



ATT-TP-76403

Grounding and Bonding Requirements for Internet Services Facilities

This Practice provides engineering, material, and installation requirements for grounding systems in Internet Services facilities containing communications systems and other equipment.

Audience: All AT&T NP&E and Internet Services employees

Effective Date: 08/07/2006

Issue Date: Issue 1 07/28/2006

Expires On: NA

Related Documents:

- ATT-TP-76416 (Grounding and Bonding Requirements for Network Facilities)
- ATT-TP-76416-001 (Grounding and Bonding for Network Facilities – Design Fundamentals)

Cancelled Documents:

Issuing Department: NP & E, Enterprise Technology Support – Common Systems

Business Unit: AT&T Services, Inc.

Author(s): John Messina, Telephone: 203-553-0232; SBCUID: jm4735

INTRODUCTION

This Practice provides engineering, material, and installation requirements for protective grounding systems in structures containing network communications systems and other equipment.

REASON FOR REISSUE

Issue	Date	Description of Changes	Author
1	07/21/2006	First Issue	jm4735

SECTION 1
Definitions, General and Material Requirements

1.1 SCOPE	6
1.2 GENERAL	6
1.3 DEFINITIONS AND ACRONYMS	6
1.4 GROUND RODS	12
1.4.1 Construction	12
1.4.2 Dimensions	12
1.5 CONDUCTORS	12
1.5.1 Exterior Buried Conductors	12
1.5.2 Equipment Grounding Conductors	12
1.5.3 AC Equipment Ground (ACEG) Conductor	13
1.5.4 Grounding Conductors Within Equipment Bays	13
1.5.5 Grounding Conductor Color 13	
1.6 CONNECTORS & CONDUIT BONDING DEVICES	14
1.6.1 Exothermic Welding	14
1.6.2 Clamp Type Pipe Connectors and Conduit Bonding Devices	15
1.6.3 Compression Connectors	15
1.6.4 Pressure Type (Mechanical) Connectors	16
1.6.5 Parallel Cable Connectors	16
1.6.6 Miscellaneous Connectors	16
1.6.7 Solder-Type Connectors	17
1.7 BUS BARS	17
1.7.1 Construction	17
1.7.2 Dimensions	17
1.8 INSTALLATION REQUIREMENTS	18
1.8.1 Routing and Support of Equalizer Conductors	19
1.8.2 General Requirements - Routing and Supporting Conductors	19
1.8.3 Connecting and Identifying Conductors	22
1.8.4 Application Of Lock Washers For Grounding Connections	23

SECTION 2
Office Ground Electrodes, Vertical and Horizontal
Equalizers, AC Service and Distribution System

2.1 SCOPE	25
2.2 EARTH ELECTRODES	25
2.2.1 Public and Private Water Systems	25
2.2.2 Water Well Metallic Casing	26
2.2.3 Driven Ground Electrodes	26
2.2.4 Other Electrodes	30
2.2.5 Interbonding of Earth Electrodes	31
2.3 DRIVEN GROUND SYSTEM FOR VIDEO SITES	31
2.4 CENTRAL OFFICE GROUND SYSTEM	31
2.4.1 Office Principal Ground Point (OPGP)	32
2.4.2 Interbonding	34
2.4.3 Design Parameters - Vertical Riser	36
2.4.4 Design Parameters - Horizontal Equalizer System	40
2.4.5 IS POP/VHO Ground Bus Bars	41
2.4.6 Designation of OPGP & IS POP/VHO Ground Bus Bars	42
2.4.7 Office Drawings	42
2.5 BUILDING ENGINEERING	42

2.6 AC SYSTEM GROUNDING	42
2.6.1 Grounding Electrode Conductor (GEC)	43
2.6.2 Main Bonding Jumper.....	44
2.6.3 Gounding of Separately Derived AC Systems	44
2.7 AC EQUIPMENT GROUNDING	44
2.7.1 Feeder and Branch Circuit Equipment Grounding System	44
2.7.3 AC Power Distribution Cabinets	47
2.7.4 AC Bus Duct System	48
2.7.5 Engine-Alternator Sets	48
2.7.6 Grounding of AC Tap Boxes	49
2.7.7 Cord Connected AC Operated Equipment	49
2.7.8 Job Drawings, Architectural	49
2.7.9 Rooftop Facilities	50
2.8 COORDINATION WITH CORPORATE REAL ESTATE	50

SECTION 3

Power Plants and Equipment, Transport and Miscellaneous Equipment

3.1 SCOPE	53
3.2 GENERAL	53
3.3 DC POWER SYSTEMS	53
3.3.1 Battery Plants	53
3.3.2 Power System Equipment Grounding	55
3.3.3 Engine Alternator Equipment	57
3.4 POWER DISTRIBUTION SYSTEMS	58
3.4.1 Battery Distributing Fuse Board (BDFB)	59
3.5 INTERNET SERVICES UNINTERRUPTIBLE POWER SYSTEMS	59
3.5.1 UPS Power	59
3.5.2 AC POWER DISTRIBUTION EQUIPMENT	60
3.6 INTERNET SERVICES, TRANSPORT AND MISCELLANEOUS EQUIPMENT	60
3.6.1 Equipment Enclosure and Unit Requirements	61
3. 6.2 Insulation	62
3. 6.3 Special Note on Isolated Ground Type Receptacles	63
3. 6.4 Main Aisle and Lineup Conductors	63
3. 6.5.Bonds to Ironwork and Other Metallic Objects	64
3. 6.6 Other Systems	65
3. 6.7 Bay Ground Lead	65
3.6.8 Conduits, Armored Cable, Shielded Wire for Other Than AC Service	65
3.6.9 Peripheral Equipment	66
3.7 DISTRIBUTING AND PROTECTOR FRAMES	66
3.8 CABLE ENTRANCE FACILITY (CEF)	67
3.9 CABLE REARRANGEMENT FACILITY	68
3.10 FIBER OPTIC CABLE TERMINATION EQUIPMENT	68

