terminal housing to the electrical supply terminal or secondary section of the transformer.

e) When telecommunication cables are buried parallel to buried power facilities (in a joint or separate trench) with fixed separation (one meter or less) and, where there is no requirement for a telecommunications pedestal/terminal, a telecommunication cable may be buried past distribution power transformers/terminals etc., without placing a telecommunications pedestal/terminal solely for the purpose of bonding the cable shield to the power ground. Ensure that no point on the cable is more than 150 m (500 ft) from a bond to the power ground and bond the bare grounding conductor and the cable shield at:

- Each transformer

- Additional locations as required.

f) In areas where a terminal housing/pedestal is subject to disturbance/damage from vehicles, etc., it shall be protected with a pedestal guard. These have typically been constructed of steel pipe. Where pedestal guards are constructed of steel pipe or other metallic materials, they shall be bonded to the pedestal with a #6 AWG copper wire. The copper ground wire shall be attached to a metallic post of the pedestal guard (using cad weld method or an approved mechanical connector) at a point 50-75 mm above the concrete encasement of the metallic post base.

4.3.4.5 Joint Burial of Power and Telecommunications OSP Cables

Separations between buried power facilities (power cable, power pedestals, etc.) and telecommunication cables (when crossing) shall not be less than 300 mm (12 in) of well-tamped earth.

In areas where this is not possible, 75 mm (3 in) of concrete or 100 mm (4 in) of masonry is permitted.

Where the power exposure is greater than 15 kV phase to phase, buried telecommunication cables shall be placed inside PVC or similar characteristic conduit at the crossing. Refer to SAES-T-928.

4.3.4.6 Electrical Protection for Fiber Optic (FO) Cable

a) All metallic members of a FO cable shall be bonded together and grounded at all splice locations. The ground shall meet these requirements:

- Have at least of 25 ohms or less resistance.
- Shall be bonded to the electrical (AC) power grounding system, when available within 3 m (10 ft). Where there is no requirement for a pedestal/terminal, a fiber optic cable may be buried past distribution power transformers/terminals, etc., without placing a pedestal/terminal solely for the purpose of bonding the cable metallic members to the power ground. Ensure that, no point on the cable is more than 150 m (500 ft) from a bond to the power ground and bond the bare grounding conductor and the cable shield at:

- Each Transformer
- Additional locations as required.

b) When a FO cable containing metallic members is placed on a pole line (and the inductive effects of nearby power lines are not calculated), bond the metallic members to the support strand at all splice points and at intervals not to exceed 2 km (1.25 miles). Where it is not practical to place bonds every 2 km, or where there are complicated power exposures. In any case, the separation between bonds will not be permitted to exceed 4.8 km (3 miles). Each bond point shall be grounded to the power ground, where available. In other areas, a ground electrode of 25 ohms resistance or less shall be provided. Joint use with delta power systems is not permitted. Refer to *SAES-T-624*.

c) Bond the support strand to the power ground at intervals of 610 m (2,000 ft) or less.

4.3.4.7 UL Listings

Central office protectors shall be UL (Underwriters' Laboratories) listed as a complete assembly. Refer to Section 3.2 above for the appropriate industry standard.

DCO Protectors shall include the following:

a) Fused and Fuse less station protectors
b) Protected cable terminals.
c) Protected terminal blocks.
d) CP protectors.

4.3.4.8 Fail Safe

Arresters used on Saudi Aramco Telecommunication circuits must be a type that always fails in the shorted/grounded condition.

4.3.4.9 Fuse Cable Protection

a) Fuse cable of a minimum length of 2 m of fine gauge (24 or 26 AWG) cable shall be installed if the outside plant entrance cable contains 22 AWG or larger gauge conductors, refer to Section 4.3.2.2 – Table 1.

b) No additional fuse cable is required if the entrance cable contains 24 or 26 AWG copper conductors and the central office connector stub (tip cable) contains conductors which are at least two gauges larger than the conductors in the entrance cable (i.e., 22 AWG for 24 AWG entrance/fuse cable), refer to Section 4.3.2.2 – Table 1.

4.3.4.10 Terminating cable conductors shall be two gauges larger than the fuse cable conductors. Indoor PVC sheath cables must not be exposed to sunlight. When the tip splice is located in the DCO equipment room, the outside polyethylene sheath cable must be wrapped with arc and fire-retardant tape from the tip splice to the building entrance point.

4.3.4.11 Heat coils protect equipment against prolonged currents of small magnitude which might eventually cause a fire or damage equipment. Central office protectors shall be equipped with heat coils unless the equipment manufacturer directs otherwise. The manufacturers' instructions must be followed to avoid the possibility of violating the warranty conditions of the manufacturer.

4.3.4.12 Fuse Cable Protection Devise

A Solid state type protectors shall be used for DCO protection.

4.3.4.13 Devise Protector Application Guidelines

a) All new telecommunication equipment projects shall specify five-pin/four pin protector modules equipped with 300 V solid state protection devices.

b) Refer to sections that applied for the protector modules, see Installation and Testing.

c) Digital Switches and Remote Line Concentrators: Existing protectors need to be replaced for maintenance and repair purpose, etc., shall be replaced with solid state protectors.

4.3.5 Copper Cable Station Protection for Telecommunication Building (less than 25 pairs)

4.3.5.1 The 60 Hz Flashover Voltage Requirements

a) A minimum of 5,000 VDC breakdown voltage between the

line cord conductors and parts of the set in constant contact with the user (telephone hand set).

b) A minimum of 1,000 VDC to parts in short term contact with the user.

4.3.5.2 Fuse less Station Protectors

a) UL Listings

Fuse less station protectors shall be Underwriter's Laboratories (UL) listed as a complete assembly. *See UL 497*, *UL 497A*, or *UL 497B* for detailed requirements.

b) Fail Safe

Arresters used on Saudi Aramco telecommunication circuits must be a type that always fails in the shorted/grounded condition.

4.3.5.3 Fuse less Station Protectors shall be used when:

a) A 24 AWG building entrance cable is used and its metal shield is grounded to the station ground and bonded to the distribution cable shield.

b) A distribution cable serves the entrance facility from:

- A cable terminal with a 24 AWG stub connecting it to the distribution facility.
- Pedestal terminal equipped with terminal blocks, provided the cable pair is connected to the terminal block binding post by a minimum of 450 mm of 24 AWG leads.

c) A distribution facility is entirely underground or buried; entrance facility may be aerial, underground, or buried.

4.3.6 Station Protection - Mobile Home Installation

Work done at mobile home locations shall be of a permanent nature.

4.3.6.1 Testing Mobile Home Chassis for Foreign Voltages

Before making bodily contact with any metal portion of the mobile home, confirm that there are no hazardous voltages on

the mobile home chassis (trailer body to ground) using a volt-ohm-meter (VOM).

4.3.6.2 Installing Station Protectors, Drop Wire and Cable

a) The Locating of the Protector shall be located on a post as near as possible (not more than 300 mm) to the mobile home. Direct protector attachment to the trailer is not permissible.

b) The Bonding for Mobile Homes home chassis must be bonded directly to the telephone ground electrode using #6 AWG ground wire to limit the differences in electrical potential that may develop between telephone equipment, metal surfaces, and the wiring of the mobile home.

c) When wiring on the post cannot be placed 300 mm or less from the mobile home, a conduit from the post to the mobile shall be used to protect station wiring from damage. If metal conduit is used, place a bond between it and the ground at each end of the conduit to prevent forming chokes.

d) Connection

- When a ground rod is used, connect the protector ground and chassis ground to the ground rod with separate UL listed clamps. Bonding of grounding connections to power ground facilities must be done in accordance with *SAES-P-111*.
- Do not make bends less than 150 mm in the ground wire (wire between protector and ground source).
- Attach a #6 AWG ground wires to the post with station wire nails or galvanized clamps and within 10 mm staples or clamps.

e) Burying A Ground Wire shall be buried to a minimum depth as follows:

- At 450 mm under lawns and driveways
- At 600 mm where the earth may be disturbed in the future.

