

Satellite Earth Station Protection Engineering Considerations

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1. General

1.1 Purpose

This practice provides engineering methods recommended for the electrical protection and grounding of satellite earth stations.

Use this information to protect:

- Personnel.
- Station buildings.
- Station Equipment including:
 - Antennas and supporting structure.
 - Transmission lines.
 - Radio or carrier equipment.

1.2 Filing Instructions

File this practice in numerical order in your practices set.

1.3 Copyright and Responsibility

This practice was published by the GTE Telephone Operations Administrative Services Department. For more information about this practice, contact the Headquarters Telephone Operations Network Engineering Department.

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1.4 Disclaimer

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2. Overview

2.1

Acronyms and Terms

The following acronyms and terms are used in this practice:

Acronym/Term	Definition
Air Terminal	A component of the lightning protection system intended to intercept lightning strikes. Also called a lightning rod
Arc	The luminous glow caused by electrical current flowing through ionized air or gas between separate electrodes or contact points
Azimuth	The angle in the local horizontal plane measured clockwise with respect to true North
Bonding	The process of establishing electrical continuity between two or more conductive objects or surfaces
Cone of Protection	The area of protection provided by a properly grounded air terminal
Down-Link	A radio signal originating at a spacecraft and terminating at one or more earth stations
Earth Station	A facility located on the surface of the earth that is used to communicate with satellites or other space vehicles
Elevation Angle	The angle above the horizon
Enclosure	A housing or cabinet for equipment or components
Grounded	Connected directly to the ground or through a conducting object that provides a low impedance path to earth
Halo Ring	A ground ring in the interior of a building or radio hut used to provide voltage equalization

(continued)

2. Overview, continued

2.1 Acronyms and Terms, continued

Acronym/Term	Definition
Isokeraunic Map	Shows the amount of lightning activity for an area and indicates the average number of days per year that thunder is heard
LNA	Low Noise Amplifier that takes very low signal inputs and amplifies them
Made Electrode	An electrode ground designed and installed for a specific site
MGN	Multi Grounded Neutral
PSI	Pounds per square inch
Side Flash	An electrical spark between conductive metal bodies caused by differences of potentials
Transponders	Microwave repeaters carried by communications satellites
Up-Link	A radio signal originating at an earth station and terminating at a spacecraft
Zone of Protection	The space adjacent to a lightning protection system that is practically immune to direct lightning strikes.

2.2 References

The following chart lists the GTE Telephone Operations Practices that provide additional information:

Practice Number	Title
795-805-071	Central Office Grounding Systems – Engineering Applications
795-805-072	AC Service Grounding – Engineering Applications

(continued)

2. Overview, continued

2.2 References, continued

Practice Number	Title
795-805-074	Inspecting Central Office Grounding and Electrical Protection
795-805-075	Remote Electronic Serving Area Grounding Systems Engineering Considerations
887-000-050	Electrical Protection – Engineering Fundamentals
887-030-085	Engineering Considerations – Radio Station Protection
887-600-070	Engineering Fundamentals of Electrode Ground Design
887-600-071	Fundamentals of Ground Measurements
903-020-070	Protection – General Considerations

2.3 Codes

The following chart lists the National Codes that provide additional information:

Code Number	Title
NEC90	National Electrical Code – 1990
NESC90	National Electrical Safety Code – 1990
NFPA-78	Lightning Protection Code – 1989

3. Background

3.1 Introduction

The earth station forms the ground portion of a satellite communications system. Exhibit 1 on page 25 shows a typical satellite communications system.

3. Background, continued

3.2 Types

In general terms earth stations may be classified as follows:

Type	Used...
Receive Only	Primarily for CATV and Direct TV broadcast.
Transmit Only	Primarily in data collection systems.
Transmit and Receive	In two-way communication systems such as: <ul style="list-style-type: none">• Video conferencing.• Long distance message circuits.

Transmission of signals can be in either analog or digital formats.

3.3 Components

Earth stations are composed of the following major subsystems:

- Power equipment (AC or DC).
- Terrestrial interface equipment.
- Transmitting equipment.
- Receiving equipment.
- Antenna subsystem.
- Control equipment.

Some of these components may be located:

- In close proximity to the antenna or dish in a weatherproof enclosure.
- OR
- Some distance away from the dish in a building or hut.

Exhibit 2 on page 26 shows a simplified block diagram of a 2-way earth station.

NOTE: Specific discussion of each subsystem and component is beyond the scope of this practice.

4. Planning

4.1 General

When preparing the engineering specifications for the installation of an earth station, consider the following preliminary site information:

- Space availability.
- Soil resistivity survey.
- Isokeraunic map of the area.
- Location and height of other structures in the area.

4.2 Layouts

Plan a site layout where water systems, electric power services and telephone entrance are in close proximity to each other so that a common bond can be easily achieved.

Avoid a location too close to:

- Pad-mounted electrical power transformers.
- Electrical power switching equipment.

5. Protection Considerations

5.1 General

Earth stations must be protected from lightning and power line surges. Every site should be studied to analyze:

- Possible ground potential rise (GPR).
- Exposure to lightning, power surges and power transients.
- Soil resistivity and terrain configuration.

Earth stations located on tall structures (towers, buildings, etc.) are very susceptible to lightning strikes.

5.2 Protection Elements

The most common elements used in the protection of equipment or structures include:

- Shielding.
- Grounding.
- Bonding.

5. Protection Considerations, continued

5.3 Rural Areas

Sites in rural or sparsely populated areas are:

- Subject to lightning strikes.
- Susceptible to damage from current surges originating from the serving power or telephone facilities.

Therefore, the protective grounding considerations for remote sites are important.

5.4 Cone of Protection

Taller structures normally provide lower structures a degree of protection against lightning within the:

- Cone-of-protection, if less than 50 feet.
- Rolling-ball circle, if over 50 feet.

Those structures falling within a 1:1 imaginary cone, where the radius of the base is equal to the height as illustrated in Exhibit 3 on page 27, receive the highest degree of protection.

6. Grounding Design Considerations

6.1 Electrode Design

Electrode grounding systems must be:

- Based on soil resistivity measurements.
- Designed to meet the ground resistance objectives.
- Designed and approved by the Administrator – Transmission & Protection.
- Inspected during construction and prior to back-filling.
- Measured to ensure that objectives are met.

NOTE: Formulas for designing the electrode grounding system are provided in GTE Telephone Operation Practice 887-600-070, Engineering Fundamentals of Electrode Ground Design.

6.2 Grounding System

The grounding system is composed of:

- Grounding electrodes.
- Grounding conductors for:
 - Electrodes.
 - Equipment.
- Bonding conductors.

6. Grounding Design Considerations, continued

6.3 Providing Access to Connections

Provide suitable access (such as a hand hole) to those points where leads 3, 5, 25, and 27 connect to lead 1. (See Exhibit 7 on page 31 for lead designations.) This access allows:

- Quality inspections.
- Isolation of segments to be tested, such as:
 - Ground ring.
 - Building steel.
 - Other ground fields (C.O., tower, etc.).

6.4 Ground Electrodes

Telephone company–constructed grounding electrodes include:

- Ground rings.
- Deep electrodes.
- On site metallic water pipe.
- Ground fields.
- Concrete encased steel or wire.
- Building steel when bonded together.

6.5 Resistance Objective

The total earth station ground system should not exceed 2 ohms as measured by the fall-of-potential method using a ground test set.

6.6 Minimum Made Electrode

A minimum made electrode includes:

- Twenty (20) feet of #2 AWG bare tinned solid copper wire.
- Two (2) or more 5/8-inch x 8 feet GTE standard rods placed at 8 feet intervals along a ring formed by the wire.

Note: This arrangement is always required.

6.7 Ground Rods

All ground rods should be placed in undisturbed soil and below the frost line.

6. Grounding Design Considerations, continued

6.8 Supplemental Electrodes

If rock formations, other terrain conditions, or soil resistivity do not allow the objective to be met, supplemental electrodes must be placed. These may include:

- Deep driven wells.
- Metal plates.
- Buried radial wires.
- Low resistivity material.

Refer to GTE Telephone Operations Practice 887-600-070, Engineering Fundamentals of Electrode Ground Design for other possible configurations.

6.9 Connections

All connections to the ground ring (Lead #1) and rods must be made utilizing GTE approved:

- Exothermic welds.
OR
- Gas tight compression fittings.

NOTE: All connections below ground level must be sealed from water and corrosion.

6.10 Common Bonding

Provide common bonding and grounding for all metal components and objects:

- Inside the building.
- Between the internal and external grounding systems.