SECTION 4

Raised Floor Environments for Internet Services

4.1 RAISED FLOOR APPLICATIONS	70
4.1.1 General	70
4.1.2 Design	70
4.1.3 Incidental Contact	70
4.1.4 Connections	70

**SECTION 5
Commercial/Leased Locations**

5.1 SCOPE	72
5.2 COMMERCIAL/LEASED LOCATION EQUIPMENT	72
5.2.1 General	72
5.2.2 Access to a Site's Earth Electrode System	73
5.2.3 Property Owner Furnished Equipment Grounding System	73
5.2.4 Cable Entrance	74
5.2.5 DC Power Systems Provided with Network Equipment	74
5.2.6 Power System(s) Provided by Customer	75
5.2.7 Grounding and Bonding within Frames, Cabinets & Enclosures	76

**SECTION 6
Video Sites and Equipment**

6.1 SCOPE	78
6.2 GENERAL	78
6.3 EXTERIOR RING GROUND SYSTEM	80
6.3.1 Earth Electrode System	80
6.3.2 Roof Ring Ground System	80
6.3.3 Interior-Exterior Bonds	81
6.3.4 Bonds to Antenna Towers	81
6.4 INTERIOR RING GROUND SYSTEM	82
6.4.1 Peripheral Conductor	83
6.4.2 Supplementary Conductors	84
6.4.3 Coaxial Cable Bonds	86
6.5 UNIT BONDS	86
6.5.1 Exterior Unit Bonds	86
6.5.2 Interior Unit Bonds	87
6.5.4 Miscellaneous Unit Bonding	89
6.5.5 Conduit, Pipe and Duct Bonding	89
6.5.6 Bonding of Units Outside the Ring Ground Periphery	90
6.6 BONDS AT STRUCTURE ENTRANCES	90
6.6.1 General	90
6.6.2 Video Entrance Bus Bar	91
6.6.3 Other Arrangements	92
6.6.4 Exterior Bonds	92
6.6.5 Interior Bonds.....	94
6.7 BONDING OF STRUCTURAL MEMBERS	95
6.8 SMALL VIDEO ANTENNA SYSTEMS	96
6.8.1 Scope	96
6.8.2 System Component Location and Other Considerations	96
6.8.3 Down Conductors	97
6.8.4 Bonding Conductors	98
6.9 MATERIAL	99
6.9.1 Protective Devices	99
6.9.2 Conductors	99
6.9.3 Connectors	99
6.9.4 Other Material	100
ANNEX A Reference Documents and Information	101
ANNEX B Revisions to Text and Figures	106

ANNEX C	107
Index to Figure and Tables	107

SECTION 1

Definitions, General and Material Requirements

1.1 SCOPE

This Practice provides engineering, material, and installation requirements for protective grounding systems in structures containing AT&T Internet Services systems and other equipment.

1.2 GENERAL

- 1) The requirements in this Practice replace all associated grounding and bonding requirements in all previous Practices, Memorandums, Engineering Letters, Technical Publications, and other documents used by AT&T.
- 2) Several documents in Annex A were the source of many of the requirements in this Practice. Several were also the source of grounding fundamentals used to develop requirements not originally contained in these documents.
- 3) See Annex B for a list of revisions of this Practice.
- 4) Requirements in this Practice will not cover every unique application that may be encountered. A grounding arrangement may be devised and used for a specific application based on design criteria provided in this Practice. This can be especially important when assessing the need for upgrades to an existing grounding arrangement.
- 5) Where applicable, the requirements in this Practice conform to or exceed the requirements in NFPA 70, *National Electrical Code* (NEC).
- 6) Where explicit grounding requirements are included in the specifications of approved equipment, they shall have precedence over the general requirements of this Practice. Where explicit grounding requirements are not furnished in system specifications or have not been updated to the requirements contained in this Practice, a grounding system meeting the requirements of this Practice shall be provided.

1.3 DEFINITIONS AND ACRONYMS

The following terms are used throughout this Practice. The terms marked with an asterisk (*) are consistent with the NEC and include the text from Article 100 of the NEC. Table 1-1 is located at the end of this section on definitions.

It contains a cross-reference between grounding and bonding terms used in this Practice and equivalent terms used by standards bodies, equipment vendors and others. Network acronyms can be found in ATT-000-000-020, Network Acronyms Dictionary.

AC	Alternating Current
ACEG	Alternating Current Equipment Ground
AG/EEE	Above Ground Electronic Equipment Enclosure
AHJ	Authority Having Jurisdiction
AWG	American Wire Gauge
BDB	Battery Distribution Board
BDCBB	Battery Distribution Circuit Breaker Board
BDFB	Battery Distribution Fuse Board
BG/EEE	Below Ground Electronic Equipment Enclosure

Battery Return – The battery return is one of two wires (the other is generally called “battery”) used to provide dc power to network equipment. The battery return wire is grounded to the IS POP/VHO GRD System via the battery return bus bar.