4.3.7 Installation - Special Services Circuit Safeguarding on User Premises

4.3.7.1 Following examples of special services lines, which require

guarding against service interruption due to accidental contact, are the following:

a) The Carrier telegraph and Program supply (radio).

b) The Remote control, signal sound and alarm systems, including fire and gas, etc., industrial security and various instrument gauge lines.

c) The Ringing supply lines for hospital, fire, and industrial security departments.

d) The Special facilities intended for use in case of major disaster.

e) The Trunk circuits (digital and analog).

4.3.7.2 Safety measures must be exercised when working on a special service circuit area due to circuit sensitivity that may result to service interruption, or unintentional start-up of an equipment.

4.3.8 Station Grounding Requirements - Description

4.3.8.1 The telephone protector grounding conductor shall be connected to prefer Ground Electrodes, as follows:

a) To the power (AC) service Panel Ground enclosure (external portions of enclosure only)

b) To the electrical (AC) grounding electrodes conductor

c) Other ground electrodes as permitted by NEC, Article 800.

4.3.8.2 If the Service (AC) Panel Ground Busbar is used and it's not located within 6 m of the telephone station protector, relocate the telecommunication protector, or one of the following electrodes may be used if it is bonded to the Service (AC) Panel Ground and forms a part of the building ground system:

a) The grounded metal frame of the building

b) The electrical (AC) grounding electrodes conductor

c) All the above grounds present on the premises must be bonded together regardless of the distance between electrodes or ground systems.

4.3.9 Station Grounds Installation

The Ground Wire shall be, as follows:

a) May be run through the same entrance as the station wire if the station protector is mounted outside, and ground is located under the building.

b) Do not run the station protector ground wire in attics.

c) Bury the ground wire running from a building to an exterior ground connection.

d) Never encircle the ground wire with a metal ring because the ring will act as an RF choke.

4.3.10 Ground Conductor Connections

In grounding (bonding) wire runs, sharp kinks and bends shall be avoided. Slack ground wire shall not be coiled or wrapped around the ground electrode. Ground wires may be stapled or clamped in position, but they must not be run through bridle rings, closed metallic clips, sleeves, metallic pipes, or wrapped around nails or any other objects.

The grounding or bonding conductor shall be connected to the grounding electrode by exothermic welding, listed pressure connectors, or listed clamps.

4.3.11 Inside Station Wire Connections

To create a choke to prevent lightning from following the wire, each of the inside station wire conductors shall be coiled with three or four turns about 25 mm diameter before being connected to the station protector

4.3.12 Conduit for Ground Wires

When conduit is required for ground wires, always use non-metallic conduit. If metallic conduit must be used, the ground wire shall be bonded to the conduit at each end. Also, when OSP cables run through metallic conduits, bond the cable metallic shield and armor if present to each end of the conduit.

Exception:

For an exception to this requirement, refer to SAES-T-629.

4.4 Telecommunications Electrical Protection - Power Plants

This section prescribes the minimum requirements for electrical protection of telecommunications facilities serving or within the area of Power Plants and Substations.

Recommendation:

*When designing telecommunication services to a new Power Plants and Substations, therefore a **non-metallic fiber optic cable** shall be the first option to be use as medium of communications.*

Commentary Note:

It is safer to use non-metallic fiber optic cables to serve electrical substations. This will prevent any fault currents at the substations form propagating back to the central office; which could harm personnel and damage telecommunications equipment.

The following mandatory requirements are listed herein when using existing copper cable in a Power Plants and Substations as follows:

4.4.1 Electrical Protection for Telecommunication OSP facilities shall be protected from foreign voltages such as the following:

1) Ground Potential Rise/s (GPR) due to the flow of lightning or power fault currents.

2) Lightning,

3) Accidental contact with light or power lines of 300 volts or more,

4) Voltages electromagnetically induced into telecommunication lines by fault currents in parallel with power lines,

5) Voltages electrostatically induced into the telecommunication lines by normal currents in parallel with power lines,

4.4.1.1 Ground Potential Rise (GPR)

a) GPR analysis shall be done when telecommunications facility using cable having a metallic member located within 1.0 km of power plants and substations.

b) The cable location shall be in such area that the GPR exposure does not exceed 50% of the cable core-to-sheath dielectric rating based on calculated GPR voltages.

c) GPR calculations, grounding, and bonding recommended protection equipment shall be provided as part of the project design package. Only if there is uncertainty regarding provided design, interpretations shall be provided through the Saudi Aramco Communications Standards Committee Chairman. A copy of the GPR analysis shall be included with the design package.

d) The primary purpose of a Ground Potential Rise (GPR) Study is to determine the level of hazard associated with a given high-voltage location for personnel and/or equipment. Things to be considered to ensure Telecommunication facility location is safer when it is expose from Ground Potential Rise (GPR).

- In the planning stage, minimum grounding systems shall be identified.
- Local (government) and Company safety guidelines procedures must be considered.

e) Things shall be needed toward proper conduct of a Ground Potential Rise (GPR) Study:

- Soil resistivity test data.
- Site drawings with the proposed construction.
- Electrical data from the power company (when it's located near a power plants and substation).

Commentary Note:

Refer to Consulting Services Department (CSD) or SAES-P Standards Committee Chairman for GPR analysis requirements.

4.4.2 Electrical Protection Design of Telecommunication facilities serving electric power stations shall be as follows:

4.4.2.1 The Minimum Protection Requirements at Power Stations are indicated in Table 3.

Table 3 - Minimum Protection Requirements at Power Stations

SPO (Service Performance Objective)	GPR (Ground Potential Rise) + Induced Voltage Level in Volts		
	GPR<300	300<GPR<1000	GPR<1000
Class A (Critical Circuits, non-interruptible type service; must work during power fault)	No special protection is required	Special high voltage protection is required (Optical Isolators such as Teleline Isolators(1), Tucon(2) Fiber links, or ABB Fiber Optic System(3), Neutralizing Transformers, dedicated cable with isolated shield)	Special high voltage protection is required (Optical Isolators such as Teleline Isolators(1), Tucon(2) Fiber links, or ABB Fiber Optic System(3), Neutralizing Transformers, dedicated cable with isolated shield)

SPO (Service Performance Objective)	GPR (Ground Potential Rise) + Induced Voltage Level in Volts		
	GPR<300	300<GPR<1000	GPR<1000
Class B (Emergency circuits that may be interrupted for not longer than duration of power fault, Service restored without human intervention)	No special protection is required	Solid state protection is required, dedicated cable with isolated shield may be Teleline Isolators(1), Tucon(2)	Special high voltage protection is required (Optical Isolators such as Teleline Isolators(1), Tucon(2) Fiber links, or ABB Fiber Optic System(3), Neutralizing Transformers, dedicated cable with isolated shield)
Class C (Circuits that can be interrupted until a station visit is made to restore service)	No special protection is required	Solid state protection is required.	Special high voltage protection is required. *(Same for Class A and B)*

Notes: (1) The Teleline Isolator is a trademark product of Positron Indus., Inc.