Bonding connections and multiple paths to the ground:

- Prevent arcing.
- Reduce dangerous voltage differences that may appear during lightning strikes or power fault conditions.

Bonding attachments must be made to clean, unpainted metal surfaces.

7. Grounding Conductors

7.1 Rules

Install all grounding conductors according to the following rules:

- **Do not** use U-shaped grounding conductor runs or bonding layouts to reduce possible arc overs.
- Run the grounding conductors in non-metallic conduits.
- Run the grounding conductors through non-metallic sleeves in floors, walls and ceilings.

NOTE: If the use of a metallic conduit cannot be avoided, both ends of the conduit must be bonded to the grounding conductor.

- Avoid long runs of ground leads.
- Keep bends in conductors to a minimum.
- Always preserve a downward to horizontal course for grounding conductors.
- Ground conductors must never:
 - Be encircled with metal clamps.
 - Run through metal walls, metal plates or short sections of metal conduit.
 - Run closer than 1 foot from DC power cables, high frequency cables, etc.

7.2 Conductor Requirements

Do not use conductors smaller than those specified in this practice for all common bonding and grounding connections to ensure:

- Adequate conductivity for lightning strike currents.
- Sufficient mechanical strength.

In order to minimize corrosion, use:

- #2 AWG bare tinned solid copper wire when burying conductors.
- Approved 5/8-inch (minimum) diameter ground rods.

7.3 Conductor Inductance

The inductance of grounding conductors is the main cause of potential differences. These potential differences build up along the discharge paths when surge currents travel through the grounding system.

In order to minimize the effects of inductance:

- Keep the length of conductors to a minimum.
- Use multiple conducting paths.
- Bond connections often to equalize voltage.

7.4 Lead Designations

Lead designations and grounding conductor sizes are shown in Exhibit 7.

8. Earth Station Sites

8.1 Station Equipment

The station equipment consists of the electronics to:

- Condition signals to the proper frequency allocation.
- Prepare signals for reception or transmission.

For example, the low noise amplifier (LNA) usually mounts close to the dish antenna, either in front or behind it.

8.2 Control Equipment

The control equipment is the manual or automatic positioning and tracking equipment.

8.3 Types

The following chart shows the types of earth stations:

Type	Description
Stand Alone	<ul style="list-style-type: none">• The station stands by itself.• The equipment is in an enclosure.
Co-Located	<ul style="list-style-type: none">• The station is next to the telephone company Central Office (CO).• The equipment is in the CO or hut.
Mobile or Transportable	<ul style="list-style-type: none">• The station is mounted on a trailer or flatbed.• The equipment is in an enclosure on the trailer.• The station is intended for temporary or emergency use only.

8.4 Installation

The antenna and the satellite tracking equipment are normally mounted on a pedestal. The pedestal must be on a concrete pad built to support the weight of the antenna and other related equipment. (PSI requirements must be furnished by the manufacturer).

8. Earth Station Sites, continued

8.5 Grounding Requirements

The grounding requirements for satellite earth stations are shown in the following chart:

If the Station is a...	Then...
Stand Alone	Install a ground ring (lead 1): <ul style="list-style-type: none">• With ground rods.• Connected to the master ground point (lead 5).
Co-Located	Connect the ground ring for the antenna pad or station to the: <ul style="list-style-type: none">• Ring for the Central Office. <p style="text-align: center;"><i>OR</i></p> <ul style="list-style-type: none">• Existing grounding electrode.
Mobile or Transportable	See Section 11 for specific requirements.

8.6 Master Ground Point

The master ground point is defined as the master ground bar (MGB) in a building or hut application. In an enclosure, the master ground point may be a small copper bar or a connection point, depending on the size of the enclosure.

All leads connected to the master ground point must be tagged with the lead number. If two or more leads have the same lead number, the "to" and "from" must be shown for each lead.

8. Earth Station Sites, continued

8.7 Common Grounding

Common grounding of all the conducting components of the structure (building, hut, enclosure, etc.) and the earth station radio or transmission equipment reduces possible differences in voltage that might create a shock hazard or cause arcing and damage.

All metallic objects (such as water pipes, conduits, metal fuel tanks without cathodic protection, metal fences, etc.) within 6 feet of the ground ring or a grounding conductor must be bonded to the ring or conductor.

NOTE: Metal fuel tanks with cathodic protection must be isolated from the grounding system and the fuel line with heavy duty protector gaps.

Intervals between bonds must not exceed 25 feet. Bonds must be placed across fence openings or gates.

8.8 Internal (Halo) Ground Rings

When the station equipment shares floor space in a wire center building or pair gain equipment hut, an internal (Halo) ground ring must be provided for:

- The entire floor or room if the radio equipment occupies more than 50% of the floor space.
- Only the area or room dedicated to the radio equipment if the radio equipment occupies less than 50% of the floor space.

The Halo ring should be connected to the master ground bar (MGB) via lead 21.

9. Antennas

9.1 Introduction

This section covers the grounding and protection considerations for satellite dish antennas.

9.2 Description

The dish antenna is a parabolic reflector with a diameter ranging from 1 meter (3 ft) to 32 meters (96 ft).

Antenna gain, or sensitivity, is improved by increasing the size of the dish.

9.3 Materials

Dish antennas are manufactured from a variety of materials. These antennas can be:

- Metallic or non-metallic.
- Solid or mesh-like.

9. Antennas, continued

9.4 Placement Depending on the intended application or use, satellite dish antennas are usually located at ground level or on roofs.

The dishes may also be mounted on the wall of a building.

9.5 Antenna Supports Antennas are supported in different ways. The most common types include:

- Pedestals or poles.
- Towers or tower-like structures.

Exhibit 4 on page 28 shows some typical earth station antenna supports.

9.6 Ground Mounted Antennas If no other buildings or structures are within a 100 yard radius of the antenna, then:

- A ground ring must be placed around the site.
- The ground ring must meet the resistance objectives.
- An air terminal must be placed at a height sufficient to provide a minimum 2:1 cone of protection. 1:1 is preferred.

See Exhibit 5 on page 29 for a typical method of grounding a pad-mounted earth station.

If a building or structure is close to the antenna, air terminals or lightning protection may not be needed.

NOTE: Follow the Risk Assessment Guidelines of NFPA-78.

9.7 Roof Mounted Antennas When the dish antenna is mounted on the roof of a building, design the grounding system by:

- Using regular lightning protection cables and hardware.
- Following the recommendation of the NFPA-78 Lightning Protection Code.
- Placing a #2/0 wire ring around the antenna support pad.
- Connecting the:
 - Antenna support structure to the ring.
 - Antenna metal members to the ring.
 - Lightning protection system perimeter wires.
 - Ring to any other metallic object on the roof within flashover range.

9. Antennas, continued

9.7 Roof Mounted Antennas, continued

- Placing at least two #2/0 AWG leads from the ground ring down the building wall to connect to:
 - A ring around the building. This is the preferred method.

OR

- Two or more rods.

NOTE: These down conductors are used in addition to the ones used in the lightning protection system.

See Exhibit 6 on page 30 for a typical method of grounding a rooftop earth station.

9.8 Roof Conductors

Support roof conductors every three feet with:

- No-nail paste-down cable fasteners.
- OR*
- Pan-type base ridge cable supporters.

9.9 Grounding the Antenna Support

The metal structure supporting the antenna dish must be grounded as follows:

If the Station is a...	Then...
Pole or Pedestal at ground level	Place the ground electrode and connect it to the: <ul style="list-style-type: none"> • Antenna ground. • Ground ring around the site.
Self Supporting Tower at ground level	<ul style="list-style-type: none"> • Connect the antenna to the ground ring. • Each leg must be grounded to a ground rod. • Each rod must be connected to the ring around the base of the structure.

(continued)

9. Antennas, continued

9.9 Grounding the Antenna Support, continued

If the Station is a...	Then...
Pole or Pedestal on a rooftop	<ul style="list-style-type: none">• Connect the antenna to the ground ring.• Connect the ring via down conductors to either a ground level ring or to ground electrodes.
Self Supporting Tower on a rooftop	<ul style="list-style-type: none">• Connect the antenna to the ground ring.• Connect each leg to the ground ring.• Connect the ring via down conductors to either a ground level ring or to ground electrodes.

9.10 Control Equipment Protection

Control devices and positioning motors used for tracking signals must be protected with arresters of the proper voltage range.

10. Lightning Considerations

10.1 General

In general, metallic antenna dishes are not damaged by a direct lightning strike, but they must be electrically connected to the metal supporting structure to eliminate arcing.