***Bonding** - The permanent joining of metallic sub-sections to form an electrically conductive path, which will assure electrical continuity and the capacity to conduct safely any current likely to be imposed.

BSP Bell System/Service Practice

CBN Common Bonding Network

CDF Combined Distributing Frame

CEF Cable Entrance Facility

Central Office Ground (CO GRD) – (See Internet Services POP/VHO GRD)The grounding system within a structure, including the Office Principal Ground Point (OPGP), the Vertical Riser, horizontal equalizers, CO GRD bus bars on each floor, the connections to ac and dc power systems, and the connections to equipment and other objects. The CO GRD system is often referred to as a *tree* since, in multifloor applications, the vertical conductors resemble a trunk and the horizontal conductors resemble branches extending from the trunk. This system is designed to:

- 1) Provide a fault current return path that permits effective operation of over current protective devices
- 2) Provide a low impedance reference to the building's principal ground point
- 3) Allow an interchange of ground currents to effectively maintain equal potential in communication circuits

Central Office Ground Bus Bar - A bus bar that references the principal ground point through the Vertical Riser. At least one of these bus bars is provided on each floor to permit the grounding of frames and power supplies, as required.

Choke - A metallic support that completely encircles a ground wire thereby increasing the inductive properties of the wire. Also known as “girdle”.

Common Bonding Network (CBN) - A set of interconnected objects that has one or more connections to a ground reference. This network, created by a multitude of connections, helps to ensure that the objects are at essentially the same potential when fault current flows through them. Building steel, water pipes, vertical and horizontal equalizer conductors, metallic raceways, raised floor systems, equipment frames and other conductive objects form a common bonding network when bonded together by intentional and incidental connections. This term is now used throughout this Practice in place of *integrated ground plane*.

CRF Cable Rearrangement Facility

DC System Grounding Conductor - The conductor used to connect one side of a dc power source to the site's grounding system. Example: In a -48 volt battery-type power plant serving central office equipment, the conductor between the positive (+) side of the plant and a point on the IS POP/VHO GRD system.

Daisy Chaining - Daisy chaining is the unacceptable practice of extending a grounding connection by using the conductive mass of two or more components bonded together (rather than using the acceptable method of installing a separate, dedicated grounding wire that has bonds to each of the components).

Direct Current Equipment Grounding (DCEG) Conductor - The conductor that bonds an equipment frame, cabinet or other enclosure to the IS POP/VHO GRD system. The DCEG conductor may also bond an equipment unit within a frame, cabinet or other enclosure to the IS POP/VHO GRD system. “DCEG conductor” is now used in place of *framework grounding conductor*.

Driven Ground Electrode

For company locations, this means a driven ground rod. Other publications may use the term *made electrodes*, which includes plate, pipe, or other electrode designs that may not be approved for use at central offices and other company structures.

EEE Electronic Equipment Enclosure

EMT Electrical Metallic Tubing

EQPT Equipment

Equalization - The process of connecting different ground reference sources together with an objective of providing a single ground reference.

Equipment Ground (EG) - Deliberately engineered conductors in communication systems and ac and dc power distribution systems to provide electrical paths of sufficient capacity to permit protective devices (e.g. fuses, circuit breakers) to operate effectively and to equalize potential between equipment.

Exothermic Weld - A mixture of aluminum, copper oxide and other powders are held in place with a graphite mold around the joint to be treated. The mixture is ignited and the heat generated (in excess of 4000^o F) is sufficient to boil away contaminating films and foreign substances while joining the pieces with a continuous metallic bridge with electrical and mechanical properties similar to the individual items joined. Proprietary names include Cadweld and Thermoweld.

Flash Over - An unintended electric discharge.

Framework Ground (FRWK GRD) - That portion of the grounding system that provides a connection between the IS POP/VHO GRD system and frames, cabinets and metallic objects.

GEC Grounding Electrode Conductor

***Ground (GRD, GND)** - A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

Ground Fault - A conducting connection, whether intentional or accidental, between any of the conductors of an electrical system and the grounding conductor or conducting material which encloses the conductors (such as conduit) or any conducting material that is grounded or that may become grounded.

***Grounded** - Connected to the earth or to some conducting body that serves in place of the earth.

***Grounded Conductor** - A system or circuit conductor that is intentionally grounded. Example: The conductor usually referred to as the *grounded conductor* is the *neutral* conductor in ac circuits and the *battery return* conductor in dc circuits.

***Grounding Conductor** - A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes. Example: The alternating current equipment ground (ACEG), also called the *green wire*, used to provide a fault current return path in ac power systems or the grounding conductors used to interconnect frames, aisle grounds, horizontal equalizers, and vertical equalizers.

Grounding Electrode - A conductor (usually buried) for the purpose of providing an electrical connection to ground.

***Grounding Electrode Conductor (GEC)** - The conductor used to connect the grounding electrode to the equipment grounding conductor and/or to the grounded conductor of the circuit at the service equipment or at the source of a separately derived system. Example: In the ac service entrance switchgear of a building, the conductor between the insulated neutral bus bar and the office principal ground point bus bar.