(2) The Tucon Optical Link is a trademark product of Ericsson

(3) The ABB Fiber Optic System is a trademark of Asea Brown Boveri

4.4.2.2 The Required Pair Identification and Physical Safeguards

Safeguards shall be provided, during installation, for Class "A" or Class "B" services circuits, wherever they appear in wires, cables, pedestals, microwave locations, radio sites, building terminals, distributing frames such as Combined Distribution Frame (CDF), Main Distribution Frame (MDF, and Intermediate Distribution Frame (IDF), and anywhere else the circuits are physically accessible. From the point of origin to the point of termination or destination, these services shall be clearly identified and safeguarded as follows:

a) Provide physical protection and identification at every point in the cable distribution system where the conductors appear outside the cable sheath.

b) Materials and supplies to be used in safeguarding these services shall be red in color and shall include cable warning tags, labels, stenciling in red ink or red paint, binding post caps, plastic separators on connector blocks, etc.

4.4.2.3 If GPR exceeds 1,000 V, the cable shield must be:

a) Isolated from ground at all locations on the power station premises and at pedestals within the zone of influence.

Pedestals shall not be placed in a zone of influence, where the GPR level is 300 volts or greater.

b) Isolate the cable shield from ground but maintain shield continuity within the zone of influence.

4.4.2.4 Safety Precautions

When working in power plants and substations and other electrical facilities where electrically energy at voltages high enough to inflict harm to a person and equipment, personnel must:

a) Use insulating gloves work as buddy system, working alone in this environment is prohibited.

b) Check the grounds with a high voltage detector (General Machine Products, B Voltage Tester or equivalent high voltage tester). Volt-Ohm meters shall not be used to test grounds and other points of probable high voltages (Volt-Ohm meter will be required to perform continuity and polarity test as part of SAES-T-634 standard).

c) If isolated cable shields are accessible to touch during any work operation, cable shields shall be bonded to the power station ground to ensure safe working conditions for communication employees while they are working on these cables. The bond must be removed after the work has been completed.

d) Put on high voltage insulating gloves and wear them when making connections to ground terminals or working on cable shields at power stations.

e) Avoid contact with other metal objects within the power station ground grid area when installing telecommunication equipment and doing cable work.

4.4.2.4 Power Station Protection, Remote Ground Arrangement

a) The Remote Drainage Location (refer to IEEE 487) must be placed outside the effective range of influence (GPR is 300 volts or less) of the power station GPR at a location where it is possible to establish a low resistance (25 ohms or less) 'man made' ground.

b) Cable pairs and cable shields or armors, when present between the high-voltage interface location and the Remote Drainage Location, must not be connected to or contact the ground structure at the power station. The cable must be routed through insulating conduit (PVC) in the station grid area if the GPR level is greater than 1,000 volts.

c) The Remote Drainage Ground must be no closer than 6 m (20 ft) to the Dedicated Cable shield ground (refer to IEEE 487). The 6 m (20 ft) spacing is the minimum distance required to prevent coupling through the earth between grounds if the dedicated cable shield should inadvertently contact the power station grounding structure.

d) Solid state protectors must be provided on all cable pairs at the Remote Drainage Location to limit voltages on cable pairs to a safe level before entering the General Use Cable (refer to IEEE 487). Protectors shall be UL 497, UL 497A, or UL 497B listed.

4.4.2.5 Fundamentals of Ground Measurements

Ground resistance and soil resistivity shall be measured in accordance with IEEE 81.

4.4.2.6 Fundamentals of Inductive Coordination for Communication Circuits

a) Approved Equipment for Noise Harmonics Measurements are as follows:

- Northwest Electronics Model TTS-37B Noise Measuring Set or equivalent.
- HP Model 3551 A or equivalent.
- Wilcom Model T 136 and Model T 132 B or equivalent.

b) The following are Mandatory Noise Requirements:

Table 4 shows the acceptable noise measurement values.

Table 4 - Noise Measurement Values

Noise Metallic	Not to exceed 20 dBrnC
Noise-to-ground	Not to exceed 80 dBrnC
Balance	Not less than 60 dB

4.4.2.7 Determination of Minimum Separation between Digital Sites and Electric Power Facilities

Telecommunication digital facilities shall not be located where the maximum Ground Potential Rise (GPR) exceeds 300 volts peak, or where the Electromagnetic field originated by a fault in the power system would impose more than 3.33 Joules within the digital communication facility when calculated as followed:

$$\text{The amount of energy (in Joules)} = (Vi^2/Rd) * t$$

Where:

Vi is the peak value of the induced voltage
= 1.414 * Imf * Zm * Ls

Imf is the maximum fault current

Zm is the mutual impedance of the site

Ls is the length of the exposed facility

Rd is the resistance of the most susceptible electronics component

t is the maximum clearing time of the power system (in seconds)

4.5 Telecommunications Electrical Protection - Radio Station

This section describes minimum specification on electrical protection for antenna support structures - towers.

4.5.1 Tower Structure Grounding Requirements

4.5.1.1 All towers shall have a grounding electrode system to form a ground ring which is consist of a ground rods and grounding conductor.

4.5.1.2 A solid bare copper conductor #2 AWG as minimum should be buried around the tower at a depth of 460 mm (as per *SAES-P-111*) below surface ground and at least 610 mm from the base of the tower footings.

4.5.1.3 A driven rod shall be driven at each base of tower leg with a minimum of 460 mm below surface ground and use minimum #2 AWG solid, bare copper conductor to bond all grounding rods using exothermic welding or by UL listed pressure clamps.

4.5.1.4 For guyed towers antenna, refer to *SASD: AA-036765*.

4.5.1.5 The Tower ground ring shall be bonded to the external grounding system of the building with a minimum of #70 AWG solid, bare copper conductor using exothermic welding or by UL listed pressure clamps.

4.5.1.6 If metal fence is present within 1,800 mm from the tower, the tower ground ring shall be bonded to the fence using a minimum of #2 AWG solid, bare copper conductor.

4.5.1.7 Grounding conductor bending radius requirements, see Section 4.1.3.8 on this standard.

4.5.1.8 When installing Fuel Tanks within the Tower perimeter:

a) Do not locate a fuel tank between towers and radio station buildings.

b) Avoid burying a tank close to a tower ground if the tank is not metallic or not bonded to the grounding systems in the site.

c) The distance between the tank and the tower grounding electrode shall be a minimum of 5.0 m (15 ft) where soil resistivity is less than 100 ohm-meter and a minimum of 8.0 m (25 ft) in areas where soil resistivity is above 100 ohm-meter.

d) Ground fuel tanks by clamping the ground wire to the filler pipe or other external hardware. Do not weld or drill on the tank itself.

e) Bond buried metallic structures (fuel pipes, water pipes, ground rings, etc.) together where they pass within 2 m (6 ft) of each other.

4.5.2 Antenna Tower Mounted on the Top of Building Protection

4.5.2.1 Refer to regular lightning protection cables and hardware following the recommendation on *NFPA 780*, Standards for the Installation of Lightning Protection Systems.

4.5.2.2 Install a roof ground ring by bonding the legs of each tower bases. And shall have a minimum of two down conductor from opposite side of the roof ground ring down to the building wall bonded to external grounding system of the building.

4.5.2.3 Roof ground conductor shall be supported every 100 mm using a no-nail paste cable fastener or by any other approved methods.

4.5.2.4 Antenna and Tower ground ring associated with the Radio Systems shall be bonded to the external grounding system of the building with a minimum of #2 AWG solid, bare copper conductor using exothermic welding or by UL listed pressure clamps.

4.5.3 Antenna, Coaxial Cable Transmission Lines, and Waveguides Protection

4.5.3.1 VHF/UHF Antennas

See *SASD: AA-036361* "VHF/UHF Antenna Installation on Self-Supporting Towers" for antenna installation and protection.

a) The coaxial type of antenna shall be protected by connecting a star gap arrestor between:

- Inner coaxial conductor (whip), and
- Outer coaxial conductor (skirt) of the antenna.

b) The radiating element of the collinear-array type omnidirectional gain antenna shall be grounded.

