

Central Office Grounding Systems Engineering Applications

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1 .General

- 1.1 Purpose** This practice provides the engineering methods recommended for all Central Office (CO) grounding systems.
- 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 provides information contrary to the information contained 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 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, contractors, 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 requirements for digital and analog offices to minimize susceptibility to:
 - Radio Frequency Interference (RFI).
 - Electromagnetic Interference (EMI).
- Conforms with, or exceeds, the requirements of the National Electrical Code (NEC), which applies to the building itself, including AC power service grounding and distribution.
- Applies fire protection standards as explained in the 742 section of GTE Telephone Operations practices.
- Is applicable to the following types of equipment:
 - AGCS GTD-5 family (host office, remote units, etc.).
 - Siemens EWSD family.
 - Northern Telecom DMS family, including remote units, as modified by GTE Telephone Operations Practice 795-805-076.
 - Stromberg-Carlson DCO family, including remote units, as modified by GTE Telephone Operations Practice 795-805-077.
 - AT&T 5ESS family, including remote units, as modified by GTE Practice 795-805-078.

NOTE: Any deviations from this practice must be documented with a Deviation Form (see GTE Telephone Operations Practice 887-000-001), which is to be approved by the Area Protection Staff.

2.2 Grounding System Attributes

The grounding system described:

- 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, and earth.
- Is extremely reliable for the service life of the equipment in the building.
- Protects equipment from damage or fire hazard by diverting excessive fault and lightning currents to earth.

2. Overview, continued

2.3 Definitions

The following chart provides definitions for the acronyms and terms used in this practice.

Acronym or Term	Definition
ATL	Above-The-Line
AWG	American Wire Gauge
Bonding	The permanent joining of metallic parts to form an electrically conductive path which will ensure electrical continuity and the capacity to conduct safely any current likely to be imposed.
BU	Base Unit (Host Office)
Building Steel	The structural steel or concrete-encased reinforcing steel (rebars). Structural steel buildings usually consist of vertical columns and horizontal beam framework. Rebars should be lashed to the anchor bolts in the footings of structured steel columns with galvanized steel to prevent lightning damage to the concrete of the footings and to permit continuous structural bonding.
CEV	Controlled Environment Vault
CO	Central Office
COE	Central Office Equipment
COEC	COE Construction
COEE	COE Engineering
Conductor	A material (usually wire, cable, or bar) suitable for carrying an electrical current.
Current-Limiting Overcurrent Protective Device	A device which, when interrupting currents in its current-limiting range, reduces 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
Digital Facilities	Telephone Company facilities carrying digital signals such as Repeater Housings, Span Lines (T1, T1 C, or higher rate), etc.

(continued)

2. Overview, continued

2.3 Definitions, continued

Acronym or Term	Definition
Digital Sites	Digital Switching Office Equipment located in: <ul style="list-style-type: none">• Host or remote offices.• A Digital Loop Carrier (DLC) in a:<ul style="list-style-type: none">- Building or hut.- Pad-mounted cabinet.• Controlled Environment Vaults (CEVs).
DLC	Digital Loop Carrier
DMM	Digital Multimeter
DMS	Digital Multiplex System
DMS SPG	DMS Single Point Ground
DSU	Disconnect Switch Unit; provides the means to disconnect and fuse main power feeders to power distribution units.
DSX	Digital Cross-Connection
E&M	Signaling lead designations
ECPGB	Entrance Cable Protection Ground Bar
Effectively Grounded	Connected permanently to earth (ground) and having sufficient current-carrying capacity to prevent hazardous voltages from building up.
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.
EMI	Electromagnetic Interference
Enclosure	A housing or cabinet for equipment or components.
FG	Frame Ground
FGB	Floor Ground Bar
FO	Fiber Optic

(continued)

2. Overview, continued

2.3 Definitions, continued

Acronym or Term	Definition
FTG	Facility Test Ground
GPR	Ground Potential Rise; a voltage difference between two or more ground electrodes due to the earth return currents. GPR can exist when currents from either lightning or power system faults flow to ground.
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 Conductor	A conductor that is intentionally grounded.
Grounded	Connected directly to ground or through a conducting object that provides a low-impedance path to earth.
Ground Electrode	One or more conductors in direct contact with the earth for the purpose of providing a connection with the earth.
Ground Grid	A mesh of horizontal bare conductors and grounding electrodes provides a common grounding system and voltage equalization for: <ul style="list-style-type: none">• Electric devices.• Metallic structures.
Grounding Conductor	A conductor that is used to establish a ground and that connects a device, equipment, wiring system, or other conductor with the grounding electrode or electrodes.
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 System	The combination of conducting elements by which all equipment is connected to the earth.
GW	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.

(continued)

2. Overview, continued

2.3 Definitions, continued

Acronym or Term	Definition
GWB	Ground Window Bar
GWE	Ground Window Equalizer
Halo Ring	A ground ring in the interior of a building or radio hut. Provides voltage equalization.
HE	Horizontal Equalizer
IG	Integrated Ground; the integrated ground building is a combination of all incidental and engineered grounds, except the isolated grounds.
IGS	Isolated Ground System; the grounded terminal of the battery, circuit ground, or discharge ground is deliberately isolated in the load equipment from its framework. All objects are isolated from contact with other grounds, except for a single point. This prevents currents in the ground paths from circulating: <ul style="list-style-type: none">• Through any part of the IGS. OR <ul style="list-style-type: none">• To or from the integrated system.
IGZ	Isolated Ground Zone
Incidental Ground	An unplanned or accidental connection to ground.
Integrated Zone	The area in a CO where all the equipment is intentionally or incidentally connected to ground through more than one point. Battery return is typically grounded at the frame or shelf (or both).
Integrated Ground (CO Equipment)	Refers to Central Office Equipment where the return side of DC circuit load conductors is deliberately bonded to the equipment frames.
Isokeraunic Map	Shows the amount of lightning activity for an area indicating the average number of days per year on which thunder is heard.
Isolated Zone	The area in a CO where all the equipment is insulated from the building and is grounded by a single connection through the main ground bus (or ground window).

(continued)

2. Overview, continued

2.3 Definitions, continued

Acronym or Term	Definition
kcml	Thousand circular mils. Replaces MCM.
L&B	Land and Buildings
Listed	Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation. The list indicates that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.
LPG	Lightning Protection Ground
LPS	Lightning Protection System
LVG	Low-Voltage Ground
m	meter
Made Electrode	A ground electrode designed and installed for a specific site.
MAP	Maintenance and Administration Position
MC	Material Code
MCM	Thousand circular mils. Replaced by kcml.
MDF	Main Distributing Frame
Meter-ohm	The resistance (in ohms) between opposite faces of a cube of earth having one cubic meter (m ³) in volume.
MGB	Master Ground Bar

(continued)

2. Overview, continued

2.3 Definitions, continued

Acronym or Term	Definition
MGN	<p>Multi Grounded Neutral; a neutral conductor of a wye-connected electric-supply system that includes:</p> <ul style="list-style-type: none">• At least four grounds per mile.• Power ground connections at individual services.• Solidly interconnected primary and secondary neutrals. <p>NOTE: If it is not definitely known if the power system is of the MGN type, the information should be obtained from the power company.</p>
Multiple Floor or Level Central Office Structure	<p>For the purpose of this practice, a CO structure is considered multiple floor or level if:</p> <ul style="list-style-type: none">• Two or more floor elevations are present that include the one at or near grade level, and one or more subsequent above.• In addition to the ground level, an excavated level exists with one or more of the following:<ul style="list-style-type: none">- Mechanical equipment.- Telephone equipment (switching and/or transmission).- DC power equipment.- AC power equipment.
Mutual Resistance	The voltage change in one electrode produced by a unit of DC current in a second electrode.
NEC	National Electrical Code
NFPA	National Fire Protection Association
NRTL	Nationally Recognized Testing Laboratory
OEM	Original Equipment Manufacturer
OSP	Outside Plant
OSPC	OSP Construction

(continued)

2. Overview, continued

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. Overvoltage may be low frequency and transient (i.e., lightning or switching surge overvoltage).
PCD	Power Control Distribution; a main DC power board found in electronic switching systems. It houses all the components of Power Control Unit (PCU) and Power Distribution Unit (PDU).
PCU	Power Control Unit; a part of the main DC power board found in electromechanical and electronic switching systems. It houses the controlling, metering, and alarm equipment.
PDF	Protector Distribution Frame
PDU	<p>Power Distribution Unit; a frame which:</p> <ul style="list-style-type: none">• Houses distribution and miscellaneous fuse panels.• Accepts the main feeder cables or bus bar from the PCU or DSU. <p>Often locally or remotely fed by a DSU. In smaller office applications, the PDU might provide the first fuse location on the load side of the battery power plant.</p> <p>It may contain single or multiple main fuses and distribution fuses. When the PDU serves as the first fuse location, the PDU may be referred to as the main power board. Subsequent PDUs may be served from the main fuses.</p>
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, thus reducing the possibility of injury and damage to personal property.
PS	<p>Plastic Sleeve; a fire-retardant nonmetallic tube:</p> <ul style="list-style-type: none">• Used to create an opening when the concrete floor is poured.• Required in all floor or wall openings used for grounding conductors.

(continued)

2. Overview, continued

2.3 Definitions, continued

Acronym or Term	Definition
PSB	Product Standardization Bulletin
PVC	Polyvinylchloride (nonmetallic)
RFI	Radio Frequency Interference
RLU	Remote Line Unit
RSU	Remote Switching Unit
SBTC	Soiid, Bare, Tinned Copper
Soil Resistivity	The measured DC resistance of a volume of earth.
SPC	Stored Program Controlled
SPG	Single Point Ground; this method requires separation of battery return from all ground sources except at one point.
Split PDU	Two power distribution units within the same frame with separate 50-volt terminations (for both battery and return bus bars) where separately paired cables are run to the DSU or battery. Refer to Section 20 for split PDU use in electronic switching systems.
Surge Impedance	Impedance of a ground electrode at the frequency of the applied AC current.
T&P	Transmission & Protection
TOPS	Traffic Operator Position System
UPS	Uninterruptible Power Supply
VE	Vertical Equalizer
VOM	Volt-ohm Meter
ZOI	Zone of Influence

2. Overview, continued

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...
237-224-214	Ground Isolation Procedures
248 series	Distribution and Protection Equipment
435 series	Station Protection
621-800 series	Radio Tower and Microwave
742 series	Building Fire Protection
742-200-070	Sealing Cable Openings and Penetrations - Fire Protection Measures
740-250-070	Central Office Grounding System - Installation and Inspection
795-001-070	Switching Systems - Power Cabling and Fusing - Engineering Application
795-002-071	Common Power Complex System Sharing Engineering Application
795-155-074	Overhead Aluminum Bus Bar and Aluminum or Copper Bus Duct- Engineering Applications
795-805-072	AC Service Grounding Engineering Applications
795-805-073	Telephone Central Office Grounding of Transmission Equipment
795-805-074	Inspecting Electronic Central Office and PABX Grounding and Protection
795-805-075	Remote Electronic Serving Area Grounding Systems - Engineering Considerations
795-805-076	Northern Telecom DMS Switching Systems Grounding Engineering Applications
795-805-077	Stromberg-Carlson DCO Switching Systems Grounding Engineering Applications
795-805-078	Engineering Guidelines for Grounding AT&T Equipment in GTE Facilities
830-000-000	Engineering Directives Preparation and Handling

(continued)

2. Overview, continued

2.4 References, continued

See...	For Information About...
887-000-001	Requesting Deviations From Protection Practice Requirements
887-000-050	Electrical Protection Engineering Fundamentals
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
887-800-044	Determination of Minimum Separation Between Digital Sites and Electric Power Facilities
887-903-026	Five-Pin Protector Module Application
NFPA 70	National Electrical Code (NEC)
NFPA 780	Lightning Protection Code
PSB 1625"	Exothermic Welding
PSB 2149"	Compression Fittings
PSB 4131.1"	Ground Rods
PSB 4143"	Ground Rods
PSB 4145"	Compression Fittings
PSB 6141*	Grounding Clamps (Fence Posts)

(continued)

2. Overview, continued

2.4 References, continued

See...	For Information About...
PSB 6238.1*	Ground Bars (MGB/FGB)
PSB 6238.3*	Test Bracket

* Product Standardization Bulletins (PSBs) are published by the GTE Telephone Operations Standardization Management Department.

3. Planning Ahead

3.1 Locations to Avoid

Avoid locating CO buildings (for host and remote sites) adjacent to:

- Power stations (generating plants and substations).
- Transmission (Extra-High Voltage [EHV]) lines.
- Foreign (non-GTE) antennas, radio and microwave/satellite sites (including radio stations).
- Fire departments.
- DC rails and 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 Area/State Network Provisioning Support Staff (or HQ Protection Engineering Support) if these sites cannot be avoided.

3.2 Ground System Fault Stress

The CO (host and remotes) should not be located close to a 300 VAC peak Ground Potential Rise (GPR) source capable of firing the entrance cable protectors or within the substation Zone of Influence (ZOI).

GPR places severe stress on:

- Main Distributing Frame (MDF) protectors.
- Fuse links.
- Jumpers.
- CO Equipment (COE).

With the increased use and deployment of solid-state protectors, a figure lower than 300 VAC may 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 calculations method.

3. Planning Ahead, continued

3.3 Cable Shield Bond Stresses

If the CO is bonded to an adjacent commercial power station through the power service neutral, fault currents might put severe stress on the outside telephone cable shields and shield bonds. In these cases, the Administrator - T&P must:

- Analyze alternatives for existing and proposed locations next to commercial power systems.
- Prepare and price alternative solutions.

NOTE: Refer to GTE Telephone Operations Practice 887-800-044 for calculations for minimum separation.

3.4 Central Office Examples

These principles are illustrated in Exhibits 1 through 5. The following chart is a guide to finding information in the exhibits.

Exhibit	Provides
1 through 5	An illustration of a complete CO grounding system. Alternatives and/or details for various portions are shown in succeeding exhibits.
6	The sizes of the conductors in Exhibits 1 through 5.

3.5 Choosing the Best Layout

Plan a building layout where power services, water systems, and telephone entrance grounding cables are on the same side or adjacent sides of the same building floor level. A short, straight grounding conductor path between these items increases the equipment protection achieved.

NOTE: All elements shown in Exhibits 1 through 5 may not be needed in a specific application. See Section 15.11.

The GTE Land and Buildings (L&B) engineer should proceed according to the instructions in the following chart.

Step	Preparing the Layout
1	Prepare specific work order job drawings for each CO building's grounding system.
2	Specify in detail the sizes, locations, and devices for connection and supporting: <ul style="list-style-type: none">• Grounding conductors.• Grounding bars.• Grounding electrodes.• AC power service protection (surge arresters).• AC and DC power enclosures or powerboards.
3	Show the location of the associated nonmetallic conduits and sleeves.

(continued)

3. Planning Ahead, continued

3.5

Choosing the Best Layout, continued

Step	Preparing the Layout
4	<p>Negotiate with the Original Equipment Manufacturers (OEMs) whose CO system is to be installed to resolve any differences in the system and associated DC power system grounding between:</p> <ul style="list-style-type: none">• This practice.• GTE's specifications.• The OEM's specifications and recommendations. <p>NOTE: For equipment to be GTE Standard, it should follow this practice.</p>

3.6

MDF Location

Locate the electronic digital switching systems and the MDF on the same floor level. When placed in this manner, it is possible to:

- Maintain proper fine circuit protection.
- Keep the switching systems and the MDF at the same equalized ground potential.

3.7

Restriction

A CO should not have more than one grounding system, unless separate building structures have:

- Separate AC and DC power.
- Switchboard cables between structures that have protectors at each end.

3.8

Segregating Grounding Systems

To enhance the desired segregation of the grounding systems, separate bus ducts or paired conductors, and separate Power Distribution Units (PDUs) are required for isolated and nonisolated systems (i.e., transmission, electromechanical, and electronic system) as shown or referenced in:

- Exhibits 1 through 5.
- GTE Telephone Operations Practice 795-002-071.
- Separations of Central Office Systems in Section 23.2.

3.9

Leased Buildings

When installing regulated Above-The-Line (ATL) switches in leased buildings, the equipment grounding system should include a direct connection to an approved grounding electrode for the building. This grounding electrode may be either as described in either:

- Section 5.5.
OR
- NEC Article 250-81 B.

3.10

Preparation of Connectors and Surfaces

All lug connections and their mating surfaces must be cleaned and lightly coated with a nonoxidizing-type conductive grease or compound (see PSB 3282) as follows:

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

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

4. Grounding System Components

4.1 Introduction This section describes the major components of the grounding system and the minimum requirements of each. See Exhibit 6.

4.2 Components The following sections address the different grounding system components, including:

- Office Grounding Electrode (Section 5).
- AC Grounding Electrode System (Section 6).
- Bonding of Building Steel (Section 7).
- Computer Flooring (Section 8).
- Master Ground Bar (MGB) (Section 9).
- Floor Ground Bar (FGB) (Section 10).
- Vertical Equalizer (VE) (Section 11).
- Horizontal Equalizer (HE) (Section 12).
- Entrance Cable Protector Ground Bar (ECPGB) (Section 13).
- Cable Vault Ground Bar (CVGB) (Section 14).

4.3 Results of Improper Grounding Improper grounding can result in:

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

5. Office Grounding Electrode

5.1 Ground Electrodes Telephone company-constructed ground electrodes include:

- Ground rings.
- Deep electrodes (ground rods or wells).
- Ground grids or plates (ground fields).
- Concrete-encased electrodes.
- On-property water pipe.

5. Office Grounding Electrode, continued

5.2 Recommended Ground Objectives

The recommended (telephone constructed) ground resistance objective of electrodes for the CO (host and remotes) is equal to or less than the objective shown in the following chart.

Objective*	Office Type
3 ohms	Electronic
5 ohms	Electromechanical
2 ohms	Offices with radio towers

* Grounding electrode measured alone.

NOTE: Refer to GTE Telephone Operations Practice 887-030-085 for objectives for radio towers and GTE Telephone Operations Practice 795-805-075 for objectives for small remote sites (huts, CEVs, pad mount DLCs).

5.3 Inability to Meet Objectives

The recommended ground electrode resistance objectives may not be economical to meet in areas which have:

- Unfavorable soil conditions.
- Very high earth resistivity.

In these locations, obtain the lowest combined ground resistance economically feasible (maximum 5 ohms) by bonding together:

- Telephone company ground electrodes.
- Power company neutral.
- Exterior water pipes.

A deviation request should be completed per GTE Telephone Operations Practice 877-000-001 and approved by the Area/State Network Provisioning Support Staff (Protection).

5.4 Electrode Ground Design

Procedures and formulas are provided in GTE Telephone Operations Practice 887-600-070. Electrode ground design should be in accordance with GTE Telephone Operations Practice 887-600-070 and be based on soil resistivity measurements at the spacing/depth required by local soil conditions.

5. Office Grounding Electrode, continued

5.5 Minimum Made Electrode (Always Required)

The minimum made electrode must be:

- A ring of #2 AWG wire (Solid, Bare, Tinned Copper [SBTC]) around the building 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 5.8).

NOTE: For large existing buildings or for leased buildings where a complete ring around the structure is not practical or feasible, a minimum of 20 feet (6m) of #2 AWG wire (SBTC) with two 8-foot-long (2.5m) driven rods will be required. Section 5.2 objectives should still be used.

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

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

5.6 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 procedure ensures that the electrode ground has not deteriorated (refer to GTE Telephone Operations Practice 887-600-072).

5.7 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.
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 5.10).
NOTE: The existing access points may be used so as to minimize the total number of handholes at the site.	

(continued)

5. Off ice Grounding Electrode, continued

5.7 Rules, continued

Rule	Explanation
Provide a minimum of two access points (handholes). More if needed by local conditions.	Permits periodic resistance testing and inspections (see Section 5. 10).
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 step-and-touch potential.

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

5.8 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 may be exposed provided the conductors are kept from contacting such things as structural steel and metal conduits.

5.9 New Buildings with Steel Columns

Steel columns on the lowest floor of a new building must be bonded to the ground ring (Lead 1) via Lead 3.

Inspect all underground connections before:

- Performing backfill operations.
- Pouring the concrete.

See GTE Telephone Operations Practice 740-250-070 for additional information.

Refer to Section 5.10 for handhole access points.

5.10 Providing Access to Lead Connections

Access points (such as a suitable handholes) should be provided to allow for testing and 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 1 should be done at a handhole. Other connection points may need to be done at a handhole if they are to be disconnected during testing of the ground ring.

5. Office Grounding Electrode, continued

5.11 Locating Ground Layouts

Exhibits 7, 8, and 15 illustrate typical grounding layouts. All ground rods should be located:

- At least two 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.

5.12 Contractor- Provided Electrodes

When a contractor agrees to engineer, furnish, and install the “man-made” electrode, the GTE L&B engineer should furnish the contractor with:

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

5.13 Requirements for Connecting to Ground Ring and Rods

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

- Exothermic weld (PSB 1625).
OR
- Compression fittings (PSBs 2149 and 4145).

NOTE: Permanent connections should be either exothermic welds or compression connections. Connections that are to be removed for testing should be of the mechanical type.

5.14 Ground Ring

The ground ring (Lead 1) is:

- Connected to the ground rods.
- A #2 AWG SBTC.
- Connected via Lead 5, from opposite sides of the ground ring, to the MGB. Refer to Exhibits 8 and 9.
- 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.

5.15 Concrete- Encased Electrodes

Concrete-encased electrodes may be constructed in footings of buildings.

Concrete-encased electrodes in building footings must be constructed in accordance with Exhibits 7 and 15.

5. Office Grounding Electrode, continued

5.16 Grounding to Water Pipe

If the CO building is provided with a metallic pipe from a public water system, as defined in Section 6.2, bond from the building side of the water meter. Connections are to be made at accessible locations:

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

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

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

Use the following procedure.

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 building at a point within 5 feet (1.5m) from where the cold water pipe enters the building or outside the building but within GTE property. |
|---|---|

NOTE: Exhibit 1 illustrates the preferred routing.

- | | |
|---|--|
| 2 | Attach grounding conductors to the water pipe with an approved ground clamp of the proper size (see Exhibit 29). |
|---|--|

- | | |
|---|---|
| 3 | Place bypass conductors of the same size around the: <ul style="list-style-type: none">• Water meter (if metallic pipe is used).• Service unions.• Other junctions that may be physically disconnected. |
|---|---|
-

5.17 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 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.

5.18 Test Arrangements

Each office should include a permanent test bracket (see Exhibit 26) 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.

5. Office Grounding Electrode, continued

5.19

The following chart lists and describes the leads.

Lead

Explanations

Lead	Explanation
1	Consists of the ground ring or minimum electrode as described in Section 5.5. Wire is #2 AWG SBTC. Larger gauge wire may be used to decrease electrode resistance. (Consider the additional cost versus the increased benefit.) Connections to ground rods or other leads are either exothermic welds or compression connections unless they are expected to be disconnected for testing.
1A	Similar to Lead 1 but encased in concrete or similar-type material. When Lead 1A is part of the slab or foundation it should be continuous and welded to the rebar.
2	A deep well consisting of a metal casing (4-inch [0.1 m] diameter minimum). Driller's mud or bentonite should be used to fill the voids between the metal casing and the drilled hole.
3	Connects the structural steel columns or the reinforcing steel in concrete columns to either 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 9). The number of runs for each Lead 5 is determined from Exhibit 9. NOTE: Lead 5 must be jacketed (insulated) when stranded conductors are run in nonmetallic conduit. No portion of the stranded conductors may be exposed or in direct contact with the soil.
6	Consists of a single #2 AWG SBTC wire from Lead 1 to 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 either exothermically welded or using compression connectors to Lead 1 below ground level. The connection of Lead 6 to the fence should be above ground level using a mechanical connector because the connection may have to be removed for testing (see Exhibit 29). 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.

(continued)

5. Office Grounding Electrode, continued

5.19

Lead Explanations, continued

Lead	Explanation
7	Connects each well electrode (Lead 2) to the MGB. The gauge is determined from Exhibit 9. NOTE: Lead 7 must be jacketed (insulated) when stranded conductors are run in nonmetallic conduit. No portion of the stranded conductors may be exposed or in direct contact with the soil.
9	Connects the building 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 building 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. Use the GAR-TC clamp or equivalent (see Exhibit 29).

6. AC Grounding Electrode System

6.1 Minimum Requirements

Grounding electrodes are metallic objects in contact with the earth. The NEC specifies the minimum requirements that must be met by the:

- AC grounding electrode system.
- AC grounding electrode conductors.
- AC equipment grounding conductors.
- AC bonding conductors.

6.2 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 metal underground water pipe and/or metal well casing (10 feet [3m] or longer) where allowed by local authority. This may include a drilled well when required to meet earth resistance objectives in high-resistivity soil or solid rock.
- An interior metal water pipe system with at least 10 feet (3m) of earth contact.
- A metal building frame. Plan ahead by including bonding of all building steel in the plans for new construction.
- A ground field designated to meet the recommended minimum ground objectives (see Section 5).

6. AC Grounding Electrode System, continued

6.3 References

The following chart shows where in this practice to find additional information that may be needed.

See...	For Information About...
Section 5	Telephone company-constructed CO ground electrode resistance objectives.
Exhibit 6	The recommended grounding conductor sizes.
Exhibit 8	A typical electrode system.
Exhibit 9	Sizing primary CO bonding Leads 5, 7, 9, 10, and 13.
Exhibit 10	Sizing the AC service grounding electrode conductors Leads 4 and 8.
Exhibit 11	Sizing AC equipment grounding conductors (the green wires). NOTE: This exhibit contains information from NEC Table 250-95.

6.4 Lead Explanations

The following chart lists and describes the leads.

Lead	Explanation
4	Grounds the neutral bus at the commercial AC service main disconnect switch to its ground electrode (see Exhibit 27). The gauge of this lead must be in accordance with Exhibit 10.
8	Provides a bond between the grounded neutral bus at the commercial AC service main disconnect switch and the metallic water pipe (building 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 10. Use the GAR-TC clamp of equivalent (see Exhibit 29).
13	Provides a bond between the grounded neutral bus at the commercial AC service main disconnect switch and the MGB. Use Exhibit 9 to determine the proper conductor gauge. This lead allows the office to remain connected to ground whenever the Lead 5's are disconnected for testing.

