Remote Electronic Serving Area Grounding Systems Engineering Considerations

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1 . General

1.1 Purpose

This practice describes the:

- Engineering methods recommended for all remote electronic serving area (ESA) grounding systems.
- Grounding system that is applicable to locations providing network:
  - Plain Old Telephone Service (POTS).
  - Special services.
  - Fiber To The Curb (FTTC) and Fiber In The Loop (FITL) applications.
  - Video services.

1.2 Filing Instructions and Supersedures

Discard all previous issues and associated addenda of this practice and file this issue numerically in your GTE Telephone Operations practices set.

This practice supersedes and cancels:

- All policies, procedures, general instructions, letters, and memoranda which address this subject.
- Any document which provrdes information contrary to the information contarned in this practice.

1.3 Reason for Reissuing

This practice has been reissued to incorporate multiple changes in the content. Read this entire practice to ensure your familiarity with the new information.

1.4 Responsibility

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

1.5 Disclaimer

This practice was prepared solely for the use of GTE Telephone Operations. It must be used only by its employees, customers, and end users when installing, operating, maintaining, and repairing GTE Telephone Operations' equipment, facilities, and services. Any other use of this practice is forbidden. The information contained in this practice may not be applicable in all circumstances and is subject to change without notice. By using this practice the user agrees that GTE Telephone Operations will have no liability (to the extent permitted by applicable law) for any consequential, incidental, special, or punitive damages that may result.

2. Overview

2.1 Introduction

This practice includes ground system requirements for small remote sites (regardless of equipment/vendor type):

- Pole-mounted and pad-mounted Digital Loop Carriers (DLCs).
- Controlled Environmental Vaults (CEVs).
- Host Digital Terminal (HDT)/Remote Digital Terminal (RDT).
- Huts (enclosed walk-in structures up to 9 ft [2.7m] by 11 ft [3.4m]).

The requirements in this practice supersede the vendor's grounding requirements outside of the switch area.

NOTE: Refer to GTE Telephone Operations Practice 795-805-071 for grounding requirements for Host Offices (Central Offices) and Large Remote Switching Units.

2.2 Grounding System Attributes

The grounding system described in this practice:

- Provides an equalized ground reference for equipment operation.
- Controls potential differences to minimize electric shock to personnel.
- Reduces noise by providing low-impedance paths between:
  - Frames.
  - Systems.
  - Cabinets.
  - Earth.
- Is reliable for the service life of the equipment at the site.
- Protects equipment from damage or fire hazards by diverting excessive fault and lightning currents to earth.

2.3 Definitions

The following chart defines the acronyms and terms used in this practice.

Acronym or Term	Definition
ACEG	AC Equipment Grounding (conductors)
ATL	Above The Line
AWG	American Wire Gauge
BETRS	Basic Exchange Telecommunications Radio Service
Bonding	The permanent joining of metallic parts to form an electrically conductive path that will ensure that there is electrical continuity and the capacity to conduct safely any current likely to be imposed.
BSTC	Bare, Solid, Tinned Copper
CEV	Controlled Environmental Vault

(continued)

2.3 Definitions, continued

Acronym or Term	Definition
CATV	Community Antenna Television
CO	Central Office
COEC	Central Office Equipment Construction
COEE	Central Office Equipment Engineering
Common Bonding	The interconnecting of separate ground electrodes necessary at locations where common grounding cannot or has not been used.
Common Grounding	The use of the same ground electrode by all services (e.g., telephone, power, CATV, etc.).
Conductor	A material usually in the form of wire, cable, or bar, suitable for carrying an electric current.
Current Limiting Overcurrent Protective Device	A device that, when interrupting currents in its current limiting range, will reduce the current flowing in the faulted circuit to a magnitude substantially less than that obtainable in the same circuit if the device was replaced with a solid conductor having comparable impedance.
CVGB	Cable Vault Ground Bar
Delta System	A system or circuit without an intentional connection to ground, except through high impedance devices such as potential measuring devices or the service transformer,
Digital Facilities	Telephone Company facilities carrying digital signals such as Repeater Housings, Span Lines (T1, T1C, or higher rate), etc.
Digital Sites	Digital Switching Office Equipment located in: • Host or remote offices. • A DLC in: - Structure or hut. - Pad-mounted cabinet. - Pole-mounted housing. • CEVs.
DLC	Digital Loop Carrier

(continued)

2.3 Definitions, continued

Acronym or Term	Definition
ECPGB	Entrance Cable Protector Ground Bar
Effectively Grounded	Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current carrying capacity to prevent hazardous voltages from building up.
EGC	Equipment Grounding Conductor
EHV	Extra-High Voltage
Electromagnetic Induction	The resultant electromotive force in a circuit or component caused by changes in the magnetic flux linking with that circuit or component.
EM	Electromechanical
EMI	Electromagnetic Inductance
Equipment Enclosure	A housing or cabinet for telecommunications electronic equipment that: • Consists of: - A weatherproof housing. - An equipment or component section. • Might be pole-mounted or pad-mounted. • Generally houses: - Switching equipment. - Carrier electronics. - Remote terminals.
ESA	Electronic Serving Area. A geographic area: • Served directly by either a: - CO. OR - Remote terminal. • Not restricted by service section boundaries. The ESA reduces feeder cooper deployment and optimizes the use of existing facilities. The size of the ESA is restricted by transmission limits, typically to a maximum of 12,000 feet [3658m] from the serving CO or remote terminal.
FGB	Floor Ground Bar

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2.3 Definitions, continued

Acronym or Term	Definition
FITL	Fiber In The Loop
FO	Fiber Optic
FTG	Facility Test Ground
FTTC	Fiber To The Curb
GPR	Ground Potential Rise
Ground	A conducting connection whether intentional or accidental between any electrical circuit or equipment and the earth, or to some body that serves in place of the earth.
Ground Electrode	One or more conductors in direct contact with the earth for the purpose of providing a connection to the earth.
Ground Grid	A mesh of horizontal bare conductors and grounding electrodes that provides a common grounding system and voltage equalization for: • Electric devices. • Metallic structures.
Ground Mat	A solid plate directly above the soil surface or a wire mesh below the surface. Used typically at power substations.
Ground Resistance	The ohmic resistance between the grounding electrode and a remote grounding electrode of zero resistance.
Ground Window	A dimensional transition zone consisting of a sphere with a 3 foot (0.9m) radius, which is the interface between the integrated ground plane and a given isolated ground plane.
Grounding Conductor	A conductor that is used to establish a ground and that connects a device, equipment, wiring system, or another conductor with the grounding electrode or electrodes.
Grounding System	The combination of conducting elements by which all equipment is connected to the earth
HDT	Host Digital Terminal
HE	Horizontal Equalizer

(continued)

2.3 Definitions, continued

Acronym or Term	Definition
HF	High Frequency
Hut	Enclosed walk-in structure up to 9 ft(27m) by 11 ft (3.4m).
IGZ	isolated Ground Zone
Incidental Ground	An unplanned or accidental connection to ground.
Integrated Zone	The area in a central office where all the equipment is intentionally or incidentally connected to ground through more than one point.
lsokeraunic Map	Shows the amount of lightning activity for an area, indicating the number of days per year on which thunder is heard.
Isolated Zone	The area in a central office where all the equipment is insulated from the structure and is grounded by a single connection through the Main Ground Busbar (or Ground Window).
kcmil	one thousand circular mils-MCM
LPG	Lightning Protection Ground
LPS	Lightning Protection System
m	meter
Made Electrode	A ground electrode designed and installed for a specific site.
Main Bonding Jumper	The connection between the grounded circuit conductor (neutral) and the Equipment Grounding Conductor (EGC) at the main service panel. It can consist of a wire, busbar, or screw.
MCM	(See kcmil.)
MDF	Main Distributing Frame
Metallic Member	A noncommunications metallic cable component such as a shield or strength member.
MGB	Master Ground Bar

(continued)

2.3 Definitions, continued

Acronym or Term	Definition
MGN	Multi-Grounded Neutral
mm	millimeter
MTU	Magnetic Tape Unit
Multi-Grounded Neutral	A neutral conductor of a wye-connected electric supply system that includes: • At least four grounds per mile. • Power ground connections at individual services. • Solidly interconnected primary and secondary neutrals. **NOTE: If it is not definitely known if the power system is of the MGN type, obtain the information from the power company.**
Mutual Resistance	The voltage change in one electrode produced by a unit of DC current in a second electrode.
NEC	National Electrical Code
NGDLC	Next Generation DLC
NRTL	Nationally Recognized Testing Laboratory
ONU	Optical Network Unit
OSP	Outside Plant
OSPC	Outside Plant Construction
OSPE	Outside Plant Engineering
Overcurrent	Is either: • Any current in excess of the rated current of equipment. OR • The ampacity of a conductor. It might result from: • Overload. • Short circuit. • Ground fault.

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2.3 Definitions, continued

Acronym or Term	Definition
Overvoltage	Abnormal voltage between two points of a system that is greater than the highest value appearing between the same two points under normal service conditions.
PCM	Pulse Code Modulation
PCU	Power Control Unit
PDF	Protector Distributing Frame
PDU	Power Distribution Unit
POTS	Plain Old Telephone Service
Protector	A device used on each circuit to limit voltage between telecommunication conductors and ground (earth). The protector must be electrically connected to a ground electrode to effectively operate and reduce the possibility of injury and damage to personal property.
PVC	Polyvinyl Chloride
RDT	Remote Digital Terminal
Remote Terminal	The location at which there is a transition between: • A telecommunications carrier facility. • The local lines serving customers.
SA	Support Assets (Formerly L&B Engineering)
SBTC	Solid, Bare, Tinned Copper
Separately Derived System	A wiring system whose power is derived from generator, transformer, or converter windings and that has no direct electrical connection, including a solidly connected, grounded circuit conductor, to supply conductors originating in another system.
Sneak Current Protector	A protective device that is intended to limit currents that are too small to operate fuse links, stub cables, or the fuse of a fused primary protector.

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2.3 Definitions, continued

Acronym or Term	Definition
SPG	Single Point Ground. Is the single point in an office where all ground sources terminate. Typically the Master Ground Bar (MGB).
Surge Impedance	Impedance of a ground electrode at the frequency of the applied AC current.
T&P	Transmission and Protection

2.4 References

The following chart provides sources of supplementary information relating to this practice. The documents could be required for performing certain tasks.

See...	For information About...
007-015-006	Digital Loop Carrier Provisioning
740-250-070	Central Office Grounding Systems Installation and inspection
740-500-070	Remote Equipment Buildings (REBs) Engineering Guidelines
742 Series	Building Fire Protection
743-200-070	Emergency Generators Engineering Application
745-622-070	Controlled Environment Vaults – Engineering Guidelines
795-805-071	Central Office Grounding Systems – Engineering Applications
795-805-072	AC Service Grounding Engineering Applications
795-805-073	Transmission Equipment – Central Office Grounding
795-805-074	Inspecting Central Off ice Grounding and Electrical Protection
830-000-000	Engineering Directives – Preparation and Handling
887-000-001	Requesting Deviations From Protection Practice Requirements
887-000-050	Electrical Protection Engineering Fundamentals

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2.4 References, continued

See...	For Information About...
887-030-085	Engineering Considerations Radio Station Protection
887-030-087	Satellite Earth Station Protection Engineering Considerations
887-050-085	Carrier System Protection – Engineering Considerations
887-600-070	Engineering Fundamentals of Electrode Ground Design
887-600-071	Fundamentals of Ground Measurements
887-600-072	Engineering Methods for Measuring Electrode Ground Systems
887-795-070	Lightning Protection Systems – Risk Assessment Guidelines – Engineering Considerations
887-800-044	Determination of Minimum Separation Between Digital Sites and Electric Power Facilities
887-903-026	Five-Pin Protector Module-Application
938-360-010	Outside Plant Engineering of Digital Loop Carrier Systems
938-360-012	Power Pedestal – Description and Applications
NFPA 70"	National Electrical Code
NFPA 780"	Lightning Protection Code

* Published by the National Fire Protection Association (NFPA).

2.5 Ordering Information

Refer to the following Product Service Bulletins (PSBs) for ordering information on certain products mentioned in this practice.

NOTE: PSBs are published by the GTE Telephone Operations Standardization Management Department.

Refer to...	For Information About...
PSB 0131	Warning Tags
PSB 1625	Exothermic Welding
PSB 2149	Compression Fittings
PSB 3282	Conductive Grease
PSB 3440.6	Power Pedestal (R-TEC)
PSB 4131 .1	Ground Rods
PSB 4143	Ground Rods
PSB 4145	Compression Fittings
PSB 4303	Solid State Five-Pin Protectors
PSB 5016	Power Pedestal (Evergood)
PSB 6141	Grounding Clamps (Fence Posts)
PSB 6238.1	Ground Bars
PSB 6238.3	Test Bracket

3. Planning Ahead

3.1 Locations to Avoid

Avoid locating remote ESA sites (huts, CEV, pole-mounted, or pad-mounted cabinets) adjacent to:

- Power stations (generating plants and substations).
- Transmission (EHV) lines.
- Foreign (non-GTE) antennas, radio, and microwave/satellite sites (including radio stations).
- Fire Departments or other municipal entities that use radio systems.
- DC rail systems and their stations.
- Cathodic Protection fields (including anode beds and rectifier sites).

Refer to GTE Telephone Operations Practice 887-800-044 to calculate minimum separation between digital sites and electric power facilities.

NOTE: Contact the Administrator - T&P or the Region Support Staff if these sites cannot be **avoided.**

3.2 Ground System Fault Stress

These sites (including huts, CEV, pole-mounted, or pad-mounted cabinets) should not be located:

- Close to a 300 Vac peak GPR source capable of firing the entrance cable protectors

  OR
- Within the substation zone of influence.

GPR places severe stress on:

- Protectors.
- Fuse links.
- Jumpers.
- Equipment.

With the increased use and deployment of solid-state protectors, a figure lower than 300 Vac might be desirable to accommodate the lower breakdown voltages of solid-state protectors.

NOTE: Refer to GTE Telephone Operations Practice 887-800-044 for the appropriate calculation method.

3.3 Choosing the Best Layout

Plan a site layout where the AC power service, water system (if any), and telephone OSP cables are on the same side or adjacent sides of the facility so that a common bonding system can be established.

A short, straight grounding conductor path between these elements increases the equipment protection.

3.4 Restriction

A remote ESA site should not have more than one grounding system unless separate structures (huts or cabinets) have:

- Separate AC and DC power.
- Cables between the structures that have protectors at each end.

3.5 Results of Improper Grounding

Improper or inadequate grounding can result in:

- Erratic equipment operation.
- Noisy circuits.
- Premature component failures.
- Potential safety hazards.

3.6 Preparation of Connectors and Surfaces

All lug connections and their mating surfaces must be cleaned and lightly coated with a non-oxidizing type conductive grease or compound as follows:

- MC 760293 (or equivalent) for copper and steel surfaces.
- MC 760294 (or equivalent) for aluminum surfaces.

CAUTION: Using the incorrect compound damages the lug connections. Painted surfaces must be scraped, cleaned, and lightly coated with the applicable compound.

3.7 Leased Structures

When installing regulated ATL remote ESA equipment in leased structures, the equipment grounding system should include a direct connection to an approved grounding electrode for the structure or site. This grounding electrode must be as described in either:

- Section 4.5.

  OR
- NEC Article 250-81B.

4. Site Grounding Electrodes

4.1 Ground Electrodes

Telephone company constructed ground electrodes include:

- Ground rings.
- Deep electrodes (ground rods or wells).
- On-property water pipe.
- Ground fields (grids or plates).
- Structural steel when tied together.
- Concrete-encased steel and/or wire.

4.2 Recommended Ground Resistance Objectives

The recommended resistance objective for telephone constructed grounding electrodes for small remote ESA sites (huts, CEVs, pad-mounted, or pole-mounted cabinets) must be equal or less than the objective shown in the following chart.

Objective* (in Ohms)	Equipment Type
25	Hut (see note).
25	Pad-Mounted Cabinet (HDT/RDT/DLC)
25	Pole-Mounted Cabinet
25	Rural radio (BETRS) at customer locations and non-clustered sites.
2	Huts co-located with radio towers (60 feet [18m] or taller).
5	BETRS cluster sites. Pad-mounted equipment co-located with poles (60 feet [18m] or less).
3	CEVs.
3	DLCs installed in CO buildings. Structures designed for future growth. Huts with ancillary equipment.

* Grounding electrode measured alone.

NOTE: **For objectives, refer to the following GTE Telephone Operations Practices:**

- **887-030-085 for radio towers.**
- **795-805-071 for COs and large remote buildings.**

A hut is defined as an enclosed walk-in structure that might include a vault with a controlled environment. Small structures and huts are typically not designed to be added on or expanded.

If the amount of ancillary equipment (PCM channel banks, FO terminals, etc.) located in the enclosure or hut is not essential to the operation of the DLC (e.g., host-remote links), use 25 ohms as the objective. Otherwise the objective is 3 ohms.

Sites experiencing excessive (or out of the ordinary) equipment failures and/or transmission impairments (e.g., noise, etc.) might need lower electrode resistance.

4. Site Grounding Electrodes, continued

4.3 Inability to Meet Objectives

The recommended grounding electrode resistance objectives of Section 4.2 might not be economical to meet in locations that have:

- Unfavorable soil conditions.
- Very hrgh earth resistivity.

In these locations, obtain the lowest combined ground resistance economically feasible (not to exceed the objectives of Section 4.2) by bonding together (before measuring):

- Telephone company ground electrodes.
- Power company neutral (MGN).
- Exterior cold water pipes (metallic).

A deviation form such as the one shown in GTE Telephone Operations Practice 887-000-001 should be completed and approved by Region Support Staff (Protection).

4.4 Electrode Design

Procedures and formulas are described in GTE Telephone Operations Practice 887-600-070.

Electrode design should be:

- Approved by the Administrator - T&P
- Created in accordance with GTE Telephone Operations Practice 887-600-070.
- Based on soil resistivity measurements at the spacing/depth required by local soil conditions and resistance objectives.

4.5 Minimum Made Electrode (Always Required)

The minimum made electrode must be:

- A ring of #2 AWG wire SBTC around the site or structure and four GTE Standard 8 foot long (2.5m) driven rods, one at each corner.

  OR
- A nonstructural rebar ring (exothermically welded) of not less than 20 feet (6m) encased in concrete foundation (see Section 4.8).

NOTE: For existing sites or for sites where a complete ring around the structure is not practical or feasible and for sites with pole-mounted DLCs, a minimum of 20 feet (6m) of #2 AWG wire (SBTC) with two 8 foot long (2.5m) driven rods will be required. Section 4.2 objectives should still be used.

The minimum multiple point contact is required to dissipate lightning faults. The minimum electrode might be supplemented with other electrodes to meet the ground resistance objectives.