4.5.3.2 Coaxial Cable Transmission Lines

a) Bond the coaxial outer conductor to tower structure or down ground lead at the top, and at the bottom of the tower and at 60 m (200 ft) maximum intervals along the length of the coaxial cable.

b) Bond the outer conductor to the ground wire at the top and at the bottom of the pole if coaxial cables are placed on wood poles.

c) Coaxial cable shall be bonded to the tower using an approved grounding kit and must comply with the grounding kits installation requirements:

- Grounding kits shall be installed near the top of the main feeder cable, at the bottom of the main feeder

prior to the horizontal run, and just prior to the cable entering the building.

- Grounding kit shall be installed as per Manufacturer's specifications.
- Grounding kit shall be sealed or install a weatherproofing to keeps connector interfaces tight and adds an additional layer of protection against the environment.
- Grounding kit shall be attached to an effectively grounded vertical member of the tower using approved methods of connection and typically a mechanical Clamp or as per tower manufacturer specification.
- Grounding kit grounding conductors shall be installed without drip loops, parallel to the transmission line, and pointed down towards the ground to provide a direct discharge path for lightning.

d) The coaxial cable should be protected by a lightning surge arrester and be bonded to the external or internal grounding bus bar with the proper size grounding conductor per manufacturer specification.

Commentary Notes:

Refer to Figure 8, Typical Tower Ground Bus Bars.

4.5.3.3 Waveguides Protection

a) Waveguide/coaxial cable shields shall be bonded to the top and bottom of the tower prior to their entry into a telecommunication building/shelter. If the tower is greater than 60 m (200 ft) in height, the waveguide or coax shield should also be bonded at the tower midpoint or every 15 m (50 ft).

b) A tinned copper ground bus bar (Waveguide Entrance Ground Bar -WEGB) shall be install located outside the telecommunications building at or near the tower horizontal cable run entry and be bonded to both the external and internal grounding system with a #2 AWG bare, tinned solid copper conductor.

4.5.3.4 RF Surge Suppressors

a) Mount Radio Frequency (RF) surge suppressors at the base

of the tower prior to the radial turn toward the building or on the bulkhead.

b) Surge Suppressors shall be installed within (2 ft) of the point of cable/s entry into the telecommunication facilities and shall be bonded to the TMGB (building or tower ground ring) with a 16 mm² CSA (#6 AWG) green jacketed, stranded copper conductor.

c) Do not install RF surge suppressors inside the building or in hazardous locations.

4.5.3.5 Others Protection Requirements for Antennas

a) Antenna Supports Ground Leads

When an antenna support is mounted on the roof of a building, ground leads connections shall follow the rules in the Lightning Protection Code *NFPA 780*. The following items shall be connected to the grounding system:

- Antenna and antenna supports
- Guy wires
- Guy wire anchors

b) Ground Leads Selection

- Where the height of the antenna plus the roof is less than 23 m (75 ft), use Class I lightning cable, (Copper 187 lbs/1,000 ft, 57,400 CM (Circular Mils) with strands no less than #17 AWG (1.29 mm²).

- Where the height of the antenna plus the roof is more than 23 m (75 ft), use Class II lightning cable (Copper 575 lbs/1,000 ft, 115,000 CM with strands no less than #16 AWG (1.31 mm²).

c) Ground down Leads

- Ground down leads shall be protected against corrosion when they enter corrosive soil by using corrosion resistant conductors and hardware up to a level no less than one meter (3 ft) above grade and for the entire length of below grade levels.

- Protect ground down leads against physical damage for a minimum of 2.5 m (8 ft) above grade level.

d) Antenna Support Protection

- If the antenna support is mounted on a building with a metal frame and the antenna support is metal, bond the antenna support and the coaxial outer conductor to the metal building frame with Class II secondary conductor cable [14 strands each of no less than #17 AWG (1.29 mm²) Copper conductor cable].
- Connect down guys to the ground rod as detailed on *SASD: AA-036765*.
- Provide a system of down leads if the building does not have a metal frame, see paragraph 5.8.2.2.
- Non-live metallic objects 2 m (6 ft) apart or less shall be bonded together using Class II secondary conductor cable [14 strands each of no less than #17 AWG (1.29 mm²) Copper conductor cable].

4.5.3.5 Radio Equipments Protection

a) Shielding Protection

When shielding of an equipment room is required, provide a shielding that is grounded to the site's grounding system with a minimum of #2 AWG (35 mm²) tinned solid copper.

b) Radio Equipment's Grounding Requirements, refer Section 4.2.2.15 of this standard.

c) Interior Ring Bus System

The interior ring bus system shall be no less than a #2 AWG (35 mm²) bare solid tinned copper cable supported on walls and shall be mounted over racks, trays, framing channels and door frames. Support the ring at a maximum of 600 mm (2 ft) intervals and at turning points.

d) Bonding Connections

- Bond all non-circuit metal objects in the radio equipment room to the ground bus or ring. This includes items such as, wave guide hatch plates, air ducts, exhausts, hoods, air dryers, metallic door frames, metal cabinets used for spare parts, distribution power panels and master ground bar (if present).

- The bond path length between metallic objects must not exceed:
  - 4.5 m (15 ft) if the objects are within 300 mm (1 ft)
  - 9.0 m (30 ft) if the objects are within 1.80 m (6 ft)
- Use a minimum of #2 AWG (35 mm²) tinned bare solid copper wire for these bonding connections.

4.5.3.6 Protection Requirements when connecting between Telecommunication Buildings

a) The shields and armors of all cables entering a radio station must be bonded together and grounded to the station ground.

b) Metallic entrance conduits must be bonded together and connected to the station ground using a minimum of #6 AWG (16 mm²) insulated tinned solid copper wire.

c) Bond cable shields and sheaths to the two ends of metallic conduits through which they pass.

d) Outside type polyethylene jacketed entrance cables placed inside buildings (maximum 50 ft, see *NFPA 70*, *NEC Article 800*) must be wrapped with approved fire proofing tape.

4.5.3.7 Terminal Grounding Requirements

a) Connect the entrance cable protector terminal ground directly to the external ground ring. The grounding conductor length shall not exceed 6 m (20 ft).

b) Bond the cable shield and armor to the ground ring at the points where they cross within 2 m (6 ft) of each other.

4.6 Special Application

4.6.1 Community Housing Grounding

4.6.1.1 An approved ground source shall be installed outside the house premises using a ground rods. Bond the ground busbar using a solid or stranded copper conductor with listed double hole connector and ensure to have a ground resistance of not less than 25 ohms. Refer to *NEC 250.66* Table for sizing of ground electrode conductor.

Commentary Note:

This only apply if electrical grounding grid is not available.

4.6.1.2 If electrical ground grid is established, bond the telecommunication busbar using a solid or stranded copper conductor with listed double hole connector. Refer to *NEC 250.66:* Table for sizing of ground electrode conductor.

4.6.2 Telecommunications Manhole/s Grounding

The ground rod shall be installed outside the Manhole with a minimum of two (2) ground rods with a minimum separation of 6 feet apart and shall be installed at opposite side of the MH end walls and connected inside the MH with a bonding ribbon and/or ground wire. A ground resistance of 25 ohms or less shall be provided in each manhole, refer to *SAES-T-911* standard for further requirements to be comply.

4.6.3 Telecommunications Shelter

An approved ground sources such as, but not limited to ground rods shall be installed within the premises along the four sides/corners of the telecommunication shelter and maintain a 6 feet separations between ground rod. Bond the ground busbar using a solid or stranded copper conductor with listed double hole connector to the ground electrode and ensure that the ground resistance complied as per Section 4.1.2.6 or Section 4.1.4.9 which ever apply. Refer to Table from *J-STD-607*-A as shown in Section 4.2.1.2, for sizing of ground electrode conductor against the required length.