7. Bonding of Building Steel

7.1

Bonding Steel-Reinforced Concrete Columns

Use the following procedure in new construction.

Step	Bonding Steel-Reinforced Concrete Columns
------	---

1 Bond:

- All steel-reinforced concrete columns around the perimeter of the building with #2 AWG SBTC wire to the ground ring. Refer to Section 2.3 for welding rebars together.
- The building steel adjacent to the VE with insulated #750 kcmil wire to the MGB and each FGB.

CAUTION: Do not bond to steel-reinforced concrete columns in existing structures or in new construction where rebars are not welded to ensure continuity. Lightning fault currents might crack such columns, causing permanent structural damage.

2 At the steel-reinforced concrete column adjacent to the VE, the #2 AWG SBTC wire is to be:

- Extended and welded to the rebar to the full height of the column (see Exhibit 15).
- Half-tapped to a compression flush plate ground connector on each level (see Exhibit 16).
- Accessed via an open or covered termination point to permit disconnecting for the purpose of periodically testing the external ground ring if used.

NOTE: The compression flush plate should be above the lowest level of the cable runway system.

3 Run #2 AWG SBTC wire for the ground ring in the same footing trench or the column trench. Exothermically weld the ground ring to both vertical and horizontal nonstructural rebars every 6 feet (1.8m) on center for at least 20 feet (6m) in both directions, except the center column.

4 After the concrete is poured, bond the flush plate ground connector with insulated #2 AWG wire to the:

- MGB.
- Each FGB.

NOTE: The flush plate ground connector technique may also be used to provide bonding and grounding access at all levels to:

- All the columns.
 - The concrete sections of walls, floors, and roof where additional shielding is desired against RFI and EMI.
-

7. Bonding of Building Steel, continued

7.2

Bonding Steel Columns

Use the following procedure in new construction.

Step	Bonding Steel Columns
1	Bond each steel column by exothermically welding #2 AWG copper conductor to the next column.
2	At the base of each steel column, bond the flush plate with #2 AWG SBTC wire (see Exhibit 16). Provide an access point for opening #2 AWG conductors from the Lead 1 ground ring for periodic testing.

In new construction, bond the nearest vertical steel column to the MGB and FGB with 750 kcmil insulated copper cable (Lead 14).

Refer to Exhibit 23 for a typical way of grounding building columns.

CAUTION: Do not bond to steel columns in existing structures or in new construction where rebars are not welded to ensure continuity. Lightning fault currents might crack such columns, causing permanent structural damage.

7.3

Bonding of Metal Roofs

On buildings that have metal roof structures but do not have metal columns and are in areas of high lightning activity, use Lead 14C to bond the steel bar joist or the interior metal skin to the MGB.

7.4

Lead Explanations

The following chart lists and describes the leads.

Lead	Explanation
14	Connects one of the columns in the building to the MGB. Typically, the column used is an interior, center column not connected to Leads 1 and 1A; however, an exterior column may be used when there are no interior, center columns.
14c	Connects interior metal roof structure members or interior metal skin to the MGB. Used only when the metal roof or building skin is not otherwise grounded through either the columns or the reinforcing steel and where the building is in an area of high lightning activity (see GTE Telephone Operations Practice 887-795-070).

8. Computer Flooring

8.1 Procedure

When computer flooring is used, proceed according to the instructions in the following chart.

Step	Using Computer Flooring
1	Run a #6 gauge Lead 14B around the perimeter of the floor plan area.
2	Splice the #6 gauge lead together once to form a closed loop.
3	Bond the Lead 14B loop to the computer flooring metal support in intervals along the loop not to exceed 20 feet (6m).
4	Bond a 2/0 AWG Lead 14A to Lead 14B.
5	Run and bond Lead 14A to MGB/FGB. NOTE: Leads 14A and 14B are intended to eliminate any hazard to personnel by: <ul style="list-style-type: none">• Draining any static charges.• Providing a fault path.
6	Refer to the computer flooring manufacturer's instructions for additional grounding and bonding information.

8.2 Conductive Floor Tile

When conductive floor tile is used:

- Splice #6 AWG wire (Lead 60) to the floor strap.
- Connect to the FGB.

8.3 Lead Explanations

The following chart lists and describes the leads.

Lead	Explanation
14A	Connects the computer floor ground loop to the closest ground bar.
14B	Essentially a ring that attaches to the computer floor support legs. The ring should be within 2 feet (0.6m) of the perimeter of the computer floor area. The point of connection may be either an exothermic weld or made with an approved clamp or connector. Lead 14B should be attached to the computer floor substructure at intervals not exceeding 20 feet (6m).

9. Master Ground Bar

9.1 Description

The MGB serves as the building's main termination point for the following types of leads:

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

The MGB:

- Is a copper ground bar, preferably on the lowest level of the building (see Exhibit 12) housing telephone switching equipment but not in the cable vault.
- Must not be connected to a lead to complete an electrical path other than those specified in this practice.

9.2 MGB Grounding Connections

Make all grounding connections to the MGB using two-hole approved copper terminal lugs. Connections can be placed on both sides of the MGB. Compression connections are required for all conductors.

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

9.3 Grounding Bar Sizes

Ground bars (see Exhibit 13) are available in two lengths:

- 20 inches (0.5m).
- 40 inches (1.0m).

Determine the correct size by considering the:

- Ultimate size of the office.
- Grounding requirements set forth in this section.

NOTE: See PSB 6238.1 for ordering information.

9.4 Ordering Connectors

Order connectors according to the specifications in PSBs 2149 and 4145.

The ground bar as supplied can mount two-hole approved copper terminal lugs, which accommodate the wire sizes (leads) listed in PSBs 2149 and 4145.

9.5 MGB Requirements

Every CO must have only one MGB (see Exhibit 12).

The MGB must always:

- Appear on building drawings.
- Appear on equipment engineering plans (drawings).
- Be isolated from the wall by using isolation standoffs.
- Be zoned (see Section 9.8).

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

9. Master Ground Bar, continued

9.6

Location

The MGB must be located:

- As close to the main AC service enclosure and Outside Plant (OSP) MDF as practical.
- 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.

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

The MGB must not be installed in the cable vault, especially when the cable vault is not environmentally controlled or when the cable vault is the only structure below grade level.

9.7

Installing Leads

Use the following procedure to install leads.

Step	Installing Leads
1	Clean the contact surfaces of the connectors and the MGB (see Section 3.10).
2	Apply a thin coat of copper-based joint (conductive) compound (MC #760293 or equivalent).
3	Label leads with the proper number identifying the lead number (description is optional). When more than one appearance of the same lead number appears on a ground bar, the to and from must be identified for each lead involved.

NOTE: Nonmetallic labels or tags are preferred.

9.8

Zoning of the MGB

Zone the MGB to reduce the voltage effects from currents flowing in surge carrying conductors connected at the MGB on other leads connected to the MGB. This procedure is recommended for new ground systems where zoning is easily accomplished.

CAUTION: Zoning is not recommended as a retrofit procedure because when changing terminations on an existing ground bar, additional bends must often be placed in the ground conductors. The bending of conductors can:

- Add inductance to the conductor impedance.
- Decrease some zoning benefits.

9. Master Ground Bar, continued

9.8 Zoning of the MGB, continued

For zoning of the MGB to be effective, the MGB must be isolated from the wall with isolation standoffs as specified by engineering (Material Code 726884). If the MGB is not zoned, do not isolate the MGB (see Exhibit 13).

New MGBs are zoned as shown in the following chart (see Exhibit 21).

Zone	Leads
Producer (P)	Conductors most susceptible to receiving and carrying the surges caused by power faults or lightning. <ul style="list-style-type: none">. 14c.● 16.. 16A.● 17.. 17B.● 21.. 23.● 23A.● 55.. 56.● 61.
Absorber (A)	Conductors that dissipate surges to ground (earth). <ul style="list-style-type: none">● 5.● 7.● 10.. 13.● 14.. 15.● 18.. 19.

(continued)

9. Master Ground Bar, continued

9.8

Zoning of the

MGB, continued

Zone

Leads

Nonisolated ground equipment (N)

Conductors that are part of the Integrated Zone.

- . 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 isolated Ground Zone (IGZ).

- . 41.
- . 41A.
- 47.
- 53A.
- . GW.

NOTE: The zone for the isolated ground equipment (I) is to be placed as far as possible from the surge producer (P) zone when using the P-A-N-I concept. Exhibit 21 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.

10. Floor Ground Bar

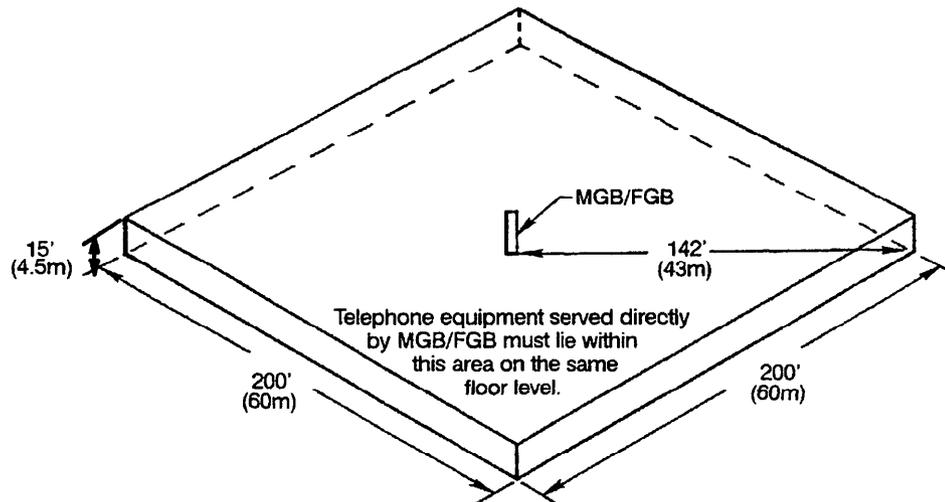
10.1 Description

The floor ground bar:

- Is a copper ground bar.
- Serves as the principal termination point of leads from the grounding system on each floor, above the lowest floor in multistory structures (see Exhibit 12).

Additional floor grounding bars are used when:

- the floor equipment area exceeds a 200 x 200 foot (60 x 60m) square or 142 foot (43m) distance on a single (or same) floor centered on the MGB/FGB. See the following illustration.



When area served exceeds these limits, building must be treated as multiple-floor structure.

OR

- Special circumstances dictate (e.g., see Sections 15.8 and 15.9).

10.2 Auxiliary FGBs Are Not Recommended

Auxiliary FGBs are often considered as a convenience for locations near a new switching system or in a new building area.

This practice does not condone this approach because:

- This auxiliary FGB becomes a tie point within the same 200 X 200 foot (60 x 60m) area. Fault currents can cause a potential rise in more than one lead carrying the fault.
- Indiscriminate locations and bends will:
 - Affect the HE inductance.
 - Increase the potential difference.

10. Floor Ground Bar, continued

10.3 Making Grounding Connections to the FGB

Use two-hole approved copper-type terminal lugs to make all grounding connections to the FGB.

Before installing the FGBs and connectors, perform the procedures shown in the following chart.

Step	Before Installing FGBs and Connectors
1	Clean the contact surfaces of the FGBs and connectors (see Section 3.10).
2	Apply a thin coat of joint conductive compound (such as copper-based joint compound [MC #760293 or equivalent]).
3	Label leads with the proper number identifying the lead number (description is optional). When more than one appearance of the same lead number appears on a ground bar, the <i>to</i> and <i>from</i> must be identified for each lead involved. NOTE: Nonmetallic labels or tags are preferred.

10.4 Zoning

New FGBs must:

- Be zoned.
- Follow the same guidelines as outlined in Section 9.8.

10.5 FGB Requirements

The location of the FGB must always:

- Appear on building drawings.
- Appear on equipment engineering plans (drawings).
- Be placed as follows:
 - No lower than 2 feet (0.6m) above the floor line.
 - No higher than 2 feet (0.6m) below the superstructure (cable runway).
- Be isolated from the wall (when zoned) by using isolation standoffs.

11. Vertical Equalizer

11.1

Description

The Vertical Equalizer (VE) (Lead 18):

- Is a 750 kcmil conductor.
- Equalizes ground potential in a vertical direction across the building from its appearance at the MGB to the FGBs on all other floors that contain communications equipment.
- Must be as straight as practical, with:
 - No offsets.
 - Unavoidable bends not to exceed 45 degrees with a turn radius no less than 36 inches (0.9m).
- Should directly bond to FGBs at each floor level. When direct contact is prohibited (due to VE location in restricted space of a cable chase or similar situation) use a Lead 19 that:
 - Is no longer than 6 feet (1.8m).
 - Has the same bend restrictions as Lead 15 HE (see Section 12 and Exhibit 24).
- Will not be required when the MGB is placed on the ground level floor where (see Exhibit 20):
 - The cable vault is the only structure below grade level.
 - All telephone equipment (i.e., switching equipment, transmission equipment, AC or DC power equipment) is on the ground floor.

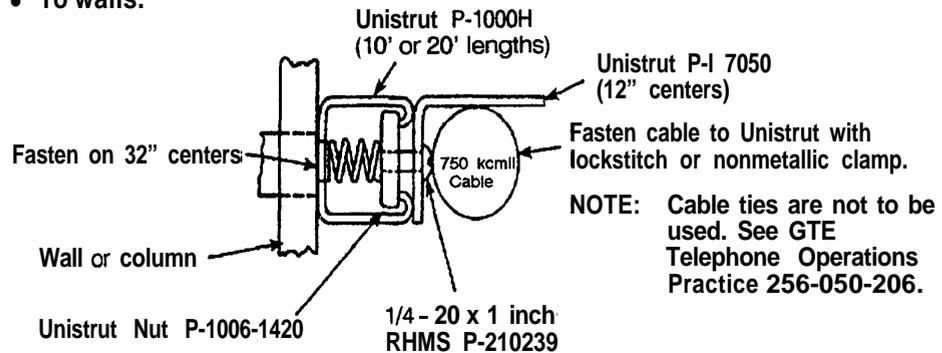
11. Vertical Equalizer, continued

11.2 Attaching and Running Equalizer Leads

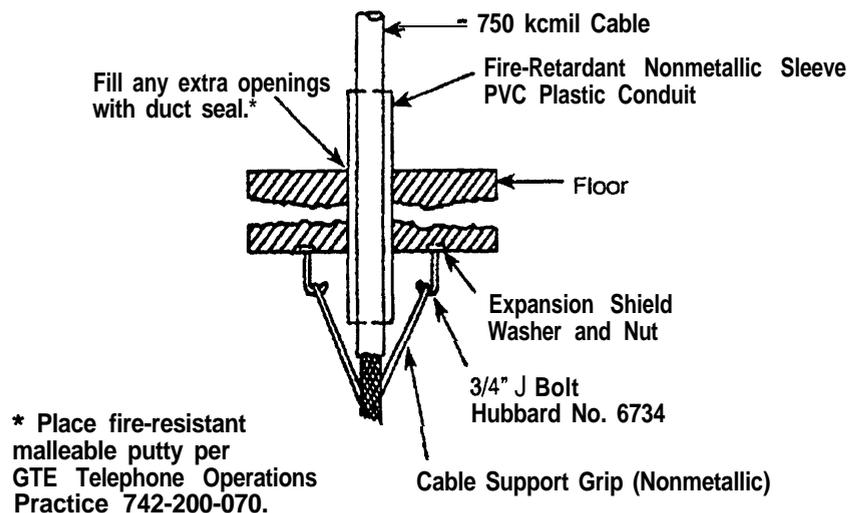
Vertical equalizer leads must be supported within 12 inches (0.3m) of the floor. The following illustrations show a typical method of attaching and running equalizer leads.

NOTE: If a metallic sleeve is in place, bond a 750 kcmil cable to the sleeve as discussed in Section 15.11.

- To walls.



- Through floors.



12. Horizontal Equalizer

- 12.1** The HE (Lead 15):
- Description**
- Must be as straight as practical, with:
 - Unavoidable bends not to exceed 90 degrees.
 - A turn radius no less than 36 inches (0.9m).
 - Is a 750 kcmil conductor.
 - Equalizes ground potential from its appearance at the MGB/FGB to the FGBs (when required) on the same floor.

13. Entrance Cable Protector Ground Bar

- 13.1** Make every attempt to locate the Protector Distribution Frame (PDF) on the same floor with the equipment-either electromechanical, electronic, or digital systems – being served. See Section 13.6 for additional information.
- Locating the PDF**
- 13.2** Some modular-type distribution frames do not have an Entrance Cable Protector Ground Bar (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.
- Description of the ECPGB**

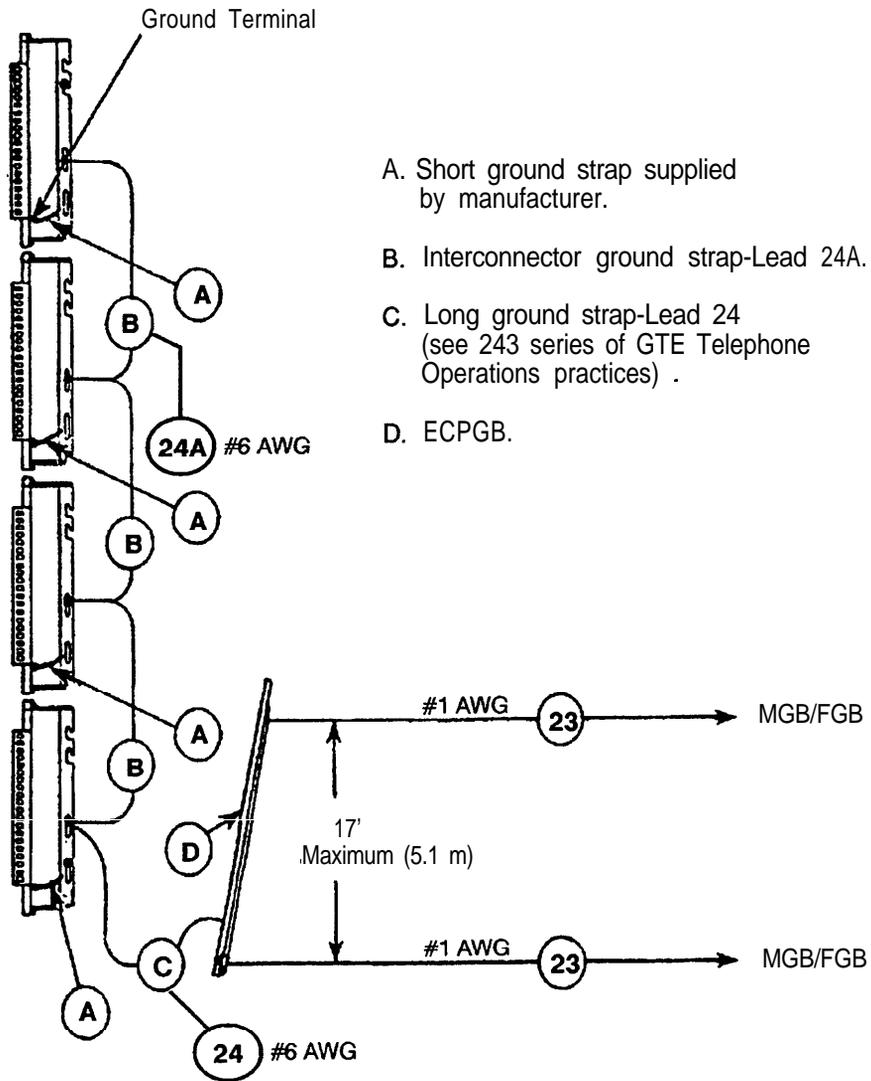
13. Entrance Cable Protector Ground Bar, continued

13.2

Description of the ECPGB, continued

The ECPGB is a copper bar attached horizontally across the top or bottom of the:

- MDF.
- OR
- PDF.



13. Entrance Cable Protector Ground Bar, continued

13.3 Grounding the Protectors

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

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

Lead 23 will be placed starting at protector vertical #1 and every 17 feet (5.1 m) thereafter so that no protector is more than $8\frac{1}{2}$ feet (2.5m) from a Lead 23. Where the bar exceeds $8\frac{1}{2}$ feet (2.5m) but is less than 17 feet (5.1m), a minimum of two Lead 23's 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 $8\frac{1}{2}$ feet (2.5m) from the first protector vertical.

No protector vertical **is** to be more than $8\frac{1}{2}$ feet (2.5m) from any Lead 23.

13.4 Protector Modules

Use standard five-pin solid-state protector modules, as indicated in GTE Telephone Operations Practice 887-903-026.

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

13.5 Leads 23 and 24

Leads 23 and 24 are:

- Sized in accordance with Exhibit 6.
- The only ground leads that may be terminated on the ECPGB.

Lead 24 is to be:

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

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

13. Entrance Cable Protector Ground Bar, continued

13.6 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 one of the following:
 - DC power cables.
 - Switchboard cables.
 - High-frequency cables.
- Avoid or minimize runs of Lead 23 or 23A parallel with:
 - DC power cables.
 - Switchboard cables.
 - High-frequency cables.
- Run Lead 23A from the MGB or FGB to the carrier system protectors in the transmission systems area. (Refer to Section 23.6.) Use Leads 24 and 24A as required.
- Locate the MDF on the same floor with the local switching system to maintain equal potentials.

NOTE: Non-GTE Standard arrangements where the MDF is on one or more floors from the switching system are to be referred to GTE Telephone Operations Headquarters Support Staff.

13.7 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 13.2.

14. Cable Vault Ground Bar

14.1 The CVGB is a copper grounded bar in the cable vault (see Exhibit 17).

Description

14.2 Use the procedure shown in the following chart before installing the CVGB and connectors.

Cleaning Procedure

Step	Before Installing CVGB and Connectors
1	Clean the contact surfaces of connectors and the CVGB (see Section 3.10).
2	Apply a thin coat of conductive copper-based joint compound (MC #760293 or equivalent).

14.3 Do not use the CVGB as a tie point for any ground leads other than Leads:

Restrictions

- . 16.
- . 16A.
- 17.
- 17A.

Lead 16 may be terminated directly to Lead 17 without a CVGB:

- For very small COs.
OR
- Where a pedestal or manhole outside the building serves as the cable splice point.

14.4 Use the CVGB to terminate the ground leads from the cable shields (Lead 16A or 17) of all incoming cables. Use compression-type lugs.

Connections

Connect the CVGB through Lead 16 to the MGB (see Exhibit 6).

14.5 The CVGB is typically placed by L&B Engineering. L&B Engineering is also responsible for Lead 16.

CVGB Lead Responsibilities

Leads 16A, 17, and 17A are the responsibility of OSP Engineering and Construction. See the following chart.

If...	Then...
The CVGB does not exist and the MGB is more than 20 feet (6m) from the cable entrance	L&B must install a Lead 16 from the MGB to the opposite end of the ironwork supporting the OSP cable. See Exhibit 25.

14. Cable Vault Ground Bar, continued

14.6

Lead Explanations

The following chart lists and describes the leads (see Exhibits 17 and 25).

Lead	Explanation
16	A continuous 1/0 AWG ground wire lead extending from the MGB to the CVGB or opposite end of the ironwork when a CVGB is not required. All cable support racking must be grounded to lead 16 when the CVGB is absent. Lead 17 bonds to Lead 16 when the CVGB is not required.
16A	A continuous 1/0 AWG ground wire lead extending from the CVGB to the opposite end of the ironwork. All cable support racking and Lead 17 must be grounded to Lead 16A.
17	A continuous #6 AWG ground wire extending vertically between all cable support racks and 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: <ul style="list-style-type: none">• 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 GTE-approved ground clamp or compression fitting where applicable. NOTE: Bends in grounding leads must consist of not less than one 6-inch (0.15m) inside diameter radius.
17A	A continuous #6 AWG grounding wire extending from: <ul style="list-style-type: none">• A Fiber Optic (FO) closure to the CVGB when the FO cable has metallic members or cable shields.• The fiber optic cable shields and metallic members of rack-mounted FO splice shelves. This lead bonds to Lead 17B above the rack.
17B	A #1 AWG lead from the rack-mounted FO splice shelves to the MGB/FGB.

NOTE: Each vertical member of the vault cable racking or ironwork in the vault should be bonded to Lead 16 (CVGB is absent) or 16A (CVGB is present).

14.7

Wall Frames

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

- Is on an exterior wall at the point where the OSP cable facilities enter the building.
- Must be grounded to Lead 16 or 16A.

14. Cable Vault Ground Bar, continued

14.8 Grounding support ironwork

Refer to the following chart to determine the method of grounding the support ironwork.

If a CVGB...	Then...
Is present	All metallic vertical support members of the cable ironwork (unistrut) in a cable vault area must be connected to the CVGB via Lead 16A.
Is <u>not</u> present	All metallic vertical support members of the ironwork (unistrut) in a cable vault area must be connected to the MGB via Lead 16.

14.9 Installing the CVGB

Refer to the following chart to determine when a CVGB is required.

When the MGB Is...	Then...
In the cable vault	Omit Lead 16 and the CVGB.
On the ground floor and the cable vault is the only structure below grade level (refer to Exhibit 25)	Run Lead 16 from the MGB to the CVGB without the need for a VE.

Whenever possible, the MGB must not appear in the cable vault. This is especially true when the vault is:

- Not environmentally controlled.
OR
- The only structure below grade level.

15. Grounding Conductor Requirements

15.1 Leads Where Ground Loops Need Not Be Avoided

Ground loops need not be avoided outside the IGZ or isolated area of the switch. The integrated ground plane is not a single-point ground system.

Some ground loops are acceptable in the following components of the grounding system:

- Office Grounding Electrode (Section 5).
- AC Power Service (Section 6).
- Entrance Cable Bonding (Section 13).
- Radio/Microwave Systems (Section 24).
- Lightning Protection System (Section 25).

15.2 Lead Constraints

Lead 1 is a continuous tinned bare copper conductor spliced to itself once.

Grounding leads must:

- Be continuous conductors without intermediate splices.