CAUTION: Obey local and state regulations when drilling through water table aquifers.

4.6 Grounding in Areas with High Earth Resistance (Supplemental to Minimum Made Electrode)

If the calculated total ground system earth resistance exceeds the recommended ground objectives, consider in addition to (but not in place of) the minimum made electrode:

- A deep driven well.

  OR

- Other approved grounding method (refer to GTE Telephone Operations Practice 887-600-070).

An annual inspection and test is required. This procedures ensures that the electrode ground has not deteriorated (refer to GTE Telephone Operations Practice 887-600-072).

4.7 Rules

Observe the rules shown in the following chart when placing ground electrodes.

Rule	Explanation
Use #2 AWG SBTC when conductors will be exposed to soil.	Minimizes the effects of corrosion or electrolysis (see Section 18.3).
Provide access points (handholes) for Leads 3, 25, 27, and 28 when they connect to Lead 1.	Permits periodic resistance testing and inspections (see Section 4.9). **NOTE: The existing access points should be used so as to minimize the total number of handholes at the site.**
Provide a minimum of two access points (handholes). More if needed by local conditions.	Permits periodic resistance testing and inspections (see Section 4.9).
Grounding electrodes or grounding conductors within 6 feet (1.8m) of another must be bonded (fences, MGN, etc.).	Equalizes voltage differences, reducing the possibility of arcing and equalizing step and touch potentials.

NOTE: **Do not bond piping or steel tanks that are cathodically protected because this would reduce the effectiveness of the cathodic protection system.**

4.8 Restriction

To permit accurate electrode ground resistance testing, do not permit Leads 5 and 7 conductors to contact other:

- Grounding conductors.
- Metallic devices or structures.

Use nonmetallic conduit to provide the required insulation of the conductors for Leads 5 and 7. The leads might be exposed provided the conductors are kept from contacting such things as:

- Structural steel.
- Metal conduits.

4.9 Providing Access to Lead Connections

Access points (such as suitable handholes or equivalent) should be provided to allow for:

- Testing.
- Inspections.

Testing of Leads 1 and 5 without connections to any other lead or metallic object is highly recommended.

Connection points of Leads 3, 25, 27, and/or 28 to.Lead 1should be done at a handhole. Other connection points might need to be done at a handhole if they are to be disconnected during testing of the ground ring.

4.10 Locating Ground Rods

All ground rods should be located:

- At least 2 feet (0.6m) from any wall.
- In undisturbed soil.
- With SBTC wire (#2 AWG minimum) at least 30 inches (0.8m) deep and below the frost line.
- No less than 6 feet (1.8m) from each other to achieve maximum efficiency.

4.11 Contractor-Provided Electrodes

When a contractor agrees to engineer, furnish, and install the “man-made” electrode, the GTE Telephone Operations engineer (OSP or Support Assets) should furnish the contractor with:

- The desired electrode earth resistance.
- A job drawing showing complete installation details of the desired electrode.

4.12 Requirements for Connecting to Ground Ring and Rods

Connections to the ground ring and rods should be GTE Telephone Operations-approved:

- Exothermic weld (PSB 1625).

  OR

- Compression fittings (PSBs 2149 and 4145).

Permanent connections should be either exothermic welds or compression connections.

Connections that are to be removed for testing might be of the mechanical type.

4.13 Ground Ring

The ground ring (Lead 1) is:

- Connected to the ground rods.
- Made of a #2 AWG SBTC.
- Connected via Lead 5, from opposite sides of the ground ring, to the MGB (see Exhibits 1 and 2).
- Buried in earth at least 2.5 feet (0.8m) below grade and below the frost line.
- Connected to metallic fence posts within 6 feet (1.8m) (Lead 6).
- Connected to other ground rings such as towers, lightning protection systems, etc. with access to permit disconnections for testing.
- Connected to the lower end of the structural steel columns with access points to permit disconnections for periodic testing.
- Connected to other grounding conductors or ground electrodes within 6 feet (1.8m) to equalize voltage differences.

Refer to Exhibits 1, 3, 4, 5, 6, 7, and 8 for additional information.

NOTE: Pole-mounted enclosures do not have a ground ring(see Section 4.5).

4.14 Concrete-Encased Electrodes

Concrete-encased electrodes:

- Might be constructed in footings of structures or pads.
- Must be constructed in structure footings in accordance with Exhibit 9.

Two corners of the prefabricated wire mesh inside the concrete pad. (when used) might be:

- Pigtailed via #2 SBTC conductors.
- Connected to the ground ring (Lead 1) at two corners using mechanical connectors.

NOTE: Low resistivity materials can be used in lieu of concrete.

4.15 Grounding to Water Pipe.

If the site is provided with a metallic pipe from a public water system, bond from the structure side of the water meter:

- To the MGB (Lead 10).
- In compliance with local codes.
- From the structure side to the exterior (street side of meter) cold water pipe system (Lead 9), where permitted by the water utility.

Connections must be made at accessible locations.

CAUTION: Metallic pipe must have a minimum of 10 feet (3m) of direct contact with the soil to be effective.

NOTE: When more than one water system serves the site, a bond must be made from the MGB to each system.

4.15 Grounding to Water Pipe, continued

The following chart describes the procedures for grounding to water pipe.

Step	Grounding to Water Pipe
1	Connect the conductor from the MGB (Lead 10) to the main metallic cold water pipe. This should be done either: • Inside the structure at a point within 5 feet (1.5m) from where the cold water pipe enters the structure. OR • Outside the structure but within GTE Telephone Operations property.
2	Attach grounding conductors to the water pipe with an approved ground clamp of the proper size (PSB 6141).
3	Place bypass conductors of the same size around the: • Water meter (if metallic pipe is used). • Service unions. • Other junctions that might be physically disconnected.

4.16 Using the Bypass Conductor

The bypass conductor (Lead 9) is needed to ground the interior cold water pipe system to the main water system. When the water meter is on GTE Telephone Operations property, Lead 9 should be added where permitted by local regulations. If the public water piping is constructed of PVC pipe, this lead should be omitted.

NOTE: The use of Lead 9 requires the permission of the local water company. Some metallic water pipes are protected against corrosion by a cathodic protection system. Any unauthorized connection might cause problems to this system.

4.17 Test Arrangements

Each site should include a permanent test bracket to allow periodic testing of the office grounding electrode. Refer to GTE Telephone Operations Practice 887-600-072 and PSB 6238.3 for additional information.

4.18 Lead Explanations

The following chart lists and describes the leads.

Lead	Explanation
1	Consists of the ground ring or minimum electrode as described in Section 4.5. Wire #2 AWG SBTC. Larger gauge wire can be used to decrease electrode resistance. (Consider the additional cost versus the increased benefit.) Connections to ground rods or other leads are exothermic welds or compression connections unless they are expected to be disconnected for testing.
1A	Encased in concrete or similar type material and similar to Lead 1. When Lead 1A is part of the slab or foundation it should be continuous and welded to the rebar or mesh.
2	Consists of a metal casing (4-inch [0.1m] diameter minimum). This is a deep well. Driller's mud or bentonite should be used to fill the voids between the metal casing and the drilled hole.
3	In a building, connects each steel column and reinforced steel to Lead 1 or Lead 1A. At a pad-mounted equipment enclosure, connects the pad's welded wire mesh to Lead 1 or Lead 1A.
5	Consists of single or multiple runs of #2 AWG SBTC wire from the MGB to two different (preferably opposite) sides, for redundancy, of Lead 1. Single runs (for each direction) of electrically equivalent gauge are acceptable (see Exhibit 2). The number of runs for each Lead 5 is determined from Exhibit 2. When the use of stranded conductor is required, the wire must be jacketed (insulated} and run in non-metallic conduit. No portion of the stranded conductors may be exposed to the elements or in direct contact with the soil. **NOTE: The use of SBTC conductors for Lead 5 is preferred.** Only one Lead 5 is needed for pole-mounted DLCs.

(continued)

4.18 Lead Explanations, continued

Lead	Explanation
6	Consists of a single #2 AWG SBTC wire from Lead 1to: • Each metallic fence post. AND/OR • Metallic fence section within 6 feet (1.8m). This lead can be extended beyond 6 feet (1.8m) if the fence is farther away to improve the ground resistance of the electrode system. Lead 6 should be connected to Lead 1 (below ground level) by either: • Exothermical welding. OR • Using compression connectors. The connection of Lead 6 to the fence should be above ground level using a mechanical connector because the connection might have to be removed for testing (see PSB 6141). Also used for the bonding of other grounding conductors within 6 feet (1.8m). **NOTE: When the metallic fencing rails span from post to post creating a conductive path, fewer connection points are needed. In this case, the distance between connection points should not exceed 20 feet (6m). If the rails are not present, each post must be grounded.**
7	Connects each well electrode (Lead 2) to the MGB. The gauge is determined from Exhibit 2. When the use of stranded conductor is required, the wire must be jacketed (insulated) and run in non-metallic conduit. No portion of the stranded conductors may be exposed to the elements or in direct contact with the soil. **NOTE: The use of SBTC conductors for Lead 7 is preferred.**
9	Connects the structure side of the metallic cold water pipe to the external side usually by jumpering across the water meter. This is done only when allowed by the water utility.
10	Connects the structure side of the metallic cold water pipe to the MGB. The 1993 NEC restricts the point of connection to the first 5 feet (1.5m) of the interior side of the water pipe (see PSB 6141).
15	Used to connect the ground bars of different equipment enclosures installed on the same pad.
28A	Used to connect the different ground rings (Lead I) that might exist at one site. This typically occurs at sites with multiple pad-mounted equipment enclosures placed at different times. The #2 AWG SBTC is direct buried (see Exhibit 5).

4.19 Multiple Facilities

If the demand for service requires multiple facilities at one site, arrange for one common electrode ground system to serve all facilities (see Exhibits 4 and 10). If multiple electrode grounds are installed (with or without ground rings), establish a #2 bare, solid, tinned copper (lead 28A) between the multiple electrode ground systems (see Exhibit 5). Provide a handhole at the point of connections for:

- Future inspections.
- Electrode ground measurements.

4.20 Structural Steel

Refer to information contained in GTE Telephone Operations Practice 795-805-071 for ways to ground structural steel in small structures or huts

5. AC Grounding Electrode System

5.1 Minimum Requirements

Grounding electrodes are metallic objects in contact with the earth. The NEC specifies the minimum requirements of AC power systems with respect to:

- Grounding electrode system.
- Grounding electrode conductors.
- Equipment grounding (ACEG) conductors.
- Bonding conductors.

5.2 Required Bonding

A grounding electrode system requires bonding with any of the following when available on the premises (i.e., physically present):

- An AC main service power neutral.
- Any external underground water pipe and/or metal well casing (10 feet [3m] or longer) where allowed by local authority. This might include a drilled well when required to meet earth resistance objectives in:
  - High resistivity soil.

    OR
  - Solid rock.
- A metal structure frame. Plan ahead by including bonding of all structural steel in the plans for new construction.
- A ground field designed to meet the recommended minimum ground objectives (see Section 4).
- An interior metal water pipe system with at least 10 feet (3m) of direct earth contact.

5.3 Lead Explanations

The following chart describes the leads related to the AC grounding electrode.

Lead	Explanation
4	Grounds the neutral bus at the commercial AC service main disconnect switch to its grounding electrode (see Exhibit 11). The gauge of this lead must be in accordance with Exhibit 12.
8	Provides a bond between the: • Grounded neutral bus at the commercial AC service main disconnect switch. • Metallic water pipe (structure side). The 1993 NEC restricts the point of connection to the first 5 feet (1.5m) of the interior side of the water pipe. The gauge of this lead should be in accordance with Exhibit 12.
13	Provides a bond between the: • Grounded neutral bus at the commercial AC service main disconnect switch. • MGB. Use Exhibit 2 to determine the proper conductor gauge. This lead allows the site to remain connected to ground whenever the Lead 5s are disconnected for testing.

6. Master Ground Bar

6.1 Description

The MGB is a copper bar that serves as the site's main termination point for the following types of leads:

- Ground reference.
- Noise reduction.
- Fault dissipation.
- Safety ground.

The MGB must not be connected to a lead to complete an electrical path other than those specified in this document.

6.2 Connections to MGB

Make all grounding connections to the MGB using two-hole approved copper terminal lugs (see PSBs 2149 and 4145). Connections can be placed on both sides of the MGB.

Compression connections are required for all conductors (solid or stranded).

NOTE: Proper die set must be used with solid conductors.

6.3 MGB Sizes

Determine the correct size of the MGB by considering the:

- Ultimate size of the structure.
- Grounding requirements of this section.

NOTE: Refer to PSB 6238.1 for ordering information.

6.4 MGB Requirements

Every site must have one (and only one) MGB.

The MGB must always:

- Appear on structural drawings.
- Appear on equipment engineering plans (drawings).
- Be isolated from the wall using isolation standoffs.
- Be zoned (except in cabinets).

NOTE: The MGB must not have leads other than those specified in this document.

6.5 Location

In huts and CEVs, the MGB must be located:

- As close to the main AC service enclosure and OSP MDF as possible.
- No lower than 2 feet (0.6m) above the floor line.
- No higher than 2 feet (0.6m) below the superstructure (cable runway).
- So as not to:
  - Cause safety hazards.
  - Interfere with the placement of equipment.
  - Obstruct access to existing equipment.
  - Violate cable bending radius requirements

NOTE: When the MGB is placed more than 2 feet (0.6m) below the superstructure, vertical cable racking might be needed to provide cable support.

6.6 Enclosure Locations

There are no location requirements for the MGB in cabinets. In enclosures the use of ground bars, rather than ironwork elements, is recommended. Bars that will accommodate 2-hole lugs are required. Compression-type connectors must be used.

Some enclosures have two ground bars, one at each end (OSP end and AC end). These two bars must be electrically connected. Either one can be used as the MGB.

6.7 Installina Leads

The following chart describes the procedures to use when installing any leads.

Step	Installing Leads
1	Clean the: • Contact surfaces. • Connectors. • MGB (see Section 3.6).
2	Apply a thin coat of copper-based joint compound (MC760293 or equivalent).
3	Label leads with proper number identifying the lead number (description is optional). When more than one conductor with the same lead number appears on the ground bar, the "to" and "from" must be identified for each lead involved. **NOTE: Nonmetallic labels or tags are preferred.**

6.8 Zoning the MGB

Zone the MGB in huts and CEVs to reduce the voltage effects from currents flowing in surge-carrying conductors connected at the MGB. This procedure is recommended for new ground systems where zoning is easily accomplished (see Exhibit 13).

Zoning is not recommended as a retrofit procedure because bends must often be placed in the ground conductors when terminations are changed on an existing ground bar. Bending conductors can:

- Add inductance to the conductor impedance.
- Reduce some of the benefits of zoning.

For zoning an MGB to be effective, the MGB must be isolated from the wall with isolation standoffs. Engineering will specify and order the isolators (MC 726884).

NOTE: If the MGB is not zoned, do not isolate it.

6.8 Zoning the MGB, continued

The following chart describes the zone new MGBs.

Zone	Leads
Producer (P)	Conductors most susceptible to receiving and carrying the surges caused by power faults or lightning are: • 14c. • 16. • 16A. • 17. • 17B. • 21. • 23. • 23A. • 55. • 56. • 61.
Absorber (A)	Conductors that dissipate surges to ground (earth) are: • 5. • 7. • 10. • 13. • 14. • 15. • 18. • 19.

(continued)

6.8 Zoning the MGB, continued

Zone	Leads
Nonisolated ground equipment (N)	Conductors that are part of the integrated Zone are: • 14A. • 20. • 20A. • 31. • 37. • 37A. • 38. • 38A. • 40. • 54 • 57. • 57A. • 60. • 64. • 65.
Isolated ground equipment (I)	Conductors that are part of the IGZ are: • 41. • 41A. • 47. • 53A. • GW.

NOTE: The zone for the isolated ground equipment (I) must be placed as far as possible from the surge protector (P) zone when using the P-A-N-I concept. Exhibit 13 shows a typical example of MGB zoning.

Under the P-A-N-I concept, the important factor is to keep each group of leads (producers, absorbers, nonisolated, and isolated) in its own zone. Within each zone, the relative position or order of each lead is not critical.

Either P-A-N-I or its mirror image (I-N-A-P) is acceptable.

Depending upon the facility being installed, all leads listed might not be required.

NOTE: Zoning of ground bars in pad mounts is not required because the MGB is often bonded to the housing and the factory-located leads conflict with zoning.

7. Entrance Cable Protector Ground Bar

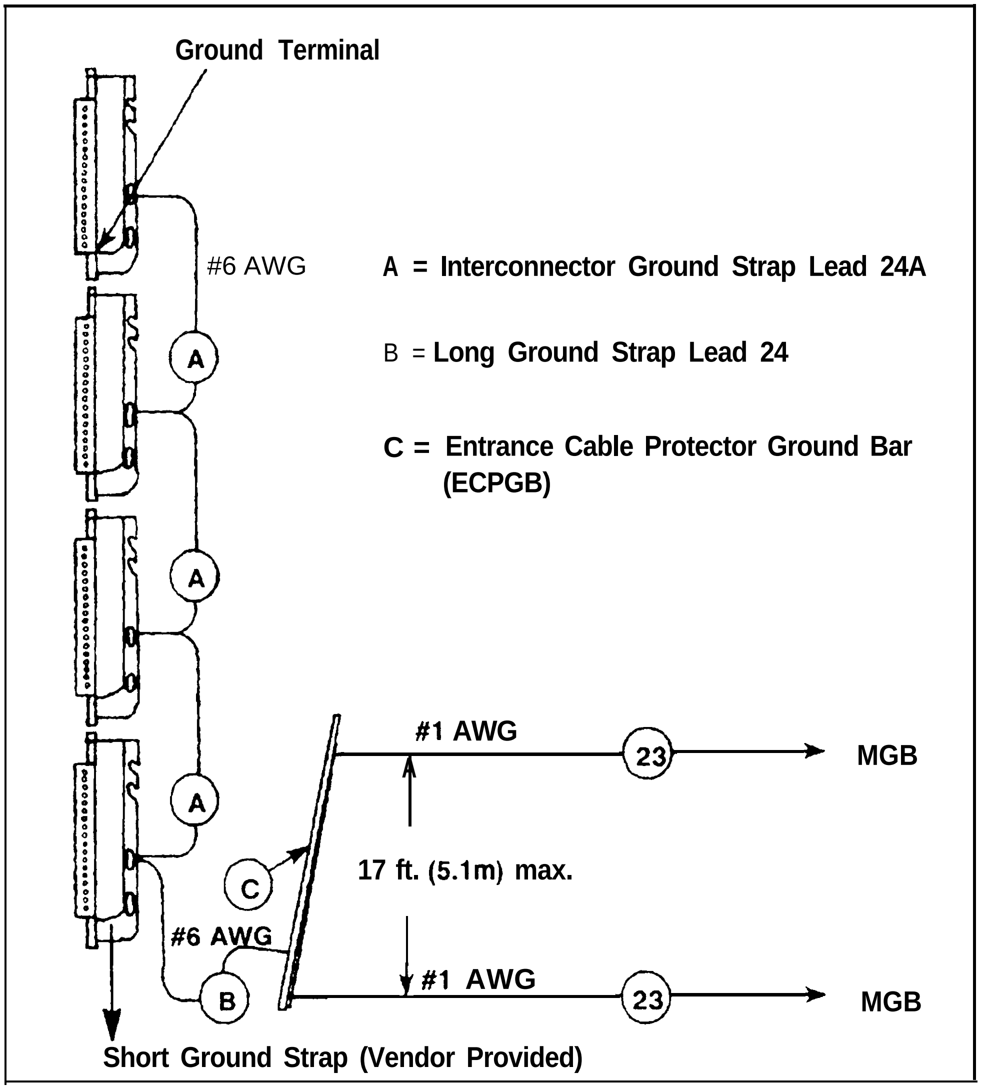
7.1 Description

The following illustration shows that the ECPGB is a copper bar attached horizontally across the top or bottom of the MDF.