Grounding Electrode System - An arrangement of intentionally bonded objects that furnish reference to earth and consist of one or all of the following:

- a) Specifically designed metallic objects such as driven ground rods, well casings, or other approved electrodes;
- b) Grounding electrodes of other systems (e.g., ac power, lightning protection);
- c) Most buried metallic objects that enter any portion of a structure

Ground Window (GW) - An imaginary spherical volume having a radius of 3 feet. This transition area contains the main ground bus (MGB), which is the physical interface between the building's common bonding network and isolated bonding network equipment. The Ground Window is the opening where grounding conductors serving isolated bonding network equipment are connected to the common bonding network.

Hatchplate / Bulkhead

The Hatchplate or Bulkhead is a solid copper plate used as a “window” through which antenna coaxial conductors pass utilizing hardware that grounds the sheath to the plate. The assembly can be installed in the side of a building, in a protected enclosure outside the building, or in close proximity to where the coaxial conductors exit the entrance conduits from outside the building. The lightning arrestors may also be installed on the hatchplate.

Horizontal Equalizers

Conductors of relatively low impedance (usually 750kcm) that interconnect:

- a) Vertical Risers in a building that is of a size that requires more than one Vertical Riser
- b) The IS POP/VHO GRD bus bar to equipment areas on the same floor
- c) Battery return bus bars in dc distribution systems for some electronic switching systems
- d) A horizontal equalizer conductor to an equipment unit or area on the same floor
- e) BDFB bus bars (non-insulated) to the IS POP/VHO GRD

HSP House Service Panel

IBN Isolated Bonding Network

IDF Intermediate Distributing Frame

IMC Intermediate Metal Conduit

Incidental Ground - Ground paths that exist within a building through contact between such items as structural steel, water piping, air ducts, conduits, superstructure, raceways, reinforcement rod, cable racks, and other conductive objects that are primarily installed for other purposes but secondarily provide an electrical path to ground.

Integrated Ground Plane (See Common Bonding Network)

Internet Services POP/VHO Ground (IS POP/VHO GRD) - The grounding system within a structure, including the Office Principal Ground Point (OPGP), the Vertical Riser, horizontal equalizers, ISO GRD bus bars on each floor, the connections to ac and dc power systems, and the connections to equipment and other objects. The ISO GRD system is often referred to as a *tree* since, in multifloor applications, the vertical conductors resemble a trunk and the horizontal conductors resemble branches extending from the trunk. This system is designed to:

- 1) Provide a fault current return path that permits effective operation of over current protective devices
- 2) Provide a low impedance reference to the building's principal ground point
- 3) Allow an interchange of ground currents to effectively maintain equal potential in communication circuits

Internet Services POP/VHO Ground Bus Bar - A bus bar that references the principal ground point through the Vertical Riser. At least one of these bus bars is provided on each floor to permit the grounding of frames and power supplies, as required.

Isolated Bonding Network (IBN) - A set of interconnected objects that is referenced to ground at a single point. This network is insulated from contact with any other conductive member not part of the same bonding network. With only one point of ground reference, the possibility that the equipment will be used as a conductive path for transient currents from exterior sources is greatly reduced. This term is now used throughout this Practice in place of *isolated ground plane*.

Isolated Ground Plane (See Isolated Bonding Network)

Isolated Ground Zone (Same as Isolated Bonding Network)

Isolated Return Bar - This is a bus bar used when a power plant serves Isolated Bonding Network equipment but does not have its battery return bus bar insulated from the framework of the power plant. It consists of either a bus bar detail or a separate bus bar. When this is a bus bar detail, one end is mounted on an insulator and the other is bolted to the existing battery return bus bar. When it is a separate bus bar, both ends are mounted on insulators and at least one 750 kcmil conductor ties this isolated bar back to the battery return bus bar.

kcmil 1,000 Circular Mills

Lightning Arrestor

A coaxial lightning arrestor conducts transient voltages to ground in the same manner as a cable protector thus protecting the down stream equipment from damaging electrical stress.

***Listed** - Equipment or materials included in a list published by an organization acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials, and whose listing states either that the equipment or material meets appropriate designated standards or has been tested and found suitable for use in a specified manner.

LPCDF Low Profile Combined Distributing Frame

***Main Bonding Jumper** - The connection between the grounded circuit conductor and the equipment grounding conductor at the service.

Main Ground Bus (MGB) - A bus bar located within the ground window that provides a physical means of connection between the Internet Services Office GRD system and the isolated bonding network served by the ground window.

MCM 1,000 Circular Mils (old term; see kcmil)

MDF Main Distributing Frame

MTCE Maintenance

NEC National Electrical Code

NRTL Nationally Recognized Testing Laboratory

Neutral - In ac power distribution, the conductor that is intentionally grounded on the supply side of the service disconnect and provides a current return path for ac power currents.

Office Principal Ground Point (OPGP) - A bus bar normally located near the AC entrance switchgear. It functions as:

- a) The connection point for all main grounding conductors and earth electrodes;
- b) The point of origin for the Vertical Riser;
- c) If convenient, the Internet Services Office GRD bus bar for the floor (typically the basement) where it is located

PBD Power Board

PBSD Pacific Bell Standard Drawing

PCF Power Control and Fuse Distribution

PD Power Distribution

PDC Power Distribution and Control

PDU Power Distribution Unit

PGP Principal Ground Point

Plating - A coating of silver, nickel or tin that is applied to copper conductors to inhibit oxidation of the copper. Tin is the least expensive of these coatings and most widely used.