NOTE: Splices with either exothermic welding or with listed irreversible compression-type connectors are acceptable; however, these splices should be held to a minimum.

- Not be installed in metal conduits.
- Not be encircled by metallic clamps.

15.3 Installation Requirements

All leads must be installed in the most direct and straight manner practical. Leads should be terminated on the nearest MGB or FGB on the same floor level. Lead 18's and 53A's are the only leads intended to extend between floors.

All deviations must be approved per GTE Telephone Operations Practice 887-000-001.

15.4 Lead Responsibilities

The functional responsibilities for the ground provisioning of the grounding conductors are described in the following sections.

15.4.1 L&B Engineering

L&B Engineering 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.

15. Grounding Conductor Requirements, continued

15.4 Lead Responsibilities, continued

15.4.1 L&B Engineering, continued

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

The contractor is to be furnished with a list of GTE Standard materials that may be used. L&B Engineering 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 sold copper wire, MC #529542).

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

15.4.2 Adminstrator - 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 on an ED (see GTE Telephone Operations Practice 830-000-001), a copy of which is to be furnished to L&B Engineering. The entire process is described in GTE Telephone Operations Practice 740-250-070.

15.4.3 Switching and/or Transmission Engineering

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 installed (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, rectifiers, etc. must be specified in accordance with the NEC.

15. Grounding Conductor Requirements, continued

15.4 Lead Responsibilities, continued

15.4.4 OSP Construction

OSP Construction (OSPC) is responsible for placing the following leads:

- 16A
- **17.**
- 17A.
- 17B.
- 24.
- 24A

15.4.5 COE Construction

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.

15.5 Size Limitations

The conductor sizes in Exhibit 6 under the heading AWG Standard (STD) require that all equipment be within a 200 x 200 foot (60 x 60m) square centered on the MGB-VE-FGB system. If not, a second system of FGB-VE-FGB is required. (Refer to the illustration in Section 10.1.)

In all cases:

- VEs must be no more than 200 feet (60m) apart.
- Telephone equipment should be located on a given floor level:
 - Within 142 feet (43m) centered around the MGB/FGB.
 - With the grounding cable length not exceeding 200 feet (60m).

If the equipment exceeds these dimensions, additional VE/FGB and HE are required.

NOTE: For electronic offices of any size, refer to the AWG-DIGITAL column of Exhibit 6.

15. Grounding Conductor Requirements, continued

15.6 Small Space Needs

When all of the equipment on one floor is within a 100-foot (30m) square centered on the MGB and only electromechanical switching equipment is present, the conductor sizes in Exhibit 6 should be used.

NOTE: Requirements for small digital offices, huts, and DLCs are included in GTE Telephone Operations Practice 795-805-075.

15.7 Lead 15 Horizontal Equalizers

Lead 15 Horizontal Equalizers (HEs) are required to bond VEs together at:

- The lowest floor.
- Every floor thereafter.

15.8 Horizontal Equalizers Required

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

The HEs placed between temporary or portable buildings must be placed in nonmetallic conduit.

15.9 Adjacent Structures

If two adjacent structures used for a CO share AC entrance services, they are to be treated as one structure for the purposes of grounding and protection.

15.10 Maintaining Same Floor Ground Resistance

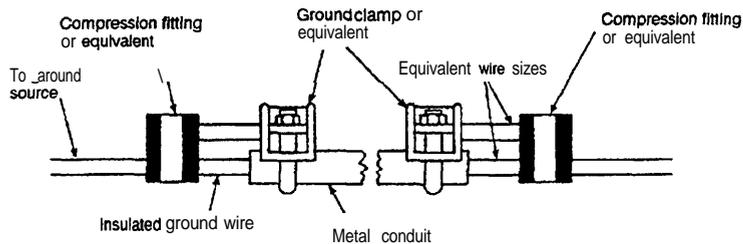
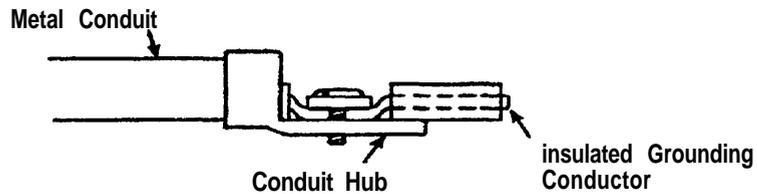
Unless specified otherwise, all grounding conductors should be terminated on ground bars on the same floor level in order to maintain an equal ground reference to all equipment on the same floor. The leads should be clearly labelled at each individual ground bar.

15. Grounding Conductor Requirements, continued

15.11 Rules for Handling Grounding Conductors

Handle the grounding conductors discussed in this practice as described in the following procedure.

Step	Rules for Handling Grounding Conductors
1	Use copper base and insulated material to allow continuity testing.
2	<p>Run:</p> <ul style="list-style-type: none"> • Only in nonmetallic conduit. <p>OR</p> <ul style="list-style-type: none"> • Not in conduit. <p>NOTE: When metallic conduit is already in use or cannot be avoided, bond both ends of the conduit to the grounding conductor per the following illustrations. (The first method illustrated is preferred.) This reduces grounding conductor lightning surge impedance. See Section 18.3 for exceptions for the green wire.</p>
3	Run only through nonmetallic sleeves in ceilings, floors, and walls.

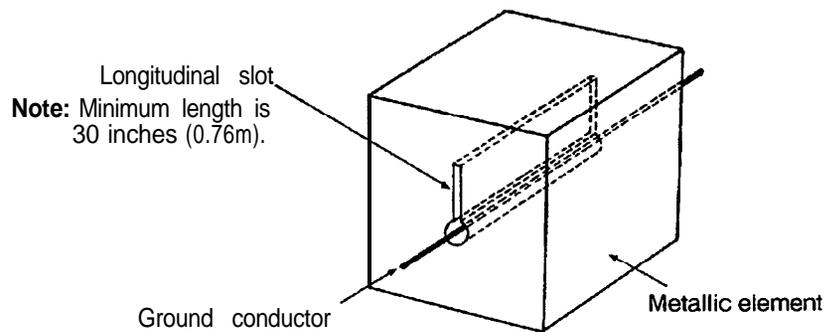


(continued)

15. Grounding Conductor Requirements, continued

15.11 Rules for Handling Grounding Conductors, continued

Step	Rules for Handling Grounding Conductors
4	<p>Observe the following restrictions:</p> <ul style="list-style-type: none">• Do not encircle with metal clamps.• Do not run ground conductors through openings of less than 1 square foot (0.1 square meter):<ul style="list-style-type: none">- Metal walls.- Metal plates.- Cable racking.- Short sections of metal conduit or duct.• Do not run ground conductors (Leads 4 through 26, and 55 and 56) with less than 1-foot (0.3m) separation from:<ul style="list-style-type: none">- DC power cables.- Switchboard cables.- High-frequency cables.• Do not run ground conductors (Leads 4 through 26, and 55 and 56) within 3 feet (0.9m) of processor and/or memory frames.
5	<p>If the ground conductor must be run through metallic elements, cut a longitudinal slot (see the following illustration):</p> <ul style="list-style-type: none">• In the metallic element to interrupt the periphery of the hole for the grounding conductor.• Through the entire depth of the metallic element.



(continued)

15. Grounding Conductor Requirements, continued

15.11 Rules for Handling Grounding Conductors, continued

Step	Rules for Handling Grounding Conductors
6	<p>Keep bends in conductors to a minimum. Conductor bends should have a large radius. Bends for appearance are prohibited. Minimum bends are:</p> <ul style="list-style-type: none">• 6-inch (0.15m) minimum for up to No. 6 gauge.• 12-inch (0.30m) minimum for up to No. 4/0 gauge.• 24-inch (0.60m) minimum for sizes greater than No. 4/0 gauge. <p>NOTE: VE and HE should avoid bends. If unavoidable, use a 36-inch (0.9m) minimum radius.</p>
7	<p>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 to 1000 amps in 10 microseconds, the inductance of the ground lead will build up a voltage of 40 volts per every foot.</p>
8	<p>Multiple conductors with equivalent cross-sectional area may be substituted in place of a single minimum sized conductor identified in:</p> <ul style="list-style-type: none">• Exhibit 6.• Exhibit 9. <p>NOTE: This generally provides equal or better protection. However, each smaller conductor must be restricted to the minimum turn radius of the larger single conductor listed in this practice.</p>

16. Integrated and Single-Point Ground Systems

16.1 This practice includes two types of ground systems:

- Types of Ground Systems**
- Integrated.
 - Isolated (or single-point).

16.2 Integrated Ground System

In the integrated ground system, the grounded positive battery distribution is not isolated, but may be connected by design in many places or incidentally to the:

- Building ground system.
- Building steel.
- Concrete floors.
- Superstructure.

16. Integrated and Single-Point Ground Systems,

continued

16.2 Integrated Ground System, continued

integrated grounding electronic switching systems and transmission equipment engineered before March 1990 use the discharge ground (return ground or plus battery) cable to ground the bays. Do not use the following leads:

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

Isolate DC power bus bars in power frames from the:

- Building structure.
- Superstructures.
- Equipment frames.

Where electronic switches and digital switches are added in the building where integrated ground planes exist, this procedure eliminates return currents in basic ground leads, especially in the VE and HE leads. Ironwork between the integrated and single-point grounding systems should be separated.

NOTE: It may be necessary to revamp the DC power system to obtain these results.

16.3 Single-Point Ground System

In the Single-Point Ground (SPG) system, also called Isolated Ground, the positive battery, circuit ground, or discharge ground does not contact other grounds except at a single point. This configuration is required for all:

- Digital switches.
- Analog electronic switching systems.
- Transmission equipment frames engineered after March 1, 1990.
- Existing transmission frames creating noise or other problems (see Section 4.3).

Refer to GTE Telephone Operations Practice 795-805-073 for additional information on the grounding of transmission-related equipment.

Separate:

- All frames with an integrated ground system from electronic isolated ground frames. Refer to GTE Telephone Operations Practice 237-224-214.
- Each electronic system entity from the others.

Refer to GTE Telephone Operations Practice 795-002-071. Maintain a physical separation of the feeders to each electronic system of at least 1 foot (0.3m).

16. Integrated and Single-Point Ground Systems,

continued

16.4 Grounding the Grid or Runway System

Lead 57 is required to bond the cable grid or runway system to the FGB/MGB. The following procedure should be used.

NOTE: Lead 57 is optional for existing installations (before January 1994).

Step	Bonding the Cable or Runway System to the FGB/MGB
1	Connect Lead 57 to a centrally located area of the grid or runway system.
2	Use a two-hole compression lug to attach this lead to the cable grid or runway system.

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

16.5 Chassis Grounds

Use the following procedure to identify chassis grounds associated with integrated equipment mounted within isolated digital and analog electronic switching systems.

Step	Identifying Chassis Ground
1	Determine if the chassis grounds exist by visually inspecting the unit to see if a power conductor is bonded to the chassis.
2	If none are noted, use a volt-ohmmeter (VOM) or digital multimeter (DMM) with R X 10,000 selector range.
3	CAUTION: Disconnect the input power conductors from the equipment to be tested. Failure to take this step may: <ul style="list-style-type: none">• Endanger personnel.• Damage the equipment under test and test equipment.
4	Touch the negative VOM or DMM lead to the metal frame of the device being tested.

(continued)

16. Integrated and Single-Point Ground Systems,

continued

16.5 Chassis Grounds, continued

Step	Identifying Chassis Ground						
5	With the input power conductors disconnected from the equipment under test, and with the power switches in the ON position, alternately touch the VOM or DMM positive probe to each of the input power conductors and the negative probe on the frame.						
	<table border="1"><thead><tr><th>For...</th><th>Touch...</th></tr></thead><tbody><tr><td>AC-powered equipment</td><td><ul style="list-style-type: none">• Phase.• Neutral.• Green wire ground.</td></tr><tr><td>DC-powered equipment</td><td>Each power conductor.</td></tr></tbody></table>	For...	Touch...	AC-powered equipment	<ul style="list-style-type: none">• Phase.• Neutral.• Green wire ground.	DC-powered equipment	Each power conductor.
For...	Touch...						
AC-powered equipment	<ul style="list-style-type: none">• Phase.• Neutral.• Green wire ground.						
DC-powered equipment	Each power conductor.						
	NOTE: Each VOM and DMM reading must be 25 megohms or more to indicate no chassis ground.						
6	Repeat the procedure with the: <ul style="list-style-type: none">• Positive VOM or DMM probe on the device frame. OR <ul style="list-style-type: none">• Negative probe on each input power lead.						
7	If a DC chassis ground exists, remove it where practical. An AC chassis ground (green wire ground) must not be removed.						
8	Repeat the tests to verify compliance where the DC ground was removed.						

(continued)

16. Integrated and Single-Point Ground Systems,

continued

16.5 Chassis Grounds, continued

Step	Identifying Chassis Ground
9	<p>When these procedures fail to provide compliance, where the removal is impractical, and where this is an AC chassis ground, place insulating hardware between the:</p> <ul style="list-style-type: none">● Unit.● Equipment frame. <p>NOTE: When an AC chassis ground exists and the DC chassis removal falls to comply or the DC chassis removal is impractical, the unit may not be used within the isolated electronic switching system. Follow the unsatisfactory condition report procedures to resolution.</p>

NOTE 1: Test equipment that requires a frame ground must be bonded to a positive 50-volt input after the frame is insulated to ensure correct operation.

NOTE 2: Chassis isolation is not intended to remove all grounds from the chassis of equipment. Isolation methods and materials are provided to prevent positive battery or green wire from being tied to the frame ground. A chassis ground is still required for safety reasons even when the chassis is isolated from the positive battery or green wire.

16.6 Six-Foot Rule

Some manufacturers have a so-called "six-foot" (2m) rule that:

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

Within GTE, the six-foot (2m) rule does not apply when the digital switching equipment is on the same floor level with the MGB/FGB that also serves the integrated equipment in the intermediate area with the digital switches.

NOTE: The six-foot (2m) rule must be applied only where the digital switch is on a different floor level from the DC power plant.

17. DC Power System Grounding

17.1 Locating Power Plant Return Bus Bars

Locate the power plant return bus bars in or above the:

- Power control and distribution units.
- PDUs.
- Battery.
- Chargers.

17.2 Isolating the Power Plant Return Bus Bar

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

- Lead 37 connects the return ground battery terminal to the nearest MGB or FGB on the same floor.
- Lead 38 connects the FGB to the PDU battery return bus.

CAUTION: Do not use Lead 38 on the same MGB/FGB where Lead 37 is used for the same power plant, except when the equipment layout exceeds wiring limits (see Section 15.5).

17.3 Selecting the DC Power System Grounding Point

Selecting the DC power system grounding point:

- Must be done carefully.
- Is a function of the physical constraints of the:
 - Building (single floor, multifloor).
 - Location of the various pieces of communications equipment in the building.

17.4 Installing Lead 37 or 38

Install Lead 37 or 38 as follows.

For...	Do the Following...
Single and multiple floor structures	<p>In the most direct manner, run Lead 37 from the positive battery terminal, or bus bar just above the terminal, to the MGB/FGB on the same floor.</p> <p>In multiple string battery plants, use the terminal of the battery electrically nearest the charger.</p> <p>WARNING: Never use the PDU return bus as a termination point for Lead 37.</p>
Transmission systems and other peripheral equipment PDUs	<p>When such a PDU is in an area served from an MGB/FGB other than where Lead 37 from the serving power plant is terminated, run Lead 38 from the PDU return bus to the MGB/FGB. Omit Lead 38 when using single-point grounding concept.</p>

(continued)

17. DC Power System Grounding, continued

17.4

Installing Lead 37 or 38, continued

For...	Do the Following...
Electronic switching systems on the same floor or one floor above or below the DC power plant	Omit Lead 38.
Electronic switching systems two or more floors above or below the DC power plant	Run Lead 38 from the PDU return bus bar to the FGB on the same floor.

17.5

Determining Gauge of Leads 37 and 38

Lead 37 must be:

- 2/0 AWG if the:
 - Office drain is less than 200 amps.
 - Lead is less than 30 feet (9m) long.
- 350 kcmil if the:
 - Building is one story (no VE lead 18 used).
 - Office drain is less than 500 amps.
 - Lead is less than 50 feet (15m) long.
- 750 kcmil if the:
 - Building is multistory.
 - Office drain is more than 500 amps.
 - Lead is more than 50 feet (15m) long.

Lead 38 must always be 750 kcmil.

NOTE: Requirements for small digital offices, huts, and DLCs are included in GTE Telephone Operations Practice 795-805-075.

17.6

Grounding Frames and Components

Ground various frames and other component units of a power plant which are not afforded equipment grounding by electronic continuity to the MGB through ground bars in contact with metal frames. These components:

- Include frames in a powerboard lineup, battery charger bays, and the metallic battery stands.
- Are bonded by an individual #6 AWG conductor extended to a 2/0 AWG aisle run (Leads 31 through 36).

17.7

Bonding Bus Duct Housing

Bond together adjacent sections of bus duct housing with a #6 AWG conductor (Lead 39) if the housing is strictly used as a protective device against equipment damage. A run of the same conductor size (Lead 40) must be run to the MGB and FGB on each floor. See:

- Section 23.2.
- Section 23.3.
- Section 23.4.
- Exhibits 1 through 5.

17. DC Power System Grounding, continued

17.8 Bonding the DC Power Plant Reference Lead

The DC power plant reference Lead 37 bonds to the return bus at or above the battery. To ensure that the lowest possible ground reference is maintained at the rectifiers and battery of electronic offices, do not insert any intentional resistive device between the rectifiers and battery:

- Positive return bus.
- OR
- Positive return conductor cabling.

17.9 Gauge and Connectors of Lead 53A

Select the gauge of Lead 53A for the chart shown in Exhibit 22. Run Lead 53A along with the power cables feeding the PDU all the way to the source at the battery room. Provide a bond to each section of cable rack with a maximum of 15 feet (4.5m) between bonds. From the battery room to the MGB or FGB keep Lead 53A close to Lead 37 or 38.

Connect Lead 53A to the frame at the PDU.

NOTE: Lead 36 is not required when Lead 53A is provided.

18. AC Power Service Wiring Requirements

18.1 Grounding Commercial Electric Power Service

GTE's electrical contractor must provide the ground connections of the commercial electric power service. The commercial electric power must be grounded in accordance with:

- Exhibits 1 through 5.
- Exhibit 6.
- Exhibits 9 and 10.
- GTE Telephone Operations Practice 795-805-072.

Bonding such things as the solidneutral bus of the main commercial power service and the water pipe on the MGB must not replace the need to separately bond the commercial electric power service as describe in Section 6.4.

18.2 Service Neutral Equalized to Telephone Equipment Area

Each SPC electronic and digital switching equipment area should be **no** more than one floor level from an AC service disconnect panel to minimize:

- Functional problems with equipment.
- Failures from AC surges and lightning.

18.2.1 Separately Derived Systems

For new construction, separately derived systems are not recommended.

NOTE: When a separately derived system is unavoidable, it must be installed and grounded as specified in GTE Telephone Operations Practice 795-805-072.

18. AC Power Service Wiring Requirements, continued

18.2 Service Neutral Equalized to Telephone Equipment Area, continued

18.2.2 Isolation Transformers

Step-down or isolation transformers not associated with a separately derived system may be provided on the different floor levels. The neutral should be extended from the serving AC enclosure to the neutral point on the secondary side of the transformer.

18.3 Ensuring an Adequate Ground Fault Return Path

To ensure an adequate ground fault return path:

- Provide a green wire grounding conductor.
 - o Enclose the green wire in the metallic raceway or conduit with the phase conductors for all branch circuits serving telephone equipment areas and DC power plants.

Secure the green wire to the:

- Main and branch service enclosure ground bus (not neutral bus).
- Equipment closure or frame at the apparatus being serviced by the AC supply.

Equipment green wire grounding conductors must be:

- Insulated.
- Sized per NEC 250-95 to safely carry the expected fault current.

18.4 Grounding Conductors

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

- This practice.
- The local building code.
- The NEC (see GTE Telephone Operations Practice 795-805-072).

18.5 Grounding Fixtures

Use Nationally Recognized Testing Laboratory (NRTL) listed fixtures to:

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

18.6 AC Surge Arresters

AC power surge arresters are required. See GTE Telephone Operations Practice 795-805-072.

18.7 Furnishing Lead 13

Lead 13 from the AC power service main should be furnished to the master or floor ground bar on the same floor level.

For multiple floor situations, the FGB where Lead 13 terminates must be associated with the VE above the MGB.

Lead 13 does not replace the need to separately bond the commercial electric power service (Leads 4 and 8) as stipulated in Section 6.4.

Refer to Exhibits 1 through 5.

18. AC Power Service Wiring Requirements, continued

18.8 Use bonding leads per the following chart.

Bonding Leads 20 and 20A

Step	Bonding Leads 20 and 20A
1	Bond #6 AWG Lead 20 from each AC branch or subpanel ground bar (not neutral) serving battery chargers, lighting, and receptacles in telephone equipment areas to the MGB/FGB on the same floor.
2	Bond Lead 20A from the AC disconnect enclosure neutral bus of existing separately derived sources, to the MGB/FGB on the same floor.
3	Use Exhibit 10 to size Lead 20A. NOTE: Lead 20A should not be smaller than #6 AWG.

18.9 AC Conduits

AC conduits must be nonmetallic just before contacting, and within, electronic frames to prevent defeating electronic frame ground isolation. If metallic conduit is used, it must be isolated from the frames. AC branch circuits serving electronic systems must not extend outside the electronic system to serve other AC-operated equipment.

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

18.10 Isolated AC Service Lead 45

Install isolated AC service per the following chart.

Step	Installing AC Service Lead 45
1	Run isolated AC service Lead 45 from the AC power neutral in the main AC enclosure, via intermediate panels and conduit without connection, to the branch enclosure serving orange outlets. NOTE: The lead is isolated in all intermediate panels and final enclosure.
2	Use green wire with yellow tracer or mark the lead with yellow tape at each AC enclosure. Orange outlets should not be served by separately derived systems. (See GTE Telephone Operations Practice 795-805-072, Exhibit 12.) NOTE: Lead 45 is a #6 AWG (minimum). See Exhibit II.

18.11 Receptacles for Test Equipment

Isolated AC ground receptacles (orange) should be provided for test equipment purposes. Lead 46 is the isolated green wire extended from Lead 45 to the orange receptacle (outlet). Lead 46 should be a green wire:

- With a yellow tracer.
OR
- Marked with yellow tape.

18. AC Power Service Wiring Requirements, continued

- 18.12
Integrated
Grounding
Frames** Serve integrated grounded frames with nonisolated (brown) AC-grounded outlets on separate branch circuits from those serving the isolated frames, unless dedicated receptacles for testing are required.
- 18.13
AC-Powered
Test Equipment** When the test equipment is AC powered, isolated (orange) AC receptacles must be used.
The nonisolated outlets must not be mounted in the regular strip at the base of the equipment bays.
- 18.14
Other
AC-Powered
Equipment
Mounted in
Frames** Any other AC-powered equipment (e.g., printers, power supplies, CRTs, modems) must be served by nonisolated (brown) AC outlets with nonmetallic:
- AC conduits.
 - Receptacle boxes.
 - Covers.
- In special cases, AC-powered equipment (other than test equipment) may be mounted within the isolated equipment frames. In these cases, a separate green wire (Lead 30) and separate AC service conductors are provided using only nonmetallic hardware (conduit, box, cover) with the receptacle mounted above the kick plate area.

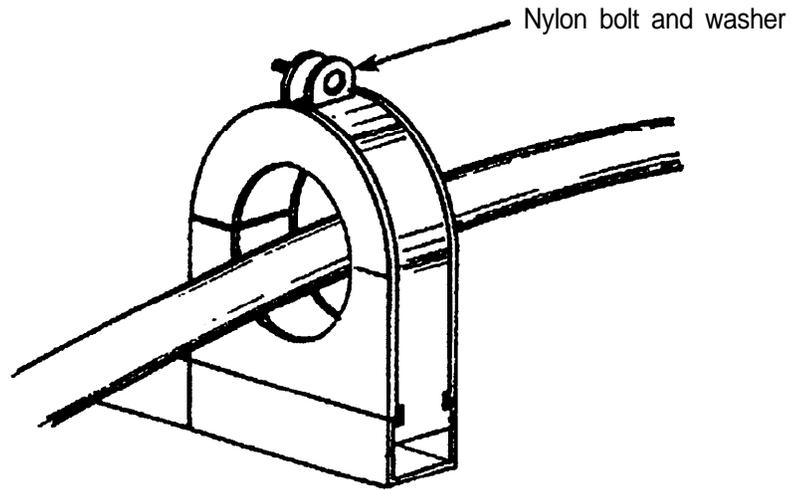
19. Entrance Cable Requirements

- 19.1
Standard
Practice** In COs where exchange and trunk cables are brought into the building, it is standard practice to:
- Bond the shield of each cable with Lead 17 upon entry.
 - Terminate the grounding conductor on a CVGB (see Exhibit 17).
- NOTE: The CVGB is bonded to the MGB via Lead 16 (see Section 14).**
- 19.2
Parallel
Grounding Path** Lead 23 from the ECPGB to the MGB/FGB provides a parallel path. Shields are bonded through the tip splice, because tip cable shields are connected to the ECPGB (as in prestubbed protector/connector).
- 19.3
References** Refer to the following GTE Telephone Operations practices for additional and specific bonding and grounding procedures for OSP cables entering a CO:
- 605-100-100.
 - 605-100-201.
 - 903-020-070.

19. Entrance Cable Requirements, continued

19.4 Using Metal Clamps

if metal clamps are used to support OSP cables (tip cables inside buildings), nylon bolts and washers must be used to break up the metal circles around the cables (see the following illustration).



19.5 Grounding Requirements

All OSP cables containing a metallic shield or strength member must be bonded to the CO grounding system as they enter. 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 the point of entry (within 50 feet [15m]).

Some offices do not have a cable vault but do have wall frames to support the OSP cables. See Sections 14.7 and 14.8.