The following illustration and Sections 7.2 through 7.6 describe how the arrangements are applicable only to CEVs and small huts.

Section 7.7 describes the requirements for pad-mounted equipment enclosures.

NOTE: **Some modular-type distribution frames do not have an ECPGB. In this case a 3/0 AWG solid bare copper conductor should be placed along the length of the distributing frame to be used in lieu of the ECPGB.**



7.2 Grounding the Protectors

Ground the protectors (connector blocks) on the cable stub or tip cable at the main MDF or PDF using:

- The ECPGB.
- One Lead 24 per vertical.
- One Lead 24A between each protector module base within the vertical.

Lead 23 will be placed starting at vertical #1 and every 17 feet (5.1 m) thereafter so that no protector is more than 8½ feet (2.5m) from a Lead 23. Where the bar exceeds 8½ feet (2.5m) but is less than 17 feet (5.1 m), a minimum of two Lead 23s are required.

On frames where sections of the frame have been reserved only for protectors, one Lead 23 is required on the first protector vertical. A second Lead 23 is required when any protector is placed on a vertical further than 8½ feet (2.5m) from the first protector vertical.

No protector vertical can be more than 8½ feet (2.5m) from any Lead 23.

7.3 Protector Modules

Use standard 5-pin, solid-state protector modules as described in GTE Telephone Operations Practice 887-903-026 (see PSB 4303).

NOTE: Cabinet locations and structures without controlled environment must use protector modules that are environmentally sealed.

All pairs, working and nonworking, terminated on the connector blocks must be equipped with protectors. Unterminated pairs not appearing on protector blocks must be bunched and grounded per GTE Telephone Operations Practice 887-000-050.

7.4 Leads 23 and 24

Leads 23 and 24 are:

- Sized in accordance with Exhibit 14.
- The only ground leads that can be terminated on the ECPGB.

Lead 24 must be:

- Run without excess slack and as direct as possible from the bottom of the vertical to the ECPGB.
- Placed maintaining a minimum of 6 inches (0.15m) bend radius.
- Connected directly to the lowest protector in the vertical.
- Run as directly as possible without excess slack to the ECPGB.

NOTE: Only Leads 23 and 24 must be connected to the ECPGB to complete an electrical path for any purpose.

7.5 Rules for Locating Leads 23 and 23A

The following rules should be observed when working with Leads 23 and 23A:

- Mount Lead 23 on the protector ground bar using a compression connector(s). One-hole connectors are allowed in this location.
- Never route Lead 23 or 23A through electronic switching common control areas:
  - Below the superstructure.

    OR
  - Within 3 feet (0.9m) of processors or memory frames.
- Maintain at least 1 foot(0.3m) separation between lead 23 or 23A (after leaving MDF) and any of the following types of cables:
  - DC power.
  - Switchboard.
  - HF.
- Avoid or minimize runs of Lead 23 or 23A parallel with the following types of cables:
  - DC power.
  - Switchboard.
  - HF.
- Run Lead 23A from the MGB or FGB to the carrier system protectors in the transmission systems area. Use Leads 24 and 24A as required.

7.6 Rules for Locating Lead 24

Observe the following rules when working with Lead 24:

- install Lead 24 ground straps according to the 243 series of GTE Telephone Operations Practices.
- Install one Lead 24A between each protector mounting base installed in the vertical. Refer to the illustration in Section 7.1.

7.7 Enclosures

Equipment enclosures are usually equipped with connector blocks for standard 5-pin protector modules, which are used to terminate copper HF pairs and line distribution pairs.

The connector blocks ground conductor may be run to several blocks before being connected to the MGB. Depending on the size and capacity of the enclosure there could be one or more protector grounding conductors.

Line distribution pairs are generally connected to a cross-connect, which may be either internal or external to the equipment enclosure (DLC cabinet). Refer to GTE Telephone Operations Practice 938-360-010 for additional information.

7.7 Enclosures, continued

When the Cross-Connect Box Is...	Ground OSP Cables to:
Mounted on the pad	The site's MGB.
Inside the perimeter of the ground ring (Lead 1) or within 6 feet (1.8m) from the ring (Lead 1).	Lead 1 preferably at an access hole location.
Not mounted on the pad and is outside the ground ring (more than **6** feet [1.8m]).	Its own ground electrode.

NOTE: The length of the grounding conductor between the cross-connect box and the site's MGB should not exceed 20 feet (6m).

8. OSP Entrance Cable Requirements

8.1 Wall Cable support

The support racking or cable support ironwork (unistrut) used in offices that do not have a cable vault:

- **Is** located inside the structure on an exterior wall at the point where the OSP cable facilities enter the structure.
- Must be connected to the MGB via Lead 16 (see Exhibit 15).

Lead 16 is typically provided by Support Assets when the **MGB** is more than 20 feet (6m) from the cable entrance.

Leads 16A, 17, 17A, and 17B are normally the responsibiiity of OSP Engineering and Construction.

NOTE: Small structures, CEVs, or huts with a large number of entrance cables can be equipped with a CVGB to reduce the number of grounding leads terminating at the MGB. The CVGB is used and installed as described in GTE Telephone Operations Practice 795-805-071.

8.2 Lead Explanations

The following chart describes the leads found in small remote sites for grounding of the entrance cables.

Lead	Explanation
16	A continuous, splice free l/O AWG ground wire lead extending from the MGB to the end of the cable support ironwork. All cable support racking and Lead 17 must be grounded to Lead 16 (see Exhibits 15 and **16).**
16A	A continuous, splice free 1 /0 AWG ground wire lead extending from the CVGB to the opposite end of the cable support ironwork. All cable support racking and Lead 17 must be grounded to Lead 16A (see Exhibits 15 and 16).
17	The continuous #6 AWG ground wire: • Extended vertically between all cable support racks. • Grounded to Lead 16 or 16A. Lead 17 includes the #6 AWG ground wire extending from the splice closure to the vertical Lead 17 and must: • Be free of splices other than those required to make the connection at Lead 17. • Not contain folds or sharp bends. • Be attached to Lead 16 or Lead 16A using a GTE Telephone Operations-approved ground clamp or compression fitting where applicable. **NOTE: Bends in grounding leads must consists of not less than 6 inches [0.15m] (see Section 9.3).**
17A	A continuous #6 AWG ground wire extending from: • A FO closure to the MGB when the FO cable has metallic members or cable shields. • The FO cable shields and metallic members of rack-mounted FO splice shelves. This lead bonds to Lead 17B above the rack.
17B	A #1 AWG grounding wire from the rack-mounted FO splice shelves to the MGB.

NOTE: Each vertical member of the vault cable racking or ironwork should be bonded to Lead 16 or 16A whichever is present.

8.3 Grounding Requirements

All OSP cables containing a metallic shield or strength member must be bonded to the site grounding system as they enter the structure. If there is no tip splice, the cable shield must be bonded to Lead 17 with a #6 AWG ground wire as close as practical to, but not exceeding 50 feet (15m) from, the point of entry.

Smaller offices, typically those with less than 5000 lines, do not have a cable vault but will have a wall frame for the support of the cable entrance facilities. The cables must be bonded to Lead 17 (see Section 8.1).

When one or two cables enter an office, the bond from each splice closure can be run directly to Lead 16. When the third cable is in place, a vertical Lead 17 must be placed and bonded to Lead 16. All cables (new and existing) must be bonded from the tip splice to the vertical Lead 17.

Ail metallic vertical support members of the cable ironwork (unistrut) in a cable vault area must be connected to the MGB via Lead 16. The only exception is when the ironwork is galvanized and unpainted in which case the horizontal member(s) provide the bonding for the vertical members.

Shield continuity must be maintained. The cable shields of tip cables must be bonded to the cable shield of the entrance cable at the main (vault) splice.

8.4 Terminating FO Cables

Metallic members in an OSP optical fiber cable if less than 50 feet (15m) can extend directly to the FO splice shelf.

When the FO splicing shelf is in the switch area and the metallic members have not been grounded in the cable entry area, the cable shield must be isolated from the relay rack frame and the splice itself.

A #6 AWG grounding conductor (Lead 17A) is used to bond the shield to the MGB either:

- Directly (1 shelf only).

  OR
- Through Lead 17B (#1 AWG) when more than one shelf in the rack is anticipated.

NOTE: The cable shield must be isolated from the relay rack frame and the splice itself IN ALL CASES.

8.5 Fire Rating Requirements

NEC Article 800-49 requires that communication wires and cables installed within a structure must be listed as being resistant to the spread of fire. Listing is not required where the cable inside the structure is not more than 50 feet (15m) long.

This is intended to:

- Prevent the spread of fire.
- Minimize the possibility of combustion through the OSP cables or in the cable area.

In structures without fireproof cable entry areas (vaults), the OSP cable (non-firerated) must be transitioned to a rated cable at a point not to exceed 50 feet (15m) from the point of entry into the structure. The cable must be fire-taped from the point of entry to the point of transition.

8.5 Fire Rating Requirements, continued

All points of entry or transit in the structure must be properly sealed to maintain the integrity of the fire walls and fire doors. (Refer to GTE Telephone Operations Practice 742-200-070.)

NOTE: It **is not the intent of this section to imply or endorse a wholesale program to retrofit existing entrance cables that do not:**

- **Have flrerated sheaths.**

  OR

- **Meet the recommendations described in this section.**

9. Grounding Conductor Requirements

9.1 Installation Requirements

All leads must be installed in the most direct and straightforward manner as practical.

9.2 Lead Responsibilities

The functional responsibilities for the provisioning of the grounding conductors are described in GTE Telephone Operations Practice 795-805-071 and shown in the following chart.

If the Organization Is...	It Is Responsible for the Provisioning of...
Support Assets	Walled structures (huts, CEVs, etc.). Refer to GTE Telephone Operations Practice 740-250-070.
OSP Engineering	Pad-mounted and pole-mounted enclosures or cabinets.

Before finalizing the purchase of the land or obtaining the easement, the Administrator - T&P should:

- Make soil resistivity tests.
- Design the ground electrode for the site.
- Approve the location of the site.

9.2 lead Responsibilities, continued

The following sections describe the functional responsibilities for the ground provisioning of the grounding conductors.

9.2.1 Support Assets

Support Assets is responsible for specifying AC grounding leads and other building-related leads. These include the following leads:

- 3 through 16.
- 18 through 22.
- 25 through 28.
- 30.
- 45 and 46
- 60.

Installation of the office grounding electrode system (Leads 1and 2) designed by the Administrator - T&P should be included in the SA work order.

The contractor must be furnished with a list of GTE Standard materials that may be used. SA is also responsible for advance ordering any materials that are not readily available but will be needed by the contractor who will perform the job (e.g., #2 AWG bare tinned solid copper wire, MC #529542).

NOTE: All AC grounding levels must be installed in accordance with the NEC.

9.2.2 Administrator - T&P

The Administrator - T&P (or equivalently trained engineer) is responsible for the design and acceptance of the grounding electrode system which is based on actual soil resistivity measurements. Typically, this will include Leads 1 and 2 for CO buildings, towers, and radio sites. The design is to be documented in an Engineering Directive (see GTE Telephone Operations Practice 830-000-000), a copy of which is to be furnished to SA. The entire process is described in GTE Telephone Operations Practice 740-250-070.

9.2 Lead Responsibilities, continued

9.2.3 Switching and/or Transmission Enaineering

Switching and/or Transmission Engineering (COEE) is responsible for including the grounding leads in their work order based on the requirements **of** this practice and the specific equipment being instatled (see Section 2.1). Typically, these include the following leads:

- 23.
- 23A.
- 29.
- 31.
- 37 through 41A.
- 47.
- 50.
- 53A through 58A.
- 61 and 62.
- 64 and 65.
- 80 through 89.
- Leads for DMS and DCO (see Exhibit 6).

Additional AC leads such as bay lighting, receptacles, and rectifiers must be specified in accordance with the NEC.

9.2.4 OSP Construction

OSPC is responsible for placing the following leads:

- 16A.
- 17.
- 17A.
- 178.
- 24.
- 24A.

9.2.5 COE Construction

COEC is responsible for placing the following leads

- 21c.
- 30*.
- 32 through 36.
- 42 through 44.
- 46*.
- 48 through 49.
- 51 and 52.
- 59.
- 59A.
- 63.

* Bay-/rack-mounted outlets/receptacles only.

9.3 Rules and Constraints

Use the grounding conductors discussed in this document according to the following rules and constraints:

- Keep bends in conductors to a minimum. (Bends for appearance only are prohibited.) A conductor bend should have a large radius.
- The minimum inside bend radius is:
  - 6 inches (0.15m) for conductors up to #6 gauge.
  - 12 inches (0.3m) for conductors #6 to #4/0 gauge.
  - 24 inches (0.6m) for conductors #4/0 gauge and up.

  NOTE: **Bends must be avoided for HE. If unavoidable, use a 36 inch (0.9m) minimum radius.**
- Avoid long runs of ground leads. Most common size leads introduce approximately 0.4 microhenrys of inductance for every foot of length. For a surge peaking at 1000 amperes in 10 microseconds, the inductance of the ground lead will build up a voltage of 40 volts for every foot.
- Use copper base and insulated material to allow continuity testing.
- Run only through nonmetallic sleeves in:
  - Ceilings.
  - Floors.
  - Wails.
- Run:
  - In nonmetallic conduit only.

    OR
  - Without conduit.

  NOTE: **When metallic conduit is already in use or cannot be avoided, bond both ends of the grounding conductor to the conduit.**
- Ground conductors must never:
  - Be encircled with metal clamps.
  - Run through metal wails, metal plates, or short sections of metal conduit or duct. Openings should be greater than 1 square foot (0.1 square meter).
  - Run less than 1foot (0.3m) of separation between surge producers and surge absorbers. Others can be a minimum of 3 inches (0.1 m).
  - Run less than 1foot (0.3m) from the following types of cables:
    - DC power.
    - Switchboard.
    - HF.

  NOTE: **This applies only to Leads 4 through 26, 55, and 56.**
- Multiple conductors with equivalent cross-sectional area can be substituted in place of a single, minimum-sized conductor identified in Exhibit 2.

  NOTE: **This generally provides equal or better protection. Each small conductor must be restricted to the minimum bend radius of the larger single conductor described in this document.**

  This could cause a problem in DLCs, NGDLCs, or ONUS with small ground bars.

9.4 Horizontal Equalizers

HEs are required between temporary or portable structures when these do not share the same AC power services with the permanent structure or CO structure.

The HEs placed between temporary or portable structures must be placed in non-metallic conduit.

If two adjacent structures used to house telecommunications equipment share AC power services, they are to be treated as one structure for the purposes of:

- Grounding.
- Protection.

9.5 Additional Details

See Exhibit 14 for specific ground conductor sizing.

10. Integrated and Single-Point Ground Systems

10.1 Types of Ground Systems

This document describes two type of grounding systems:

- Integrated.
- Isolated (or single-point).

10.2 Integrated Ground System

In the integrated ground system, the grounded positive battery distribution is not isolated; however, the grounded positive battery distribution can be connected in many places (by design or incidentally) to the:

- Structure's ground system.
- Structural steel.
- Concrete floors.
- Electrical conduits.
- Superstructure.

Integrated grounded electronic switching systems and transmission equipment installed after March 1990 use the discharge ground (return ground or plus battery) cable to ground the bays. Equipment shelves and/or frames must be isolated from all other ground sources.

CAUTION: Do not use the following leads in integrated systems:

- **41 through 44.**
- 58.
- 59.
- **41 A.**
- **58A.**
- **59A.**

Isolate DC power busbars in power frames from the:

- Structure.
- Superstructure.
- Equipment frames.

10. Integrated and Single-Point Ground Systems, continued

10.2 Integrated Ground System, continued

Where electronic switches and digital switches are added in the structure where integrated ground planes exist, this procedure will eliminate return currents in basic ground leads, especially in HE leads.

Separate the ironwork between the integrated and isolated (single-point) grounding systems.

Revamping the DC power system might be required to obtain these results.

10.3 Single-Point Ground System

In a SPG (also called isolated ground) system, the positive battery, circuit ground, or discharge ground does not contact other grounds (e.g., superstructure, floor, and frame grounds) except at a single point. This configuration is required for all:

- Digital switches.
- Analog electronic switching systems.
- Transmission equipment frames installed after March 1990.
- Existing transmission frames creating noise or other problems (see Section 3.5).

For additional information on grounding of:

- Transmission related equipment, refer to GTE Telephone Operations Practice 795-805-073.
- Switching related equipment, refer to GTE Telephone Operations Practice 795-805-071.

10.4 Physical Separations

Separate:

- Each electronic system entity from the others.
- All frames with an integrated ground system from electronic isolated ground frames.

NOTE: For further information, refer to GTE Telephone Operations Practice 795-805-071.

10.5 Grounding the Superstructure

Lead 57 is used to bond the cable grid or runway system to the MGB using the following procedure:

- Connect Lead 57 to a centrally located area of the grid or runway system.
- Use a two-hole compression lug to attach Lead 57 to the cable grid or runway system.

For Lead 57 to be effective, all metallic elements of the cable grid or runway system must be bonded together using joining methods that ensure that there is electrical bonding of all the elements.

NOTE: The use of Lead 57 is OPTIONAL and is required only when the switch/equipment manufacturers require the bonding of cable rack sections.

10.6
Six-Foot Rule

Some manufacturers have what is referred to as a "six-foot" (2m) rule that:

- Requires a 6 foot (2m) air space around the equipment that is not part of the IGZ.
- Ensures that the personnel in the area cannot contact surfaces having differences in potentials.
- Requires insulating screen where the 6 foot (2m) separation cannot be obtained.