***Premises Wiring (as applied to a System)** - That interior and exterior wiring, including power, lighting, control and signal circuit wiring together with all of its associated hardware, fittings, and wiring devices, both permanently and temporarily installed, which extends from the load end of the service drop or load end of the service lateral conductors, or source of a separately derived system to the outlet(s). Such wiring does not include wiring internal to appliances, fixtures, motors, controllers, motor control centers, and similar equipment.

***Raceway** - An enclosed channel designed expressly for holding wires, cables, or bus bars, with additional functions as permitted in the National Electrical Code (NEC).

Ring Ground (for earth electrodes) - A buried conductor that forms a ring around a structure. The ring ground usually includes a series of driven ground rods bonded to the conductor.

SBGL Stranded Bay Ground Lead

Separately Derived Source - A power source that has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system. This definition is similar to the NEC definition of *Separately Derived Systems*. Example: A standby ac reserve arranged so that the neutral is switched or power supplies with isolation between input and output such as most delta-wye transformers and some inverters and converters.

Shall – Use of the word “*shall*” in this Practice is a directive or mandatory requirement.

Single Point Ground - A method used to ground a circuit at only one physical point. It is important to note that “point” in this context actually refers to an area on a bus bar from which a common ground reference is obtained. It is a single point (area) for obtaining ground reference but there may be multiple conductors that terminate at this point for ground reference.

Solidly Grounded - A method of grounding either a power supply or a frame that uses a grounding conductor connection in which no additional impedance has been intentionally connected in series with the grounding path.

UL Underwriters Laboratories

Vertical Riser (VR) - This conductor, also called the Vertical Equalizer, extends ground reference from the OPGP to one or more Internet Services Office GRD bus bars on each floor of the structure. The portion of this conductor that is routed horizontally between the OPGP and the first connection to a Internet Services Office GRD bus bar is also called the vertical riser.

Withstand Rating - The maximum current an unprotected (no over current device) electrical component can sustain for a specified period of time without the occurrence of extensive damage.

Term Used in this Practice	Equivalent Terms
Battery Return (BR)	0 Volt Reference, -48 V Return, Battery Ground, DC Return, Power Return
Internet Services Office (ISO GRD)	Building Grounding System, Central Office Protection, COG
Internet Services Office Ground Bar	COG, COGB, FGW, Floor Ground Bar
Common Bonding Network (CBN)	Integrated Ground Plane, Integrated Ground System, Integrated Ground Zone
DC Equipment Grounding (DCEG) Conductor	Frame Ground Conductor, Framework Ground Conductor
Ground	Earth
Grounding Conductor	Earthing Conductor, Protective Conductor
Grounding Electrode System	Earthing Network
Ground Window	SPC Window
Isolated Bonding Network (IBN)	Isolated Ground Plane, Isolated Ground System, Isolated Ground Zone
Logic Ground	Logic Return, Signal Ground
Main Ground Bus (MGB)	Single Point Ground, Single Point Connection (SPC)
Office Principal Ground Point (OPGP)	Building Principal Ground, Facility Ground, Master Ground Bar, Main Earthing Terminal, OPGPB, PGP Bus, Principal Ground Point, Reference Point 0, Zero Potential Reference Point
Vertical Equalizer	IS POP/VHO Ground Riser, Equipment Ground Riser, Vertical Riser

**Table 1-1
Cross Reference of Grounding and Bonding Terms**

1.4 GROUND RODS

1.4.1 Construction

Ground rods shall be either solid stainless steel or copper clad steel. Stainless steel rods shall be of A.I.S.I grade 302 or 304 alloy. Copper clad rods shall be manufactured by a process that applies molten copper to a steel core.

Steel rods, bare or galvanized, or rods covered with copper or stainless steel tubing, or hollow core pipes of any type shall not be used as driven ground rods.

1.4.2 Dimensions

The minimum dimensions for a ground rod are 5/8"; diameter by 8 feet long. These dimensions equal or exceed the requirements in Article 250 of the NEC.

1.5 CONDUCTORS

Except where allowed per standard drawings, grounding conductors shall not be used to carry normal load currents.

1.5.1 Exterior Buried Conductors

1.5.1.1

All direct-buried conductors shall be a minimum #2 AWG uninsulated solid tinned or untinned copper, using soft (annealed) or semi-hard drawn commercial grade copper. They shall not be:

- a) Insulated
- b) Direct-buried stranded copper conductors
- c) Placed in conduit
- d) Aluminum conductors of any type

Note: Items (a) and (b) are acceptable for existing locations if installed prior to 1993 provided all other requirements for the earth electrode system are met. Items (a) and (b) are always acceptable for use in cathodic protection systems.

1.5.2 Equipment Grounding Conductors

1.5.2.1

Conductors used in an equipment grounding system, including IS POP/VHO GRD system extensions to frames, cabinets and other units, shall be of the same cable type(s) approved for power system conductors (see drawing ATT-E-00581-E.pdf on the ATT Woodduck website). Grounding conductors, whether stranded or solid, shall be tinned copper. Aluminum conductors shall not be used. Uninsulated, tinned, stranded conductors may be used for lineup grounding conductors and uninsulated conductors of any type may be used when part of apparatus or equipment that has been approved for use.

1.5.2.2

A conductor used for a vertical equalizer may be type THW or other if its insulation is rated UL 94V-0 or UL 94V-1.

1.5.2.3

Other types of equipment grounding conductors may be used if they are in accordance with system specifications for equipment approved for use.

1.5.2.4

All grounding cable (750 kcmil - 14 AWG single conductor, stranded or flex) shall be of the type approved by AT&T for the specified application as listed on the Minor Materials List (MML). Coated or tinned power cable shall be utilized, unless otherwise specified and approved by AT&T..