19.6 OSP Fiber Optic Cable

Metallic members in an OSP optical fiber cable if less than 50 feet (15m) may extend directly to the FO splice shelf, which could be in the:

- Vault area.
OR
- Switchroom area.

When the Splice Shelf Is...	The Metallic Members...
in the vault	Are bonded per Sections 14 and 19.1.
in a frame in the switchroom	Must be treated similar to an HF copper cable described in Section 23.

19. Entrance Cable Requirements, continued

19.7 Fire Rating Requirements

NEC 800-49 requires that communications wires and cables installed as wiring within a CO building must be listed as being resistant to the spread of fire.

Listing is not required where the cable in the building is not more than 50 feet (15m) long (NEC 800-50, Exception 3).

The code is intended to:

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

19.7.1 Buildings with Fire-Proof Cable Vault Areas

The OSP cable (nonfire rated) must be transitioned to a rated cable at a point not to exceed 50 feet (15m) from the point of entry into the vault.

19.7.2 Buildings without Fire-Proof Cable Vault Areas

NOTE: It is not the intent of this section to endorse or imply a wholesale program to retrofit existing entrance cables that do not have fire-rated sheaths and do not meet the above recommendations.

The OSP cable (nonfire rated) must be transitioned to a rated cable at a point not to exceed 50 feet (15m) from the point of entry into the building. The cable is to be fire-taped from the point of entry to the point of transition.

NOTE: This is also applicable in buildings where there is no separation between the cable entry area and the switching or transmission equipment.

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

20. Electromechanical Switching System Grounding

20.1 Grounding Frames

The frames of electromechanical switching systems must be grounded in accordance with Exhibits 1 through 5 using Leads 47 through 49.

20.2 Upgrading Existing Electro- mechanical Offices

Upgrade the existing electromechanical offices when:

- They are colocated with an electronic system.
- Required by the conditions in Section 20.3.

Make grounding updates if an existing electromechanical office grounding system:

- Is detrimental to:
 - Personnel safety.
 - Equipment operation.
 - Reliable service.
- Requires reducing circuit noise levels.

20.3 Dealing with Building Additions

Whenever building additions are made to expand the electromechanical areas:

- Improve grounding and protection whenever practical.
- Make no effort to add the following leads:
 - 3.
 - 14.
 - 20.
 - 33 through 36.
 - 47 through 49.
- Provide grounding Leads 47 through 49 to bays containing solid-state equipment.

NOTE: Digital equipment in these buildings must have Leads 41, 41 A, 58, 58A, 59, and 59A.

21. Electronic Switching System Equipment Frame Grounding

21.1 Introduction

Each equipment frame must be bonded to the CO grounding system:

- New installations and new equipment lineups must follow Exhibit 18 using Leads 41, 58, and 59.
- Existing sites may follow Exhibit 19 using Leads 41 through 44 to complete existing equipment lineups. Methods from Exhibits 18 and 19 must not be used together in the same continuous equipment lineups.

21 .Electronic Switching System Equipment Frame Grounding continued

21.2 Grounding Equipment Frames

Use the following procedure to ground equipment frames.

Step	Grounding Equipment Frames
1	Run the primary frame ground Lead 41 from the MGB/FGB of the main aisle, perpendicular to the equipment frame lineups.
2	Install Lead 58 down each aisle of electronic equipment (Exhibit 18).
3	Bond Lead 58 (which must be #2 AWG) to Lead 41.
4	Bond Lead 58 to each frame with #6 AWG (Lead 59). NOTE: For the standard sizes of the frame ground lead(s), refer to Exhibit 6. RESTRICTION: Lead 59 must not be longer than 5 feet (.5m) to minimize ground loop size formed between two adjacent frames, the No. 59 leads, and the associated Lead 58.
5	Place one Lead 41 on each side of the cable runway to avoid crossing the runway with Lead 58 (see Exhibit 18).
6	Connect Lead 41 to the MGB/FGB by the most direct route (see Exhibit 18.)
7	Use Lead 54 to ground: <ul style="list-style-type: none">• Storage cabinets containing static-sensitive circuits.• Workbenches or work stations where static-sensitive circuits are handled.• Static mats.

21.3 Keeping System Grounding Updated

All new electronic switching systems (analog or digital) must be installed per the latest available GTE practices and specifications. The grounding for the existing electronic switching systems (analog or digital) should be kept up to date with manufacturer's recommendations and specific retrofit policies of GTE Telephone Operations.

Required updates may be done at the next major power or equipment addition or rearrangement.

22. Electronic Ground

22.1 Introduction

Electronic systems cannot tolerate excessive transient voltages that can be carried by the grounding system. The high-speed solid-state switching logic is insulated from the equipment frame. Its DC power leads are kept separate and isolated all the way back to the battery or DSU.

22.2 GTD-5 Low-Voltage Ground

Use the following chart to run the low-voltage ground (LVG) from the low-voltage circuit ground plane.

When Sewed by...	Take the Following Action...
A single PDU	Run the ground with one or more conductors from the PDU DC power positive return bus to the switch area.
Multiple PDUs	Establish an isolated LVG copper bus at a central location in the switch area. Run one or more conductors from the LVG bus to the switch area. Run a single 500 kcmil insulated conductor from the LVG isolated bus to the common DC power positive return point. The common DC point is where the feeder conductors (bus or cable) serving the multiple PDUs originate (multiple together) and are supplied from a common source.

NOTE 1: me LVG must **not** connect to the MGB or FGB.

NOTE 2: Some vendors might use terms such as *signal ground* or *logic ground*. The requirements for other vendors might be different from those presented in this section; if so, the vendor's practices take precedence.

22.3 E&M Signaling

Some switching equipment is required to use approved Type II E&M signaling adapters, which:

- Must be used to convert Type I transmission equipment to Type II E&M.
- Must be in the transmission equipment area and powered by the PDU serving the transmission equipment.

NOTE: Consider analog-to-digital channel banks as an alternative to avoid this situation.

Battery and ground pulsing trunks must **not** be used with digital systems.

NOTE: The requirements for other vendors might be different from those presented in this section; if so, the vendor's practices take precedence.

22. Electronic Ground continued

22.4 High-Frequency Lines

The high-frequency T-carrier type lines in digital switching systems must have shields grounded at the switching system end of the cables. The digital cross-connection (DSX) end of such cable shields must be ungrounded.

Cables from the DSX to the transmission equipment must have shields grounded at the transmission equipment end only. Do not bridge the DSX ends of T line shields across the DSX.

NOTE: The requirements for other vendors might be different from those presented in this section; if so, the vendor's practices take precedence.

22.5 Miscellaneous Circuits

Some miscellaneous circuits entering or leaving the digital switching system must be converted to isolated balanced circuits with isolated dry contacts on one end with both battery and ground supplied. This prevents battery or ground from defeating frame isolation by:

- Entering from a foreign source
- OR
- Leaving to a foreign path.

NOTE 1: Examples of miscellaneous circuits are:

- Sense and control leads.
- Supervisory circuits.
- Alarm circuits.
- Data circuits.

NOTE 2: The requirements for other vendors might be different from those presented in this section; if so, the vendor's practices take precedence.

22.6 Optional and Nonoptional Connections

Some vendors' equipment often provides optional and nonoptional connections between input power and the unit chassis. Optional connections must be removed for isolated electronic systems. The following usually contain the optional connections:

- Ringing machines.
- Coin telephone converters.
- DC-DC converters.

Any units with nonoptional chassis grounds must be electrically isolated from the telephone equipment frame and other rack-mounted equipment. If chassis grounding of equipment is unknown:

- Assume that it has nonoptional chassis grounds.
- Electrically isolate it from the telephone equipment framework.

This chassis-to-frame isolation is also required for AC-powered equipment where the AC green wire ground attaches to the chassis of the unit.

NOTE: See Section 16.5 to identify chassis grounds handling frame grounds for test equipment.

22. Electronic Ground, continued

22.7 Using Separate PDUs

Feed each electronic system from a separate PDU or split PDU having separate return ground bar and separate power feed conductors back to the Disconnect Switch Unit (DSU) or battery.

22.8 Separations

Any integrated ground frame, PDU, or battery charge bay in the same lineup with electronic systems must be:

- Relocated.
OR
- Physically separated and electronically isolated from adjacent electronic frames, but remain integrally grounded.

Electronically isolate all electronic switching system equipment bays for such things as the:

- Floor.
- Ironwork.
- Building.
- AC conduits.

23. Transmission Systems and Terminal Equipment Grounding

23.1 Introduction

Transmission systems (e.g., microwave, radio, and carrier-FDM or -PCM), related terminal equipment, and testboards require a different approach to effective grounding. These equipment types may have their frame ground (metal chassis or shelf) surrounding the printed wiring cards connected directly to circuit ground.

23.2 Separate Electronic Switching and Transmission Systems

As indicated in Section 20, electronic and digital switching systems are designed to have separate frame and electronic circuit grounds. Transmission equipment engineered after March 1990 should also have separate frame and circuit grounds.

Nonisolated transmission systems use the battery return ground as an integrated circuit/rack ground. Therefore, a separate PDU and a separate ground distribution are required to separate the nonisolated transmission-type systems from digital switching systems (isolated).

23.3 Transmission Systems

Integrated transmission systems must be:

- In a separate floor plan area.
- Powered and grounded according to GTE Telephone Operations Practice 795-805-073.

23. Transmission Systems and Terminal Equipment Grounding, continued

23.4 Bonding and Fusing Transmission Systems

Transmission equipment carrier 130V power plants have return or ground bonded with Leads 37A and 38A.

Electronic, electromechanical, and transmission systems might share a common PDU in accordance with GTE Telephone Operations Practice 795-002-071. This practice also requires separate dedicated primary fuses (in the PCU or DSU) for each system.

23.5 Potential for Damage In Older Systems

Where older isolated grounded transmission equipment is mixed with integrated grounding equipment, the older transmission bays were bonded by Lead 50 to the MGB, FGB, or ECPGB. Potential rise at the ECPGB can cause damage to transmission equipment.

NOTE: In all cases, reterminate the transmission equipment bays Lead 50 to ground return at the transmission system's PDU. Doing this:

- Makes the equipment bays compatible with the newer bays.
- Complies with GTE Telephone Operations Practice 795-805-073.
- Offers better protection.

23.6 Isolating Protector Mounting Bars

Use approved insulators to isolate the protector mounting bars on carrier high-frequency line protector frames (bonded via Lead 24, which is connected to Lead 23A):

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

This isolation prevents fault currents from damaging transmission systems equipment (see Exhibit 30).

23.7 Using Lead-Sheathed Cable Stubs

Lead-sheathed cable stubs to carrier high-frequency line protector frames in the transmission area must:

- Be replaced with cable stubs having nonconductive sheaths.
- OR
- Have isolated splices installed.

This must be done to eliminate fault currents flowing onto carrier frames and associated ironwork. This is particularly essential in offices with an electronic switching system.

23.8 Terminating Fiber Optic Cables

When the fiber optic splicing shelf is in the switch area and the metallic members have not been grounded in the vault, the cable shield must be isolated from the relay rack frame and the splice shelf. A #6 AWG grounding conductor (Lead 17A) is used to bond the shield to the MGB/FGB either directly (one shelf only) or through Lead 17B (#1 AWG) when more than one shelf in the rack is anticipated (see Exhibit 31).

24. Radio System Grounding

24.1 Effects of Electromagnetic Fields of Lightning Currents

Stored Program Controlled (SPC) electronic switching systems are affected by electromagnetic fields produced by lightning fault currents on towers and associated down conductors. The effects range from memory errors to component damage.

Lightning fault currents on roof-mounted towers must be distributed equally over the top and down each side of the building to minimize effects on SPC electronic switching systems. Four or more down conductors (one for each of four corners) help to:

- Distribute the fault fields.
- Neutralize intensities inside the building.

External towers adjacent to the CO building should be located 6 feet (1.8m) from the building structure to minimize the affect on the foundation. Practical considerations, however, must be taken into account. The down conductors used to ground the tower must be terminated on the tower ring, which is then bonded to the building's Lead 1.

Roof-mounted towers should be grounded via down conductors, preferably external to the building.

WARNING: Vertical (roof-to-ground) down conductors must not be routed through the switching area because this would increase the electromagnetic fields inside the building.

When electrical or digital systems are installed in structures with existing roof-mounted towers that have grounded conductors through the building, the structure must be encompassed with additional grounding conductors.

24.2 Grounding Towers

For towers on buildings:

- Connect the tower base footings to the:
 - Tower ground ring.
 - Waveguide or coaxial outer conductor.
 - Lighting AC branch circuit conduit and green wire.
 - Lightning arrester ground (see GTE Telephone Operations Practice 795-805-072).

OR

- Lead 22 must be either (see Exhibits 1 through 5 and Section 25.2):
 - Run from the tower ring to the lightning down conductor at each corner and the middle of each side of the building.
 - Connected to the corner structural steel building columns and extended from the lower ends of the corner columns to the external lightning ground system.

NOTE 1: Follow National Fire Protection Association (NFPA) 780 guidelines when using either method of grounding.

NOTE 2: See GTE Telephone Operations Practice 887-030-085 for additional information on tower grounding and GTE Telephone Operations Practice 887-795-070 for lightning protection.

24. Radio System Grounding, continued

24.3 Adding Bonds

Bonds should be added at various locations to the building grounding system and outer metal objects within 6 feet (1.8m), according to NFPA 780 (Lead 26). The closest lightning system ground must be bonded to Lead 1 via Lead 25.

24.4 Extending Leads 27 and 28

Leads 27 and 28 should be extended to the radio grounding systems from the ground ring Lead 1 of the building with access points that permit disconnection for periodic resistance testing.

24.5 Locating Radio Equipment

Radio equipment in the building served by adjacent external towers should be located on the:

- Building ground floor.
- OR**
- Lowest possible level.

24.6 Choosing the Proper Lead

Select the proper lead to bond radio or waveguides from the following chart.

Use Lead...	To Bond...
55	Waveguides and coaxial cables (outer conductor) upon entering the CO building.
56	AC-powered radio transmitter cabinets.

24.7 Interior (Halo) Rings

An interior ring, or Halo, is used as part of the grounding system for radio systems. When the radio system(s) are collocated with electronic switching systems, the Halo ring should be placed as follows:

- Around the radio equipment only when the radio equipment occupies less than 50% of the floor (room) space. Use Lead 21 to the MGB/FGB.
- Around the entire equipment area (room) when the radio equipment occupies more than 50% of the floor (room) space. Use Lead 21 to the MGB/FGB.
- If the radio equipment is contained in one relay rack, then use Lead 56 to the MGB/FGB.

NOTE: Do not use the Halo ring as a battery return ground path.

Integrated radio equipment racks must be bonded to the Halo with compression connectors.

NOTE: Do not violate the integrity of the IGZ.

24. Radio System Grounding, continued

24.8 References

Refer to GTE Telephone Operations Practice 887-030-085 for specific information on:

- Grounding towers.
- Antenna supports.
- Transmission lines.
- Radio station equipment.

NOTE 1: Radio transmitter must be located away from electronic switching systems to avoid hard-to-solve problems that may occur in the system due to:

- Transmitter electromagnetic radiation.
- Lightning fault currents that may reach the radio and expose the electronic system to equipment damage and operational problems.

NOTE 2: Buried fuel tanks near tower footing and grounding electrodes must be avoided. A separation of at least 25 feet (7.5m) should be maintained if practical.

25. Lightning Protection System

25.1 Lead 22 Requirements - Roof

In high lightning areas, Lead 22 must be used to bond the mechanical equipment mounted on the building roof that has metal piping or ducts leading into the building.

NOTE: This bonding is essential to minimize lightning discharges entering the building on:

- Metal piping.
- Ducts.

Lead 22 must be:

- As straight as practical. Required bends must have a minimum 36-inch radius.
- The proper size and material according to the NFPA 780 Lightning Protection Code guidelines. A minimum of two to four leads must be used in opposite directions down the outside of the building to ground.

NOTE: See GTE Telephone Operations Practice 795-805-070 for information on determining areas of high lightning activity.

25. Lightning Protection System, continued

25.2

Lead 22

Requirements - Towers

Roof-mounted towers provide a major lightning path that requires adequate bonding to safely divert fault currents to:

- Protect personnel.
- Prevent disruption of equipment operation.
- Prevent component damage.

To maximize protection, four or more conductors should be used on the tower to direct fault currents to the extreme four corners of the structure. Either steel building columns or conductors may be used to draw these currents vertically down the four corners.

Lead 22 must be used to bond the lower end of the corner steel building columns. This further directs fault currents to a lightning electrode system that is completely separate from the CO ground field.

If steel building columns are not used, Lead 22 should be continuous from the tower to the ground electrodes. Consult NFPA 780 Lightning Protection Code guidelines for the proper size and materials.

NOTE 1: Do not place down conductors (Lead 22) or use the steel building columns to establish a path for the fault current to flow to earth through only one or two sides of the building. One at each of the four corners is best.

NOTE 2: Do not use the steel building columns directly beneath the tower footings unless the tower base spans the entire top of the building.

NOTE 3: Refer to Section 24.1.

25.3

Reference

The decision on whether or not to provide a lightning protection system on a building should be based on the Risk Assessment Guide, Appendix I, of the Lightning Protection Code, NFPA 780 and GTE Telephone Operations Practice 887-795-070.

26. Job Completion Procedures

26.1 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 the telephone company (see Exhibit 32).

26.2 Identification Tags

Identification tags or labels with nonmetallic straps should be affixed **to** each lead attached to the:

- **FGBs.**
- **CVGB.**
- **MGB.**

These tags designate the ground system lead number (description is optional). Refer to Section 9.7.

26.3 Reports

The appropriate inspection reports must be completed (see Section 28.1) and must include the:

- Completion data.
- Ground resistance measurements take at the time of installation.

This information is needed for comparing ground resistance measurements which are to be made annually. See GTE Telephone Operations Practices:

- 795-805-074.
- 887-600-072.

27. Material Requirements

27.1 Approved Materials

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

- Telephone switching systems.
- Building ground.
- Protection.

27.2 Listed Materials

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

27.3 Substitutions

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

CAUTION: Substituting untinned bare copper wire increases corrosion of these bonding leads.

28. Central Office Grounding Inspection

28.1 Reference

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

To document CO grounding conditions, use Form 90001528 (GTE Telephone Operations Practice 795-805-074):

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

These inspections will help identify deviations from:

- This practice.
- GTE Telephone Operations Practices:
 - 795-805-072.
 - 795-805-073.
 - 795-805-075.
 - 795-805-076.
 - 795-805-077.
 - 795-805-078.
 - 887-030-085.
 - 887-030-087.