Non-metallic antennas, such as those made of fiberglass, are susceptible to damage from direct lightning strikes.

10.2 Probability of Lightning

An antenna on the roof of a building does not significantly increase the probability of lightning striking the building.

The antenna structure, however, is a prime target for lightning and is an excellent transmission path for conducting high currents into the equipment or building.

10. Lightning Considerations, continued

- 10.3 Lightning Protection** A vertical air terminal must be installed to provide a maximum cone of protection (1:1) for sites where that type of protection does not exist or cannot be guaranteed.
- The ground strap from the air terminal must be bonded to the metallic surface of the antenna. Bonding equalizes the voltages between the two and prevents arcing. The strap must be grounded to the metal supporting structure of the antenna.
- 10.4 Common Bonding** All metallic items on the roof must be connected to the ground ring to minimize arcing and side-flashing.
- 10.5 Stationary Antennas** If the antenna is stationary (no movement to track satellite signal), the air terminals may be mounted on the antenna itself.
- 10.6 Non-Stationary Antennas** If the antenna tracks satellite movement or receives signals from several satellites, locating the air terminal on the dish, may not be practical. In this case, the air terminal must be placed on a pole (or similar structure) close to the dish and at a height sufficient to provide a minimum of a 2:1 cone of protection. The air terminal must not impede or restrict the dish's movement.

11. Mobile or Transportable Earth Stations

- 11.1 General** Transportable stations are earth stations that are:
- Not designed for permanent installation.
 - Used for a short time or for emergency service restoration.
- 11.2 Description** A transportable station typically has a dish antenna and enclosure with the electronic equipment permanently mounted on a wheeled trailer that is pulled by a motorized vehicle.
- 11.3 Grounding Requirements** In addition to the grounding requirements mentioned earlier, the specific grounding requirements listed below are applicable to transportable stations.
- All transportable earth stations must be grounded using a ground rod or other approved and verifiable ground, such as an MGN.

11. Mobile or Transportable Earth Stations, continued

11.4 Short Time Usage If the site is for a one-time use only, ground the station using a ground rod. Use an air terminal if no taller structure is in close proximity.

11.5 Extended Temporary Usage If the site will be used on a regular basis, but not permanently, a ground ring must be permanently installed, especially when the site is used over 24 hours at a time.
The ring and other protection items must be installed so that they can be reused.

12. AC Power Service

12.1 General The protective grounding scheme for the AC service, including the grounding conductor gauge, must meet the requirements of the NEC and local ordinances.

The site's power-service ground must be bonded to the master ground bar or the external ground ring. See Exhibit 8 on page 34 and Exhibit 9 on page 35.

12.2 Service Arresters AC service arresters are protective devices that are added to power circuits. AC service arresters:

- Protect power circuits by limiting:
 - Abnormal surges.
 - Transient voltages.
- Discharge longitudinal surge currents on a phase conductor to:
 - Ground.

OR

 - Neutral.

The arresters must be located on the load side of the service entrance disconnect box.

12.3 Reference For additional information on the grounding of AC Power Entrance facilities, see GTE Telephone Operations Practice 795-805-072, AC Service Grounding – Engineering Applications.

13. Transmission Lines

13.1 General

The transmission line is usually a coaxial cable sized according to the frequency being used. Occasionally the transmission line may be a waveguide.

13.2 Coaxial Transmission Line Grounding

The magnetic field produced by high currents in the outer conductor, or shield, may cause dielectric failure of the coaxial transmission line or waveguide.

Transmission lines, whether coaxial or waveguide, must be grounded at:

- A point close to the dish.
- The entrance to the building.
- Intervals not to exceed 50 feet.

NOTE: Use GTE standard ground-kits compatible with the transmission line used.

The transmission line support must also be grounded at both ends.

13.3 Bulkhead Grounding

The entrance hatchplate, or bulkhead, must be:

- Bonded to the waveguide and to any other metal structure such as an ice bridge.
- Connected directly to the external grounding network with a lead in a downward direction.

If a steel tube or pipe is used instead of the hatchplate, the waveguide can be bonded to the pipe. The interior (Halo) ring must be connected to the pipe. The pipe must be connected directly to the exterior ring. See Exhibit 12 on page 38 and Exhibit 13 on page 39.

13.4 RF Surge Suppressors

RF Surge suppressors or lightning arresters must be mounted:

- On the bulkhead or hatchplate.
- OR*
- At the base of the antenna support.

NOTE: The RF Surge suppressors or lightning arresters must not be located inside the station building or equipment enclosure.

Connect the RF suppressor's ground lead to the ground ring.

14. Radio Station Equipment

14.1 Protection Guidelines

The following guidelines must be observed in co-located sites:

- Locate the transmitter and receiver equipment at least 6 feet away from:
 - Digital switching equipment.
 - Electronic processor equipment.
- Keep the coaxial and waveguide cables separated (1 foot minimum) from:
 - Telephone switching cables.
 - Voice frequency cables.
 - High frequency cables.
 - DC Power cables.
- Ground the transmitter and receiver equipment to the interior ground ring (“Halo”) or to the MGB using lead 56.
- Ground the inside of the bulkhead or hatchplate to the MGB using lead 55.
- Provide AC power to all the satellite station equipment from a dedicated AC service run and a dedicated breaker.

NOTE: Do not share the breaker or power cable with other equipment such as data, carrier, switching equipment, etc.

To provide common bonding of station equipment, a ground ring bus must be installed around the interior perimeter of the station building with interconnections to an external ring bus buried in the earth around the building and antenna pad.

14.2 Reference

For supplementary protection requirements for the other equipment located inside the station building itself, refer to GTE Telephone Operations Practices 887-030-085, Engineering Considerations – Radio Station Protection and 795-805-071, Central Office Grounding Systems – Engineering Applications.

15. Connecting Facilities

15.1 Telephone Service Protection

Earth station sites with telephone service must have the station protector, NID and building entrance terminal properly grounded to the site’s grounding system with direct and straight connections.

15. Connecting Facilities, continued

15.2 Radio Frequency (RF) Interference

To avoid or minimize RF interference, shield telephone facilities. This shielding must consist of:

- Protectors and building terminals in a grounded metal enclosure.
- Punch blocks (type 66) inside a grounded metal enclosure.

Severe cases of interference may require the installation of copper wire meshes:

- Embedded in the walls.
- Bonded to the building steel.

15.3 Reference

For protection requirements of telephone facilities serving the earth station refer to GTE Telephone Operations Practices:

- 795–805–071, Central Office Grounding Systems – Engineering Applications.
- 887–030–085, Engineering Considerations – Radio Station Protection.
- 605 Outside Plant Series.
- 435 Customer Equipment Series.

16. Inspections

16.1 Reference

Refer to GTE Telephone Operations Practice 795–805–074, Inspecting Central Office Grounding and Electrical Protection for inspection guidelines.

Use Form 90001528 to document all inspections and to verify grounding and electrical protection of earth stations.