Within GTE Telephone Operations, the 6 foot (2m) rule applies only where the digital switch is on a different floor level from the DC power plant.

11. DC Power System Grounding

11.1
Isolating the Power Plant Return Busbar

Isolate the power plant return (or positive) busbar from the framework in both single-point and integrated grounding systems.

NOTE: The power frames must be isolated from the floor and the superstructure when they are in a continuous lineup with digital (isolated) equipment.

11.2
Running Power Cable

Run the power cabling (feeder and distribution) to switching systems, transmission systems, and special service with parallel paired conductors of equal gauge.

NOTE: Some switch manufactures cable running procedures allow for the free running of power feeds in their trough areas above the switch.

Tightly lash the parallel conductors together to eliminate stray fields caused by loops. This requirement applies to all DC power cabling (e.g., 24 volt, 130 volt, and -130 volt).

11.3
DC Power Plant Grounding

Lead 37 is used to ground the DC power plant. Lead 37 is run in the most direct manner from the MGB to the positive battery terminal (or junction/splice busbar just above the battery terminal). Size Lead 37 per Exhibit 14.

In multiple string battery plants use the battery terminal electrically nearest the charger.

WARNING: Never use the PDU return bus as a termination point for Lead 37.

11.4 Grounding Frames and Components

Ground the various frames and other component units of a power plant that are not otherwise grounded by electrical continuity to the MGB. These components:

- Include frames in:
  - Power board lineup.
  - Charger bays.
  - Metallic battery stands.
- Are bonded by an individual #6 AWG conductor extended to an aisle run (leads 31 through 36).

Refer to GTE Telephone Operations Practice 795-805-072 for information on modular power boards.

12. AC Service Ground Requirements

12.1 Introduction

This section explains the:

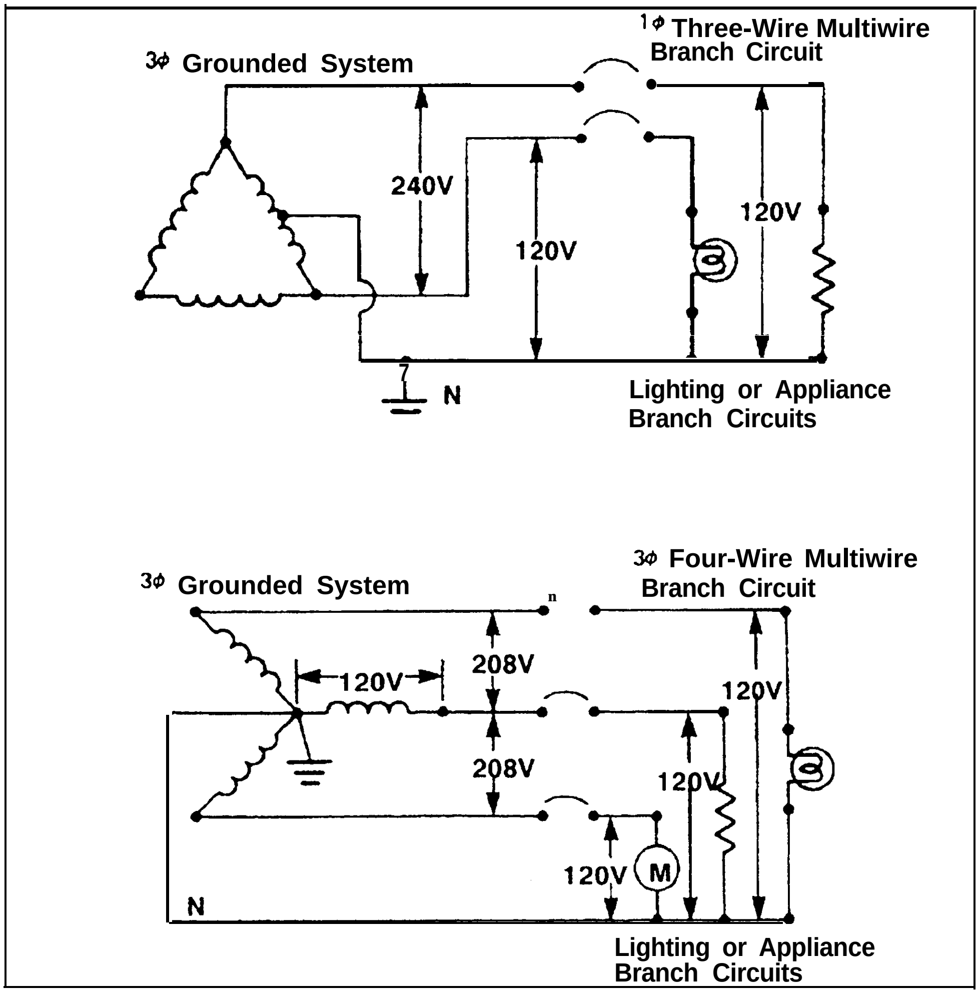
- Grounded circuit conductor as the neutral conductor.
- Conductor connected to the ground electrode as the grounding electrode conductor.

12.2 Grounded AC System Voltage

Grounded AC systems normally provide two or more voltages for telephone COs. In a typical three-phase, four-wire grounded system connected to a 120V/208V wye-wound transformer secondary winding, connecting loads:

- Across the phase legs (line-to-line) create the 208V potential.
- Between one phase ieg and the neutral conductor (line-to-neutral) create the 120V potential.

The following illustration shows how these voltages are obtained.



12.3 Three-Phase Grounded AC Systems

A three-phase grounded wye system uses four wires where:

- Three separate wires connect to each of the three-phase windings.
- One common wire connects to the opposite end of each phase winding of the wye secondary.

The grounded circuit conductor:

- Is called the neutral.
- Is bonded to an earth electrode with a grounding electrode conductor (Lead 4) at the:
  - Transformer (if outside the structure).
  - Service main disconnect.
- Serves as a point of ground reference for AC voltages.
- Carries the current when an unbalanced load exists between phases.

The grounded circuit conductor (neutral) must not connect to a grounded object between the main service disconnect and the load. A connection creates a permanent path in parallel with the neutral through the multiple ground connections and violates the NEC.

NOTE: **Isolate the neutral bus in all downstream branch circuit enclosures (see Section 12.7).**

12.4 Single-Phase Grounded AC Systems

Single-phase grounded systems use a service transformer with a secondary winding. Three conductors extend from the center and two ends of the secondary winding.

The center tap wire is bonded to earth and:

- Serves as the neutral.
- Serves as a point of ground reference for AC voltages.
- Carries the current when an unbalanced load exists between phases.

12.5 Neutral Conductor

me neutral is:

- A grounded, current-carrying circuit conductor.
- Grounded only by terminations on the:
  - Supply transformer.
  - Busbars of the main branch service enclosure

NOTE: The neutral is <u>not</u> the EGC.

A neutral conductor is extended:

- To the alternators of emergency engine (generator) when provided.
- With only those feeder or branch circuits that serve (of partially serve) equipment designed to operate on lower voltages (e.g., 120V line-to-neutral).

CAUTION: Do <u>not</u> ground the neutral conductor to the framework of the alternators.

12.5 Neutral Conductor, continued

Size the neutral conductor using the criteria for the phase conductors of a three-phase system to ensure that there is sufficient current-carrying capacity of:

- Residual currents.
- Fault currents.

The following chart describes the safety information.

Work with the...	Being Careful mat...
Neutral Conductor	The AC current is confined solely to the neutral conductor throughout the premises. When installing AC equipment, do not connect the neutral and the chassis, exposed metal, and metal frames at any point on the load side of the main and adjacent branch circuit enclosures.
Neutral Busbar	Branch circuit enclosures served by feeder circuits from the main service enclosure must have an insulated neutral busbar. Never use the branch circuit enclosure neutral busbar for terminating AC green wire grounding conductors. **NOTE: The neutral busbar can be used to terminate AC groundlng conductors if a branch circuit panel enclosure serves as a main service disconnect panel.**

12.6 AC Service Grounding Electrode Conductor

The AC service grounding electrode conductor must connect the neutral of the AC service distribution system directly to an electrode system prescribed by the NEC (see to Section 5.)

NOTE: Although NEC rules are fulfilled if the AC service neutral is bonded to the grounding system, GTE Telephone Operations requires an AC electrode system that is not bonded directly to the site's ground field except through Lead 13.

The AC service grounding electrode system is separate from the site's electrode ground field. This separation allows for periodic resistance measurements of the electrode ground field with no interruptions to the grounding electrode system.

The AC service neutral and ground electrode system provide a referenced ground for the AC system.

12.6 AC Service Grounding Electrode Conductor, continued

The grounding electrode conductor (Leads 4 and 8):

- Is made of insulated copper (solid or stranded).
- Has wire sized according to NEC Article 250-94.
- Is run with no sharp bends, and as few bends as possible.
- Is surface-supported and easy to see, helping with inspection.
- Is continuous without splices.

NOTE: The NEC allows splices with either:

- **Exothermic welding.**

  OR

- **Listed irreversible compression-type connectors.**

The number of splices must be held to a minimum.

The following chart describes the procedure used when running a grounding electrode conductor.

Step	Action
1	Run the conductor through rigid nonmetallic conduit. **NOTE: Use nonmetallic sleeves when the conductor is run through walls or partitions.**
2	Mount the conduit using nonmetallic clamps.

Do not run the conductor through:

- Metallic conduit.
- Metal that forms a ring.

If routing through metal is unavoidable, use conduit bonding-type locknuts to solidly bond the conductor to:

- Any enclosing ring.
- Each end of the metallic conduit.

12.7 AC Service Ground System

Bond the grounding electrode conductor to the frame of the enclosure of the main service disconnect, Make this bond at the point of connection to the neutral (only in the main AC service panel).

In a typical installation, the main service disconnect panel:

- Mounts the service disconnecting switches or breakers (house service board).
- Has the ground bus mounted, bonded, or bolted in electrical contact with the enclosure metal
- Terminate both the neutral (white) conductors and the AC equipment ground (green) conductors. These conductors run in distribution circuit conduit or raceways.

12.7
AC **Service Ground System, continued**

In the event of a line-to-line or line-to-neutral fault in a secondary service network, a low-impedance circuit:

- Exists though shorted AC service conductors.
- Ensures that there is a quick clearing of the circuit.
- Allows a heavy current surge through the load circuit breakers.

A line-to-ground fault dumps current into the AC equipment ground system. The current does not follow a direct path back to the source without a direct bond between equipment ground conductors and the neutral.

The ground conductors carry the fault current directly to the neutral and back to the load circuit breakers by transformer windings and phase leg conductors.

12.7.1 Main Panel

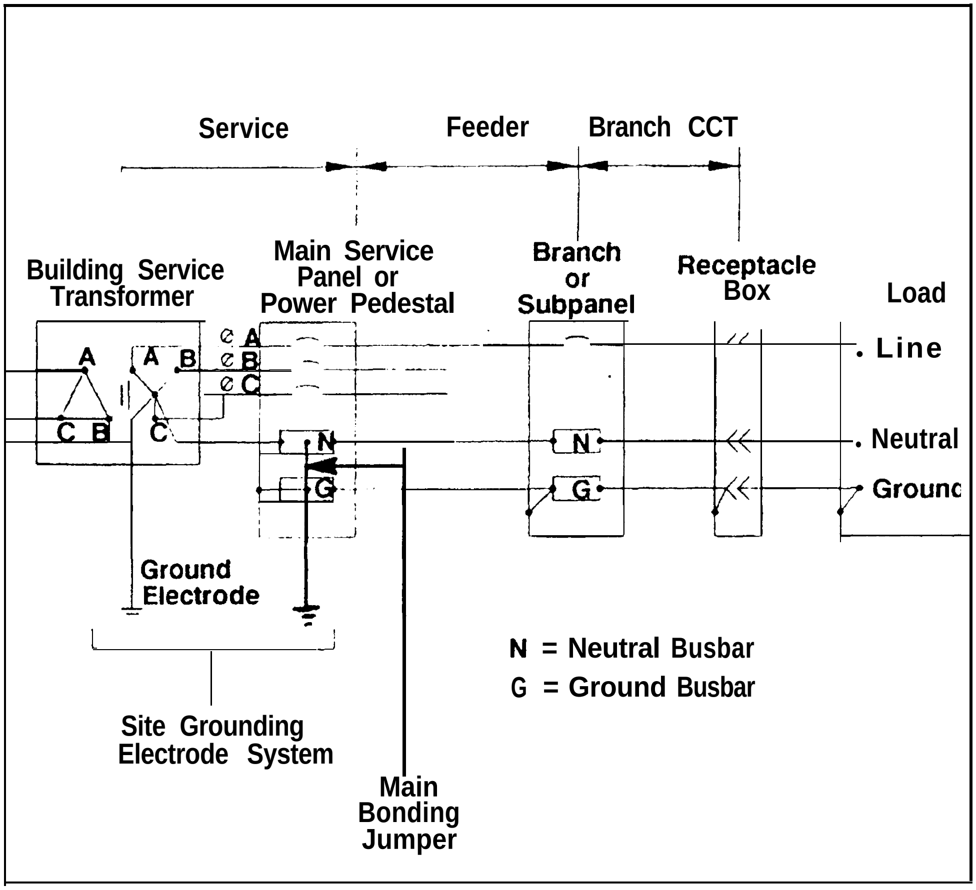
The main service disconnect panel will have a neutral busbar (N) that can be insulated from the enclosure. Most main panels also have a ground busbar (G) which is bonded or connected to the enclosure. The safety grounds or “green wire” grounds (EGC) terminate at the G busbar. The NEC requires that both busbars (N and G) be connected through the main bonding jumper. The NEC allows the use of a green screw in the N busbar to terminate the EGC (refer to NEC Article 250-79).

12.7 AC Service Ground System, continued

12.7.2 Branch Panels

Branch panels will have a neutral busbar (N) that is isolated from the enclosure while the ground busbar (G) is bonded or connected to the enclosure. See the following illustration. Some branch panels can also have a dedicated, isolated ground busbar feeding the isolated (orange) outlets.

NOTE: **There must not be any connections between the different busbars in the branch panels.**



13. AC Power Service Requirements

13.1 Introduction

Always solidly ground the AC service distribution system for communications networks. A solidly grounded system has a low impedance bond in the AC secondary network that extends from one or more of the AC service conductors directly to a ground electrode.

Bonding the AC service by Lead 13 (see Exhibit 2) to the MGB satisfies the NEC; however, GTE Telephone Operations requires a separate grounding electrode. The separate electrode is essential because of:

- Communications ground system changes.
- Periodic testing.

NOTE: Do not bond the AC service disconnect neutral by a direct path (other than Lead 13) to the communications ground field or system.

system:

- Uses a service transformer with a wye-connected secondary.
- Provides three-phase grounded AC service.

In new installations or upgrades where the AC service system transformer(s) uses a delta-connected secondary, establish a grounded conductor by grounding one phase of the transformer or the center tap of one phase, depending upon the secondary service voltage required.

NOTE: In small installations, use a single-phase grounded system for the secondary system.

13.2 GTE Telephone Operations' Responsibility

GTE Telephone Operations must inspect and accept all AC electrical installations to ensure that the requirements of this practice are met. GTE Telephone Operations is responsible for having a certified electrician install and connect all AC service distribution systems to comply with:

- The NEC.
- Local electrical codes.
- This practice.

NOTE: Usually the department that arranges for the site is responsible for the electrical installation.

13.3 Grounding Commercial Electric Power Service

GTE Telephone Operations' electrical contractor must provide the ground connections of the commercial electric power service. The commercial electric power service must be grounded in accordance with the specifications of this practice and GTE Telephone Operations Practice 795-805-072.

13.4 Service Disconnect Location

The following sections describe where the AC service disconnect is located.

13.4.1 Small Structures

In small structures and huts the AC service disconnect must be mounted on the side of the structure. The basic requirements of GTE Telephone Operations Practices 795-805-072 and 740-500-070 apply (see Exhibit 17).

13.4.2 Enclosures and CEVs

For enclosures and CEVs the AC service disconnect is located at the power pedestal (refer to GTE Telephone Operations Practice 938-360-012). The power pedestal can be located on or away from the enclosure pad.

For small DLCs the power pedestat can be pole-mounted (see Exhibit 1).

NOTE: When using a power pedestal, the AC panel in the enclosure or CEV must be treated as a branch panel to avoid violations of the NEC. Disconnect the main bonding jumper in the enclosure or CEV.

The local electrical contractor and the Administrator - T&P wilt verify that the installation does not violate:

- The NEC.

  OR
- Local electrical codes.

The size of the breakers (the ones in the power pedestal and in the enclosure/CEV) must be coordinated.

13.5 Ensuring Adequate Ground Fault Return Path

To ensure that there is an adequate ground fault return path, provide a green wire grounding conductor. Enclose this conductor in the metallic raceway or conduit with the phase conductors for all branch circuits serving telephone equipment areas and DC power plants.

NOTE: For minimum grounding conductor (green wire) size requirements, see Exhibit 18.

Secure the green wire to the:

- Main and branch service enclosure ground bus.
- Equipment enclosure or frame at the apparatus being served by the AC supply.

Equipment green wire grounding conductors must be:

- Insulated.
- Sized to safely carry the fault current (per NEC).

13.6 Grounding Conductors

AC power and equtpment grounding conductors must be at least as large as required by:

- This practice.
- Local structural codes.
- NEC (refer to GTE Telephone Operations Practice 795805072)

See Exhibit 14 for recommended sizes of conductors.

13.7 Grounding Fixtures

Only NRTL listed fixtures should be used. The following describes how these fixtures must be grounded:

- Provide a path for fault currents with the green wire grounding conductor.
- Attach the AC power wiring conduit or raceway to service and equipment enclosures.

13.8 Bonding leads 20

Bond a #6 gauge Lead 20 from each AC branch or subpanel framework (not neutral) serving battery chargers, lighting, and receptacles in telephone equipment areas to the MGB/FGB on the same floor.

13.9 AC Conduits

AC conduits must be nonmetallic just before contacting electronic frames (and within electronic frames) to prevent defeating electronic frame ground isoiation. AC branch circuits serving electronic systems must not extend outside the electronic system to serve other AC-operated equipment.

Refer to GTE Telephone Operations Practice 795-805-072 for required treatment of AC conduits serving electronic systems.

13.10 Other AC-Powered Equipment Mounted in Frames

In special cases, AC-powered equipment (other than test equipment) can be mounted within the electronic switching equipment frames. In these cases, provide a separate green wire (Lead 30) and separate AC service conductors, using only nonmetallic hardware (conduit, box, cover). Mount the receptacle above the kick plate area.

13.11 Integrated Grounding Frames

Serve integrated grounded frames with nonisolated (brown) AC-grounded outlets on separate branch circuits from those serving the electronic frames.