Exhibits

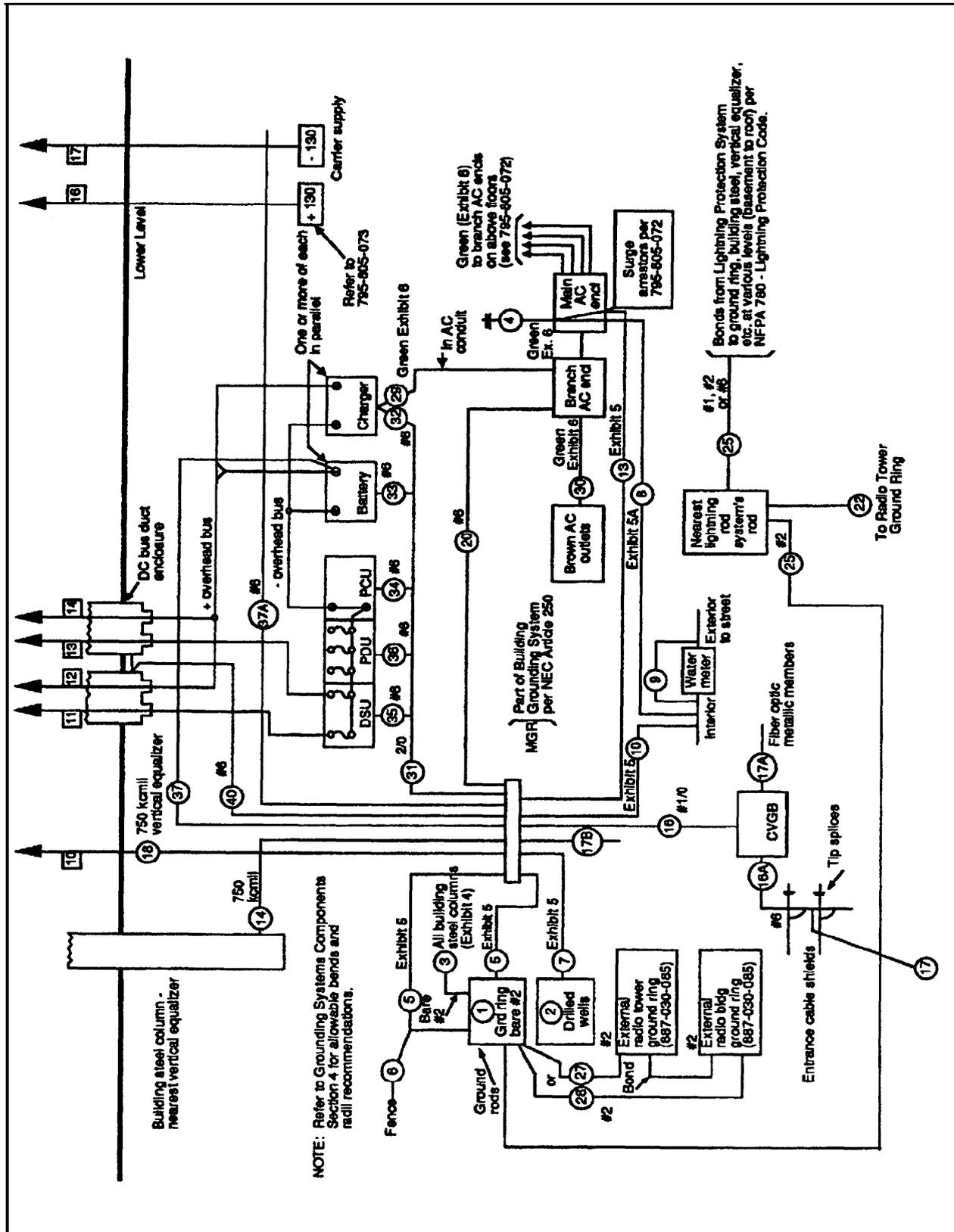


Exhibit 1 - Central Office Grounding System, Lower Level

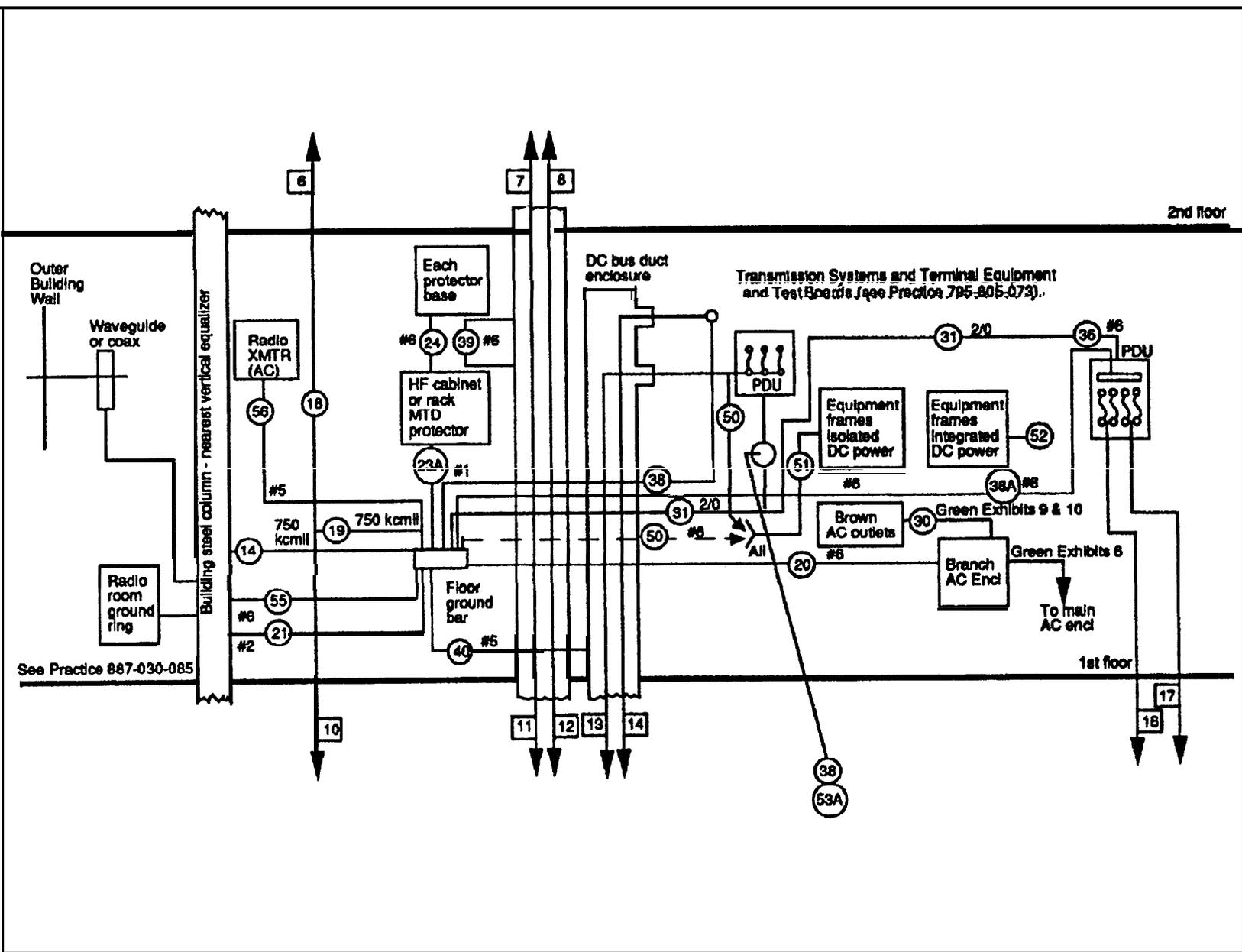


Exhibit 2 - Central Office Grounding System, First Floor

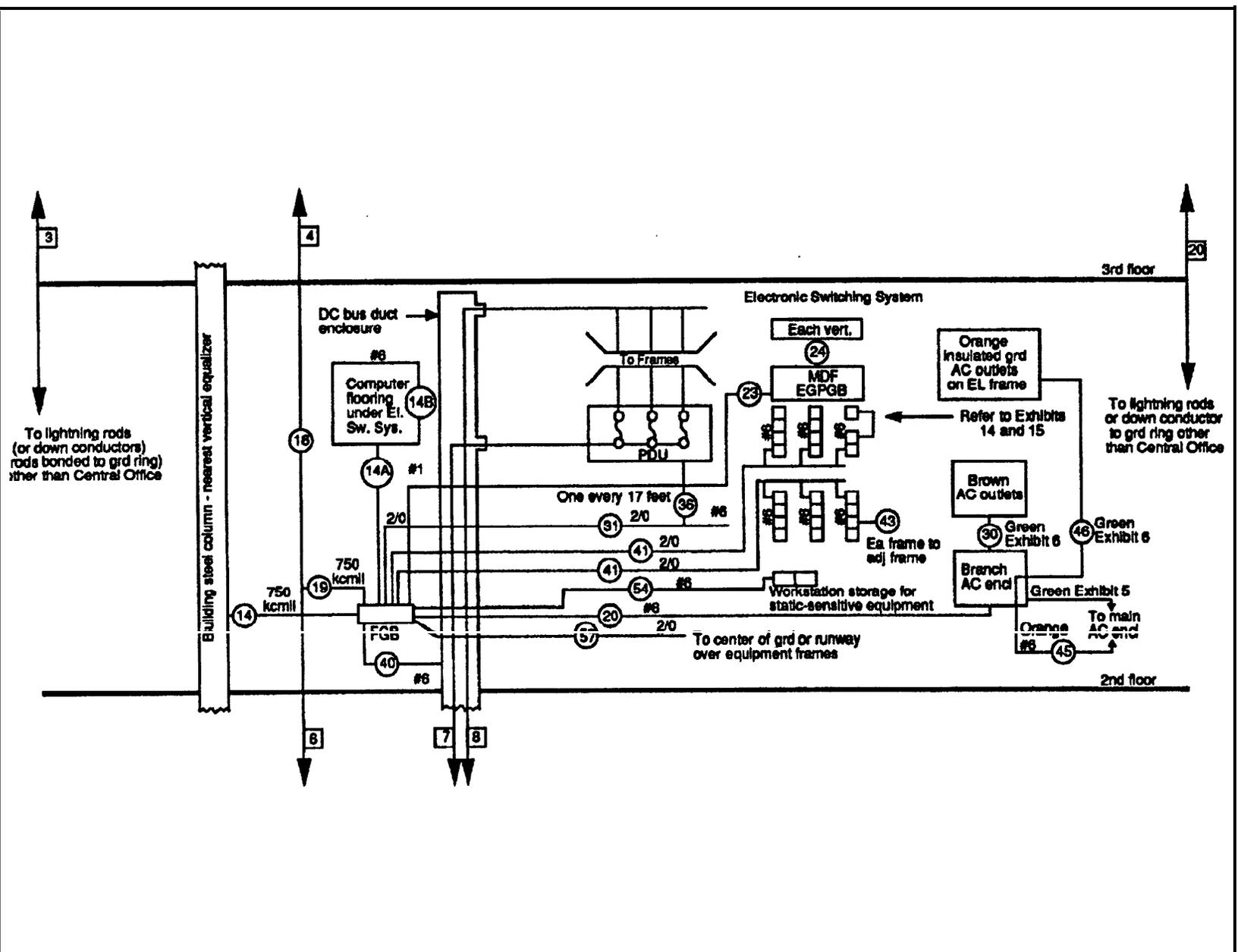


Exhibit 3 - Central Office Grounding System, Second Floor

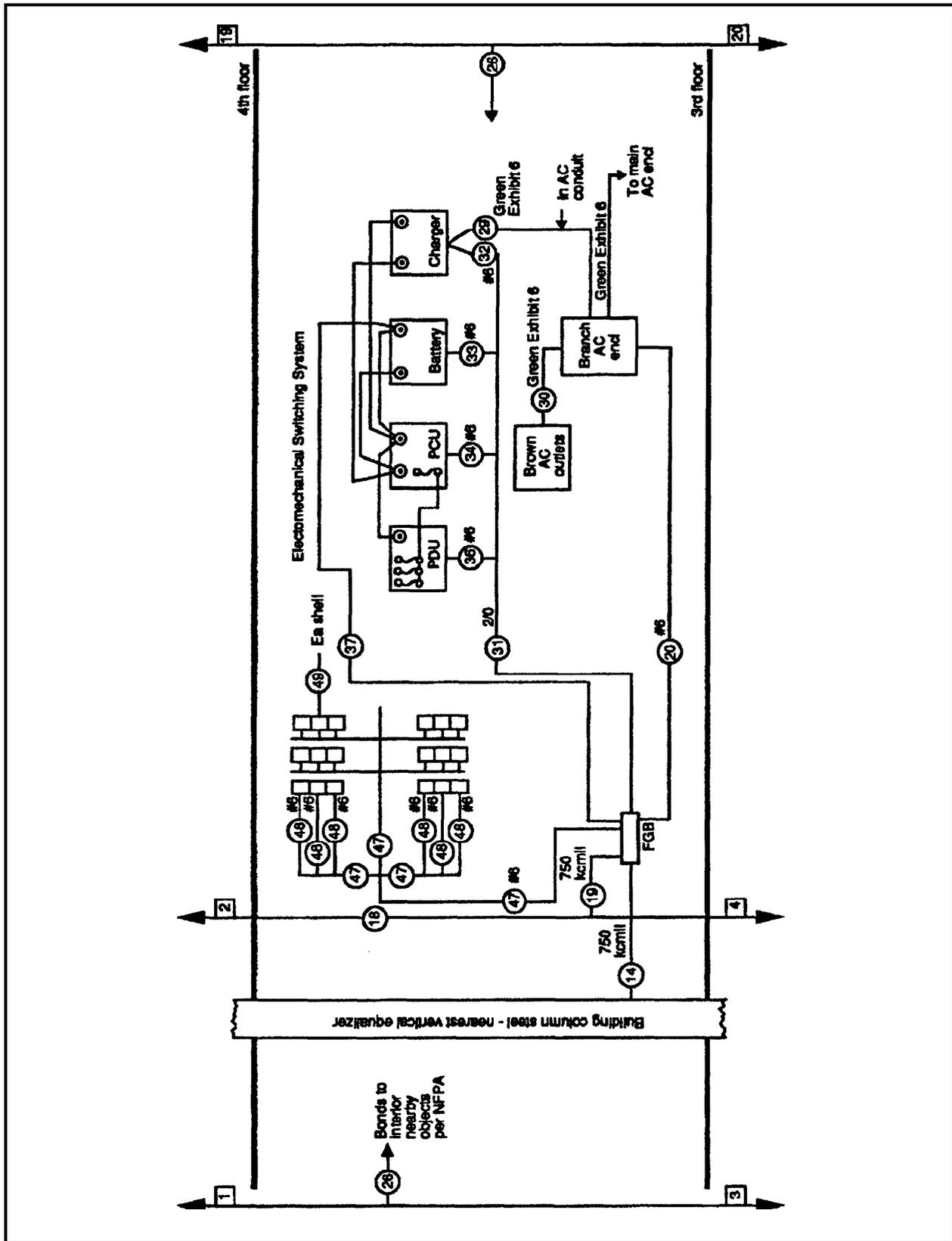


Exhibit 4 - Central Office Grounding System, Third Floor

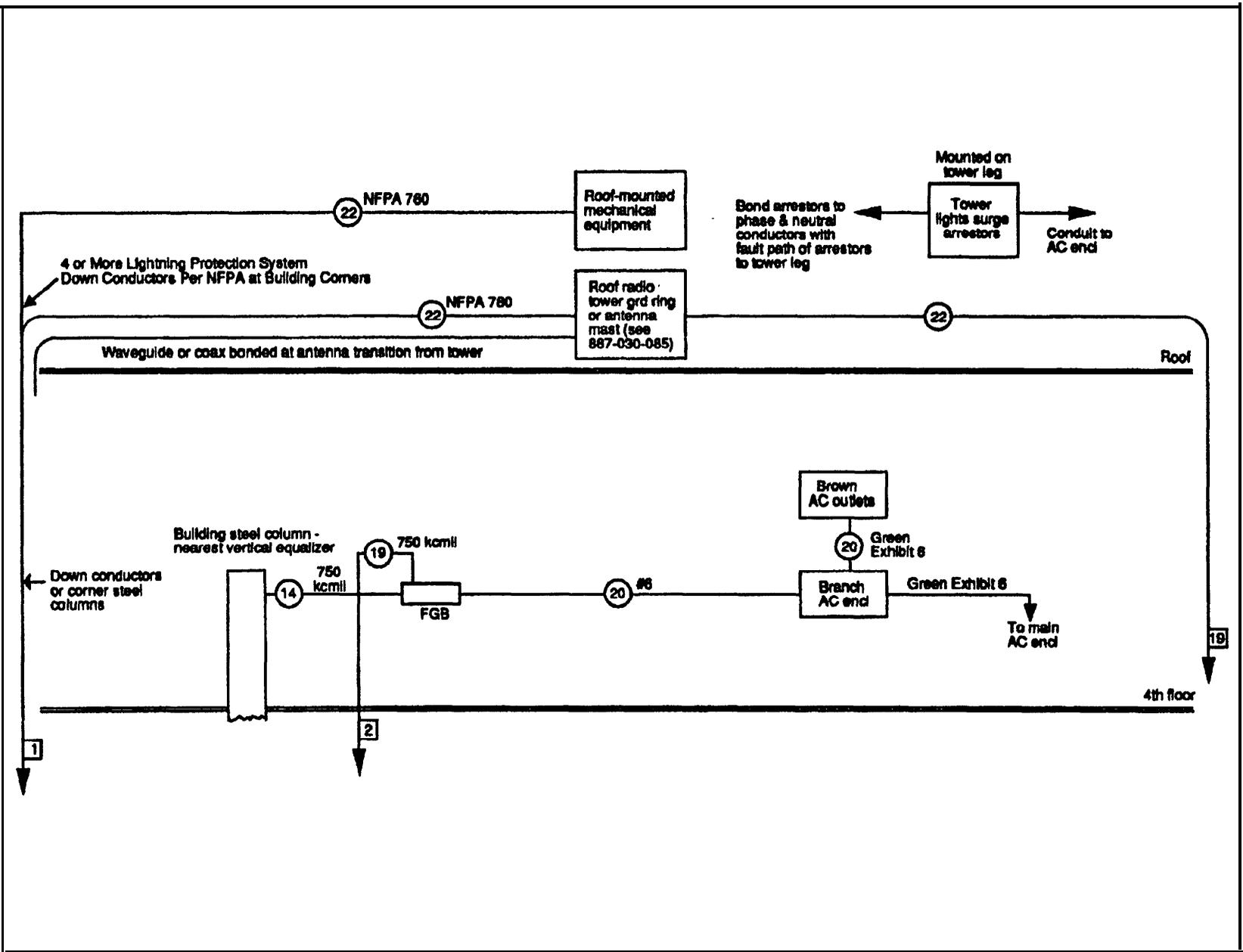


Exhibit 5 - Central Office Grounding System, Fourth Floor and Roof

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
1	T&P L&B	Grd ring (w/ rods) external electrode	----	2	2	SBTC
1A	T&P L&B	Grd ring concrete- encased electrode	----	2	2	SBTC
2	T&P L&B	Wells deep anodes	or ----	--	--	Steel pipe or duriron anodes
3	L&B	Lead 1/ MGB	Bach bldg 2 column		2	SBTC. Refer to Section 5.10 for required access points.
4	L&B	Main AC enclosure neutral bus	Grounding electrode. Refer to GTEP 795-805- 072.	NEC 250-94	--	Refer to Section 18.1 and GTEP 795-805-072.
4A	Deleted					
5	L&B	Lead 1 Min. 2 Lead 5 opposite sides	MGB	Exhibit 9	Exhibit 9	SBTC
5A	Deleted					
6	L&B	Lead 1	Metallic fence	2	2	Metallic fence/post or other metallic objects.
7	L&B	Each Lead 2	MGB	Exhibit 9	Exhibit 9	SBTC
8	L&B	Main AC enclosure neutral bus	Interior of water meter. Refer to GTEP 795-805- 072.	NEC 250-94		Refer to Section 18.1.

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 1 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
9	L&B	Ext water pipe	Int water pipe	Exhibit 9	Exhibit 9	Insulated copper
10	L&B	Int water Pipe	MGB	Exhibit 9	Exhibit 9	insulated copper
11	Deleted					
12	Deleted					
13	L&B	Main AC enclosure neutral bus	MGB except per Furnishing Lead 13 (Sec. 18.7)	Exhibit 9	Exhibit 9	Insulated copper. Refer to GTEP 795-805-072.
14	L&B	Each MGB/FGB on each floor	Center bldg 750 kcmil column		4/0	Insulated copper
14A	L&B	Lead 14B closed ring	MGB/FGB	2/0	--	Insulated copper
14B	L&B	Closed ring to computer floor metal superstructure	Lead 14A	6	--	Insulated copper
14c	L&B	MGB/FGB	Interior metallic roof or metal skin	1/0	1/0	Insulated copper
15	L&B	MGB/FGB	FGB for HE 750 kcmil on same floor		--	Refer to Exhibit 12.
16	L&B	MGB	CVGB or Lead 17 per Sec. 14.3.	1/0	1/0	Insulated copper
16A	OSPC CVGB		Cable vault racking	1/0	1/0	Insulated copper
17	OSPC CVGB or Lead 16 per Restriction in Sec. 14.3.		Cable shields	6	6	Insulated copper

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 2 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
17A	OSPC	CVGB	Fiber optic 6 metallic members		6	Insulated copper
17B	OSPC	MGB/FGB	Fiber optic 1 splice shelf		1	Insulated copper
18	L&B	Bottom floor MGB/FGB	Intermediate FGB and top floor FGB	750 kcmil	--	Vertical equalizer insulated copper
19	L&B	Lead 18	FGB on each floor	750 kcmil	--	Insulated copper. (Use only if FGB cannot bond to VE and limit to 6 ft [1.8m].)
20	L&B	MGB or FGB on each floor	Branch AC 6 enclosure on same floor (green wire) ground, not neutral		--	Insulated copper. Not required if there is only one panel.
20A	L&B	MGB or FGB on each floor	Disconnect enclosure on same floor neutral bus for step-down transformer or separately derived source.	Exhibit 10	Exhibit 10	Insulated copper
21	L&B	MGB/FGB	Radio room 2 ground ring (halo). Lead 21 A.		2	Insulated copper
21A	L&B	Interior (halo) ring	----	2	2	Insulated copper
21B	L&B	Lead 21 A	Lead 1	2	2	Insulated copper
21c	COEC	Lead 21 A	Equipment 6		6	Insulated copper
22	L&B	Roof radio tower grd ring and building mechanical equipment	Comer bldg cols or lightning rod system	NFPA 780	NFPA 780	Insulated copper (min. 4 leads per NFPA)

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 3 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
23	COEE	MGB or FGB (same floor)	Ent CA prot grd bar (MDF (ECPGB	1	1	Insulated copper (1 for each 17' [5.1m] of ECPGB). Refer to Section 13.6 for special situations.
23A	COEE	MGB or FGB (same floor)	CXR HF line protectors	1	1	Insulated copper
24	OSPC	ECPGB (MDF) or Lead 23A	Bottom prot assy ground terminal (not entire vertical mounting strip)	6	6	On each vertical (insulated copper). See the 234 series of GTEPs.
24A	OSPC	Lower prot assy grd terminal	Next higher prot assy grd terminal	6	6	See the drawing on Entrance Cable Protector Ground Bar in Section 13.2.
25	L&B	Lead 1	Nearest lightning rod	2	2	Insulated copper
26	L&B	Lightning rod system	All nearby objects - all floors	NFPA 780	NFPA 780	Per NFPA 780
27	L&B	Lead 1	External radio tower gnd ring	2	2	SBTC. Refer to Sec. 24.2 for required access points.
28	L&B	Lead 1	External radio bldg grd ring	2	2	SBTC. Refer to Sec. 24.2 for required access points.

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 4 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
29	COEE	Branch AC enclosure (green wire) grd, not neutral	Battery charger frame	Exhibit 11	Exhibit 11	Green insulated copper in AC conduit
30	L&B COEC	Branch AC enclosure nonisolated (green wire) grd, not neutral	AC outlets (brown)	Exhibit 11	Exhibit 11	Green insulated copper in AC conduit
31	COEE	MGB/FGB (same floor)	Leads 32-36 and/or modular power board	2/0	6	Insulated copper
32	COEC	Lead 31	Battery charger frame or shelf	6	6	Insulated copper. Must terminate at Lead 29 punching.
33	COEC	Lead 31	Battery rack frame	6	6	Insulated copper
34	COEC	Lead 31	PCU frame	6	6	insulated copper
35	COEC	Lead 31	DSU frame	6	6	insulated copper
36	COEC	Lead 31	PDU frame	6	6	Insulated copper
37	COEE	MGB/FGB (same floor)	Battery positive ground	See Section 17.5.	2/0	Insulated copper
37A	COEE	MGB/FGB	Return terminal carrier supply (130V DC)	6	6	Insulated copper
38	COEE	FGB (same floor)	PDU grd bar. Refer to Section 17.4.	750	kcmil --	Insulated copper

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 5 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
38A	COEE	FGB	PDU grd bar (not used when Lead 37A is on same floor) carrier supply	2/0	--	insulated copper
39	COEE	DC bus duct enclosure	Next en- closure section	6	--	insulated copper
40	COEE	Bus duct enclosure	MGB/FGB on each floor	6	--	Insulated copper
41	COEE	FGB	Lead 42 (Exhibit 19) or Lead 58 (Exhibit 18)	2/0	--	Insulated copper
41A	COEE	MGB/FGB	Lead 58A	2/0	---	Insulated copper
42	COEC	Lead 41	Each frame lineup	EI 6	--	Insulated copper. (Use restricted to existing lineups.)
43	COEC	Each EL frame	Each adjacent EL frame (Exhibit 19)	--	--	Junction plate
44	COEC	Bypass missing frame	Exhibit 19	6	--	Insulated copper. (Use restricted to existing lineups.)
45	L&B	Main AC enclosure neutral	Branch AC enclosure (separate Lead 46)	Exhibit 11	--	See Section 18.10 and GTEP 795-805-072.
46	L&B COEC	Branch AC enclosure (separate isolated) Lead 45, not neutral	Dedicated AC outlets (orange) (green wire) ground	Exhibit 11	--	See Section 18.10 and GTEP 795-805-072.

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 6 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
47	COEE	FGB	Lead 48 (each EM frame lineup)	6	6	Insulated copper. EM systems only.
48	COEC	Lead 47	Each EM frame	6	6	insulated copper. EM systems only.
49	COEC	EM frames	EMEQ shelves	--	--	Mounting with int-ext tooth lockwashers under both head & nut of mountingbolts. EM systems only.
50	COEE	PDU battery return grd bus or FGB. See Potential For Damage In Older Systems (Section 23.5).	Lead 51	2/0	2/0	Insulated copper. (Use restricted to existing lineups.)
51	COEC	Lead 50	Each trans frame isolated DC power	6	6	insulated copper. (Use restricted to existing lineups.)
52	COEC	Each trans frame fuse panel grd bar	Each trans frame's vert or horiz rack ground bar, or direct to frame w/ int-ext tooth lockwasher next to frame	8	8	Insulated copper (see GTEP 795-805-073).
53	Deleted					
53A	COEE	MGB	PDU	Exhibit 23	--	Based on largest fuse installed at DSU.
54	COEE	FGB or MGB	Storage cabinets for static-sensitive circuits, static mats, and work benches	6	--	Insulated copper (see Section 21.2).

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 7 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
55	COEE	FGB or MGB	Waveguide or coax just where enters bldg	6	6	Insulated copper
56	COEE	FGB or MGB	AC power radio transmitter cabinet	6	6	Insulated copper
57	COEE	FGB or MGB	Center of cable grid or runway system	2/0	--	Insulated copper
57A	COEE	MGB/FGB	Center of cable grid or runway system	2/0	--	Insulated copper
58	COEE	Lead 41	Aisle frame 2 ground		--	Insulated copper
58A	COEE	Lead 41A	Aisle frame 2 ground		--	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
60	L&B	Conductive floor tile	FGB	6	--	Insulated copper
61	COEE	MGB/FGB	Lead 62 each EL frame lineup	2/0	--	Insulated copper- LPG
62	COEE	Lead 61	Aisle lineup I/O		--	Insulated copper
63	COEC	Lead 62	Terminal block	12	--	Insulated copper
64	COEE	MGB/FGB	Facility Test Ground (FTG)	6	--	Insulated copper - FTG
65	COEE	MGB/FGB	ESARTS MTU	6	--	Insulated copper - one per frame

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 8 of 10)

Exhibits, continued

LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
80	5ESS	Ground window bar isolated side	PDU (PCFD) or misc cab equip grd	1/0	--	Insulated copper
81	5ESS	Ground window bar isolated side	Lead 82	1/0	--	Insulated copper
82	5ESS	Lead 81	Aisle frame 6		--	Insulated copper to bare in trough
83	5ESS	Lead 82	Individual equipment frames	6	--	Bare copper to each frame
84	5ESS	Grd window bar isolated side	MCC or STLWS	6	--	Insulated copper
85		Not used				
86	5ESS	Grd window bar integrated side	ICB	1/0	--	Insulated copper
87	5ESS	Grd window bar integrated side	Lead 88	2	--	Insulated copper
88	5ESS	ICB or Lead 87	Metallic objects within 6ft	6	--	Insulated copper
89	5ESS	Grd window bar isolated side	MMSU quiet grd	16	--	Insulated copper
FBE	DMS-100	FGB	MGB/SPG Note 1		--	Insulated copper. See GTEP 795-805-076.
FG	DMS-10	FGB	MGB/SPG Note 1		--	Insulated copper. See GTEP 795-805-076.
GW	DCO	GWB	MGB	2/0	--	Insulated copper. See GTEP 795-805-077.
ICB	DMS (all)	ICB	MGB/SPG Note 1		--	Insulated copper. See GTEP 795-805-076.

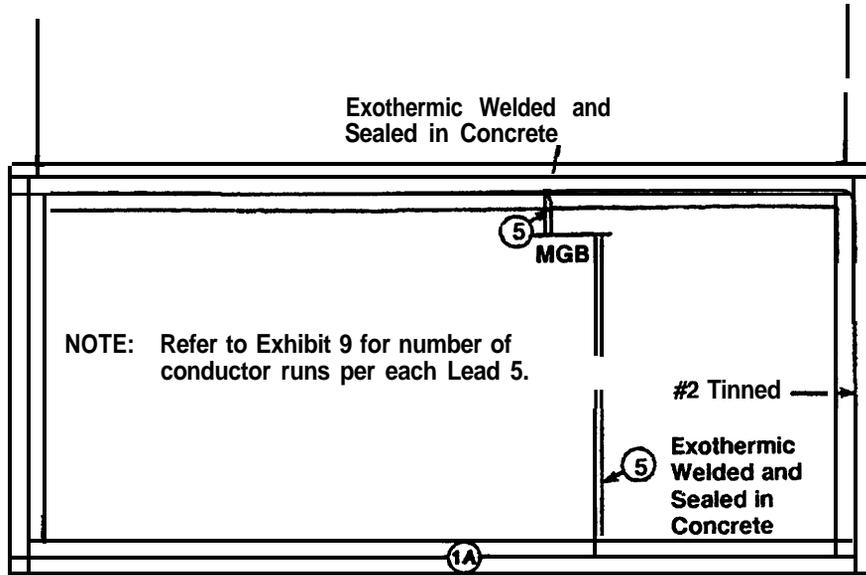
Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 9 of 10)

Exhibits, continued

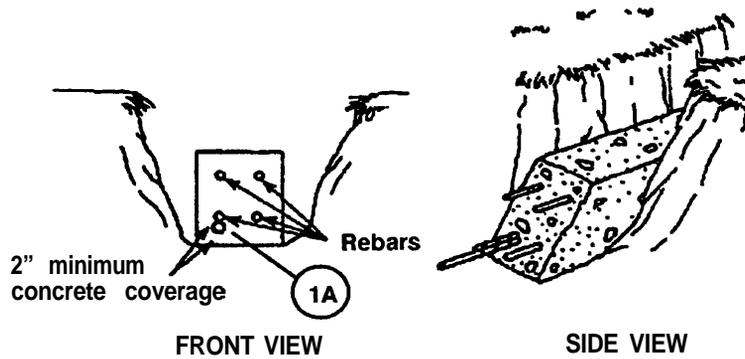
LEAD NO.	BY	FROM	TO	AWG-DIGITAL	AWG-SMALL ELECTRO-MECHANICAL	NOTES
LRE	DMS-100	Logic return bar	MGB/SPG	Note 1	--	Insulated copper. See GTEP 795-805-076.
MAP	TOPS	TOPS	MGB/SPG/ FGB	#6 AWG	--	Insulated copper. See GTEP 795-805-076.
TOP	TOPS	TOPS	MGB/SPG/ FGB	#6 AWG	- -	Insulated copper. See GTEP 795-805-076.

NOTE 1: Use 2/0 AWG for 0-50 feet (0-10m).
 Use 350 kcmil for 50-l 50 feet (15-45m).
 Use 750 kcmil for more than 150 feet (45m).