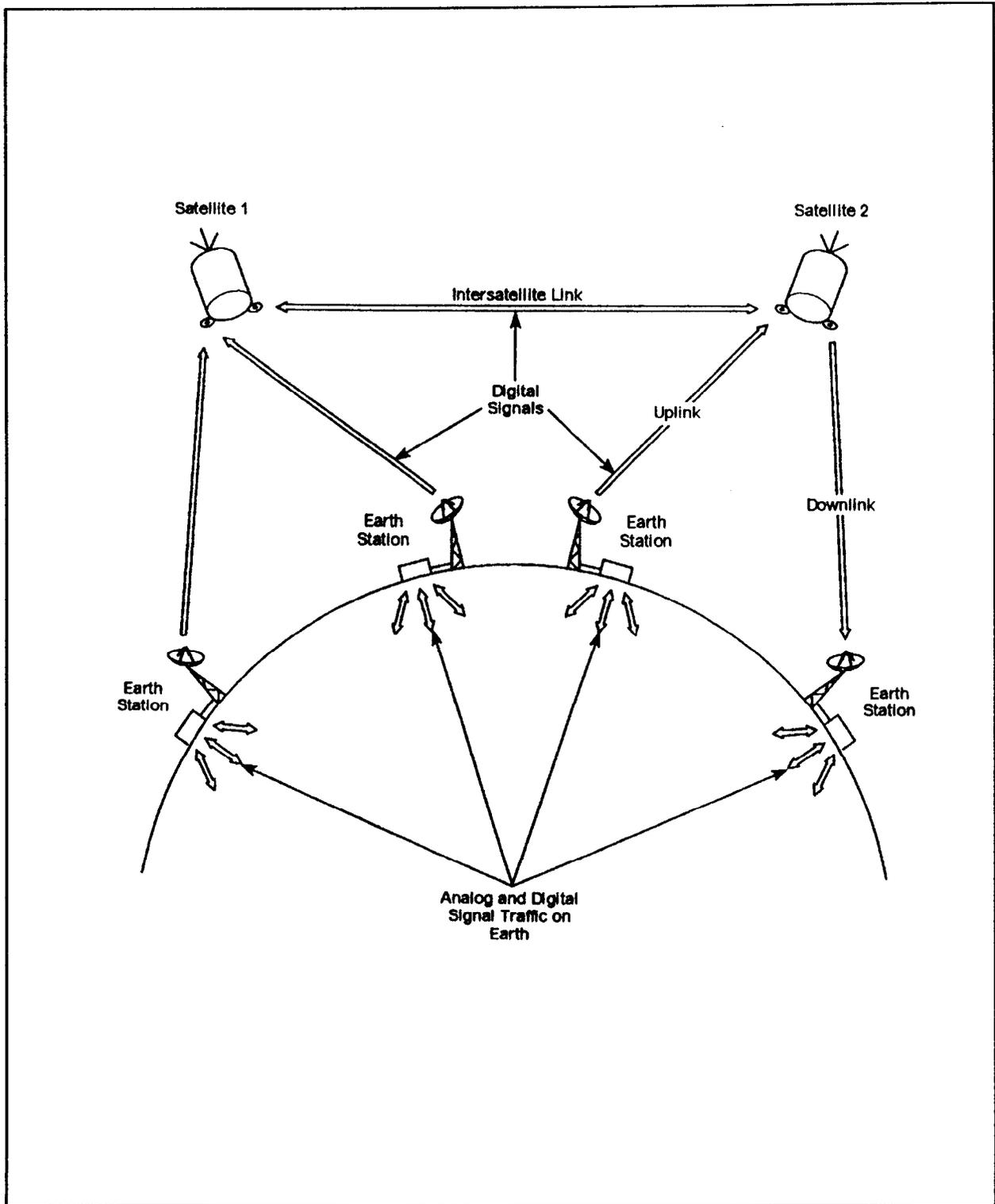


Exhibit 1 – Typical Satellite Communication System

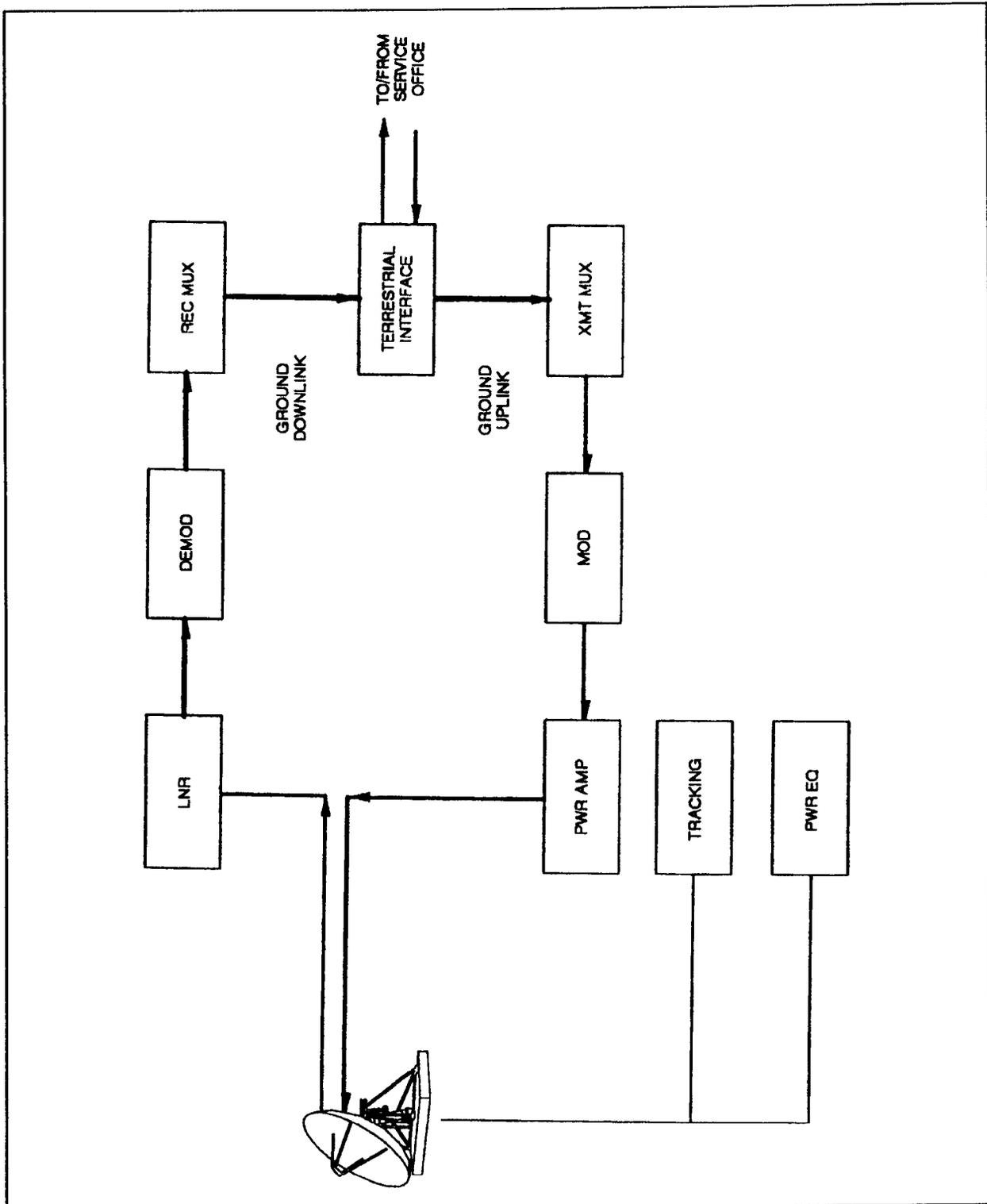


Exhibit 2 – Simplified Block Diagram of a 2-Way Earth Station

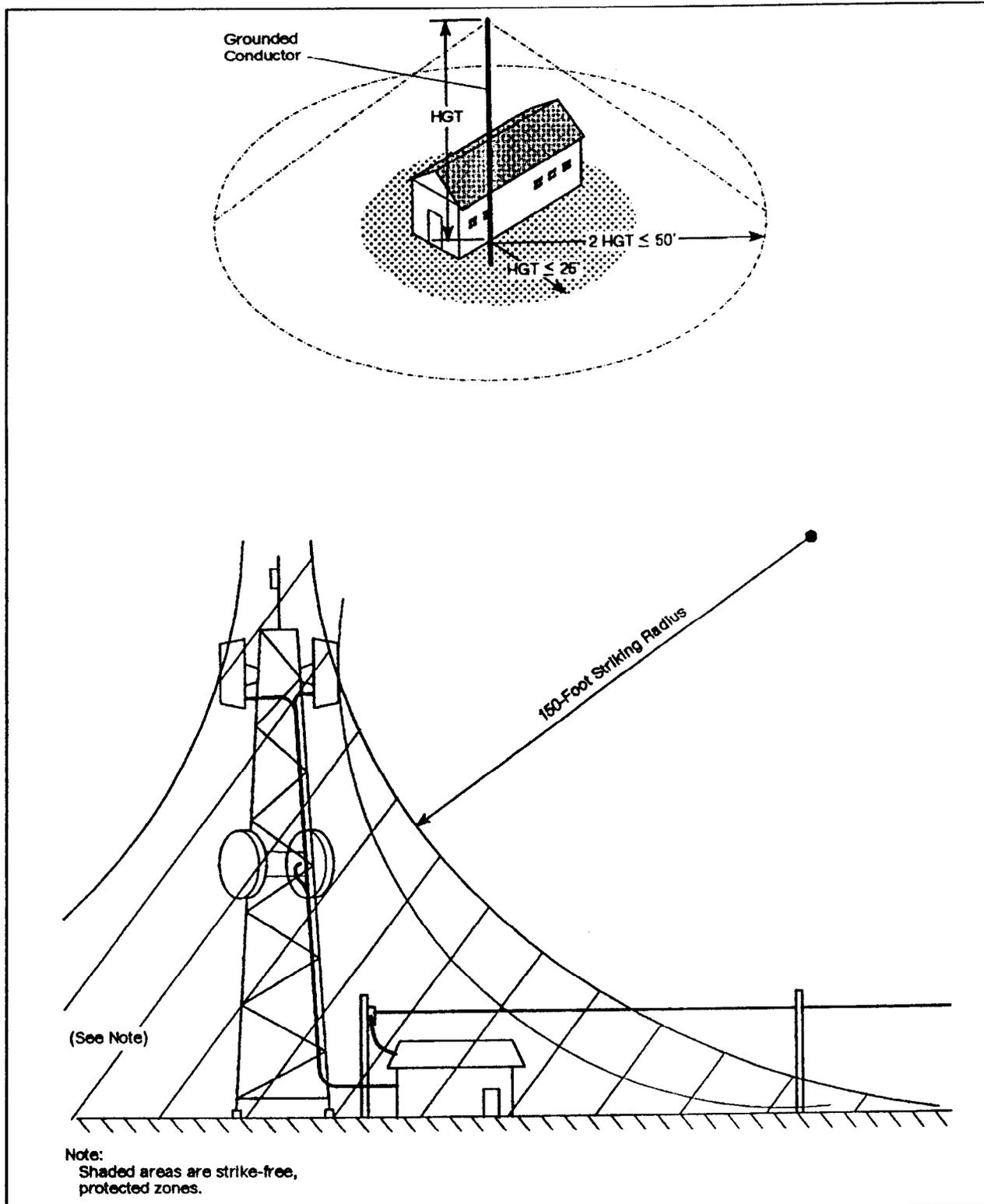


Exhibit 3 – Cone of Protection

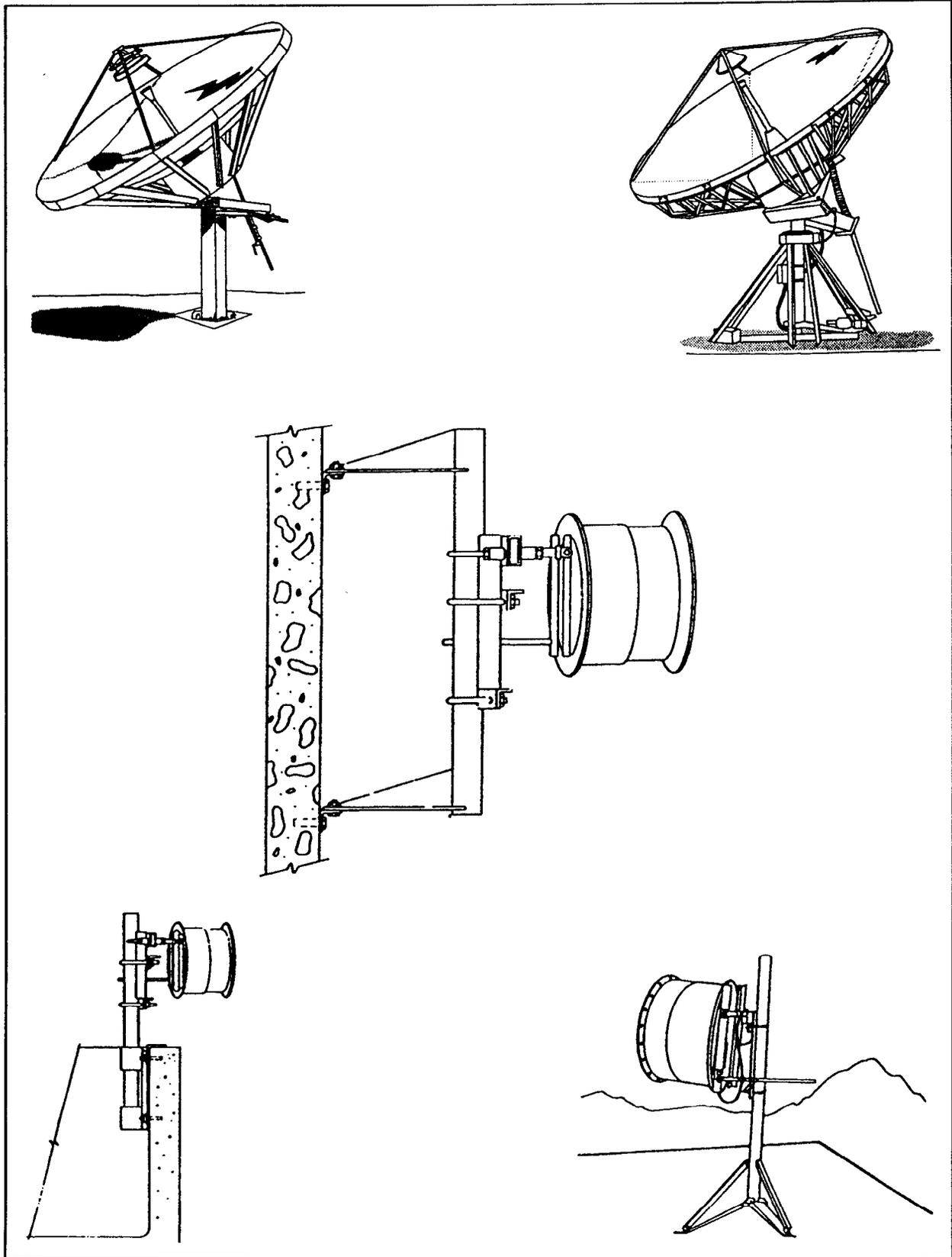


Exhibit 4 – Typical Antennas and Supports

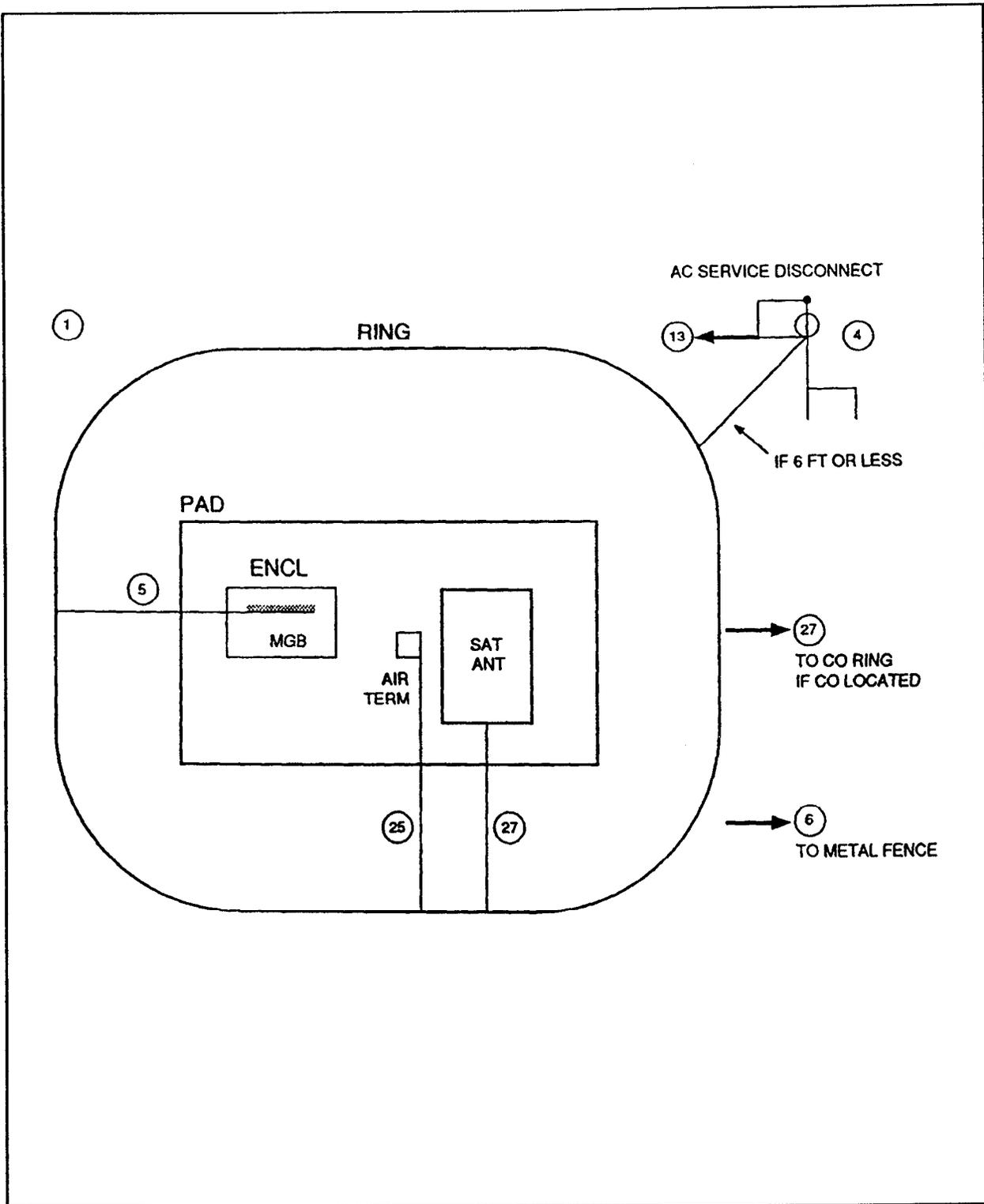
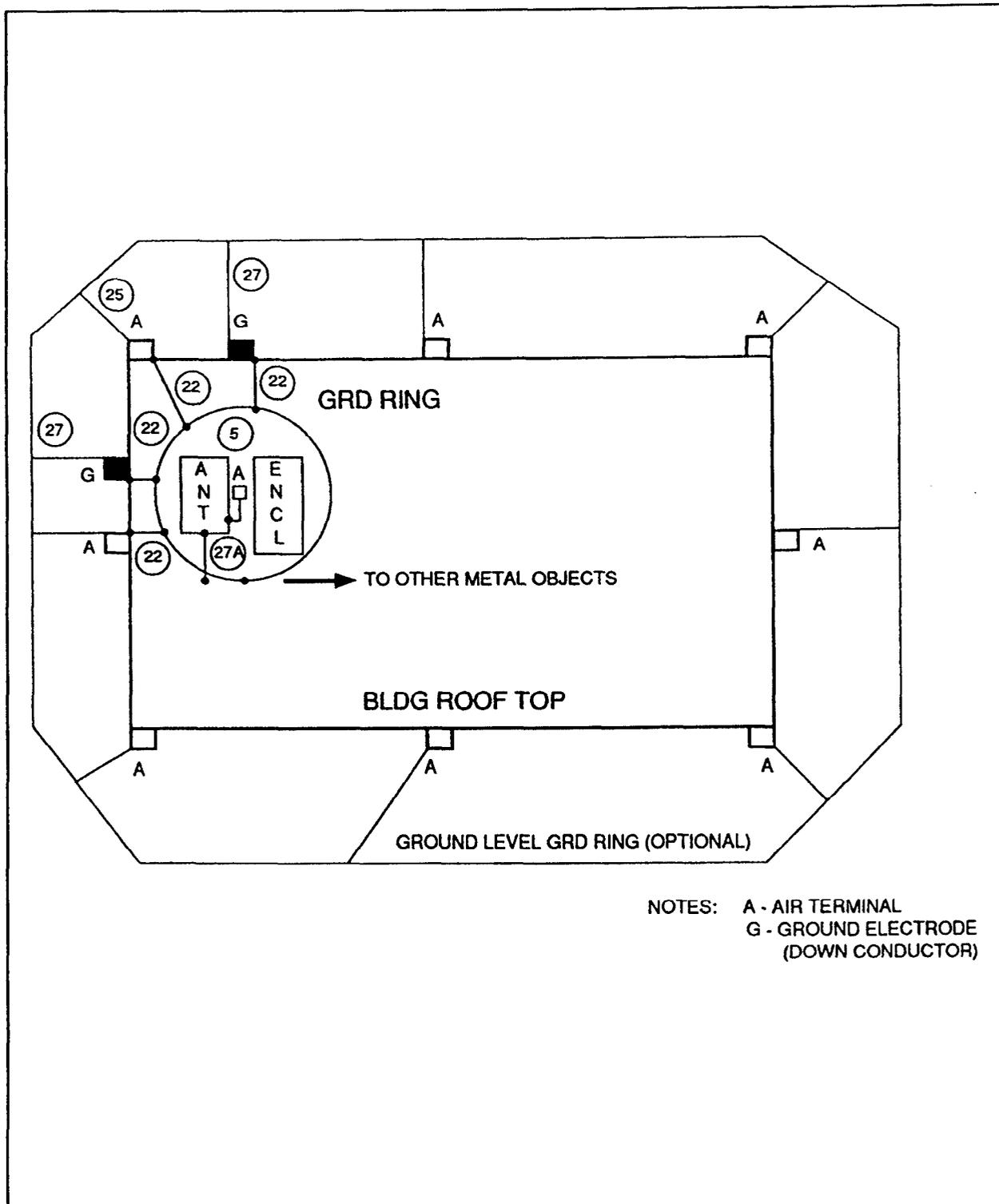


Exhibit 5 – Typical Grounding for a Pad-Mounted Earth Station



NOTES: A - AIR TERMINAL
G - GROUND ELECTRODE
(DOWN CONDUCTOR)

Exhibit 6 – Typical Grounding for a Rooftop Earth Station

Exhibits, continued

Lead Number	By	For	From	To	AWG STD	Notes
1	GTE Telephone Operations	Bldg.	Ground ring & rods		2	Bare tinned solid copper
1A	GTE Telephone Operations	Bldg.	Ground ring concrete encased electrodes		2	Bare tinned solid copper
2	GTE Telephone Operations	Bldg.	Wells or deep deep anodes			Steel pipe
3	GTE Telephone Operations	Bldg.	Lead 1	Each bldg. column	2	Bare tinned solid copper