1.5.3 AC Equipment Ground (ACEG) Conductor

1.5.3.1

Conductors that are part of the ACEG system shall be copper, and should be insulated. Insulation shall be the same as that of phase conductors and shall have an insulation temperature rating at least equal to that of the phase conductors. When armored cable is used, the ACEG conductor shall be a separate conductor, and shall not be the sheath continuity strand.

1.5.3.2

Insulation for the ACEG conductor shall be green or green with one or more yellow stripes, or the conductor shall be uninsulated (bare). ACEG conductors larger than #6 AWG may be identified by marking the exposed insulation with green tape or paint at each end and at every point where the conductor is accessible.

1.5.3.3

Connectors furnished as part of electrical equipment may be used to terminate ACEG conductors. Otherwise, connectors specified in 1.6 shall be used.

1.5.4 Grounding Conductors Within Equipment Bays

1.5.4.1

A grounding conductor located within an equipment bay shall be a copper bus bar, ribbon, or a solid or stranded copper conductor. It may be insulated or uninsulated and while a tinned surface is preferred, it may be unplated.

1.5.4.2

Except for early vintage equipment, the frame or cabinet metalwork should not be in contact with any current-carrying conductor.

1.5.5 Grounding Conductor Color

1.5.5.1

All newly installed DC grounding conductors covered by this practice and that require insulation shall be green. Conversion of existing insulation colors purely for the sake of uniformity is not warranted.

1.5.5.2

Insulation on grounding conductors used in ac power systems shall either be green or green with one or more yellow stripes. The most common of these are:

- a) Equipment grounding conductors run with feeder and branch circuit conductors
- b) Grounding electrode conductors from house service panels and the sources of separately derived systems
- c) Main and equipment bonding conductors

When these conductors are larger than #6 AWG, they may be identified with a suitable means of green marking (tape, paint, etc.).

1.5.5.3

Insulation color for grounding conductors may be specified by equipment vendors for conductors provided as part of the equipment installation and within the footprint of the installed equipment.

1.6 CONNECTORS & CONDUIT BONDING DEVICES

1.6.1 Exothermic Welding

1.6.1.1

The primary method of thermal welding described in this section is exothermic welding. Any equivalent method of molecular welding similarly utilizing brass or copper to form the bond may also be used.

1.6.1.2

Two brand names: *Cadweld* and *Thermoweld* are often used in place of the generic term *exothermic weld*. The generic term is used throughout this Practice.

1.6.1.3

Exothermic welds should be used for all buried connections and for connections to building steel. Exothermic welds should also be used for above ground terminations on the exterior of the building, where practical,

1.6.1.4

Within buildings, exothermic welding may be used at water pipes, connection of the IS POP/VHO GRD riser to IS POP/VHO GRD bus bars and bonds to building steel. Other applications may also be practical, such as connection to the peripheral ground ring in microwave stations and elsewhere.

Note: In occupied areas within a building, the use of exothermic welds should be restricted to those methods that use "smokeless" or "low smoke emitting" processes, such as the EXOLON® process from Erico Products, Inc.

1.6.1.5

Exothermic welding shall not be used for connections to thin wall pipe or tubing (.035 inch wall or less).

1.6.2 Clamp Type Pipe Connectors and Conduit Bonding Devices

1.6.2.1

For terminations on pipes, grounding clamps should be used when it is not practical to use exothermic welds or threaded type grounding hubs or bushings. When used, clamps, hubs, bushings or other bonding devices shall be listed for their intended use by a nationally recognized testing laboratory (NRTL). For clamps, the heavy-duty type using bronze saddles are preferred.

The bonding conductor for a conduit may also be attached to the conduit by drilling the conduit and using a compression type connector fastened to the conduit. Conduit 3' or longer shall be bonded in order to mitigate inductive properties of the conduit.

1.6.3 Compression Connectors

1.6.3.1

Compression type bolted tongue connectors shall be used to terminate stranded grounding conductors. The connectors shall be tin plated copper, either short barrel or long barrel, and shall be listed for their intended use by an NRTL. Tin plated aluminum connectors installed prior to January 2001 or that are part of an approved product are acceptable.

1.6.3.2

Compression type connectors used on solid conductors must be listed by an NRTL for use on solid conductors, and must be installed with the dies specified by the manufacturer of the connector.

1.6.3.3

Two-hole bolted tongue connectors shall be used except where single hole connectors are specified in the standard equipment drawing.

1.6.3.4

Two-hole bolted tongue connectors shall have an "inspection window" between the tang and the barrel to allow verification that the wire is fully inserted into the connector. See Figure 1-1.

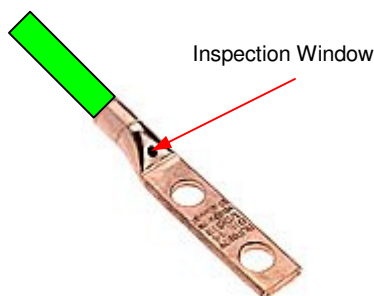


Figure 1-1
Compression Connector with Inspection Window

1.6.3.5

If a single hole connector is specified, and the surface is not prepared by cleaning and the application of an anti-oxidant compound, the securing hardware shall include an external tooth type lock washer (star washer) placed between the connector and the surface to which the connector is secured. The connection shall also have a split ring or external tooth lock washer installed between the lug and the screw head securing it. See Figure 1-5.