Exhibit 6 - Standard Grounding Conductor Sizes and Lead Designations (Page 10 of 10)



TOP VIEW



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

Exhibit 7 - Concrete-Encased Electrode

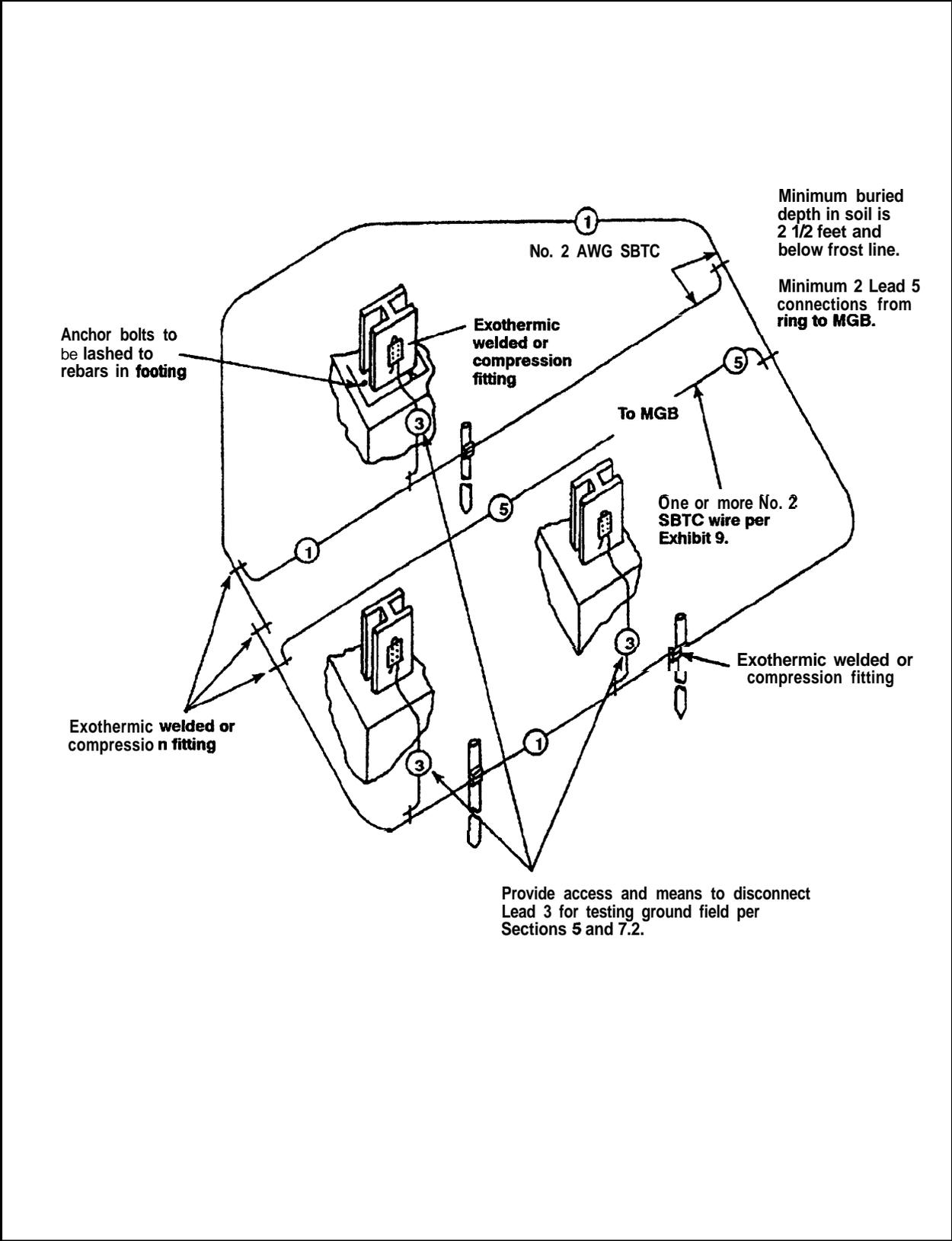


Exhibit 8 - Typical Ground Field-New Structural Steel Building

Exhibits, continued

Maximum Service Load (Amperes)	Size of Largest AC Service Phase Conductor or Equivalent Area for Multiple Conductors - Note 1.		Minimum Size Stranded Insulated Copper Leads 9, 10, 13	Minimum No. of Runs No. 2 AWG TBSC for Each Lead 5 and 7 (Note 2)
	Copper (preferred)	Aluminum or Copper-Clad Aluminum		
Up to 260	Up to 350 kcmil	Up to 500 kcmil	3/0	1
260-455	Over 350 kcmil thru 1000 kcmil	Over 500 kcmil thru 1100 kcmil	250 kcmil	2
456-560	Over 1000 kcmil thru 2000 kcmil	Over 1100 kcmil thru 2100 kcmil	350 kcmil	3 (1000 thru 1250)
More than 560	Over 2000 kcmil	Over 2100 kcmil	500 kcmil	See Note 4.

NOTES

1. (a) Calculate square inches cross-sectional area of multiple conductors per service entrance phase by:
 - Reading the area in square inches from NEC Table 8 for the AWG or kcmil size.
 - Multiplying the number of conductors comprising the single phase for cable entrances.
 - Determining the dimensions of each calculating the square inch cross-section.
 - Multiplying by the number per phase for a bus entrance.
- (b) Locate on NEC Table 8 the area of value in square inches that exactly equals or is larger.
- (c) Use the AWG or kcmil conductor size that corresponds with the area value in the table. Always round the value to the next higher in the table.
- (d) Never sum kcmil values of multiple conductors because such a summed value does not have an overall equivalent area.
2. Multiple runs on #2 AWG may be replaced by single runs of the electrically equivalent gauge.
3. The above required sizes exceed the requirement of NEC Table 250-94.

Exhibit 9 - 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 (Page 1 of 2)

NOTES, continued

4. Determine required number of No. 2 AWG SBTC conductors per lead using NEC Table 8.
 - (a) Calculate square inches cross-sectional area of conductor(s) per service entrance phase by:
 - Reading the area in square inches from NEC Table 8 for the AWG or kcmil size.
 - Multiplying by the number of conductors comprising the single phase for cable entrances.
 - Determining the dimensions of each bus and calculating the square inch cross-section.
 - Multiplying by the number per phase for a bus entrance.
 - (b) Divide the value in (a) by 8 to determine the size of the individual conductor.
 - (c) Divide the value obtained in (b) by 0.052. Whenever there is a remainder, round the value obtained to the next highest whole number. This final number represents the number of No. 2 AWG bare tinned copper conductors required for each Lead 5 or Lead 7, respectively.
-

Exhibit 9 - 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 (Page 2 of 2)

Exhibits, continued

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

Where there are no service-entrance conductors, the grounding electrode conductor size is determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

* See installation restrictions in NEC Sections 250-92(a) and 250-23(b).

Exhibit 10 - Sizing Leads 4 and 8 (Based on NEC Table 250-94)

Exhibits, continued

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 11 - Minimum Size of AC Equipment Grounding Conductor (Green)
per Table 250-95 of the NEC**

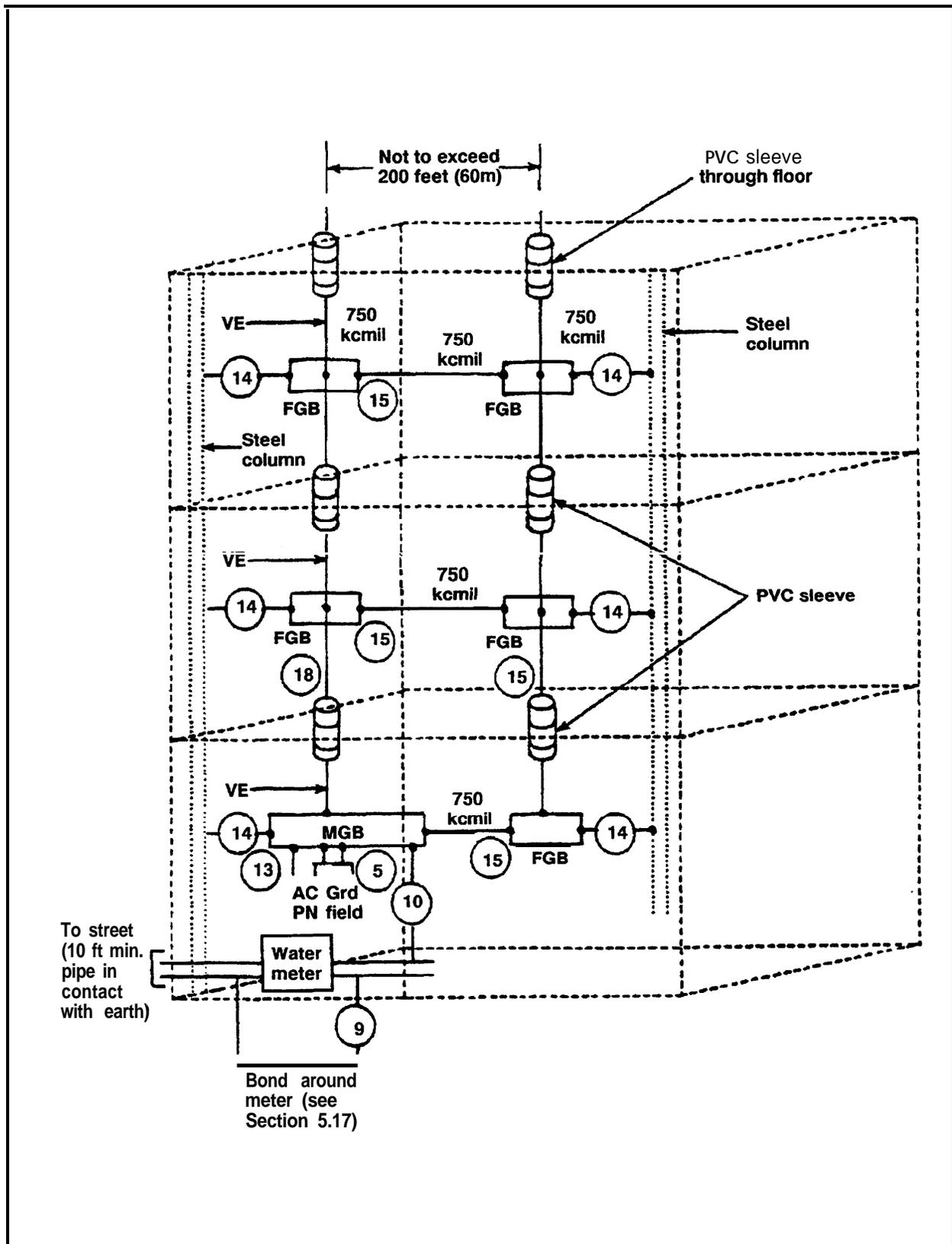


Exhibit 12 - Multilevel Main Ground System

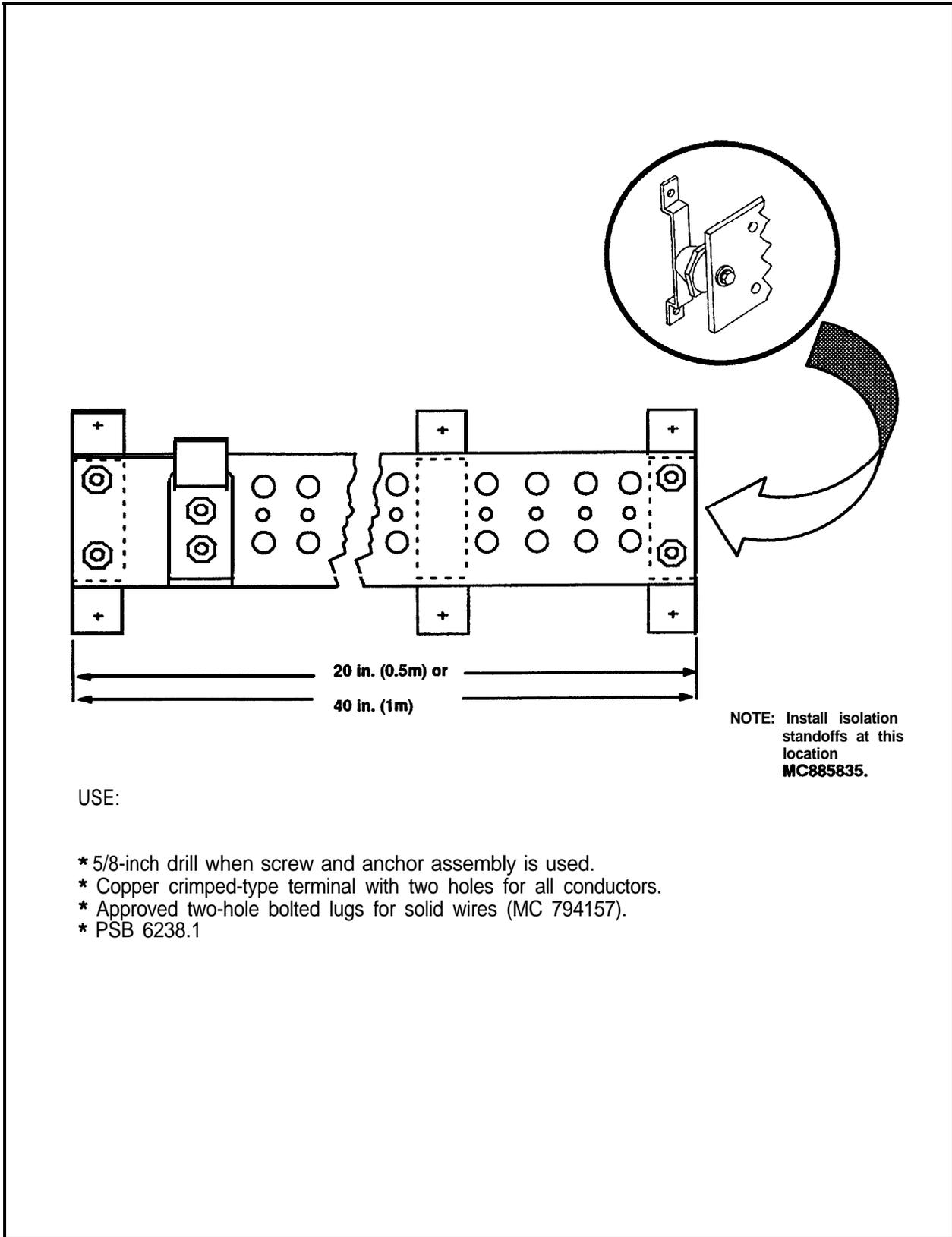


Exhibit 13 - Ground Bar Assembly for MGB or FGB

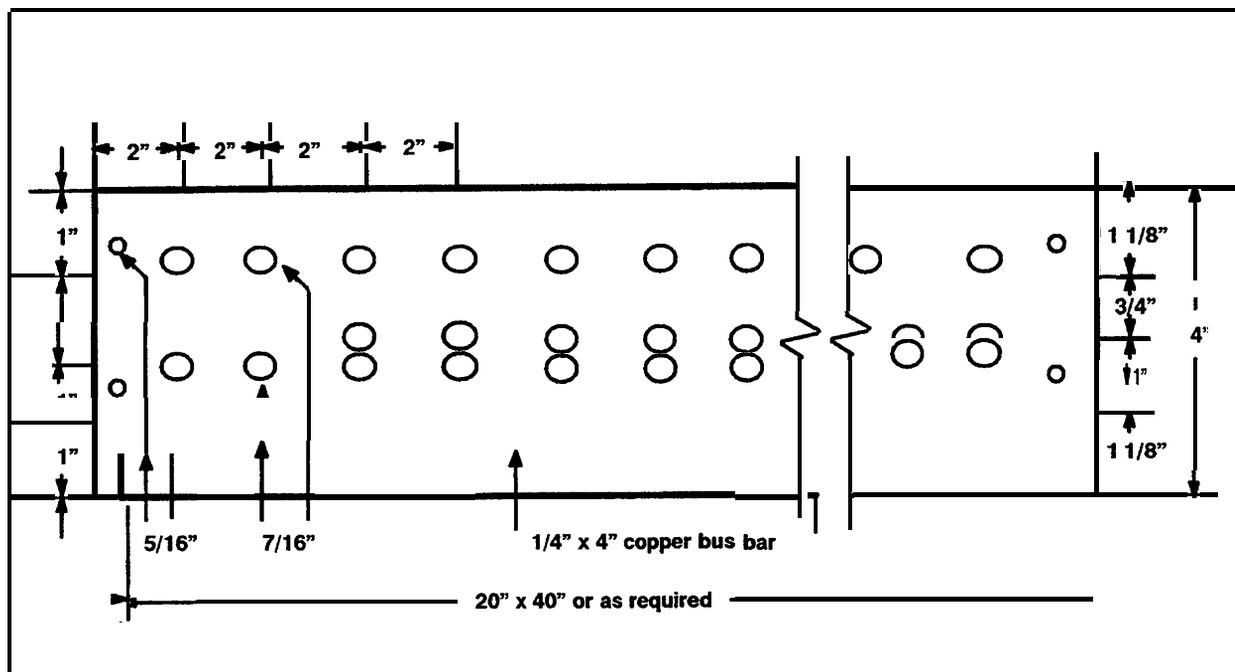


Exhibit 14 - Detail of Ground Bar for MGB or FGB

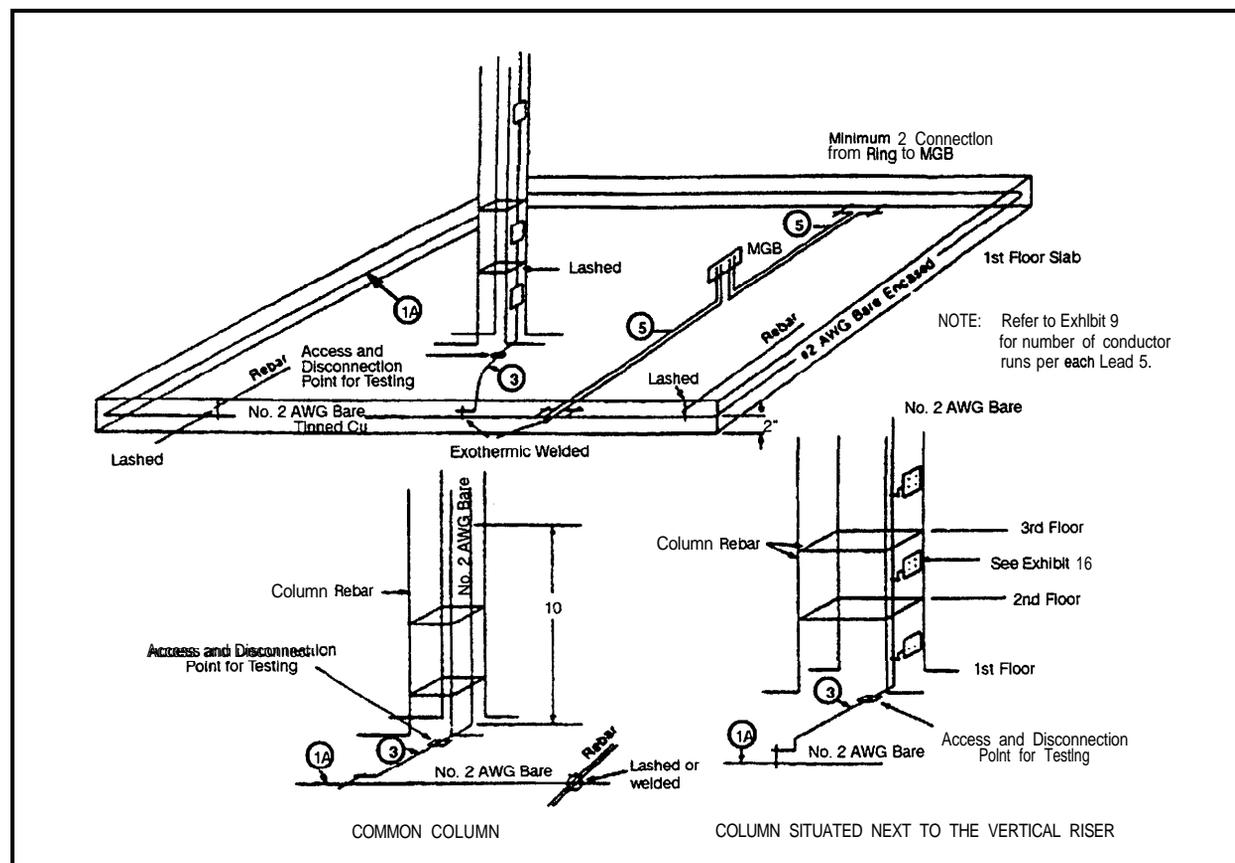


Exhibit 15 - Concrete-Encased Electrode in a Building with Steel-Reinforced Concrete Columns