4	GTE Telephone Operations	Bldg.	Main AC enclosure neutral bus	Grounding electrode	See Exhibit 11	See Exhibit 8
5	GTE Telephone Operations	Bldg.	Lead 1 min 2 leads #5 (opposite sides)	MGB	See Exhibit 10	Bare tinned solid copper
6	GTE Telephone Operations	Bldg.	Lead 1	Metallic fence	2	Metal fence/posts
7	GTE Telephone Operations	Bldg.	Each Lead 2	MGB	See Exhibit 10	Bare tinned solid copper

(continued)

Exhibit 7 – Standard Lead Designations and Grounding Conductor Sizes (Page 1 of 3)

Exhibits, continued

Lead Number	By	For	From	To	AWG STD	Notes
8	GTE Telephone Operations	Bldg.	Main AC enclosure neutral bus	Interior water meter See Note	See Exhibit 11	Bare tinned solid copper
9	GTE Telephone Operations	Bldg.	Exterior water pipe	Interior water pipe	See Exhibit 10	Bare tinned solid copper
10	GTE Telephone Operations	Bldg.	Interior water pipe	MGB	See Exhibit 10	Insulated copper
13	GTE Telephone Operations	Bldg.	Main AC enclosure neutral bus	MGB	See Exhibit 10	Insulated copper (See Note 1)
21	GTE Telephone Operations	Bldg.	Hut Interior ground ring	MGB	2	Insulated copper
22	GTE Telephone Operations	Bldg.	Roof station ground ring and other equipment	Corner bldg. steel columns or lightning rod system	NFPA-78	Insulated copper (4 leads minimum) (See Note 2)
25	GTE Telephone Operations	Bldg.	Lead 1	Nearest lightning rod	2	Insulated copper
26	GTE Telephone Operations	Bldg.	Lightning Rod system	All nearby objects	NFPA-78	(See Note 2)

(continued)

Exhibit 7 – Standard Lead Designations and Grounding Conductor Sizes (Page 2 of 3)

Exhibits, continued

Lead Number	By	For	From	To	AWG STD	Notes
27	GTE Telephone Operations	Bldg.	Lead 1	Station exterior grd ring	2	Bare tinned solid copper
55	GTE Telephone Operations	Trans	Waveguide or coax bulkhead	MGB	6	Insulated copper
56	GTE Telephone Operations	Trans	Station Equipment Enclosure	MGB	6	Insulated copper

NOTE 1: Refer to GTE Telephone Operations Practice 795-805-072, AC Service Grounding - Engineering Applications.

NOTE 2: Refer to NFPA-78 Lightning Protection Code.