1.6.4 Pressure Type (Mechanical) Connectors

Some grounding conductor termination points preclude the use of exothermic welds or compression type connectors. This may be due to physical constraints or because the mechanical connector or terminal is a component of a listed or Company-approved product, such as the ACEG bus in an ac distribution panel. At these locations, pressure type (mechanical) connectors or terminals may be used to terminate grounding conductors. All connectors and terminals shall be listed or recognized for their intended use by an NRTL.

1.6.5 Parallel Cable Connectors

1.6.5.1

Compression type connectors (H-taps) shall be used to join one (or more) conductors to a main conductor.

1.6.5.2

While in-line type compression connectors are preferred, a compression type parallel connector may be used to splice grounding conductors. Connectors shall be listed by an NRTL for their intended use.

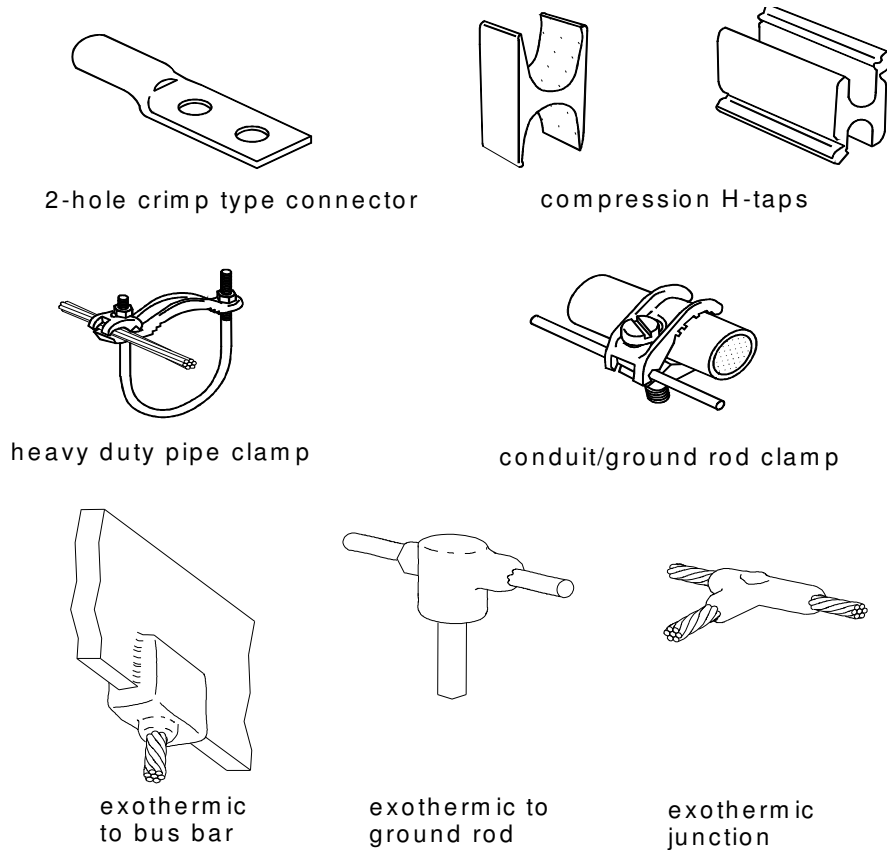
1.6.5.3

H-Tap compression connectors shall be protected using fire retardant hard shell or soft shell covers with an oxygen index rating of 28 or better. Clear covers shall be used.

1.6.6 Miscellaneous Connectors

1.6.6.1

A variety of pressure type connectors are commercially available. Where exothermic welds or compression connectors cannot be used due to physical constraints, and the design of the commercial connectors make them desirable for a specific application, they may be used for grounding connections.



**Figure 1-2
Typical Conductor Terminations**

1.6.7 Solder-Type Connectors

1.6.7.1

Connection methods that depend entirely on solder shall not be used for grounding or bonding connections.

1.6.7.2

A bare, solid #6 AWG tinned copper conductor has been used for many years as a bay ground lead. Although discontinued and replaced by the stranded bay ground lead (ATT-E-00174-E.pdf) many are still in use. Compression C-taps are available for connecting solid #6 AWG bay ground leads to a stranded "pigtail". The "pigtails" come with wire wrap terminals on the other end that are suitable for terminating smaller gauge grounding conductors.

The "C" taps are preferred over wire wrapping and soldering the pigtail to the solid bay ground lead. Wire wrapping and soldering grounding wire from network equipment to the wire wrap terminals is acceptable.

1.7 BUS BARS

1.7.1 Construction

Bus bars shall be copper and may be tinned or un-tinned. Un-tinned bus bars shall be burnished to a bright finish before anti oxidant is applied and terminations completed.

Ground bars furnished as part of a listed assembly or an assembly that has been approved for use may be used without regard to material.

1.7.2 Dimensions

Bus bars shall be sized to accommodate the initial conductors plus a 50 percent growth factor, and in no case shall it be smaller than the minimum size for a IS POP/VHO GRD bus bar: 3/8" x

6" x 16". When bus bars specified in standard drawings are different in size from those in this Practice, the dimensions specified in the standard drawing shall be used.