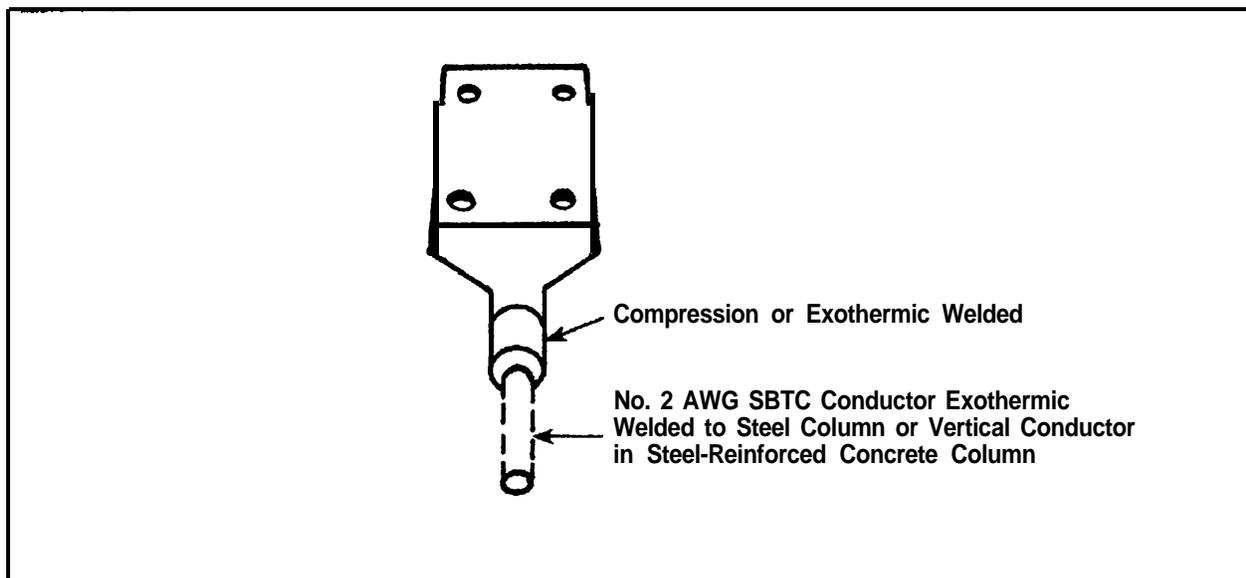


Exhibit 16 - Flush Grounding Plate, MC5209XX

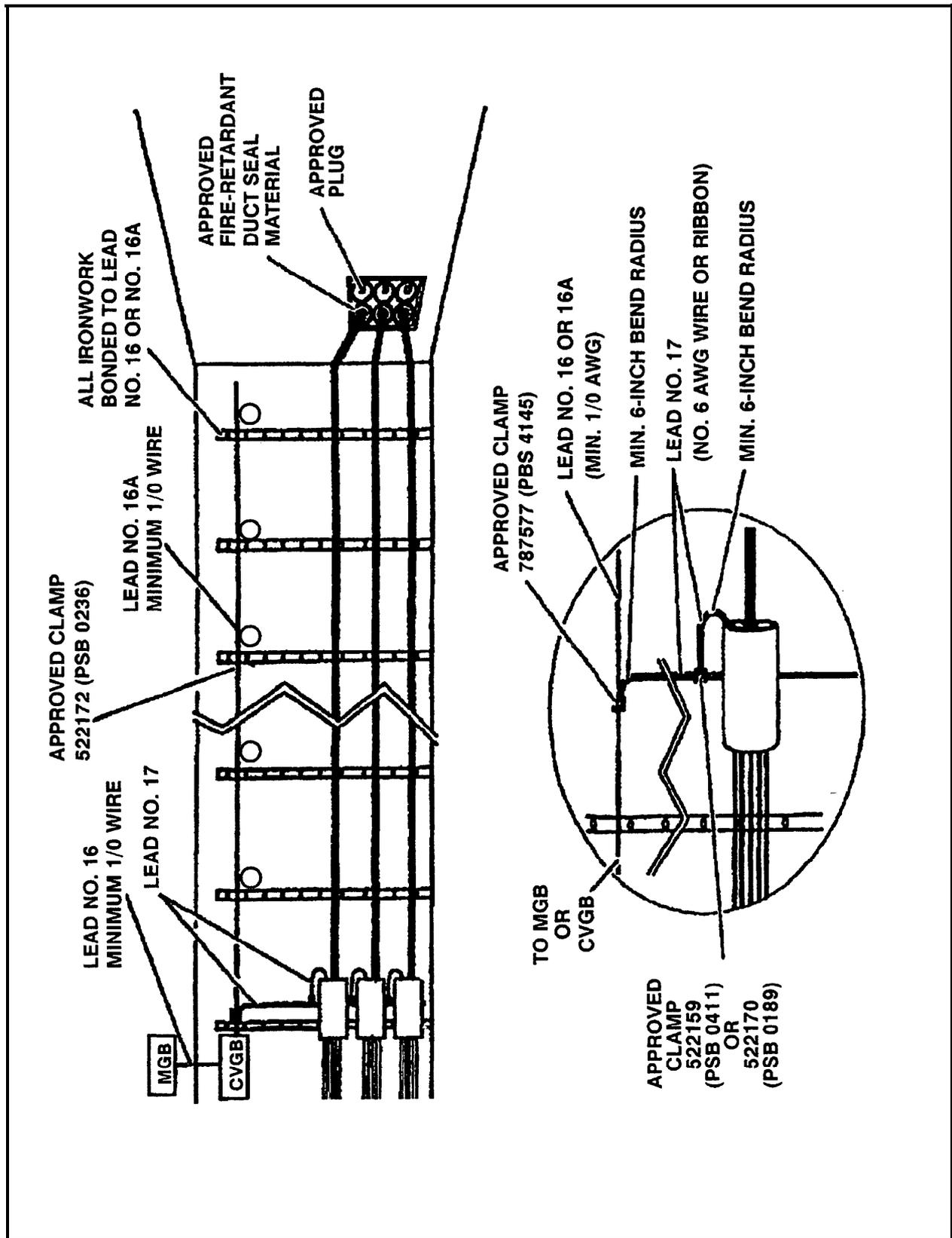


Exhibit 17 - Entrance Cable Bonding

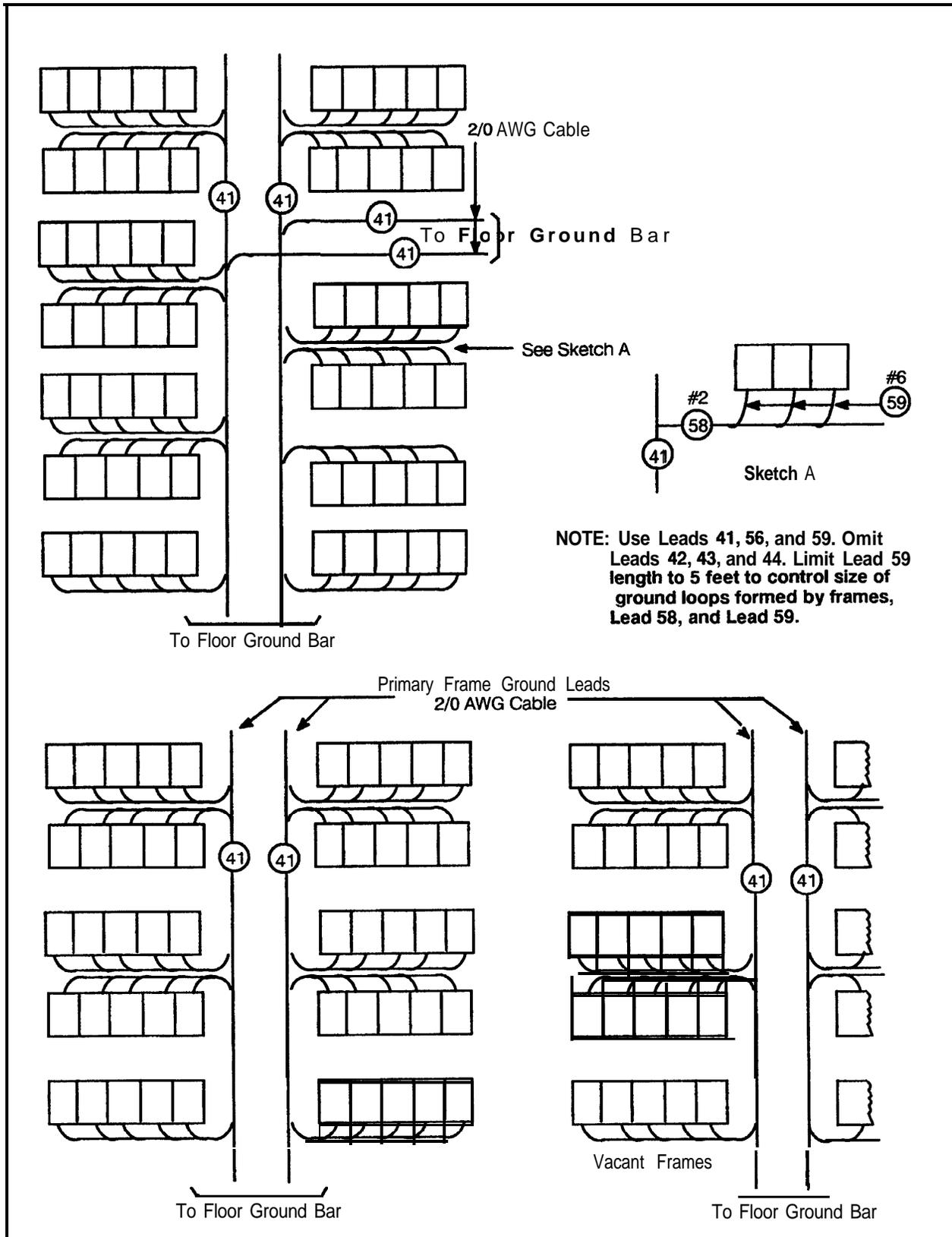


Exhibit 18 - Electronic System Frame Grounding Required for Using Isolation

Exhibits, continued

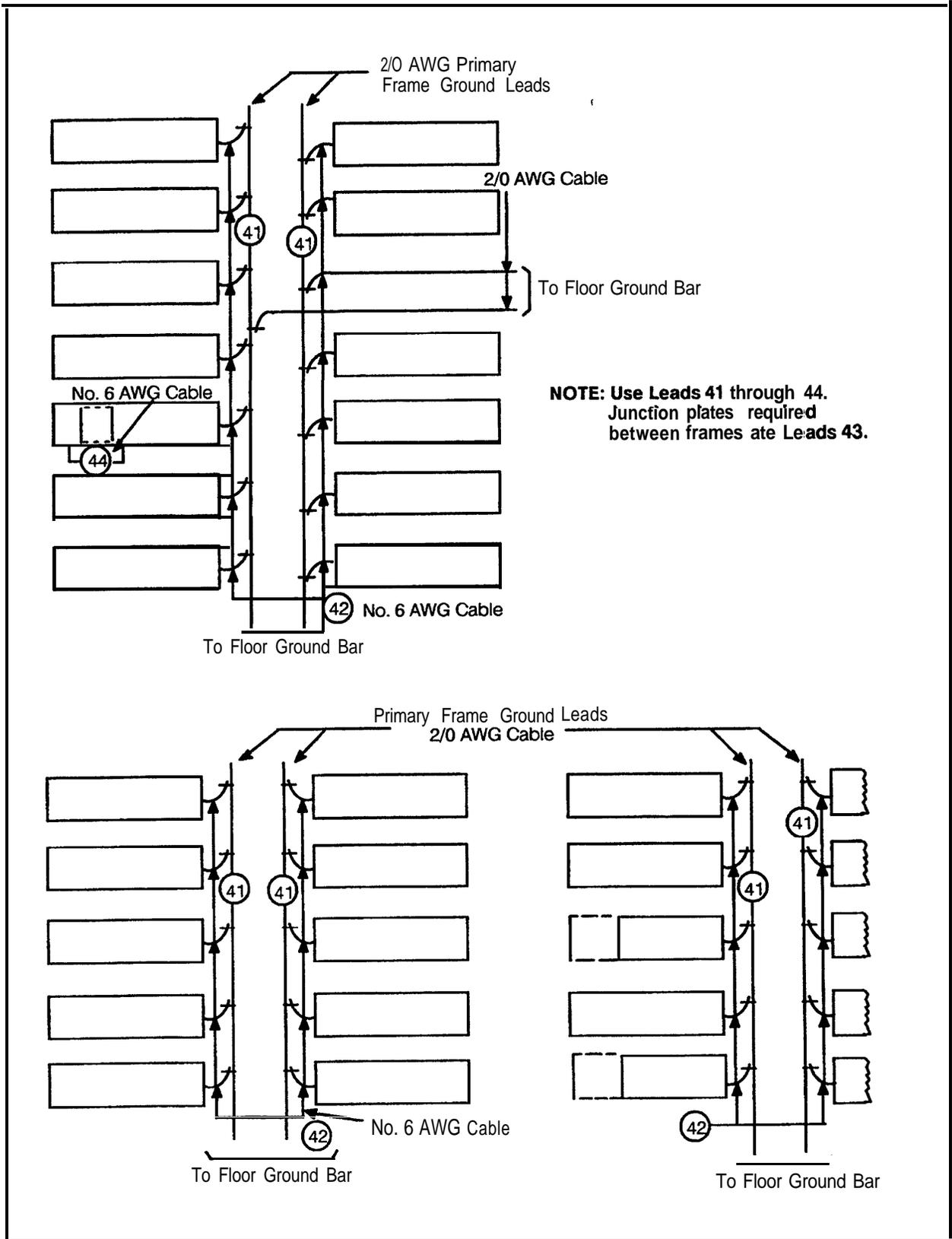


Exhibit 19 - Electronic System Frame Grounding for Existing Sites and Additions to Existing Lineups before Isolation

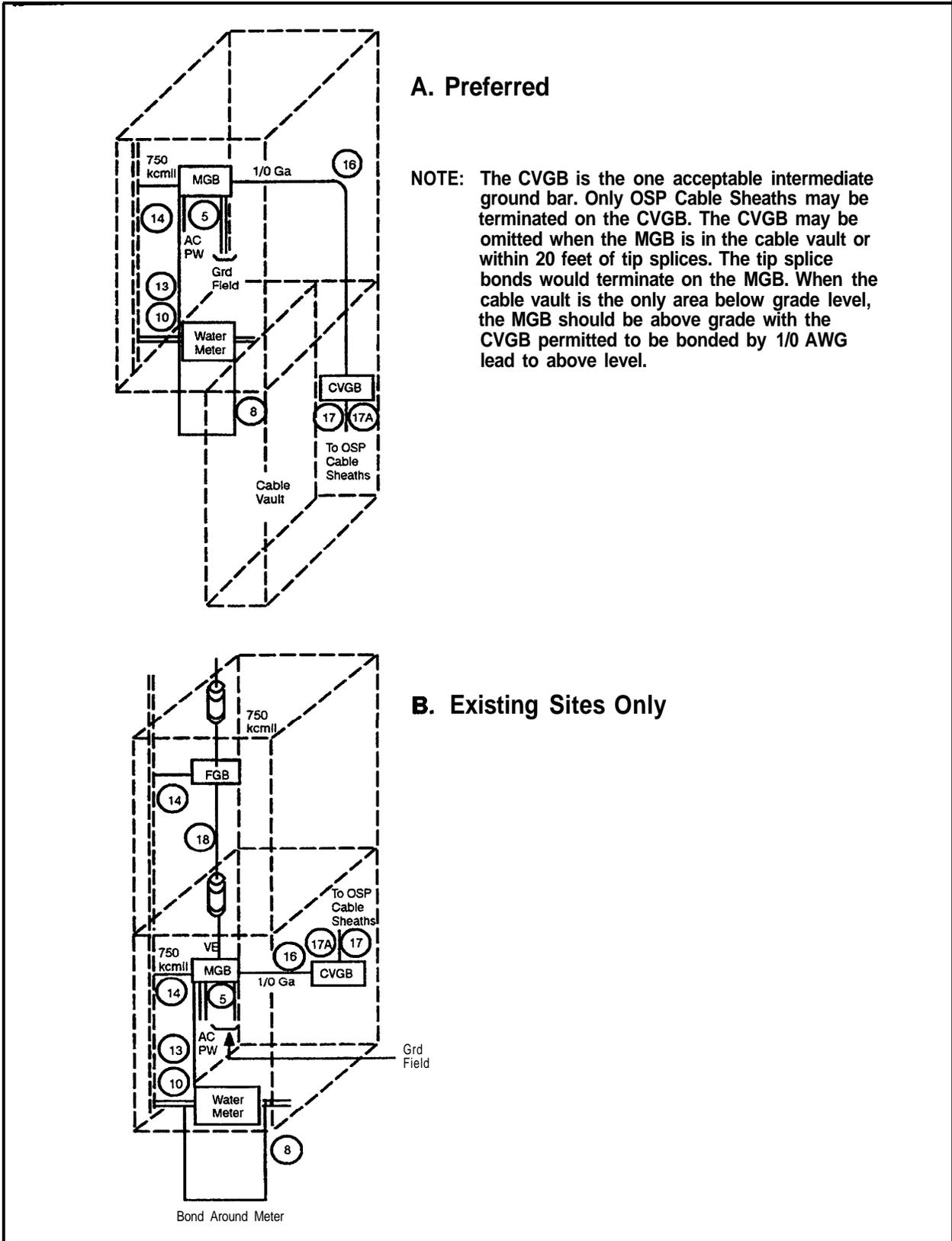


Exhibit 20 - Cable Vault Ground Bar

Exhibits, continued

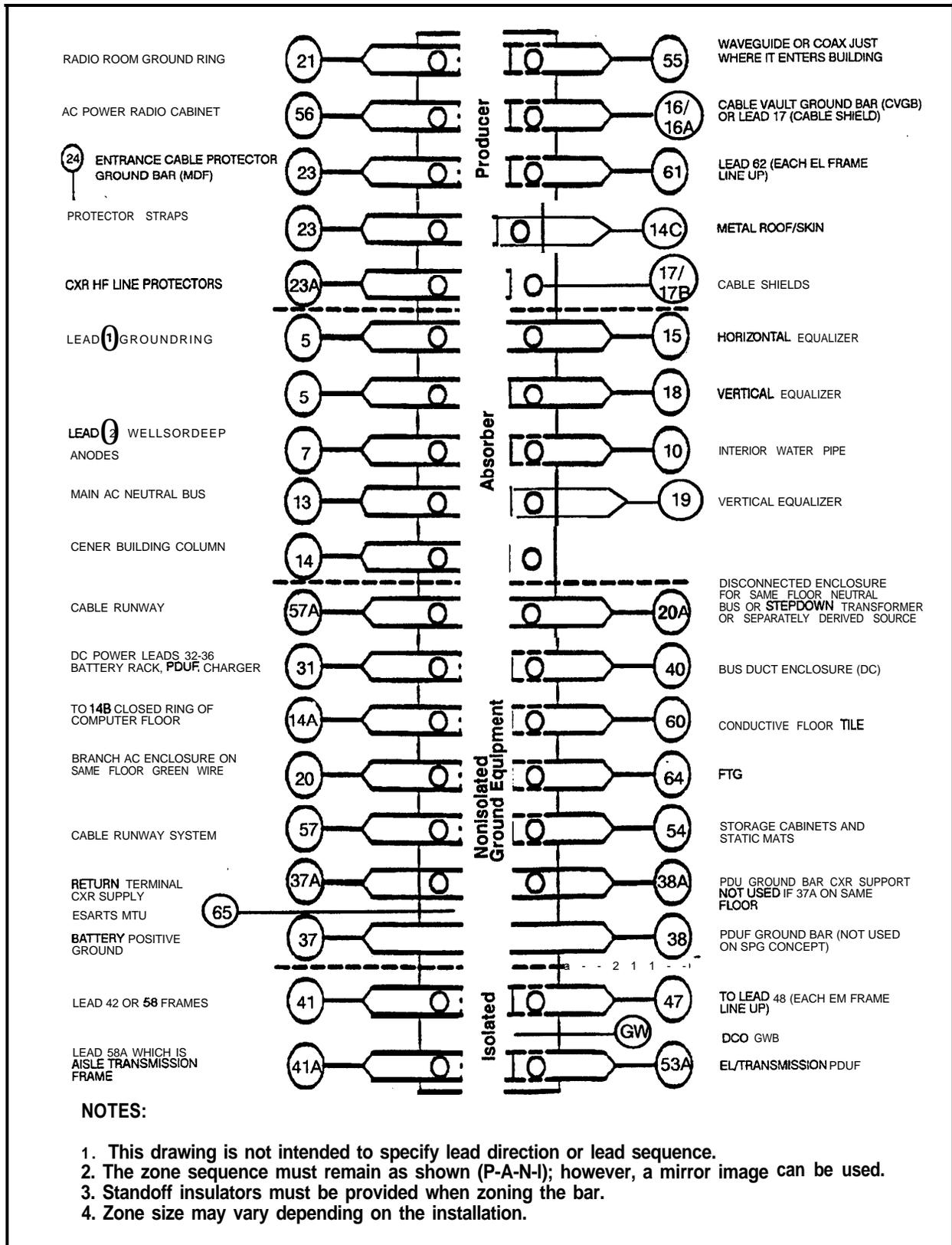


Exhibit 21 - Ground Bar Zoning

Exhibits, continued

SIZE OF FUSE AT DSU (largest fuse used at the DSU, PCU, OR PCD feeding transmission equipment)	MINIMUM GAUGE OF LEAD 53A**	GAUGE OF LEAD 41A*	GAUGE OF LEAD 58A*	GAUGE OF LEAD 59A*
250 amperes or less	2/0 AWG	2/0 AWG	No. 2 AWG	No. 6 AWG
400 amperes	250 kcmil	2/0 AWG	No. 2 AWG	No. 6 AWG
600 amperes	500 kcmil	2/0 AWG	No. 2 AWG	No. 6 AWG
1000 amperes	750 kcmil	2/0 AWG	No. 2 AWG	No. 6 AWG
Larger than 1000 amperes specifically designed, consult Telops engineering staff.				

NOTE: All gauges are made of insulated copper.

* Extend Lead 41A (58A in smaller installations) to the MGB/FGB bar.

****NOTE:**

- Run Lead 53A along with the power cables feeding the PDU all the way to the source at the battery, then from the battery to the MGB or FGB. On this last part of the run, keeping Lead 53A close to Lead 37 or 38 is important.
- Bond Lead 53A to each runway or grid section supporting the power cables and space the connections no more than 15 feet (4.5m) apart.
- One Lead 53A could serve more than one PDU in the equipment area. In this arrangement Lead 53A is extended from ground bar only if the same power cable route is used by each PDU.
- Omit Lead 53A when PDU is not served by a DSU, PCU, or PCD.