5 Installation

Installation criteria shall comply as follows;

a) *SASD:AA-036391* (Communications Equipment Grounding for Telecommunications Facilities) shall be complied for planning, design, preparation, ground conductor sizing, routing and terminating.

b) National Electrical Code, National Electrical Safety Code, and other related Saudi Aramco Engineering Standard such as *SAES-T-916* for all electrical protection and procedures applied to Company telecommunications network. Also, instructions issued by manufacturers will be consider to avoid the possibility of violating the warranty conditions of the manufacturer.

6 Testing and Inspection

6.1 The grounding resistance measurement shall be in accordance with this standard and testing shall be witnessed by PID (Project Inspection Division). PID shall inspect all Telecommunications facility grounding systems as per in accordance with this standard and applicable standards as listed in Section 3 of this standard.

6.2 Electrical protection equipment, apparatus and devices/materials shall be tested with the cable according to *SAES-T-634* requirements. All DCO and station protectors shall be Underwriters Laboratories (UL) listed or equivalent.

6.3 The Saudi Aramco Inspection Department must be notified a minimum of 48 hours in advance prior to beginning of any construction or testing; hence, that all necessary inspections can be scheduled. Also, this include backfilling any trenches or starting any acceptance testing.

Revision Summary

1 June 2014	Revised the Next Planned Update, rearranged the content of the document for clarity, and reissued as major revision.
18 October 2016	Major revision that will attain a cost savings in the next future projects, and alignment with the international standards and other related SA engineering standards.
1 January 2018	Editorial revision to modify/delete paragraphs 4.3.4.6, 4.5.3.5, and 4.6.1.2 (Commentary Note).

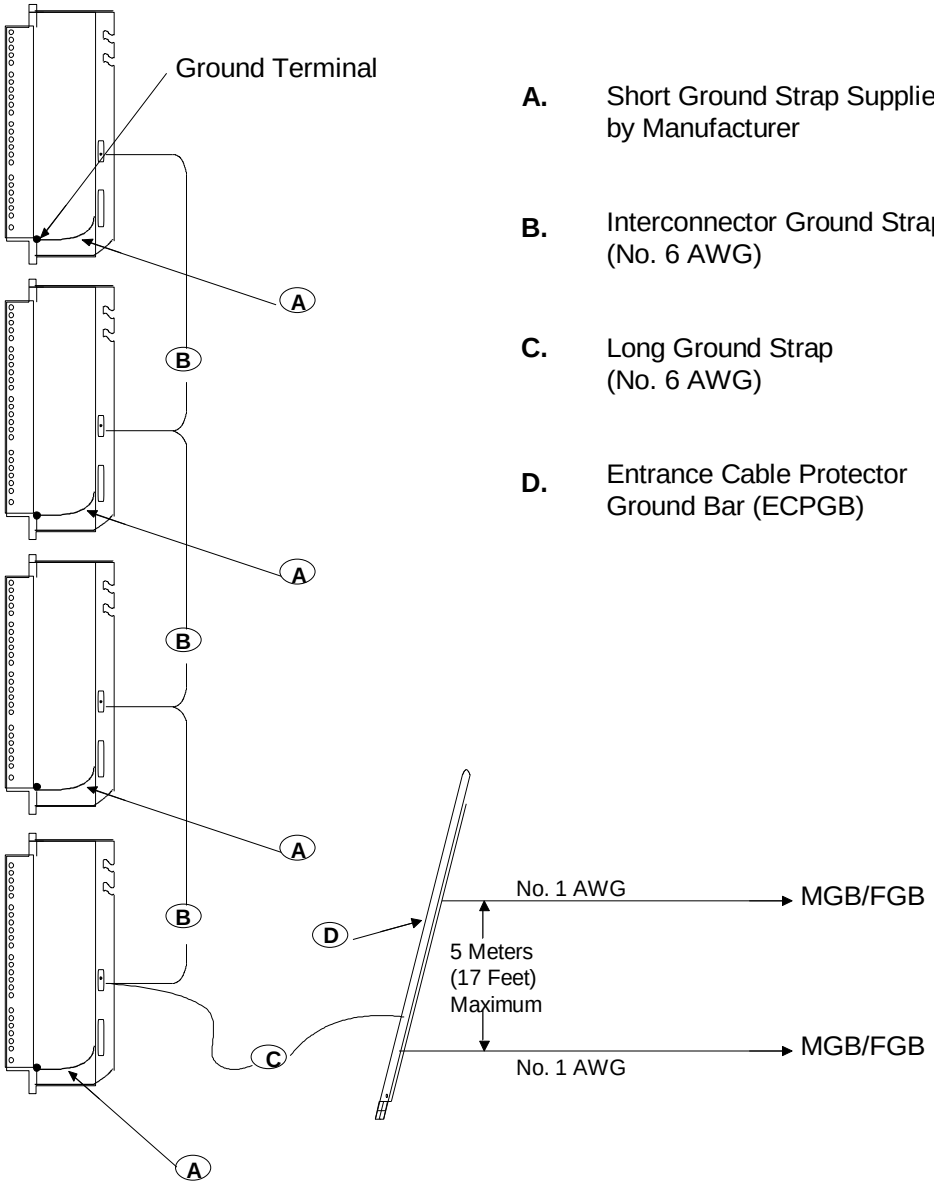

Figure 1 - Entrance Cable Protector Ground Bar (ECPGB)