13.12 Lead Explanation

GTE Telephone Operations identifies all grounding leads by number. The master list is in GTE Telephone Operations Practice 795-805-071. The following chart describes the leads related to AC service grounding.

Lead	Explanation
20	Connects the ground bus (not the neutral bus) in each AC branch panel enclosure serving battery chargers, lighting, and receptacles in telephone equipment areas to the FGB/MGB located on the same floor as the branch panel. Per NEC Article 312 this lead is a #6 AWG copper conductor with: • Green insulation. **OR** • Marked with green tape at each end and other enclosures it passes through.

(continued)

13.72 Lead Explanation, continued

<table>
<tr><th>Lead</th><th>Explanation</th></tr>
<tr><td>20A</td><td>Connects secondary of a separately derived source (transformer neutral) to the nearest ground bar (MGB/FGB). Used on separately derived systems such as step-down transformers. Required by NEC Article 250-26 and sized per NEC Table 250-94 (but not smaller than #6 AWG).</td></tr>
<tr><td>29</td><td>Connects the ground bus (not the neutral bus) in an AC branch panel enclosure to the frame of battery charger/rectifier. This lead is:
• Sized per NEC Table 250-95.
• Terminated at the appropriate ground terminal/lug inside the charger or rectifier.
NOTE: See GTE Telephone Operations Practice 795-805-072 for specific information.</td></tr>
<tr><td>30</td><td>Connects the ground bus (not the neutral bus) in an AC branch panel enclosure to the nonisolated (brown) AC outlets. This lead is sized per NEC Table 250-95.
NOTE: See GTE Telephone Operations Practice 795-805-072 for applications of brown outlets in COs.</td></tr>
<tr><td>45</td><td>Connects the AC power neutral bus in the main disconnect switch, via intermediate panels, to the isolated ground bus (not neutral or ground) of an AC branch circuit enclosure serving the isolated ground (orange) outlets. This lead is sized per NEC Table 250-95 but no less than #6 AWG .
Perform one of the following procedures:
• Use a green wire with a yellow tracer.
• Mark the lead with yellow tape or tag at each AC enclosure.
NOTE: Lead 45 is isolated in:
• All intermediate panels.
• The final enclosure.</td></tr>
<tr><td>46</td><td>Connects to Lead 45 at the isolated bus in a branch panel and feeds the dedicated (orange) AC outlets green wire ground. This lead is a green insulated conductor with a yellow tracer or marked with yellow tape. This lead is the green wire ground of a given 120 Vac circuit, originating at a branch panel isolated (orange) ground bus serving the isolated grounded outlets (orange in color).
This lead is sized per NEC Table 250-95 but no less than #6 AWG.</td></tr>
</table>

13.13 Surge Arrester Locations

GTE Telephone Operations will provide surge arresters on the load side of the distribution center. Locate arresters next to the:

- AC main service disconnect cabinet.
- Junction box of branch circuits leaving the structure.
- Junction box on the tower leg where the conduit makes its transition into the structure.

Optionally, surge arresters can be placed on the load side of the emergency generator transfer switch for generator produced surges.

13.13.1 Small Structures

In small structures and huts the AC surge arrester must be mounted as close as possible to the AC service disconnect. The basic requirements of GTE Telephone Operations Practices 795-805-072 and 740-500-070 apply (see Exhibit 17).

GTE Telephone Operations standard surge arresters are described in PSBs 2725 and 2725.3.

13.13.2 Enctosures and CEVs

For enclosures and CEVs the AC surge arrester is located in the power pedestal (refer to GTE Telephone Operations Practice 938-360-012).

Auxiliary power sources supply on-site generated power to selected loads either:

- Manually.

  OR
- Automatically.

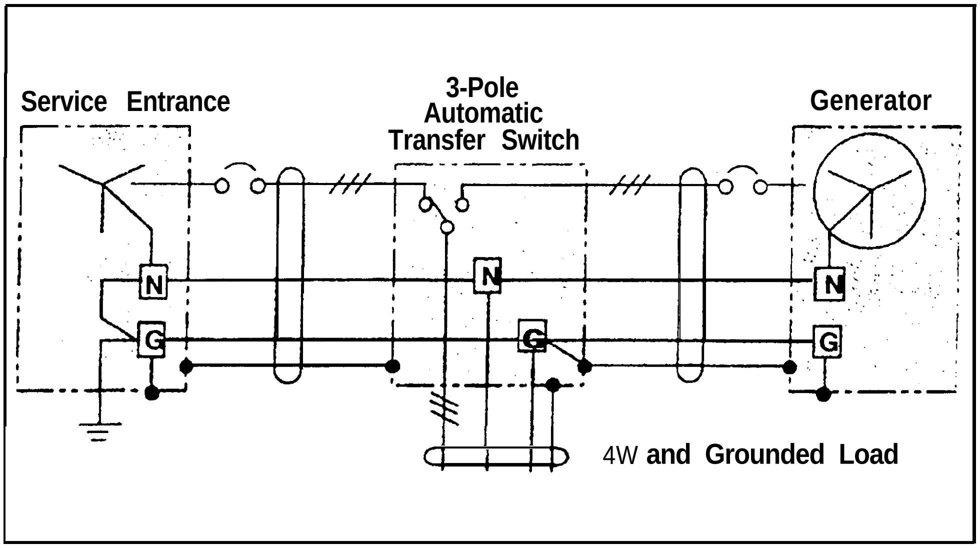
Emergency generators:

- Are devices used as auxiliary sources of electric power to provide electricity during cases of commercial AC power failure.
- Must be treated as non-separately derived sources.

13.13 Surge Arrester Locations, continued

13.13.2 Enclosures and CEVs. continued

must be continuous and solidly interconnected to the power service neutral. This is accomplished using three-pole transfer switches as shown in the following illustration.



Small structures and huts have generator plugs provided (refer to GTE Telephone Operations Practice 740-500-070). Power pedestals are equipped with generator plugs.

14. Transmission Systems

14.1 Application

Transmission system frames engineered after March 1, 1990 must be powered and grounded by the isolated SPG system.

Existing integrated grounded transmission frames engineered before March 1,1990 can remain and additional equipment can be added to those frames.

Equipment mounted/installed after that date must be isolated from all ground sources.

Whenever integrated frames cause an operational equipment problem, the integrated transmission equipment must be retrofitted to an SPG system.

Refer to GTE Telephone Operations Practices 795-805-071 and 795-805-073 for additional information on transmission equipment grounding.

14.2 Isolating HF Protectors

Use approved insulators to isolate the connector block mounting bar for carrier HF protectors:

- In transmission equipment frames.
- From the equipment frame.

This isolation prevents fault currents from damaging transmission system equipment (see Exhibit 19.)

NOTE: There are no isolation requirements for HF protector blocks in equipment enclosures.

14.3 Fiber Optic Cables

When the fiber optic splicing shelf is in the switch area, isolate the cable shield from the:

- Relay rack frame.
- Splice shelf.

A #6 AWG grounding conductor (Lead 17A) is used to bond the cable shield to the MGB (see Exhibit 20).

NOTE: There are no isolation requirements for fiber optic cables in equipment enclosures.

15. Radio System Grounding

15.1 Common Bonding

Remote sites containing radio towers are generally more susceptible to lightning than remote sites without towers. Common bonding between metal objects and separate electrode systems will:

- Prevent arcing.
- Reduce dangerous potential differences.

Use an exothermic weld to make ail ground connections.

Refer to GTE Telephone Operations Practices 795-805-071 and 887-030-085 for additional information and guidelines.

16. Lightning Protection System

16.1 Application

The decision on whether or not to provide an LPS should be based on the Risk Assessment Guidelines described in GTE Telephone Operations Practice 887-795-070. All LPS systems must be Installed per NFPA 780.

17. Job Completion Procedures

17.1 Warning Tags

Warning tags should be attached to water pipes at a point where the grounding conductor is connected to the pipe at:

- The bond around the water meter.
- Other junctures.

The tags should warn against removing the connection or bonds without first notifying GTE Telephone Operations (refer to PSB 0131).

17.2 Identification Tags

Affix identification tags or labels with nonmetallic strips to each lead attached to the MGB or FGB. These tags should indicate the ground system lead number. The description is optional.

17.3 Reports

This information is needed for comparing ground resistance measurements which must be made annually. See GTE Telephone Operations Practices 795-805-074 and 887-600-072.

Complete the form as described in GTE Telephone Operations Practice 795-805-074. The inspection must be performed:

- On every new installation.
- When any upgrade, addition, or change occurs to the grounding system.

17.4 Site Inspections

Refer to GTE Telephone Operations Practice 795-805-074 for site grounding inspection guidelines.

To document site grounding conditions, use Form 90001528, Inspection -- Central Office Grounding and Electrical Protection:

- Before switching system replacement.
- Before equipment additions.
- Whenever noise or protection problems are suspected.

The form can be obtained from the local stationery-storeroom. Order through regular supply channels.

These inspections wilt help identify deviations from:

- This practice.
- The following GTE Telephone Operations Practices:
  - 795-805-071.
  - 795-805-072.
  - 795-805-073.
  - 795-805-076.
  - 795-805-077.
  - 795-805-078.
  - 887-030-085.
  - 887-030-087.

18. Material Requirements

18.1 Approved Materials

Only GTE Telephone Operations-approved materials should be used for the following:

- Telephone switching systems.
- Structure grounding.
- Protection.
- DLCs.
- HDTs.
- RDTs.

18.2 Listed Materials

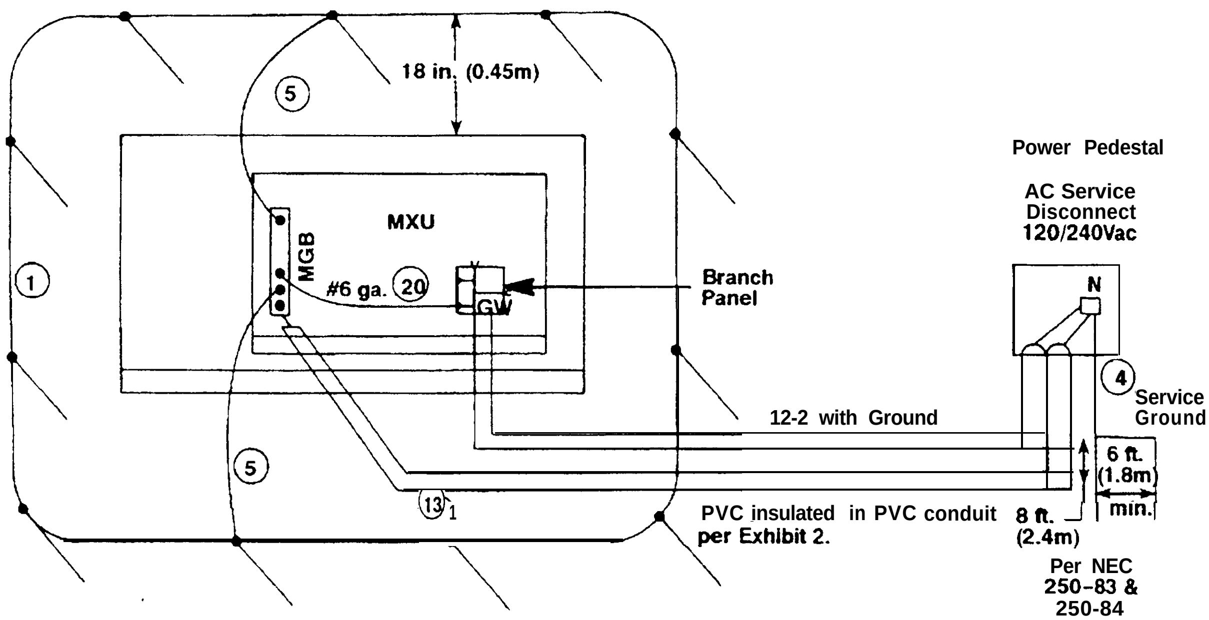
All materials for bonding, grounding, and AC power must be listed for the purpose as required by the NEC.

18.3 Substitutions

All material that is not GTE Telephone Operations standard must be approved via the deviation process. Refer to GTE Telephone Operations Practice 887-000-001.

CAUTION: Substituting untinned bare copper conductors for SBTC wire that must be direct buried (such as Lead 1 and Lead 5) will increase the corrosion of these leads.

Pad-Mounted
Standard AC and Grounding



Each of two Lead 5's and continuous ring Lead 1 must be #2 ga. bare tinned copper wire. Each connection must be made using the exothermic welding process. Ground ring must be a minimum of 30 in. (0.75m) deep and below the frost line.

Note: Power company can provide AC power with separate meter pole which might have a disconnect switch and a ground electrode.

Exhibit 1 – Pad-Mounted Standard AC and Grounding

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

Note 1: Not applicable to pole-mounted enclosures.

Note 2: Multiple runs of #2 AWG can be replaced by single runs of the electrically equivalent gauge.

Exhibit 2 - Minimum Sizing of Leads 5, 7, 9, 10, and 13 (Based on Conductor[s] Size of a Single Phase, Entering the Main Service Disconnect Panel)