Exhibit 7 - Standard Lead Designations and Grounding Conductor Sizes (Page 3 of 3)

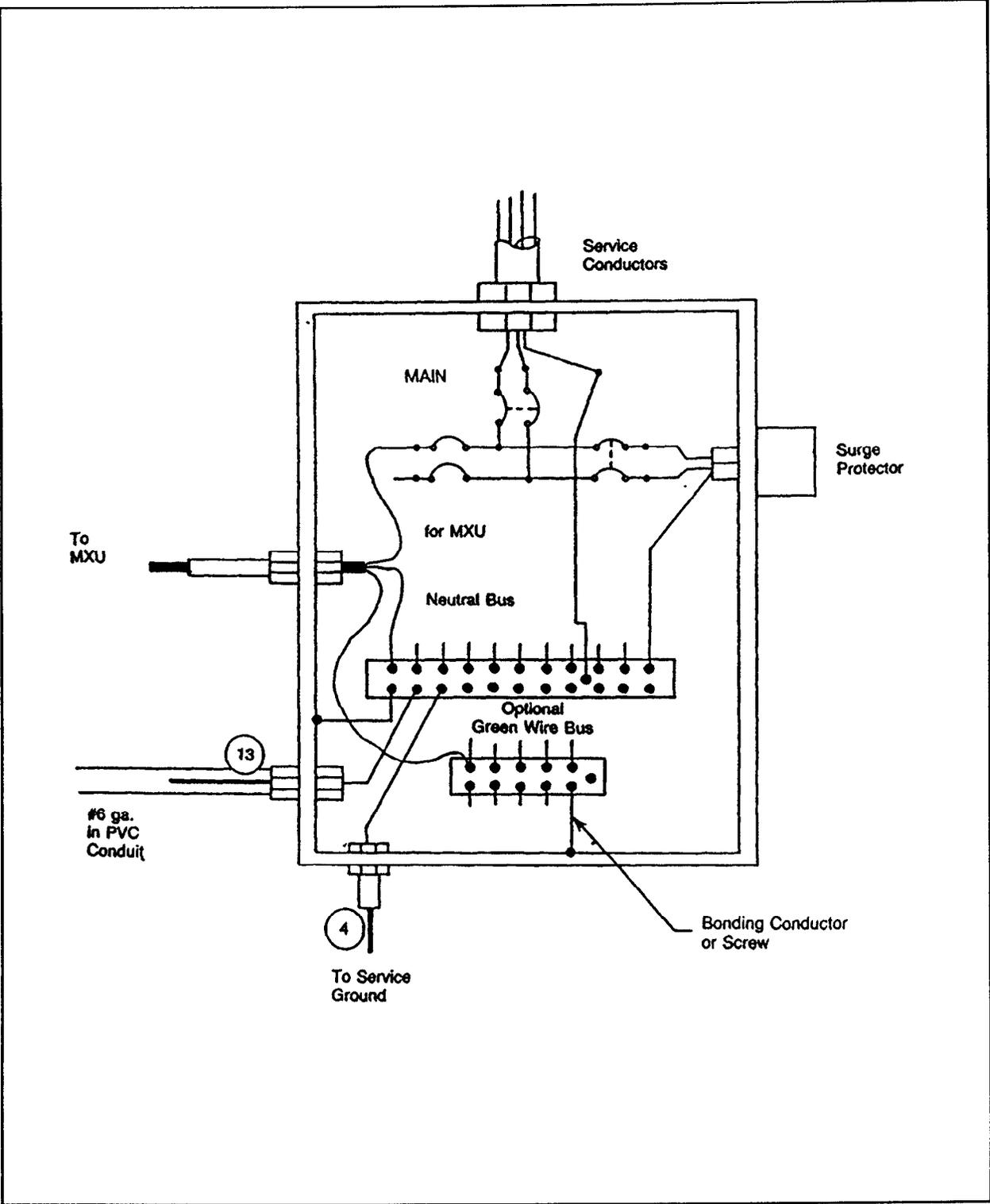


Exhibit 8 – Service Disconnect

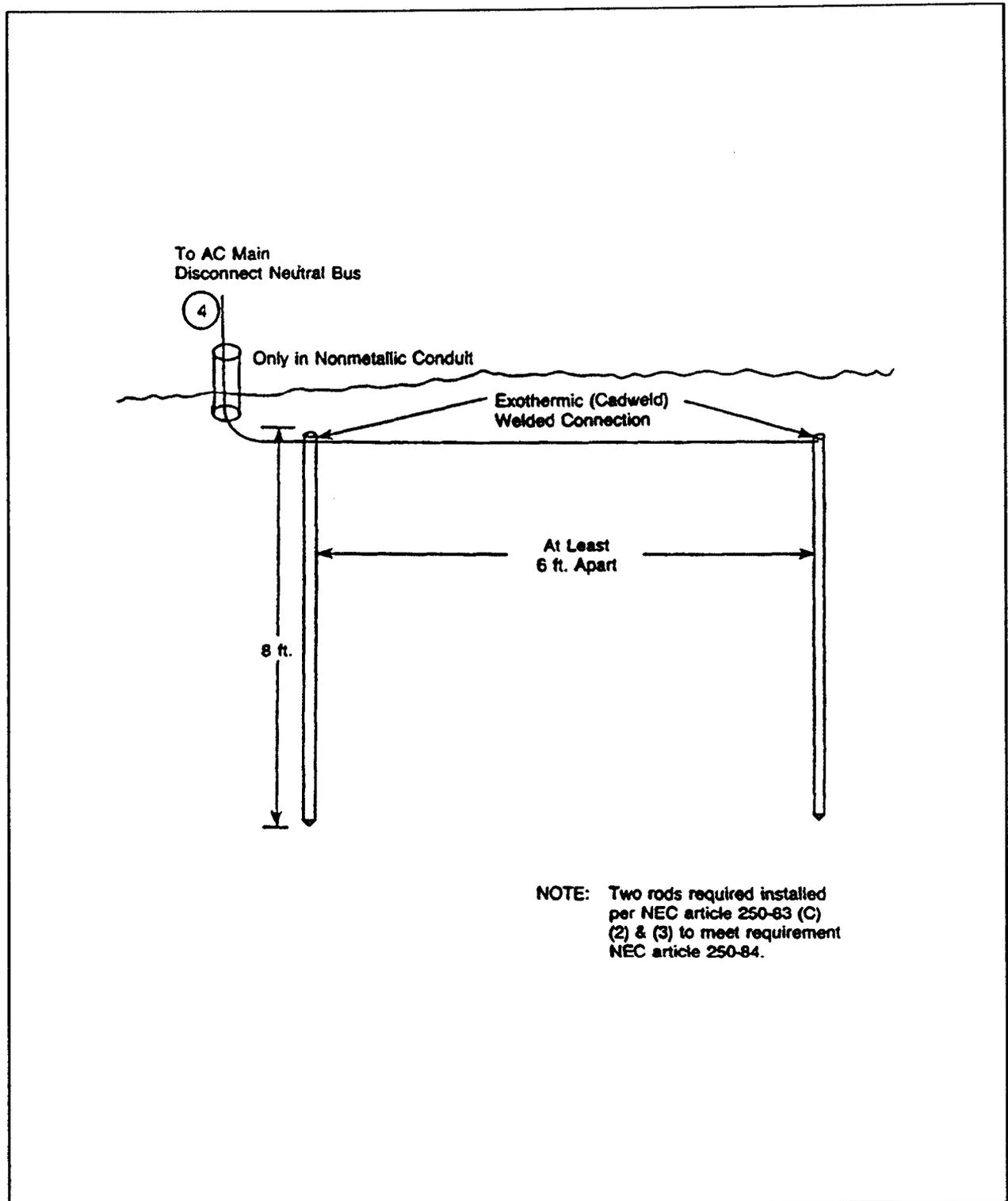


Exhibit 9 – Required Driven Electrode Grounding of AC Service

Exhibits, continued

Copper (Preferred)	Aluminum or Copper-Clad Aluminum	Minimum Size Stranded Copper Leads 9, 10, 13	Minimum Number of Runs #2 AWG Bare Tinned Solid Copper for Each Lead 5 & 7
Up through 350 MCM	Up through 500 MCM	2	1
Over 350 MCM through 1,000 MCM	Over 500 MCM through 1,100 MCM	2/0	2
Over 1,000 MCM through 2,000 MCM	Over 1,100 MCM through 2,100 MCM	3/0	3 (1,000 through 1,250) 4 (over 1,250)

NOTE: Minimum sizing is based on conductor size of a single phase, entering the main service disconnect panel.