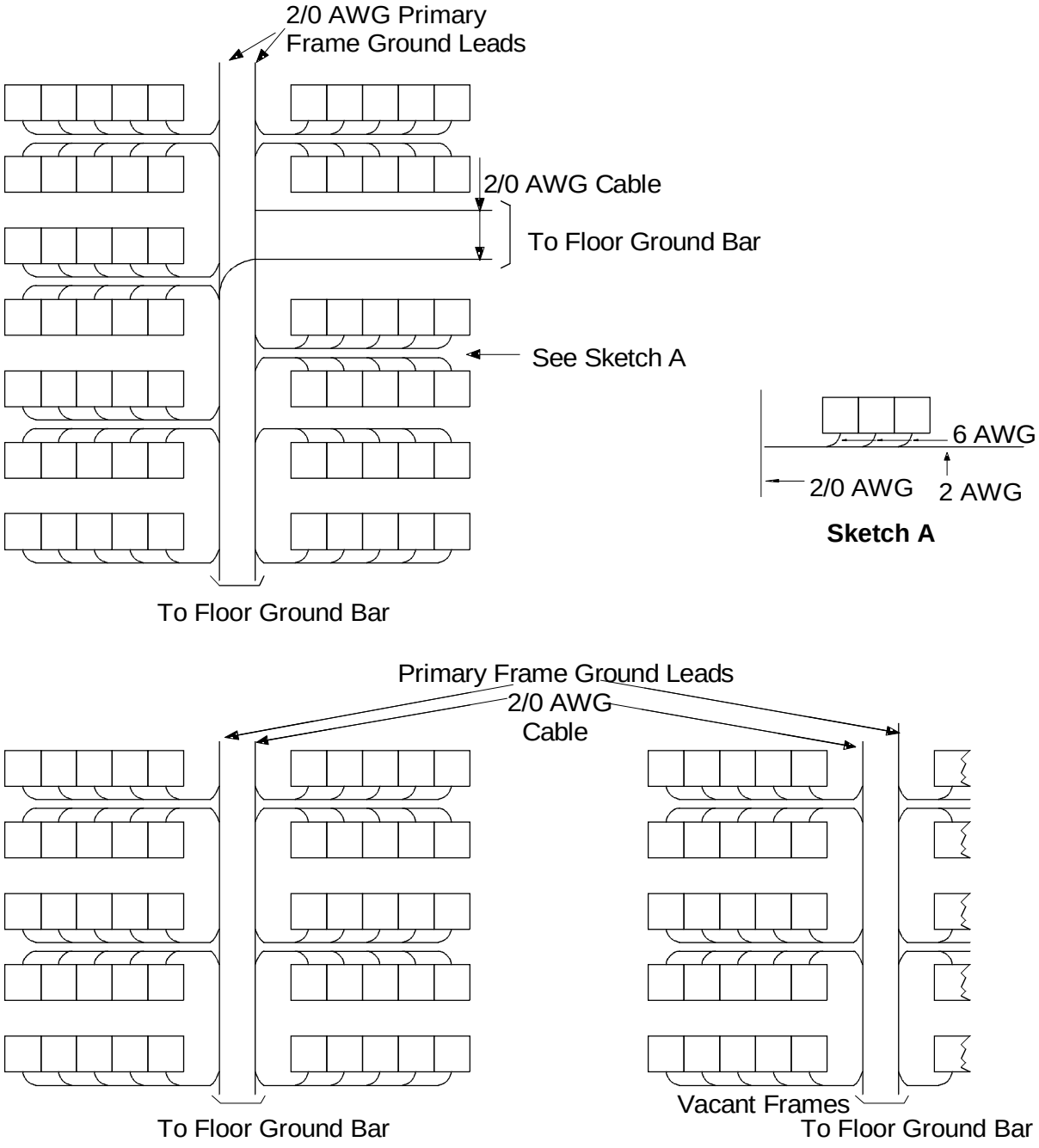

Figure 2 - Electronic Switching Equipment Frame Grounding

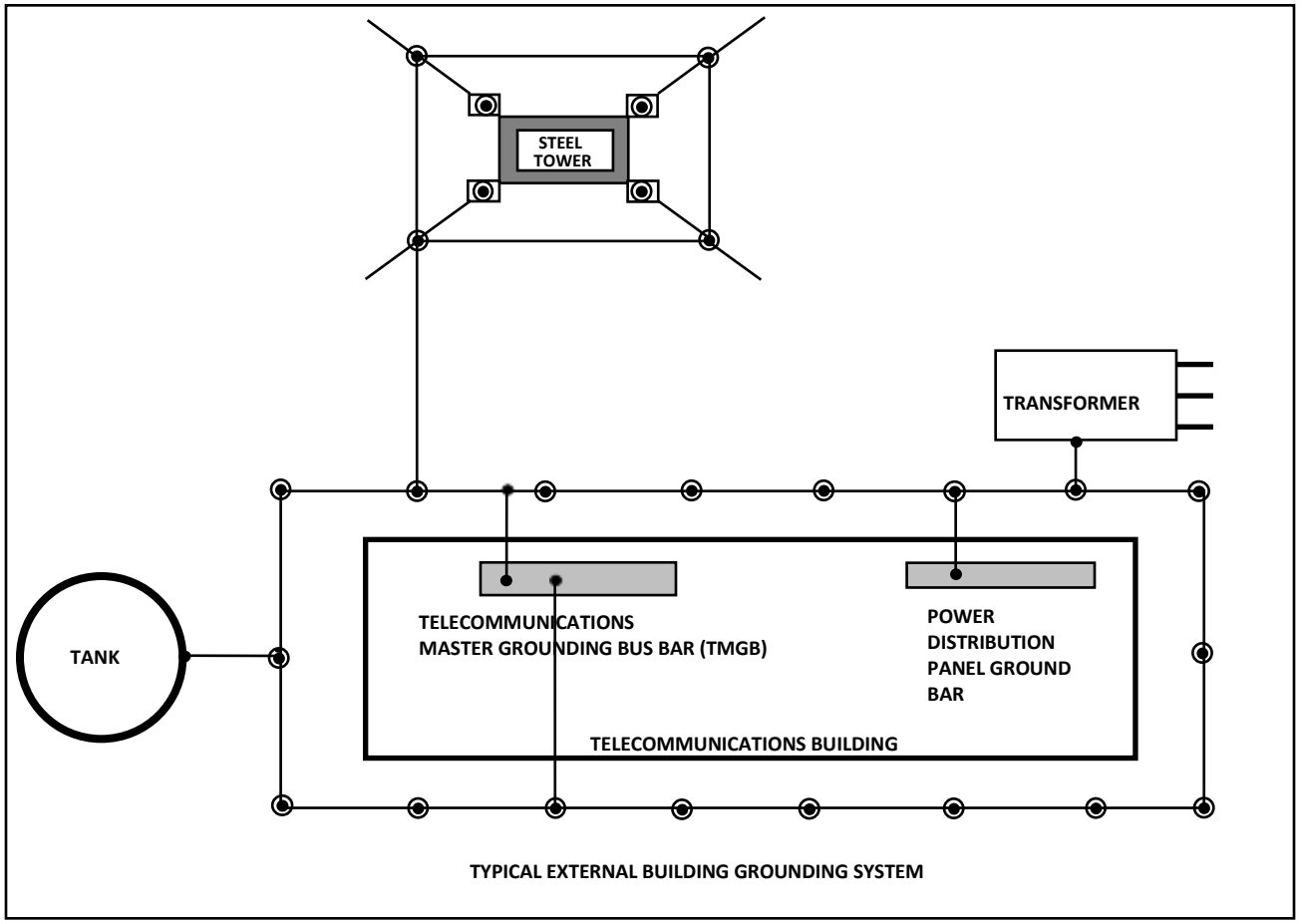

Figure 3 - Typical External Grounding System Arrangement

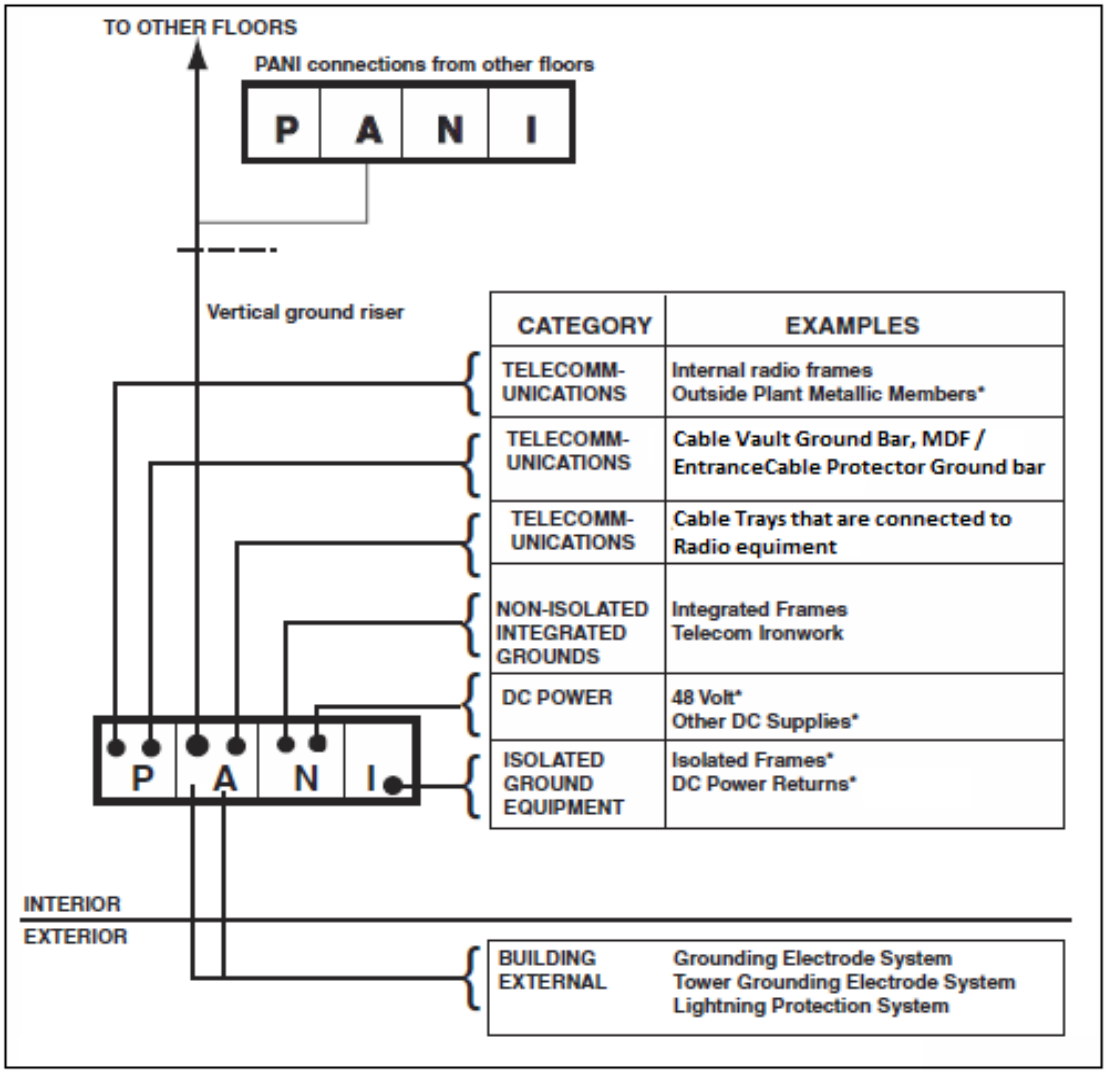