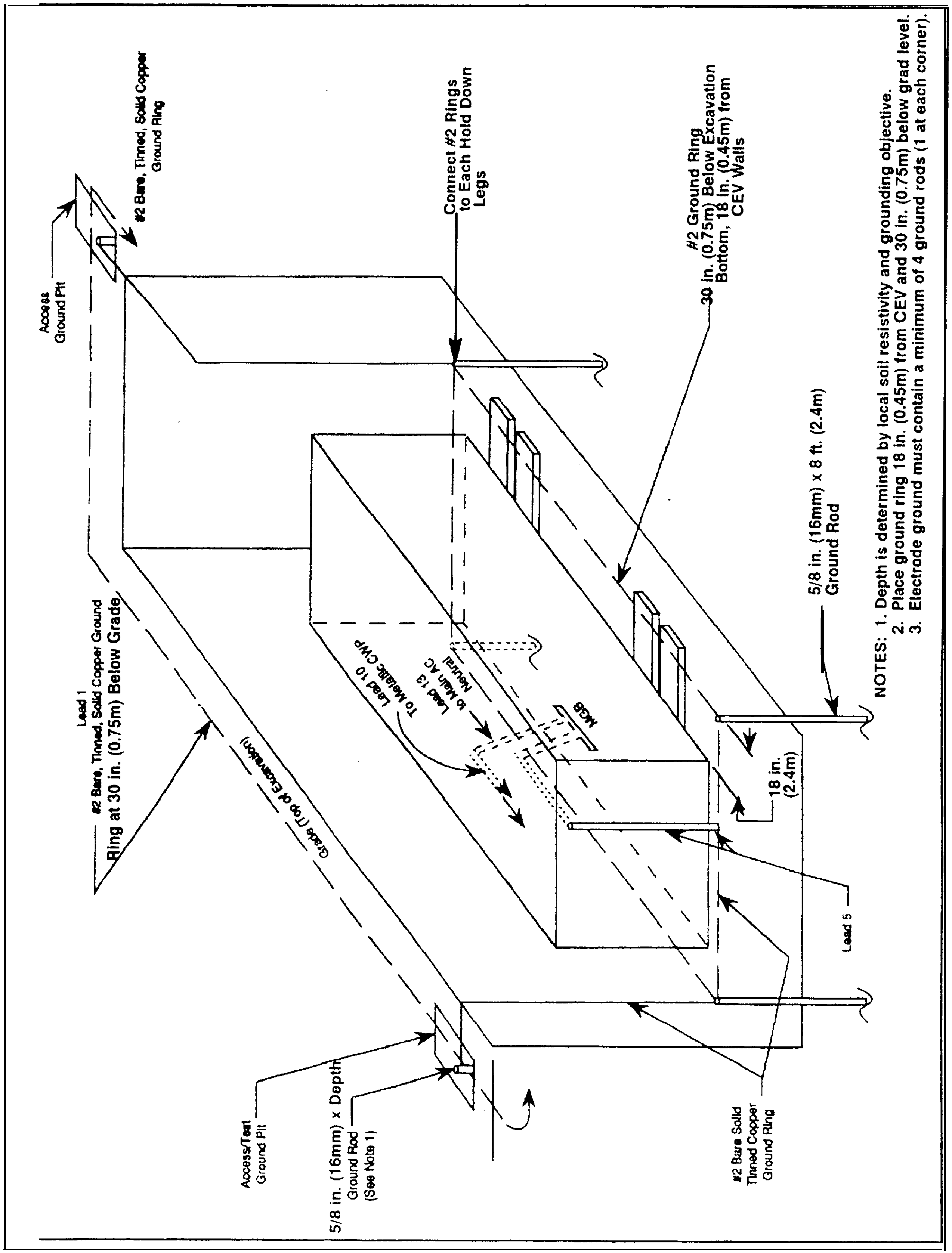


Exhibit 3 - Cutaway View of a Single CEV Grounding System

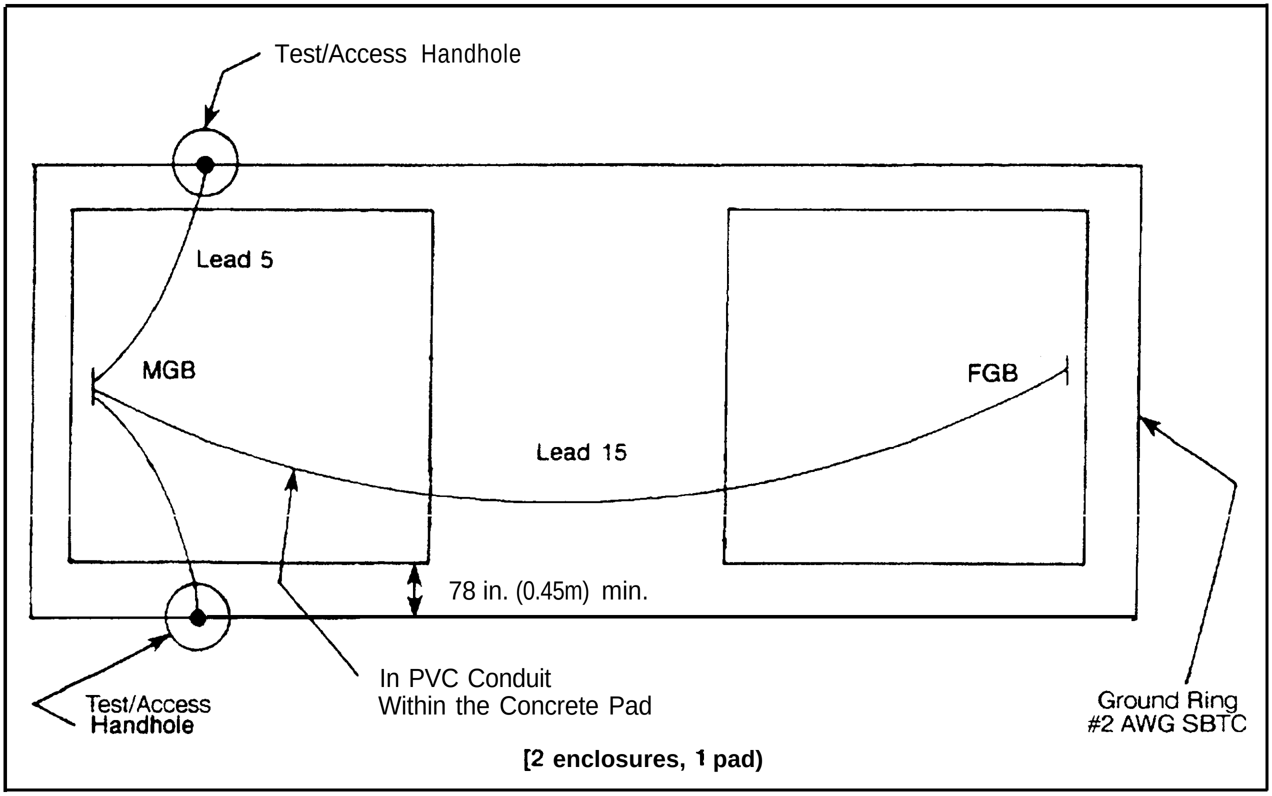


Exhibit 4 - Multiple Pad Mounts at One Site

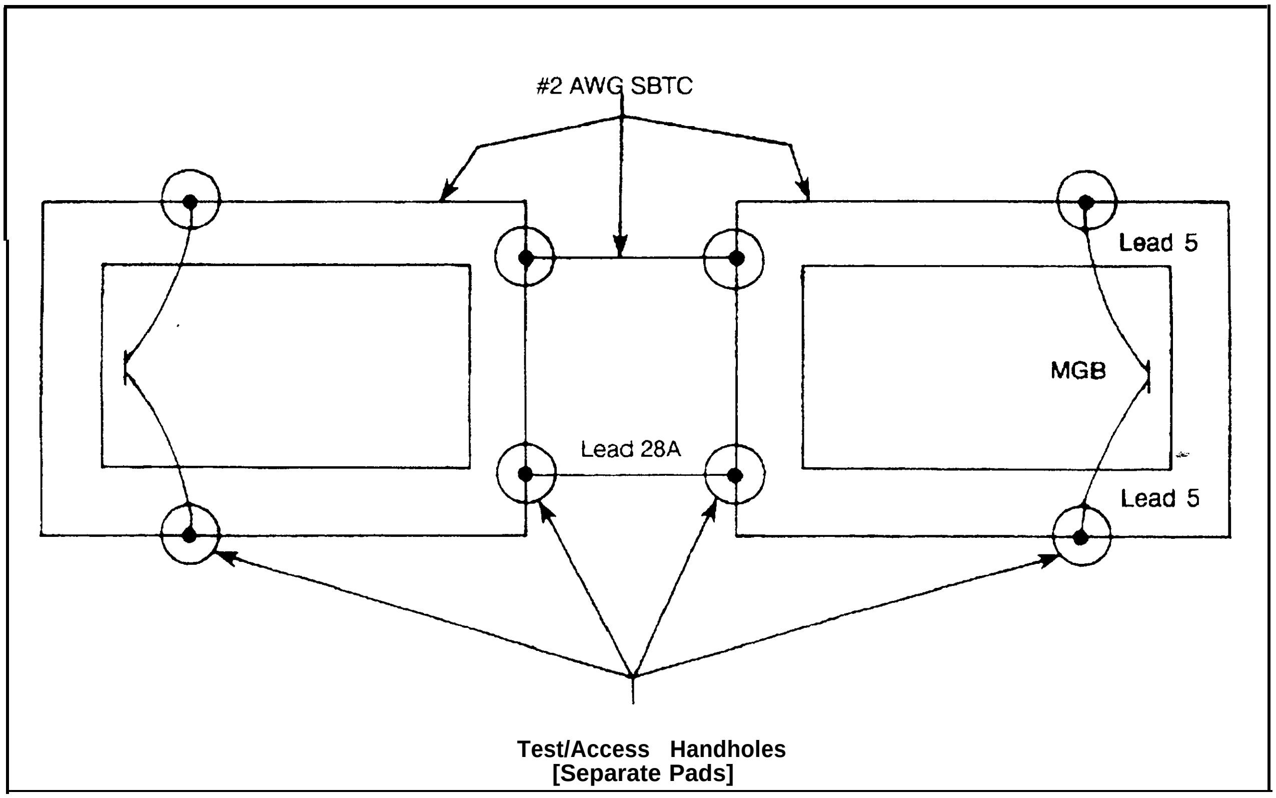


Exhibit 5 - Multiple Pad Mounts Placed at Different Times or Engineered for Future Unit

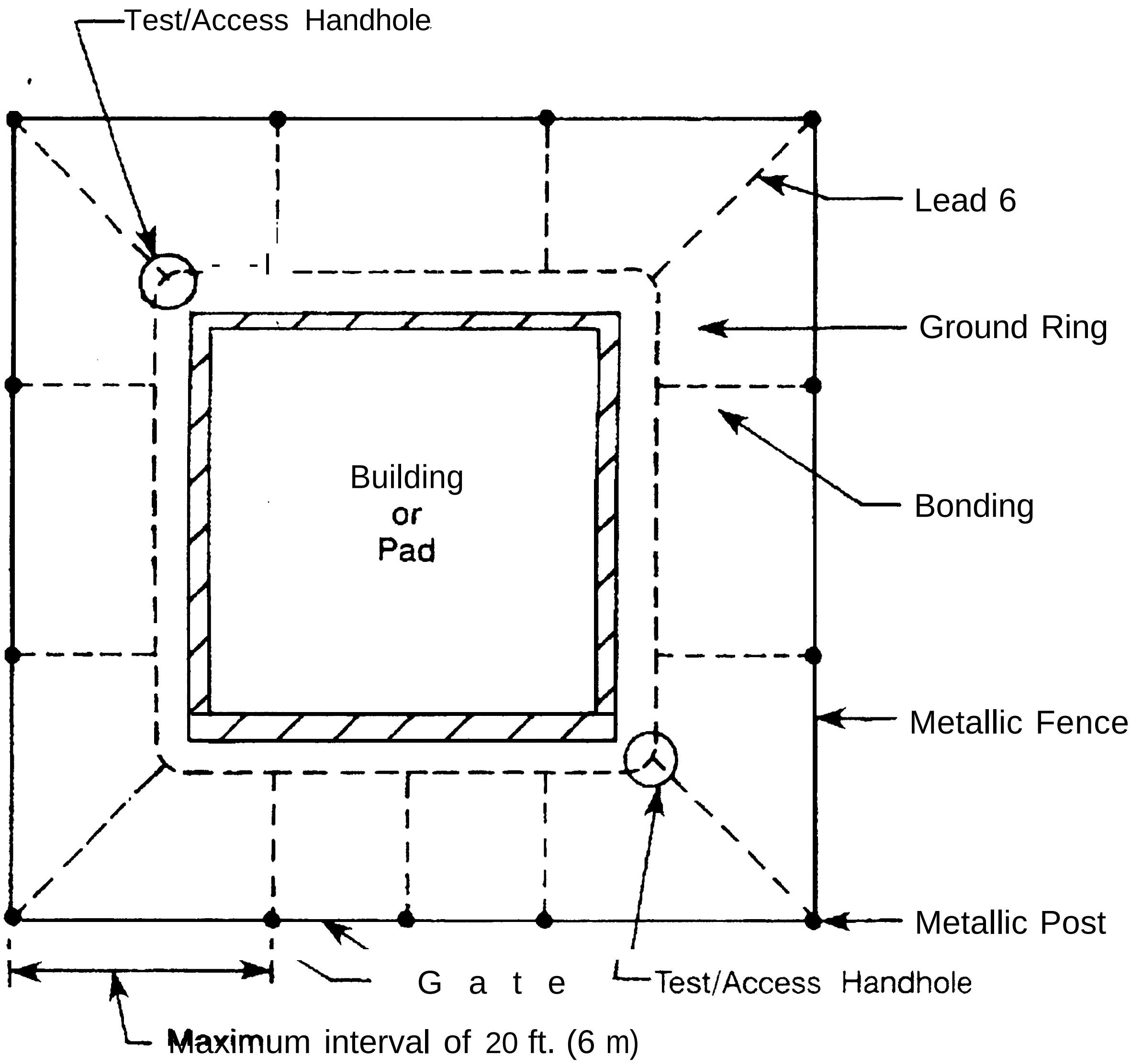


Exhibit 6 - Metallic Fence with All Sections Within 6 Feet (1.8m) of Ground Ring

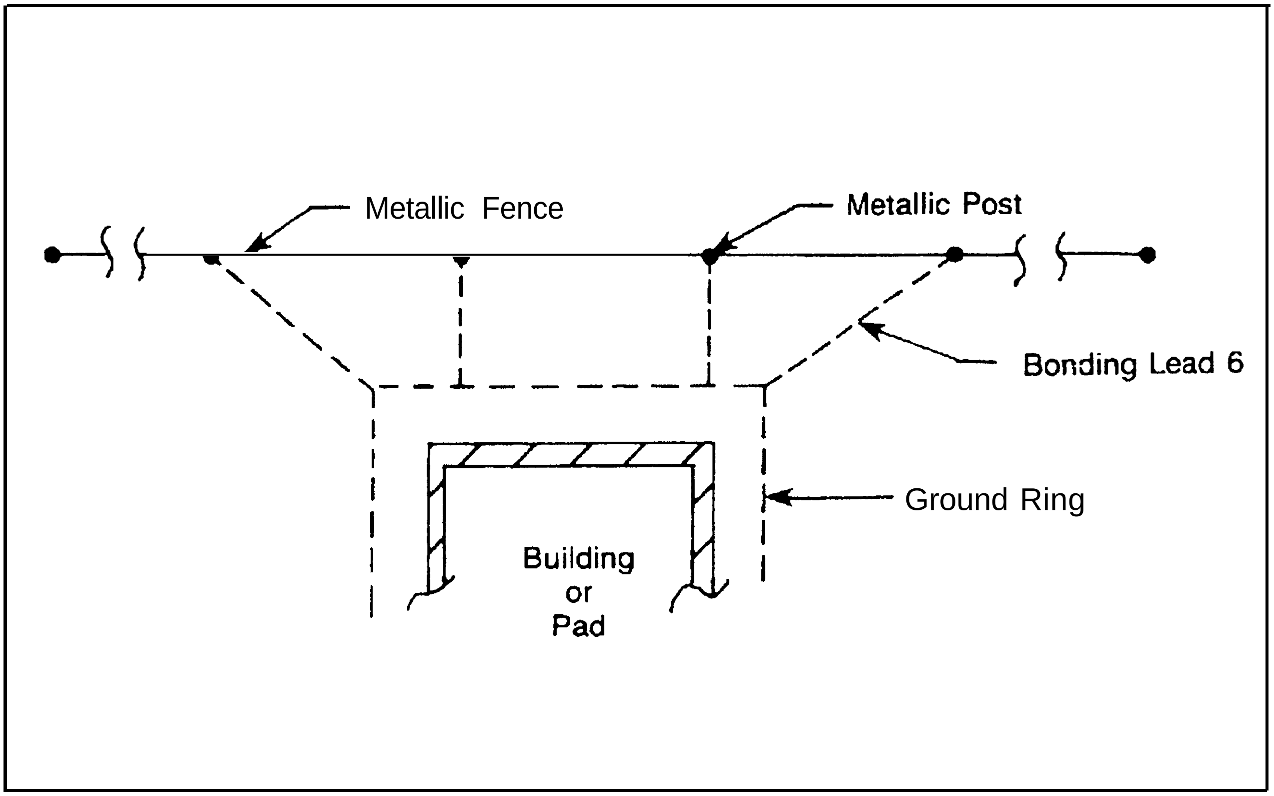


Exhibit 7 – Metallic Fence with Three Sections Within 6 Feet (1.8m) of Ground Ring

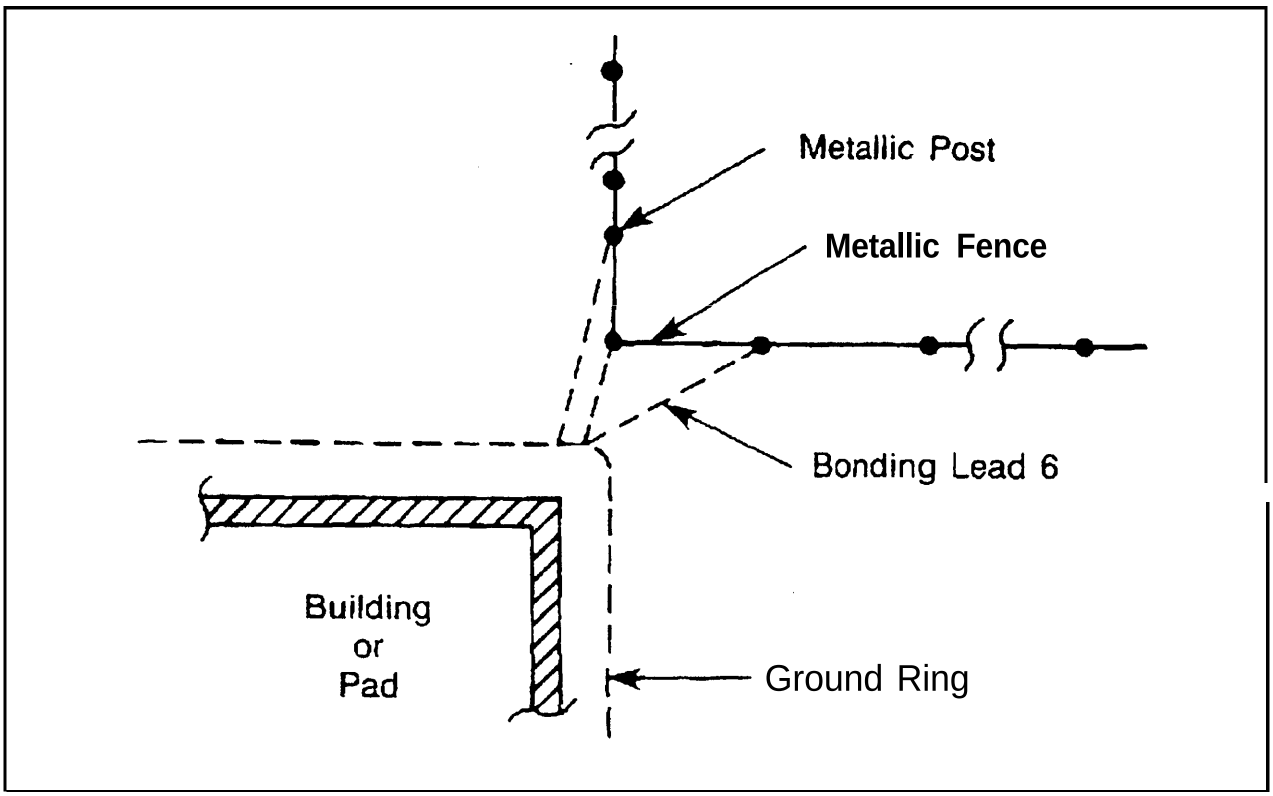
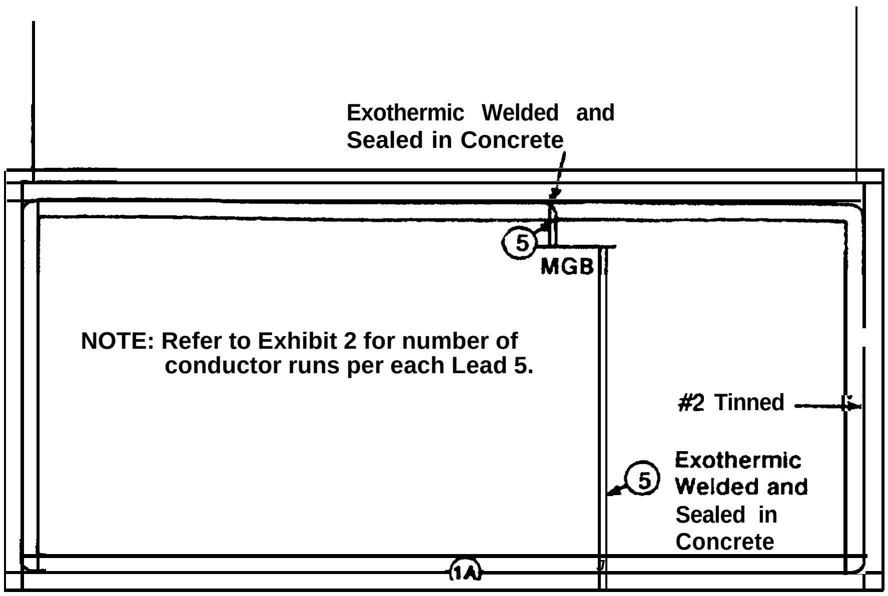
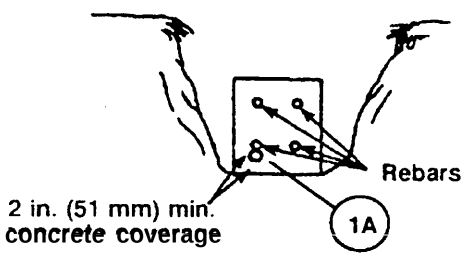


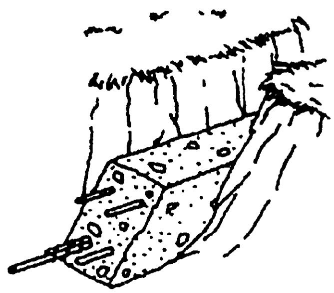
Exhibit 8 - Metallic Fence with Corner Post Within 6 Feet (1.8m) of Ground Ring