Exhibit 10 – Minimum Sizing of Leads 5, 7, 9, 10, and 13

Exhibits, continued

Size of Largest Service Entrance Conductor or Equivalent Area for Parallel Conductors		Size of Grounding Electrode Conductor	
Copper	Aluminum or Copper-Clad Aluminum	Copper	Aluminum or Copper-Clad Aluminum
2 or smaller	0 or smaller	8	6
1 or 0	2/0 or 3/0	6	4
2/0 or 3/0	4/0 or 250 MCM	4	2
Over 3/0 to 350 MCM	Over 250 MCM to 500 MCM	2	0
Over 350 MCM to 600 MCM	Over 500 MCM to 900 MCM	0	3/0
Over 600 MCM to 1100 MCM	Over 900 MCM to 1750 MCM	2/0	4/0
Over 1100 MCM	Over 1750 MCM	3/0	250 MCM

Where no service-entrance conductors exist, determine the grounding electrode conductor size by the equivalent size of the largest service-entrance conductor required for the load to be served. See the installation restrictions in Section 250-92(a).

NOTE: This is not recommended by GTE.

Exhibit 11 – Grounding Electrode Conductor for AC Systems (Leads 4 and 8)

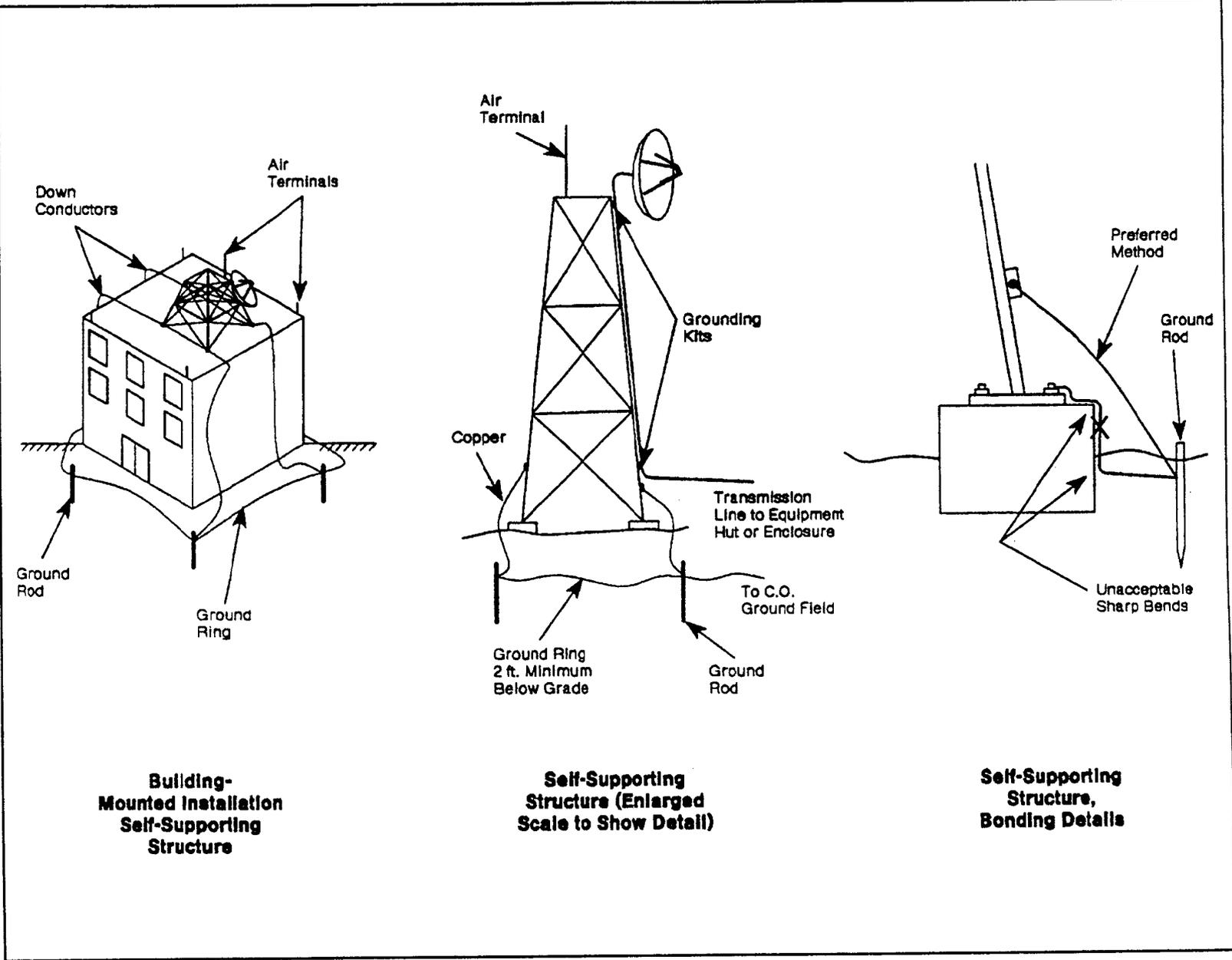


Exhibit 12 - External Grounding

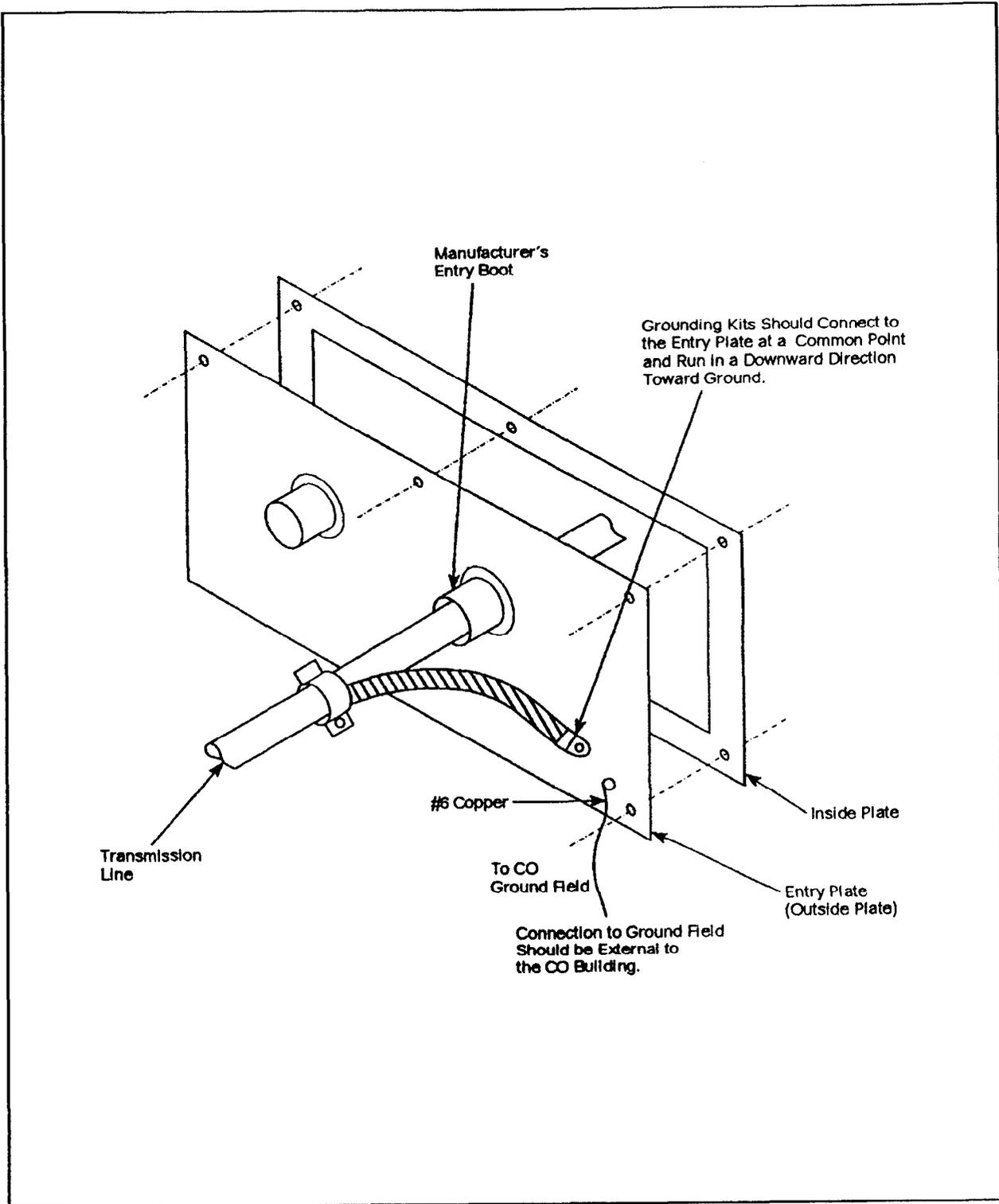


Exhibit 13 – Building Entrance Grounding Bulkhead