Figure 4 - Telecommunications Master Grounding Busbar (TMGB) Configuration

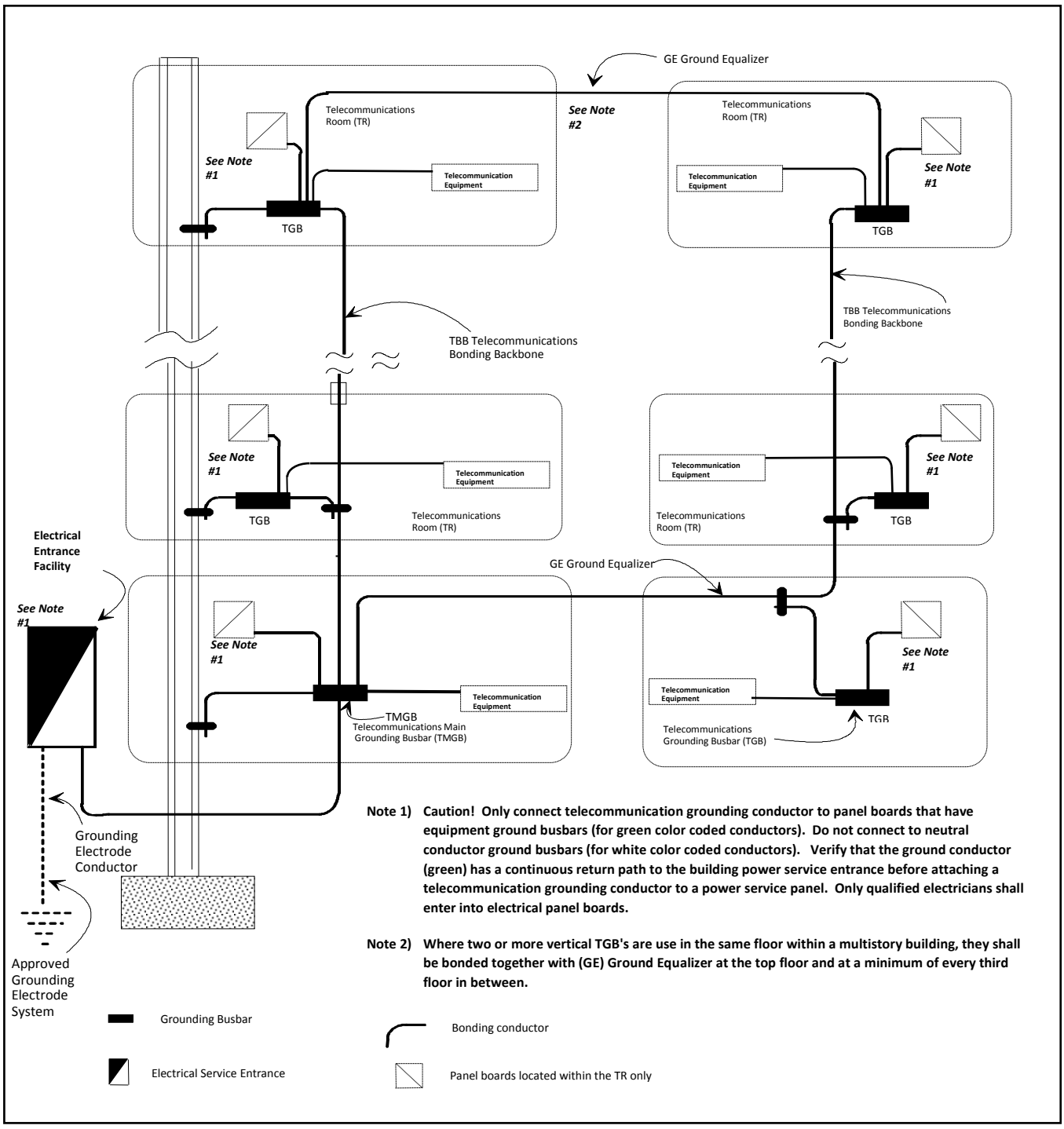

Figure 5 - Typical Arrangement of TMGB, TGB and TBB Structure

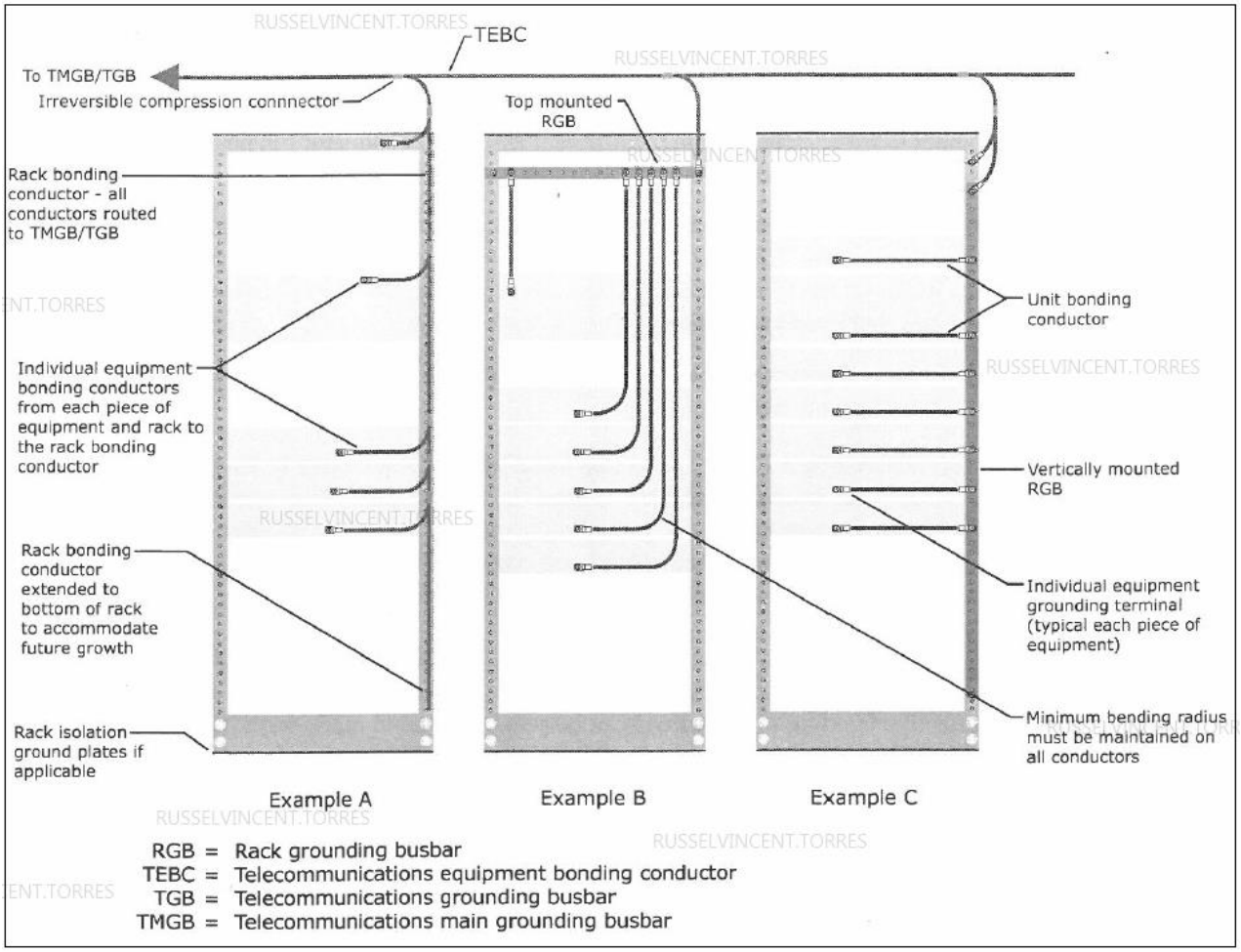