TOP VIEW



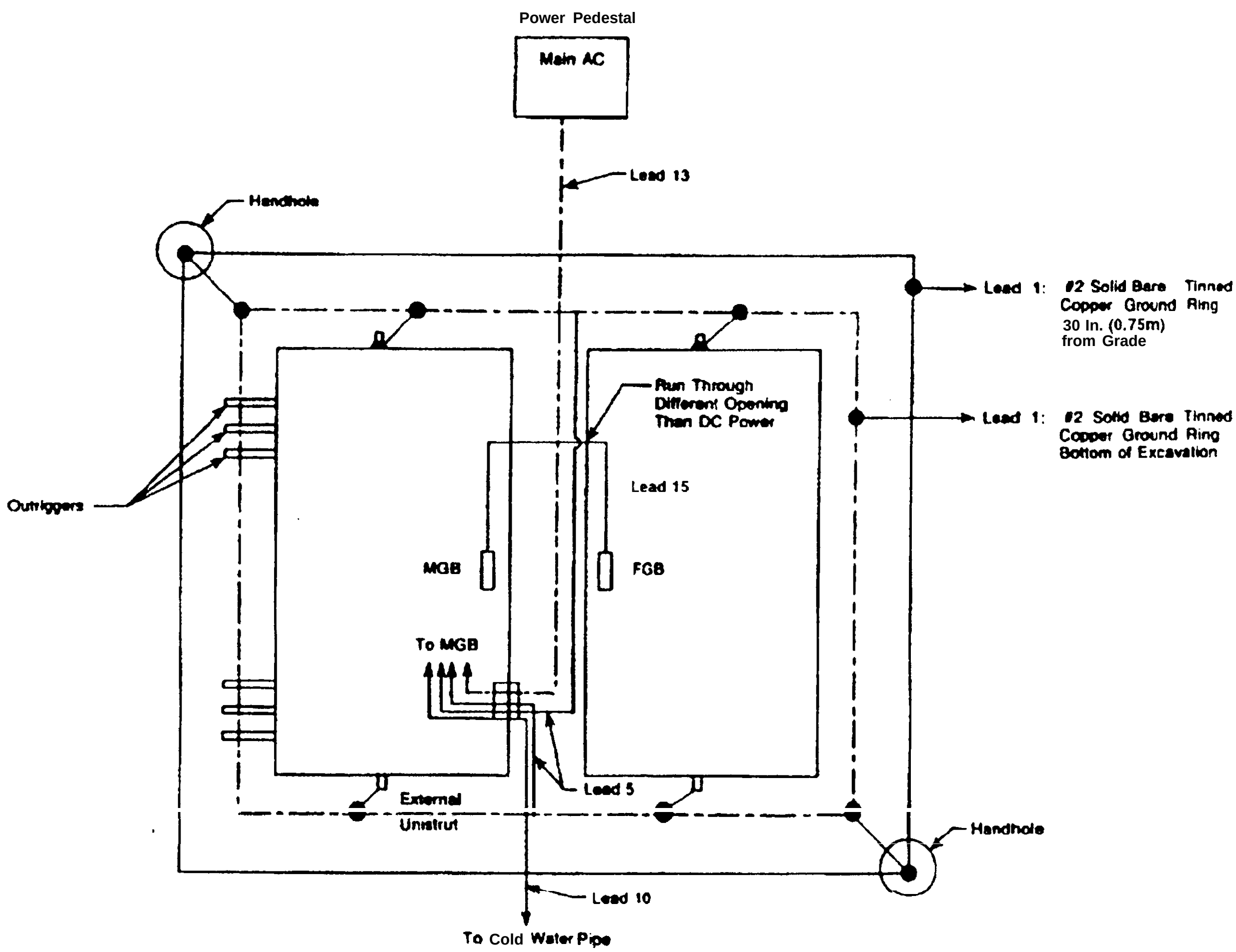
FRONT VIEW



SIDE VIEW

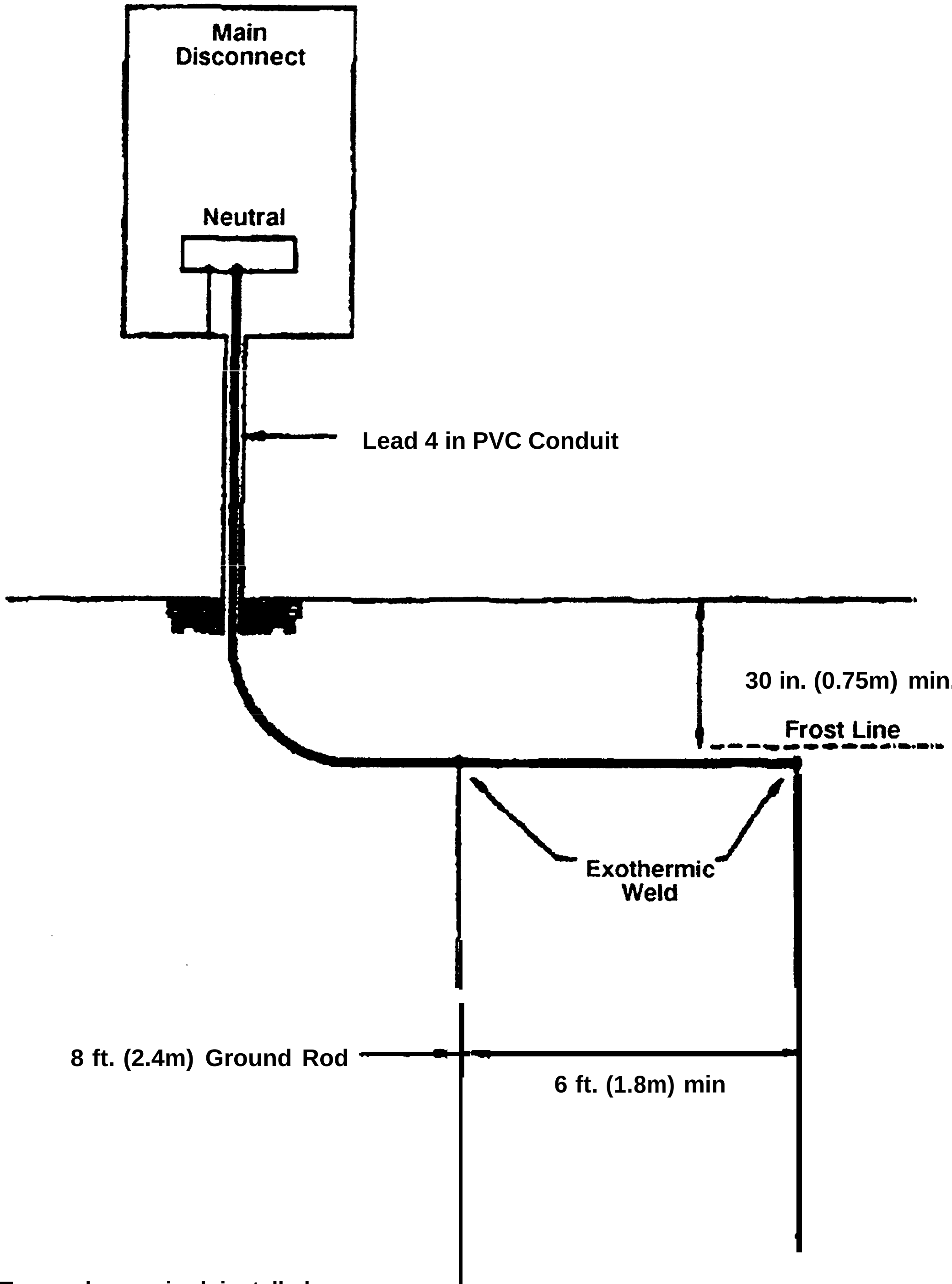
Make deliberate bonds to rebar.
See NEC Article 250-81-b.

Exhibit 9 – Concrete-Encased Electrode



NOTES:
- Bond internal Unistruts (EV racks) together by a 2/0 THW cable originated from the MGB (internal equalizer bond).
- Gmund DC power frames to the MGB per GTE Telephone Operations Practice 795-805-071.
- See also Exhibit 3.

Exhibit 10 - Dual CEVs Grounding System



NOTE: Two rods required installed per NEC Article 250-83 (C) (2) and (3) to meet requirement of NEC Article 250-84.

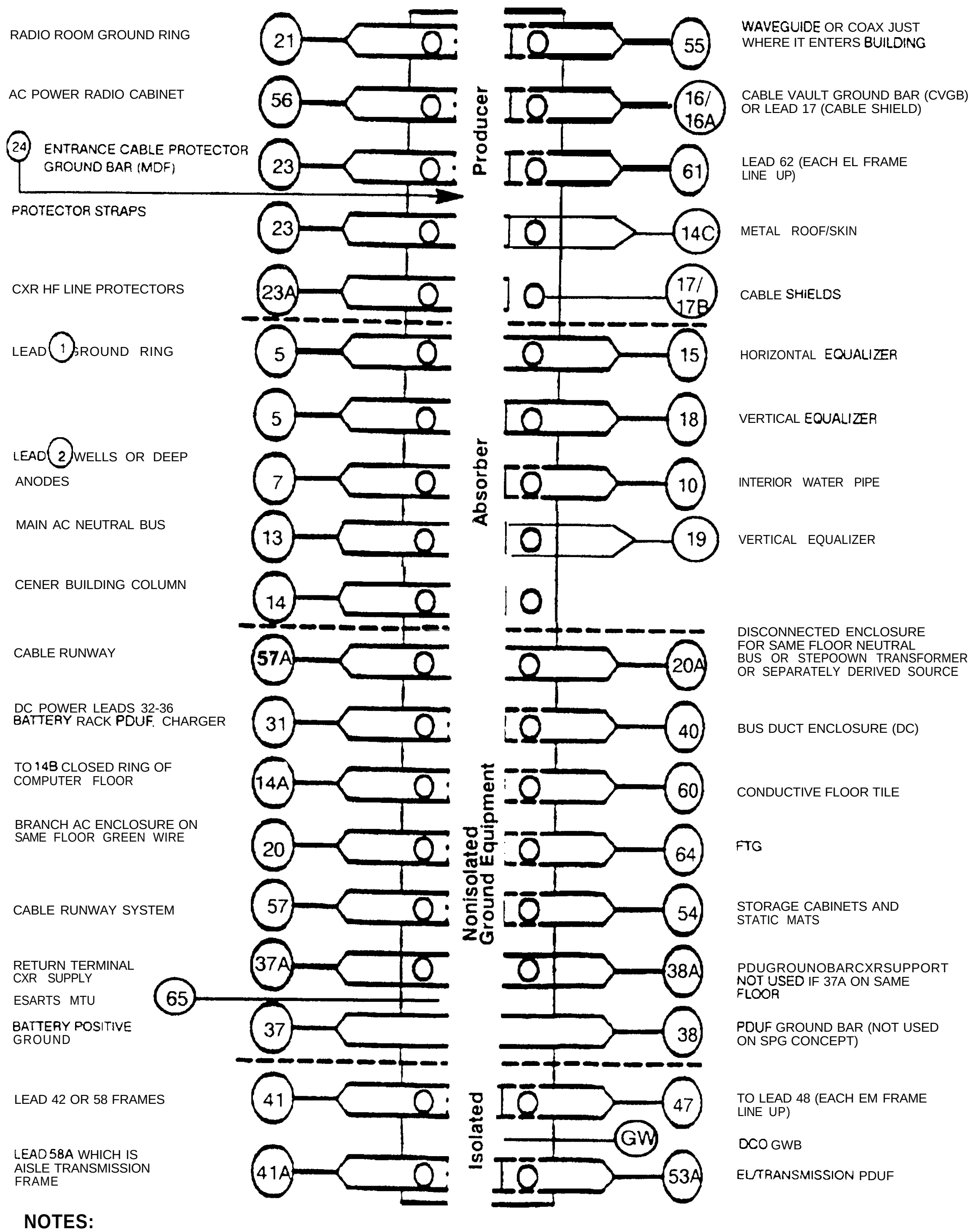
Exhibit 11 - Lead 4 Typical AC Service Ground

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

Where there are no service-entrance conductors, 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) and 250-23(b).

Exhibit 12 - Leads 4 and 8 Grounding Electrode Conductor for AC Systems



NOTES:

1. **This drawing is not intended to specify lead direction or lead sequence.**
2. **The zone sequence must remain as shown (P-A-N-I); however, a mirror image can be used.**
3. **Standoff insulators must be provided when zoning the bar.**
4. **Zone size can vary depending on the installation.**

Exhibit 13 – Ground Bar Zoning

Item No.	By	From	To	AWG	Notes
1	T&P SA OSPE	Grd ring (w/ rods) external electrode	----	2	SBTC
1A	T&P SA OSPE	Grd ring concrete-encased electrode	----	2	SBTC
2	T&P SA OSPE	Wells or deep anodes	----	- -	Steel pipe or duriron anodes
3	SA OSPE	Lead 1/ MGB	Each bldg column	2	SBTC. See Section 4.9 for required access points.
4	SA OSPE	Main AC enclosure neutral bus	Grounding electrode. Refer to GTE Telephone Operations 795-805-072	Exhibit 12	See Section 13.3 and GTE Telephone Operations Practice 795-805-072.
5	SA OSPE	Lead 1 Min. 2 Lead 5 opposite sides	MGB	Exhibit 2	SBTC. See Section 4.5.
6	SA OSPE	Lead 1	Metallic fence	2	Metallic fence/post or other metallic objects
7	SA T&P	Each Lead 2	MGB	Exhibit 2	SBTC
8	SA	Main AC enclosure neutral bus	Interior of water meter. Refer to GTEP 795-805-072	Exhibit 12	SBTC

(continued)

Exhibit 14 - Standard Grounding Conductor Sizes and Lead Designations (Page 1 of 8)

Item No.	By	From	To	AWG	Notes
9	SA OSPE	External water pipe	Interior water- pipe	Exhibit 2	Insulated copper
10	SA OSPE	Interior water pipe	MGB	Exhibit 2	Insulated copper
13	SA OSPE	Main AC enclosure neutral bus	MGB	Exhibit 2	insulated copper. Refer to GTE Telephone Operations Practice 795-805-072.
14C	SA OSPE	MGB/FGB	Interior metallic roof or metal skin	I/O	Insulated copper
15	OSPE	MGB	FGB next enclosure	2	See Exhibit 4.
16	SA OSPC	MGB	CVGB or Lead 17 pe f Section 8.2	1/0	Insulated copper. See Exhibits 15 and 16.
16A	OSPC	CVGB	Cable support Racking	1/0	Insulated copper. See Exhibits 15 and 16.
17	OSPC	MGB	Cable shields	6	Insulated copper
17A	OSPC	MGB	Fiber optic metallic members	6	Insulated copper
17B	OSPC	MGB/FGB	Fiber optic splice shelf	1	Insulated copper. See Exhibit 20.

(continued)

Exhibit 14 - Standard Grounding Conductor Sizes and Lead Designations (Page 2 of 8)

Item No.	By	From	To	AWG	Notes
20	**SA** OSPE	MGB	Branch AC enclosure (green wire) ground, not neutral	6	Insulated copper. Not required if there **is** only one panel.
20A	SA	MGB	Disconnect enclosure on same floor neutral bus for step-down transformer or separately derived source.	Exhibit 18	Insulated copper
21	SA	MGB/FGB	Radio room ground ring (halo). Lead 21A.	2	Insulated copper. Refer to GTE Telephone Operations Practice 795-805-071.
21A	SA	Interior (halo) ring	----	2	Insulated copper
21B	SA	Lead 21 A	Lead 1	2	Insulated copper
21B	SA	Lead 21 A	Lead 1	2	Insulated copper
21c	COEC	Lead 21A	Equipment	6	Insulated copper
22	SA	Roof radio tower ground ring and structure mechanical equipment	Corner bldg cols or lightning rod system	NFPA 780	Insulated copper (min. 4 leads per NFPA).

(continued)

Exhibit 14 - Standard Grounding Conductor Sizes and Lead Designations (Page 3 of 8)

Item No.	By	From	To	AWG	Notes
23A	COEE	MGB or FGB (same floor)	CXR HF line protectors	1	Insulated copper.
23	COEE	MGB or FGB (same floor)	Ent CA prot ground bar (MDF)	1	Insulated copper (1 for each 17ft [5.1 m] of ECPGB. Refer to Section 13.6 for special situations.
24	OSPC	ECPGB (MDF) or Lead 23A	Bottom prot assy ground terminal (not entire vertical mounting strip)	6	On each vertical (insulated copper).
24A	OSPC	Lower prot assy grd terminal	Next higher prot assy grd terminal	6	See the illustration on Entrance Cable Protector Ground Bar in Section 7.
25	SA	Lead 1	Nearest lightning rod	2	Insulated copper.
26	SA	Lightning rod system	All nearby objects – all floors	NFPA 780	Per NFPA 780
27	SA	Lead 1	External radio tower ground ring	2	SBTC. Refer to GTE Telephone Operations Practice 795-805-071.
28	SA	Lead 1	External radio structure ground ring	2	SBTC. Refer to GTE Telephone Operations Practice 795-805-071.
28A	OSPE	Lead 1 (one field)	Lead 1 (another field)	2	SBTC. See Exhibit 5.

(continued)

Exhibit 14 - Standard Grounding Conductor Sizes and Lead Designations (Page 4 of 8)

Item No.	By	From	To	AWG	Notes
29	COEE	Branch AC enclosure (green wire) ground, not neutral	Battery charger frame	Exhibit 12	Green insulated copper in AC conduit
30	SA COEC	Branch AC enclosure (nonisolated green wire) ground, not neutral	AC outlets (brown)	Exhibit 12	Green insulated copper in AC conduit
31	COEE	MGB/FGB (same floor)	Leads 32-36 and/or modular power board	6	Insulated copper
32	COEC	Lead 31	Battery charger frame or shelf (Lead 29)	6	Insulated copper. Must terminate at Lead 29 punching.
33	COEC	Lead 31	Battery rack frame	6	Insulated copper
34	CCEC	Lead 31	PCU frame	6	Insulated copper
36	COEC	Lead 31	PDU frame	6	Insulated copper
37	COEE	MGB/FGB (same floor)	Battery positive ground	2/0	Insulated copper
37A	COEE	MGB/FGB	Return terminal carrier supply (130 Vdc)	6	Insulated copper

(continued)

Exhibit 14 - Standard Grounding Conductor Sizes and Lead Designations (Page 5 of 8)

Item No.	By	From	To	AWG	Notes
41	COEE	MGB	Lead 58	1	Insulated copper. Refer to GTE Telephone Operations Practice 795-805-071.
41A	**COEE**	**MGB/FGB**	Lead **58A**	1	Insulated copper
45	SA	Main AC enclosure neutral	Branch AC enclosure (separate Lead 46)	Exhibit 18	Refer to GTE Telephone Operations Practice 795-805-072.
46	SA COEC	Branch AC enclosure (separate isolated) Lead 45, not neutral	Dedicated AC outlets (orange) (green wire) ground	Exhibit 18	Refer to GTE Telephone Operations Practice 795-805-072.
47	COEE	MGB	Lead 48 (each EM frame lineup)	6	Insulated copper. EM systems only.
48	COEC	Lead 47	Each EM frame	6	Insulated copper. EM systems only.
49	COEC	EM frames	EM EQ shelves	--	Mounting with internal-external tooth lockwashers under both head and nut of mounting bolts. **EM** systems only.
52	COEC	Each trans frame fuse panel ground bar	Each trans frame's vertical or horizontal rack ground bar, or direct to frame with int/ext tooth lockwasher next to frame	6	Insulated copper (refer to GTE Telephone Operations Practice 795-805-073).