Exhibit 22 - Size of Fuse at DSU

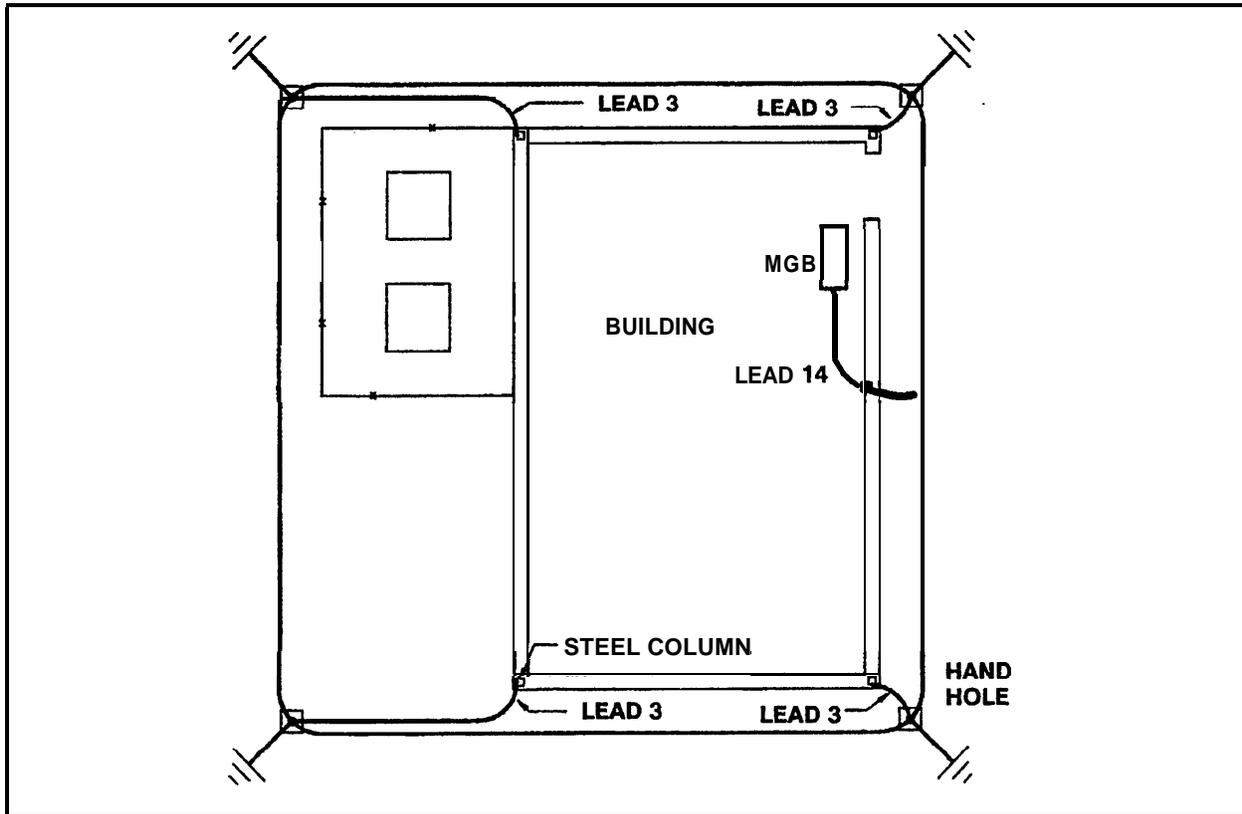


Exhibit 23 - Typical Building Column Grounding

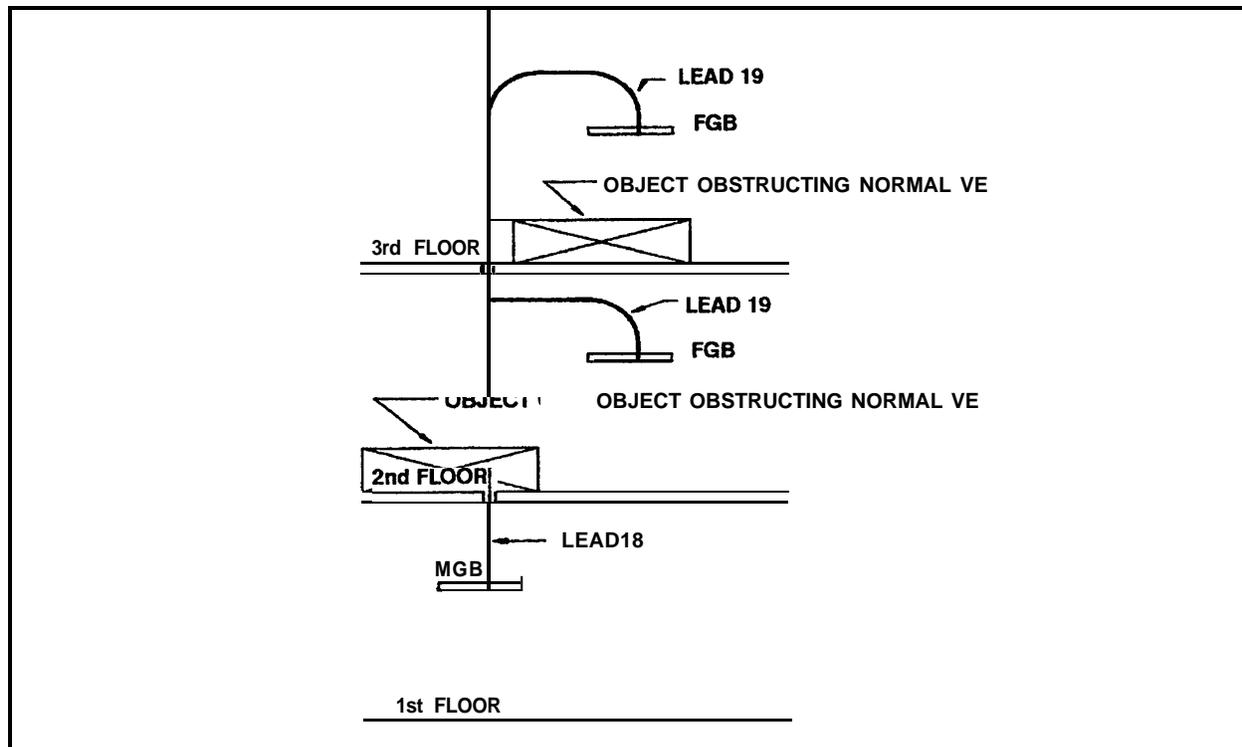


Exhibit 24 - Alternate FGB Connection Vertical Equalizers

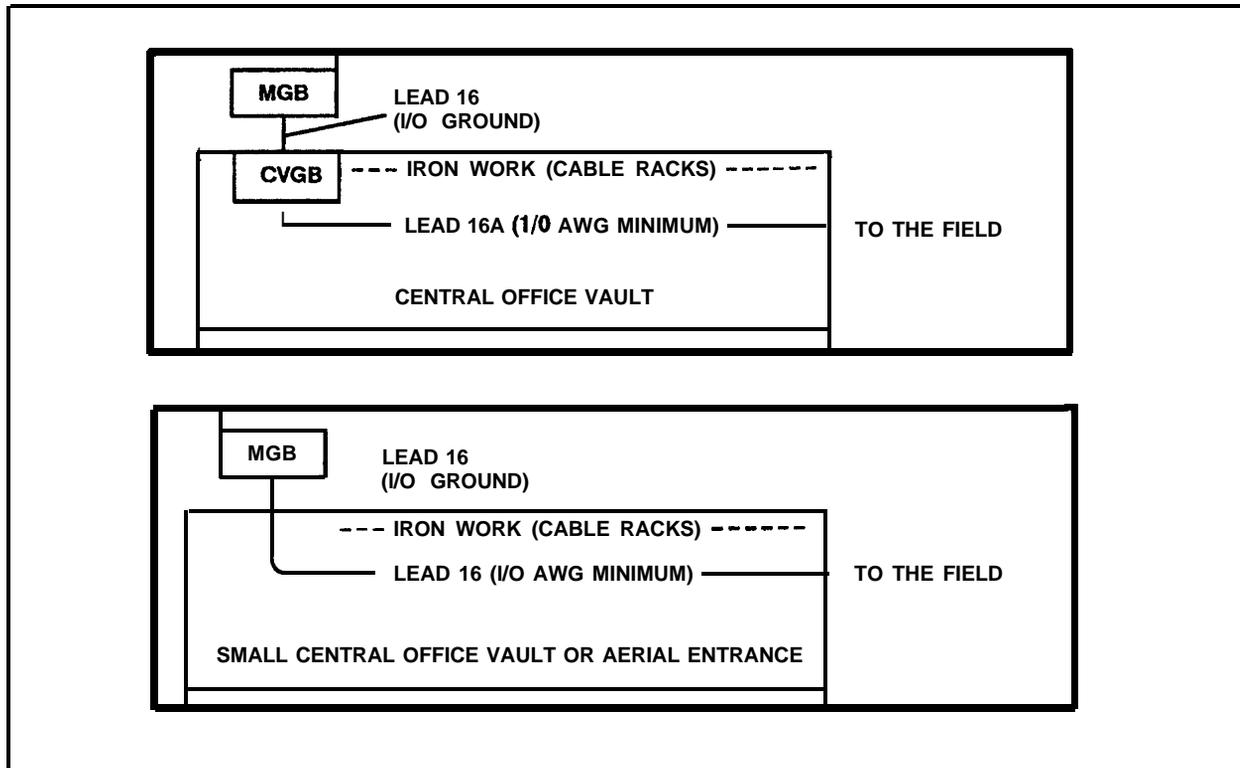


Exhibit 25 - CVGB Options

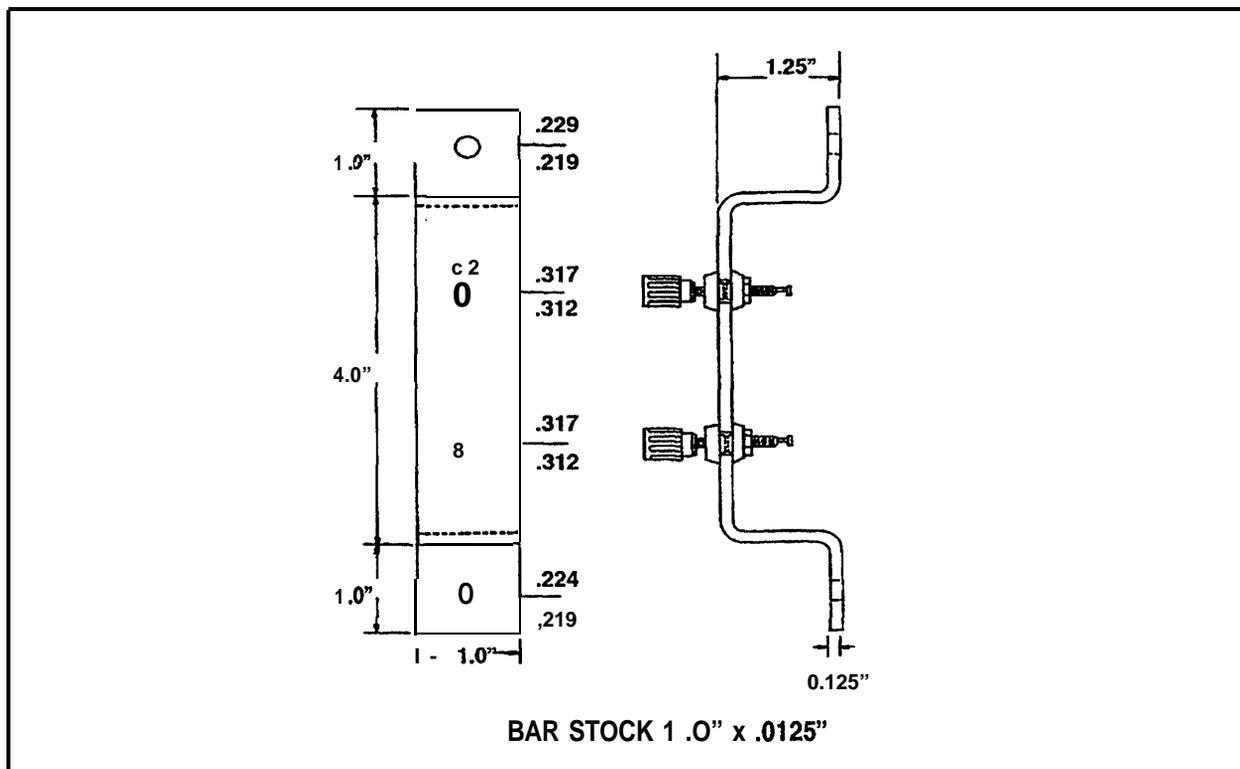


Exhibit 26 - Permanent Test Points Bracket

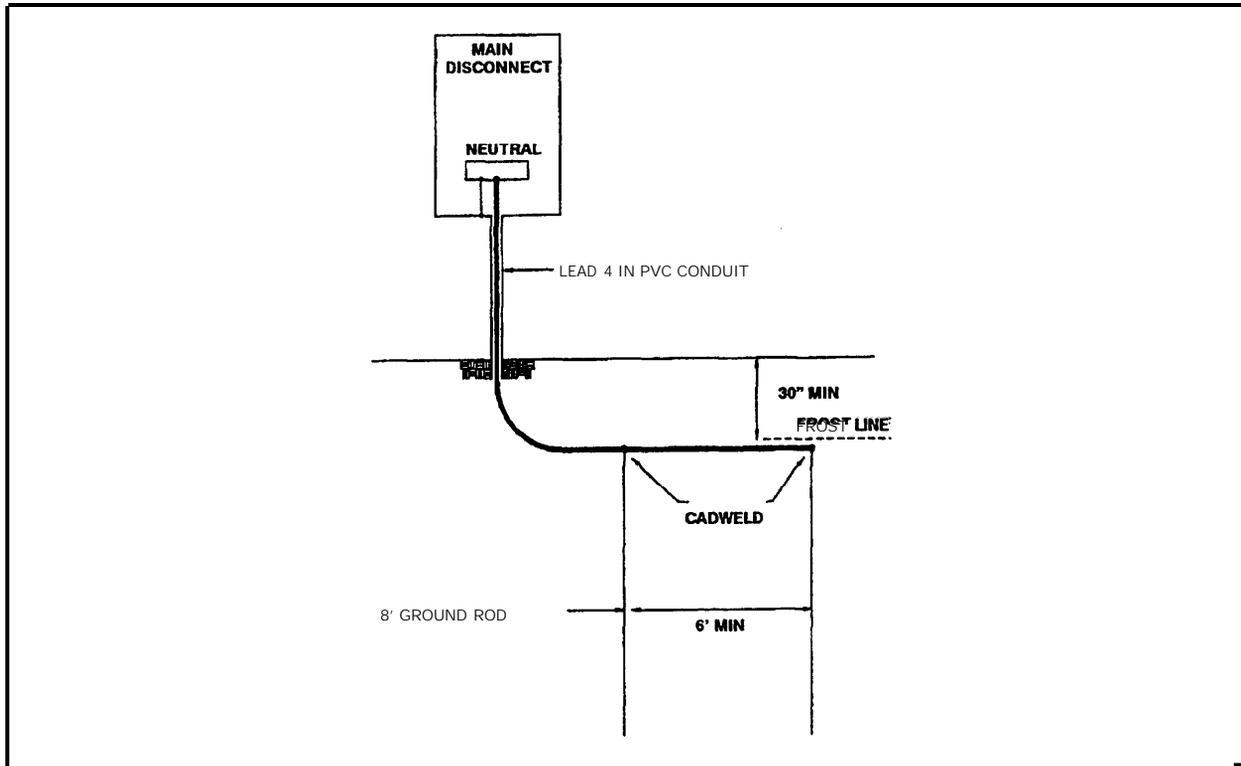


Exhibit 27 - Lead 4 Typical AC Service Ground

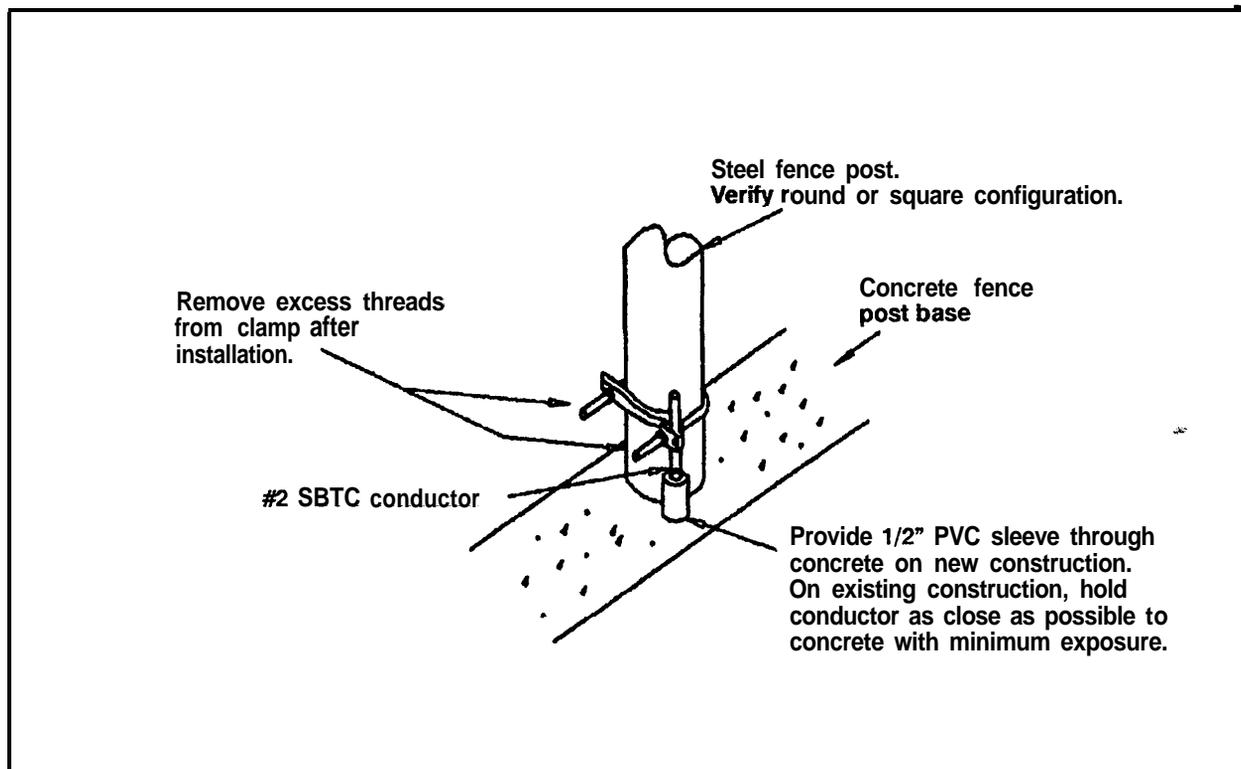
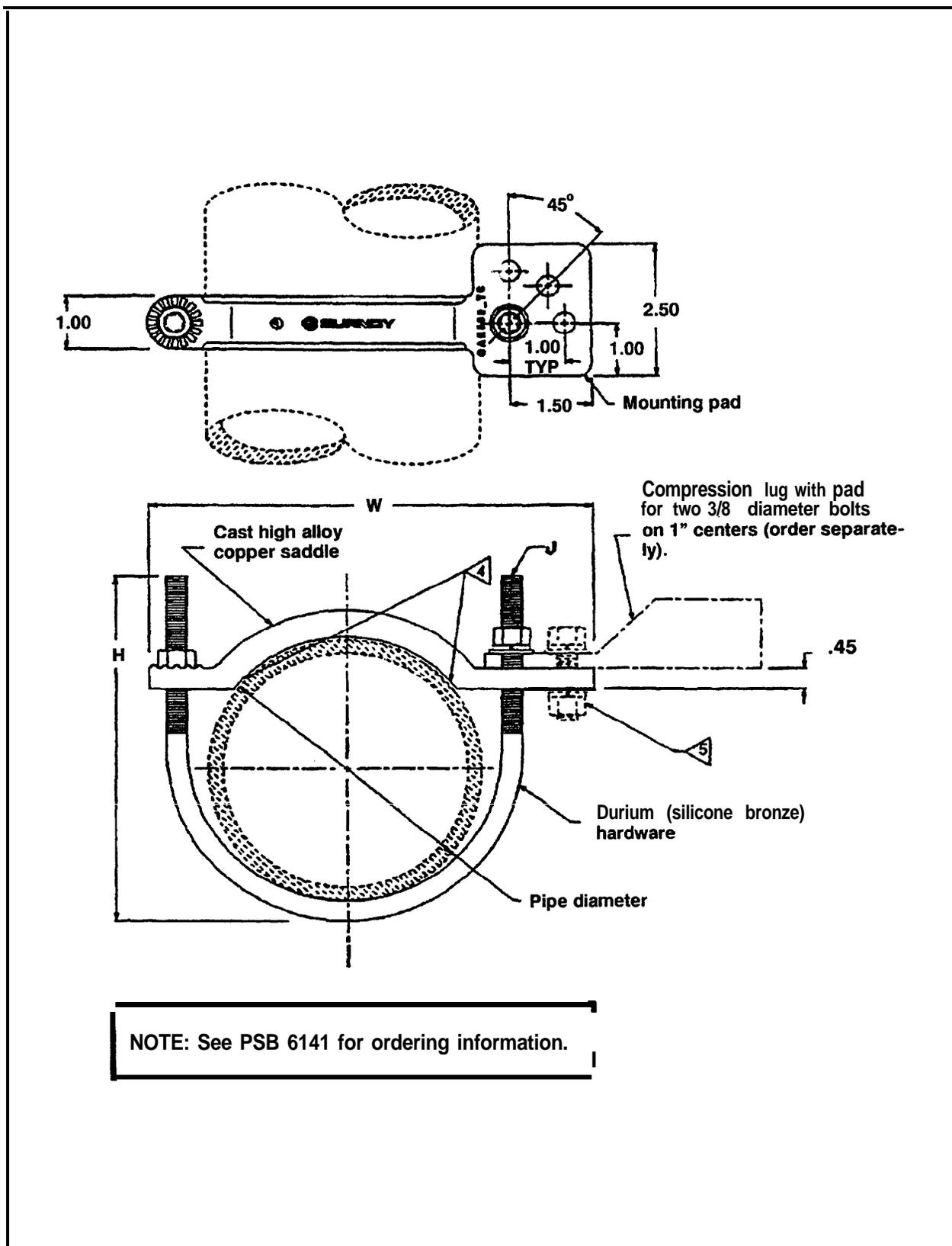


Exhibit 28 - Steel Fence Post Detail



NOTE: See PSB 6141 for ordering information.

Exhibit 29 - Ground Clamp Detail

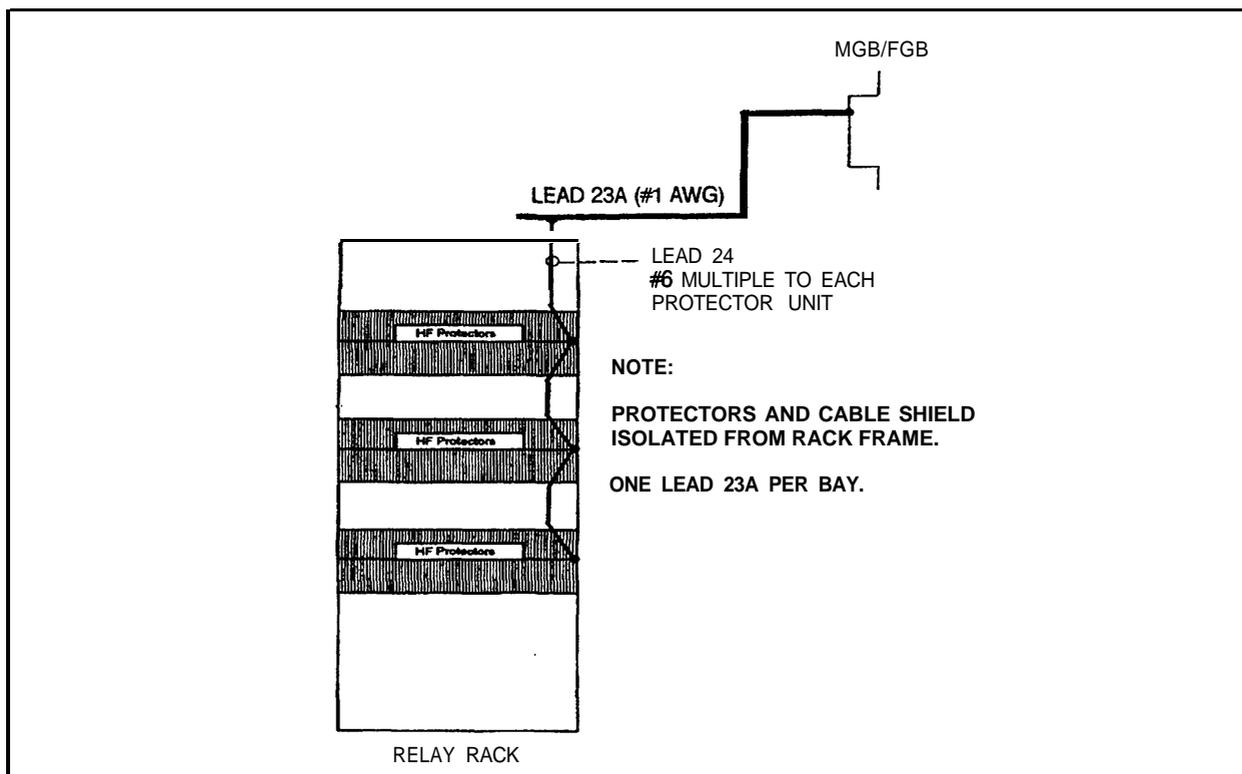


Exhibit 30 - HF Protector Grounding

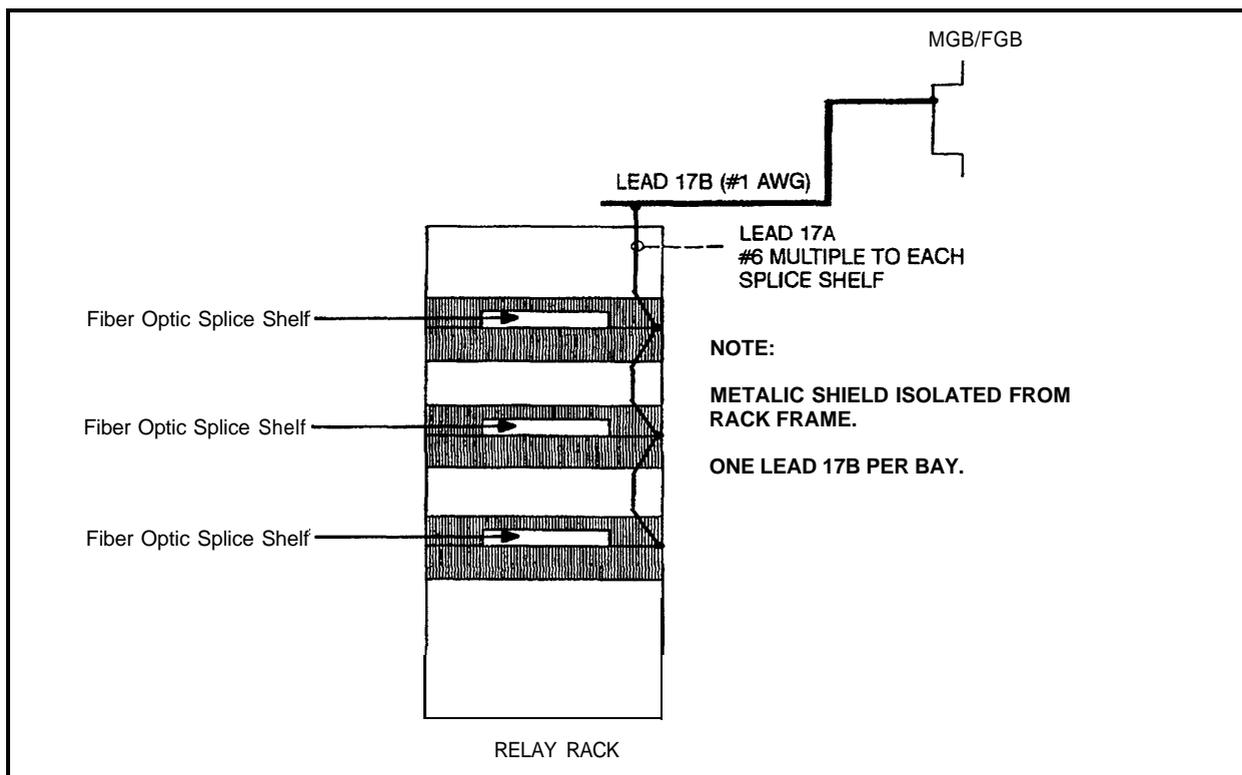


Exhibit 31 - Fiber Optic Splice Shelf Grounding

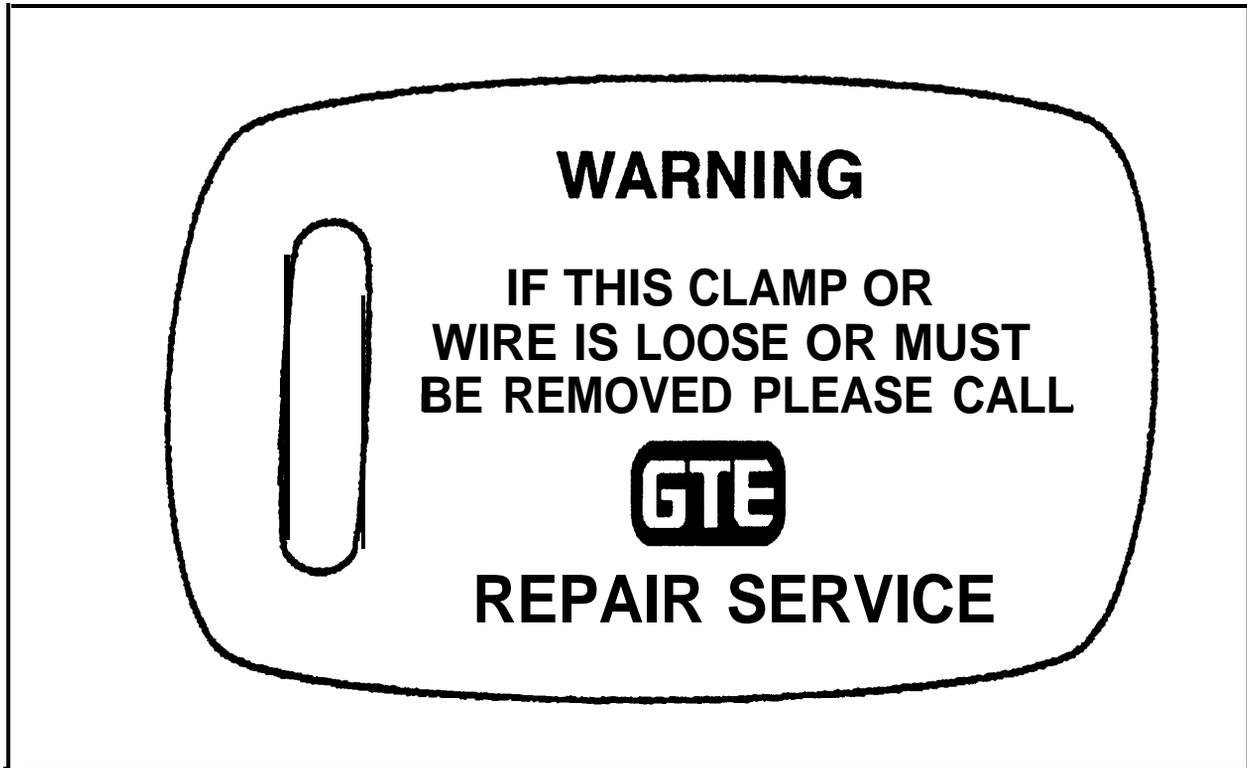


Exhibit 32 - Ground Wire Warning Tag (MC 558860, PSB 0131)

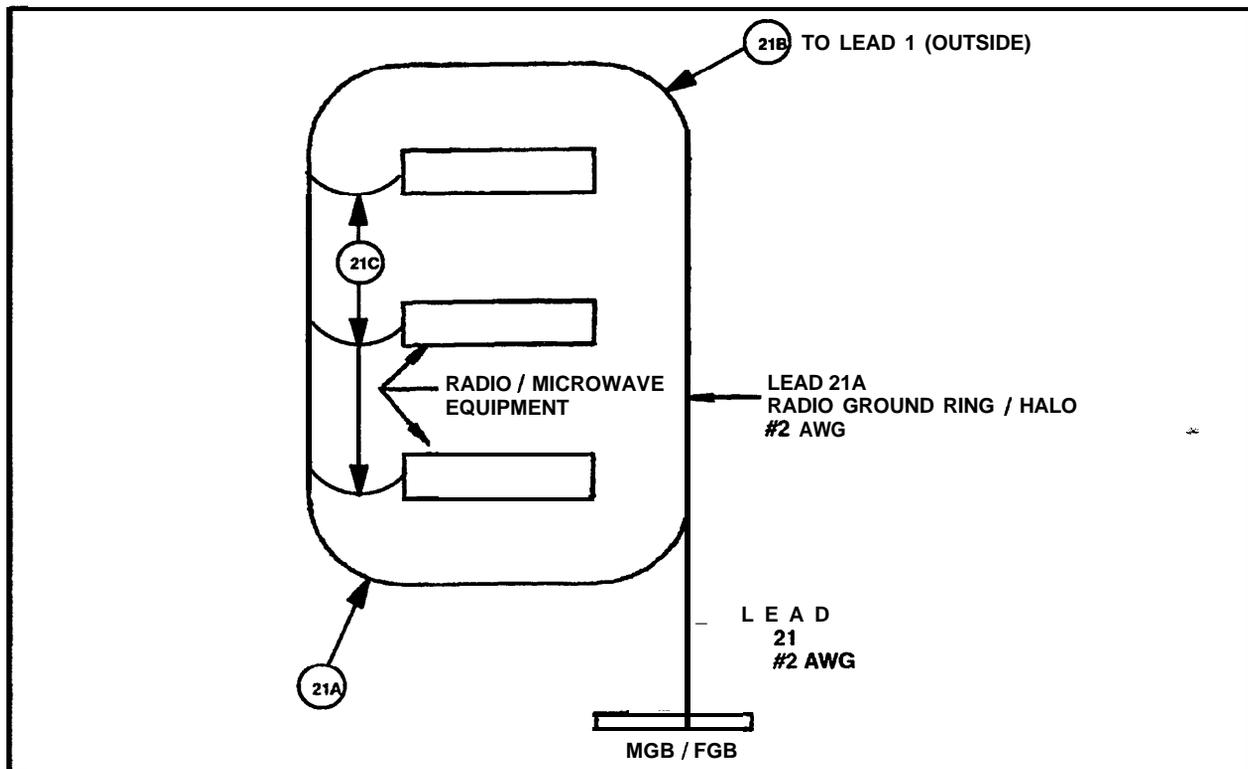


Exhibit 33 - Lead 21 Interior Radio Ground Ring Connection