Figure 6 - Equipment Rack Grounding and Bonding

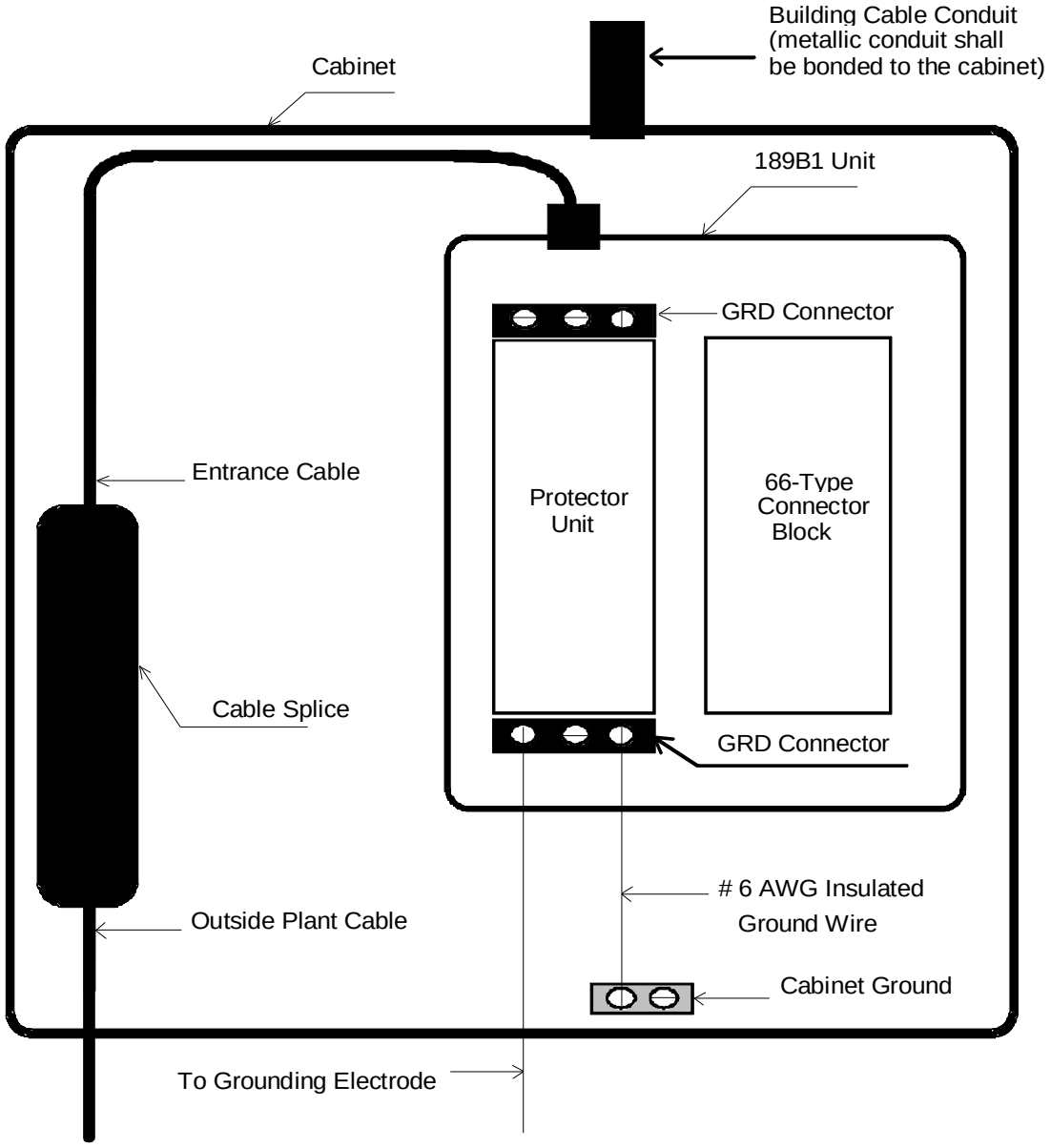

Figure 7 - Bonding and Grounding at Cable Entrance (OSP Cable)

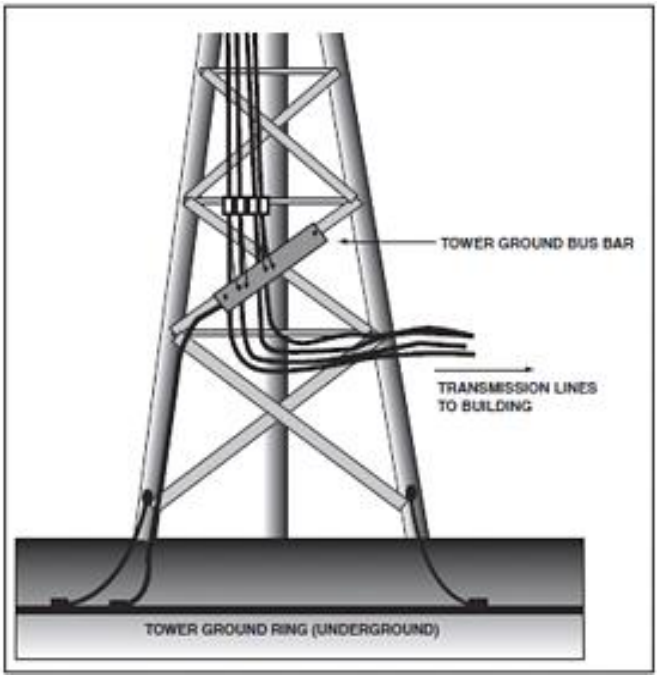

Figure 8 - Typical Tower Ground Bus Bar