(continued)

Exhibit 14 - **Standard Grounding Conductor Sizes and Lead Designations (Page 6 of 8)**

Item No.	By	From	To	AWG	Notes
54	**COEE**	MGB	Storage cabinets for static-sensitive circuits, static mats, and work benches	6	Insulated copper (refer to GTE Telephone Operations Practice 795-805-071).
55	COEE	MGB	Waveguide or coax just where enters structure	6	Insulated copper
56	COEE	MGB	AC power radio transmitter cabinet	6	Insulated copper
57	COEE	MGB	Center of cable grid or runway system	2/0	insulated copper. Optional. See Section 10.5.
57A	COEE	MGB	Center of cable grid or runway system	2/0	Insulated copper. Optional. See Section 10.5.
58	**COEE**	Lead 41	Aisle frame ground	2	Insulated copper
58A	COEE	Lead 41A	Aisle frame ground	2	Insulated copper
59	**COEC**	Lead 58	Individual equipment frames	6	insulated to each equipment frame
59A	**COEC**	Lead 58A	Individual equipment frames	6	Insulated to each equipment frame

(continued)

Exhibit 14 - Standard Grounding Conductor Sizes and Lead Designations (Page 7 of 8)

Item No.	By	From	To	AWG	Notes
61	**COEE**	**MGB/FGB**	Lead 62 each **EL** frame lineup	2/0	Insulated copper – LPG
62	COEE	Lead 61	Aisle lineup	1/O	Insulated copper
63	COEC	Lead 62	Terminal block	10	Insulated copper
64	COEE	MGB	FTG	10	Insulated copper – **FTG**

Exhibit 14 - Standard Grounding Conductor Sizes and Lead Designations (Page 8 of 8)

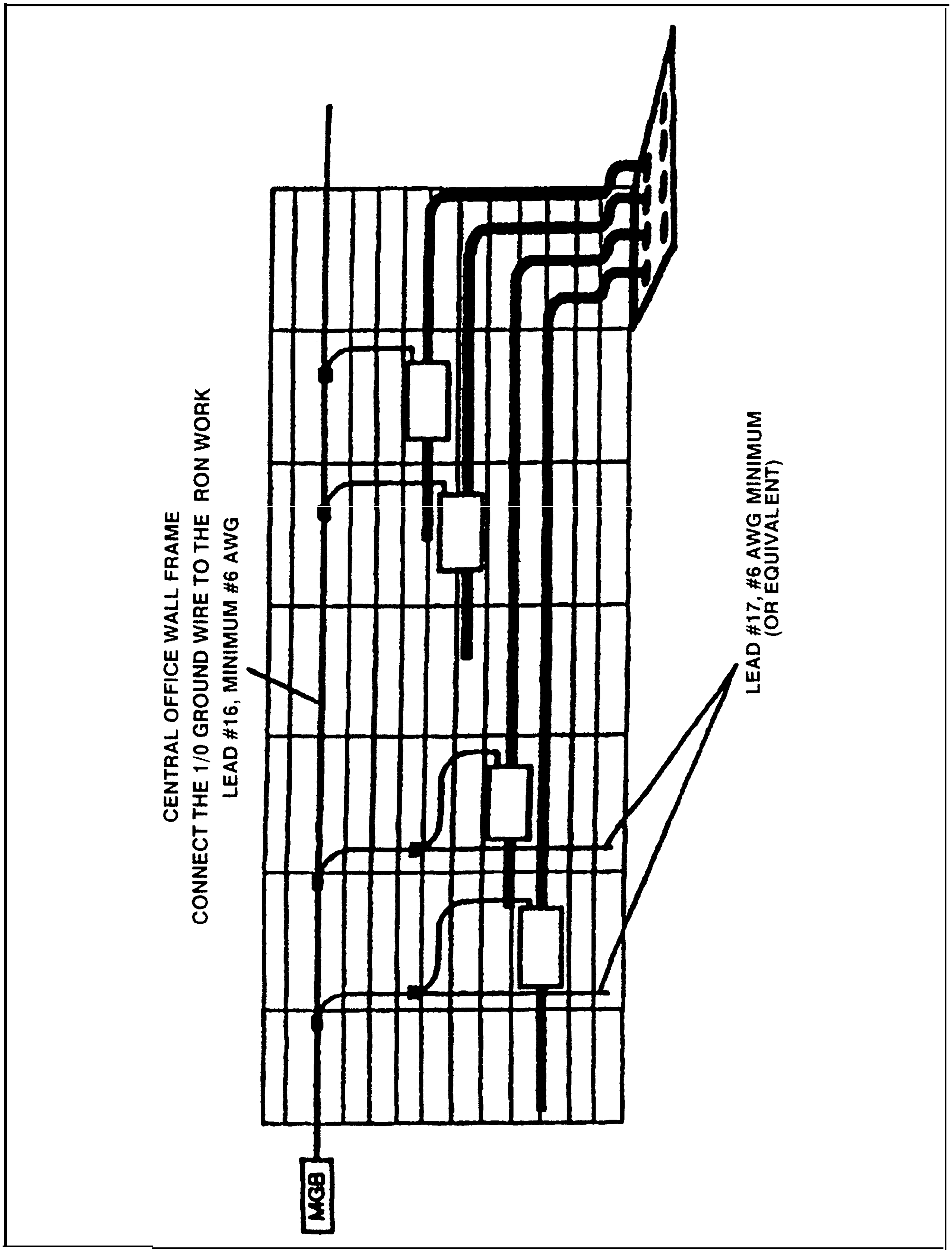
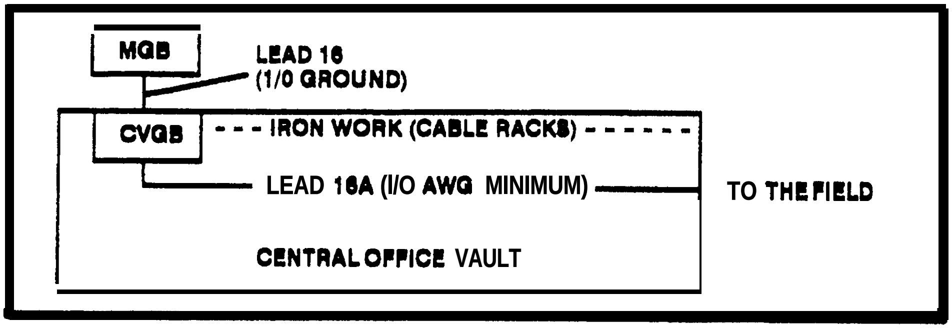


Exhibit 15 - Typical Entrance Cable Grounding



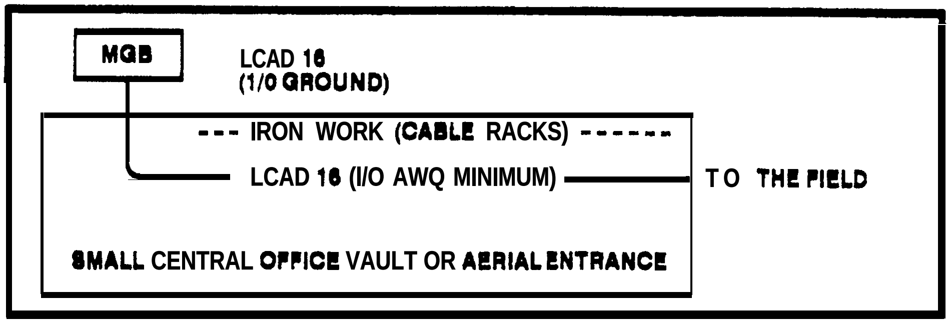


Exhibit 16 – CVGB Options

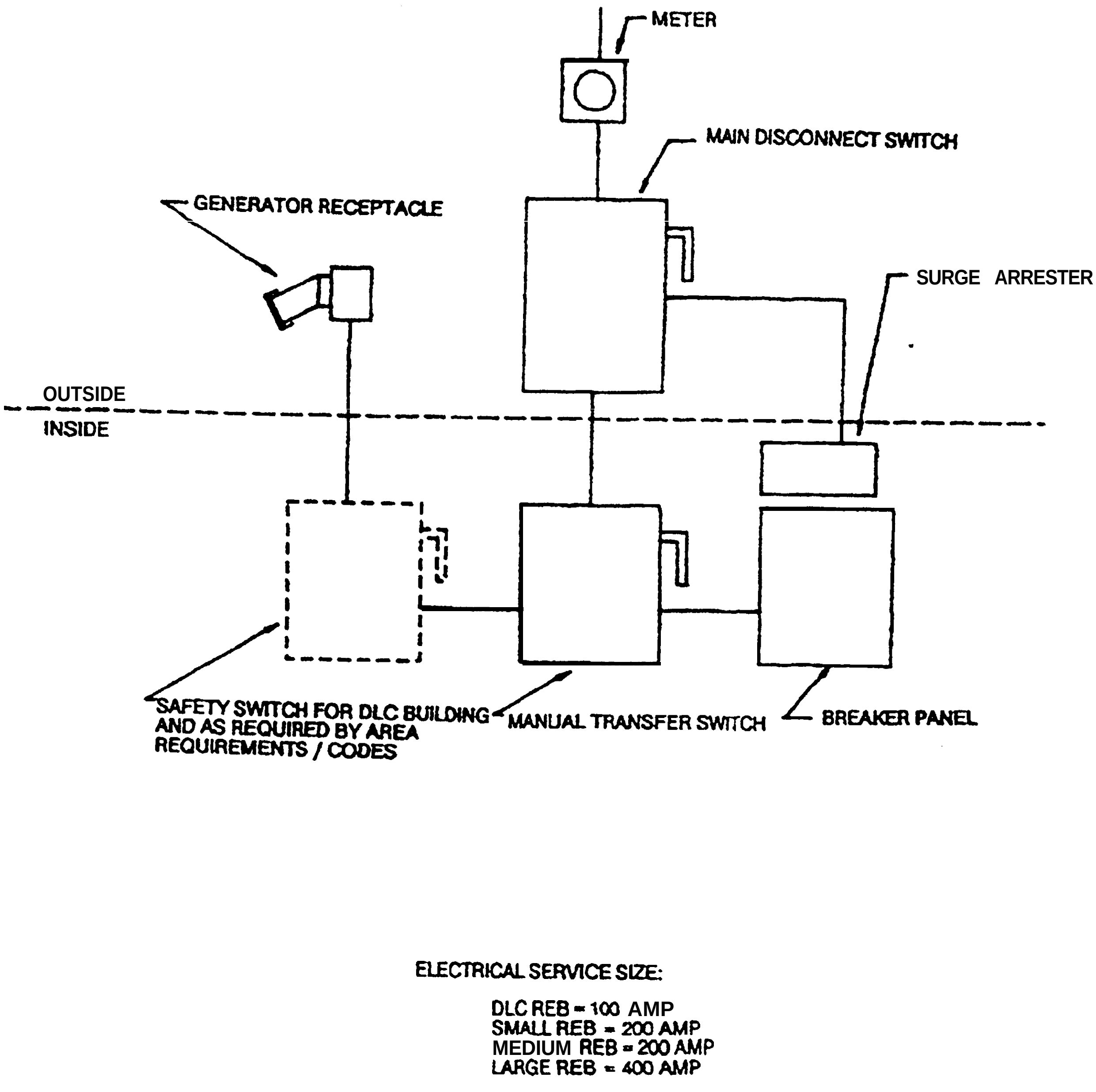


Exhibit 17 – Standard Electrical Single Line Diagram for Small Structures

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, Etc., Not Exceeding (Amperes)	SIZE: Copper Wire No. (Required)
15	14
20	12
30	10
40	10
60	10
100	8
200	6
300	4
400	3
500	2
600	1
800	1/0
1000	2/0
1200	3/0
1600	4/0
2000	250 kcmil
2500	350 kcmil
3000	400 kcmil
4000	500 kcmil
5000	700 kcmil
6000	800 kcmil

Note: (NEC 250-95) - When conductors are adjustable in size to compensate for voltage drop, equipment grounding conductors, where required, should be adjusted proportionately according to the circular mils area.

Note: GTE requires that Lead 45 be no less than a #6 AWG. See GTE Telephone Operations Practice 795-805-072 for additional Information.

Exhibit 18 - Minimum Size of AC Equipment Grounding Conductor (Green) Per Table 250-95 of the NEC

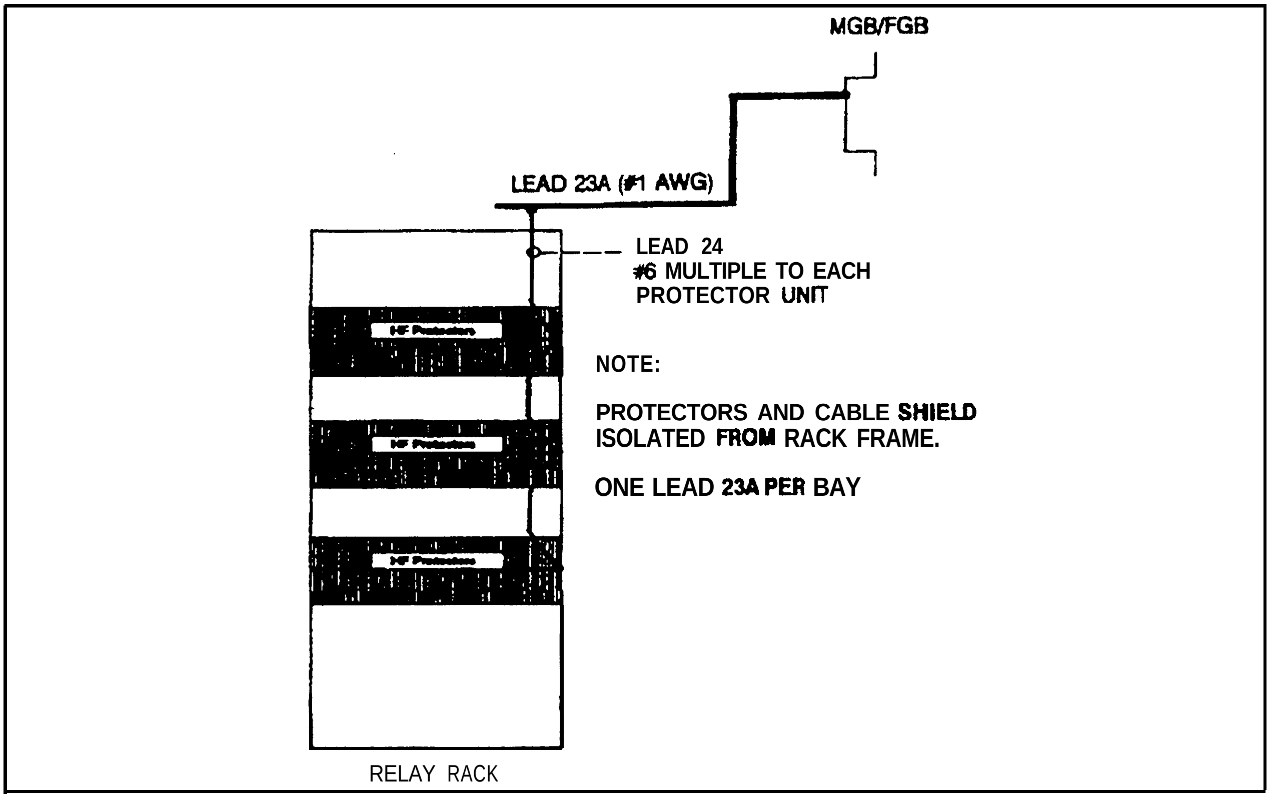


Exhibit 19 - HF Protector Grounding

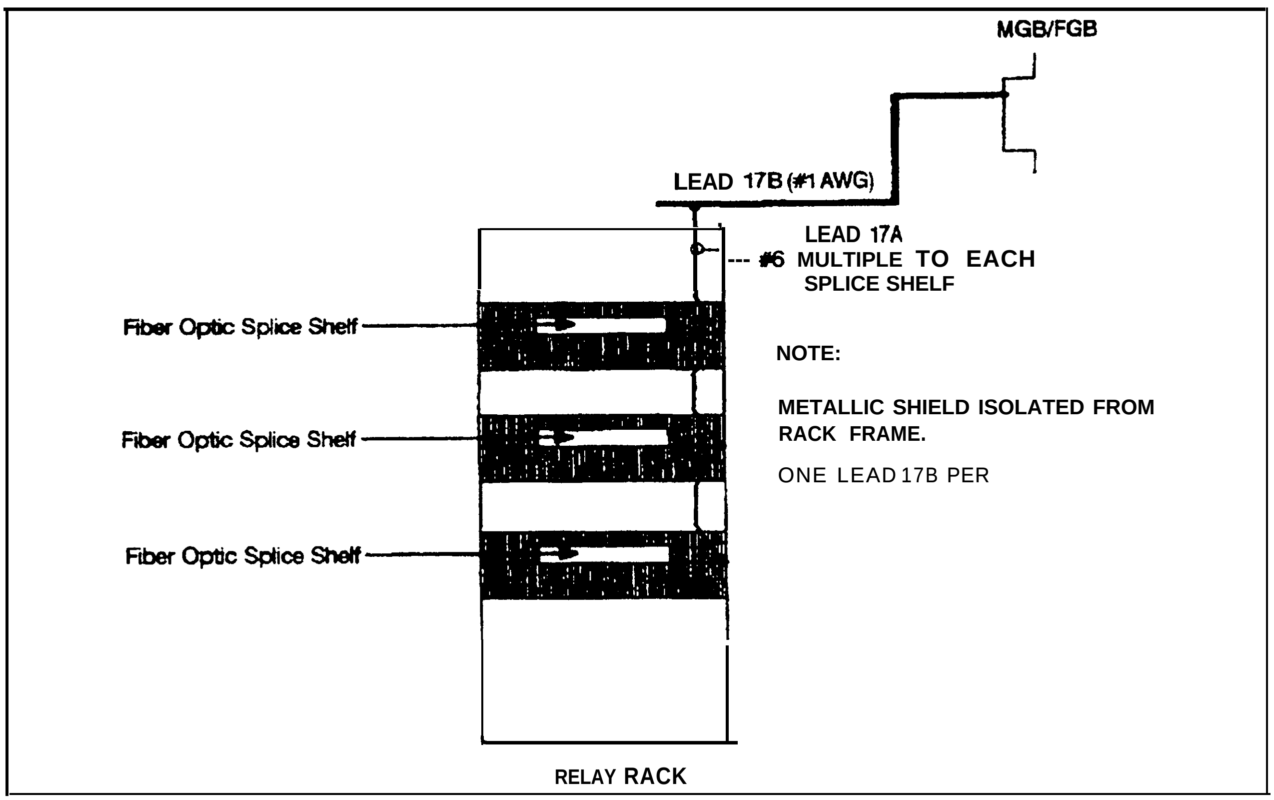


Exhibit 20 Fiber Optic Splice Shelf Grounding