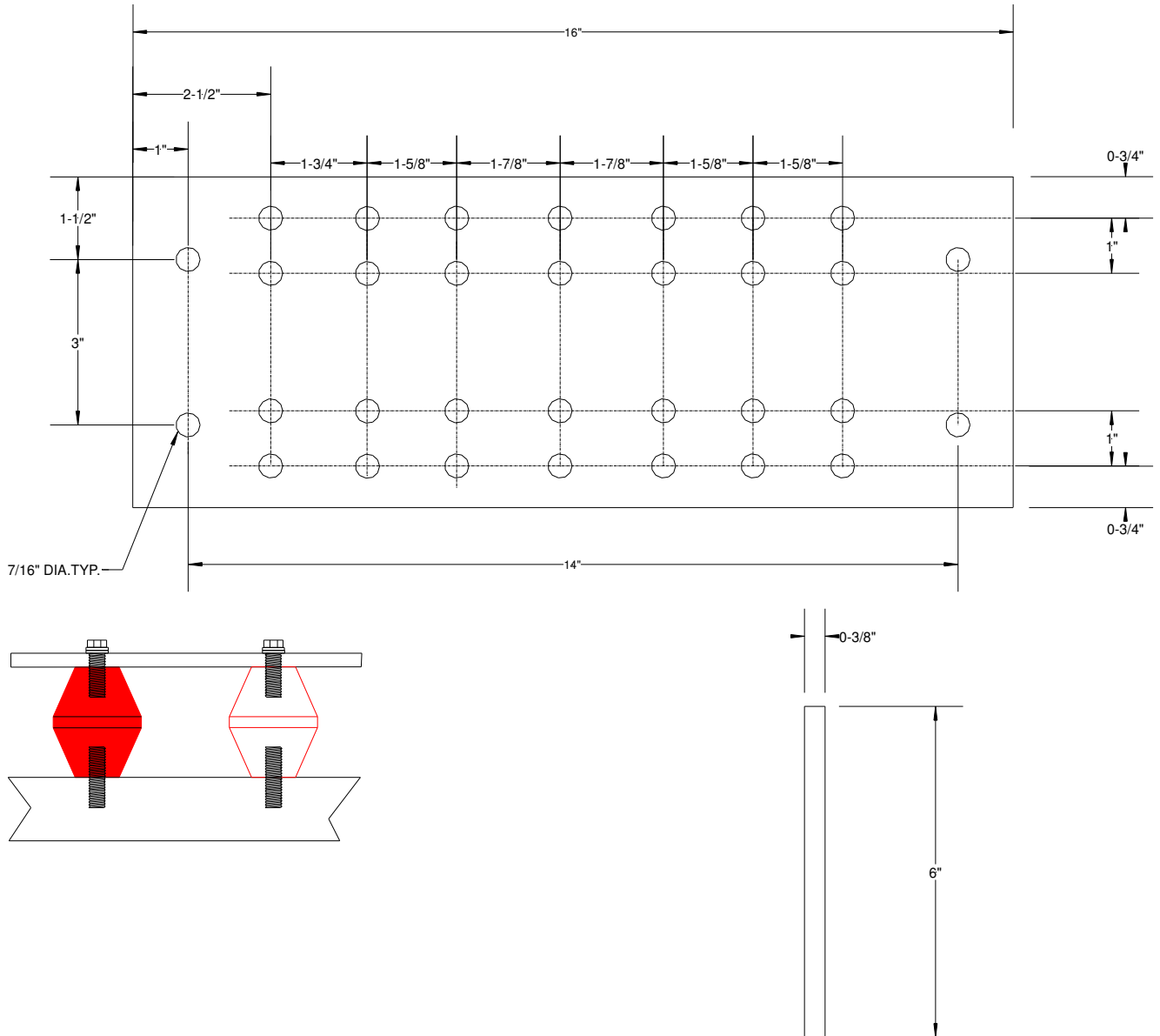


Figure 1-3 Typical Internet Services Ground Bar

1.8 INSTALLATION REQUIREMENTS

If an installation requirement in another section of this Practice differs from the installation requirements in Section 1.8, the requirement in the other section shall apply.

1.8.1 Routing and Support of Equalizer Conductors

1.8.1.1

All vertical and horizontal equalizer conductors should be routed so that U shaped configurations are avoided. Where such turns are unavoidable, they shall be made with the greatest possible radius.

1.8.1.2

Vertical and Horizontal Equalizers shall be run exposed so as to afford visual inspection of the entire system and to provide access for adding connectors.

1.8.1.3

Vertical and horizontal equalizer conductors shall be run through concrete or other permanent masonry floors and walls in core-drilled holes or non-ferrous metal conduit. If a cable hole is adjacent to the vertical or horizontal equalizer, it may be used in place of non-ferrous metal conduit as long as a discernable separation is maintained between the vertical riser and other conductors routed through the cable hole.

1.8.1.4

Vertical risers shall be secured to columns and walls using supports located approximately 2 feet from the floor, the ceiling, each side of any intervening bus bar, and at an interval of 2 feet (or less) between these points. The requirement (that applies to power cable) to provide a minimum of 20 feet of conductor supported on horizontal cable rack every third floor shall not be applied.

1.8.1.5

The vertical conductor may be supported by cable brackets or similar details fastened to sections of strut channel or other material anchored to a wall or column. An auxiliary support shall be provided on every other floor consisting of either wedge plugs in the top of sleeves or cable support grips suspended from J-bolts secured by anchors in the ceiling.

1.8.2 General Requirements - Routing and Supporting Conductors

1.8.2.1

All IS POP/VHO GRD system conductors shall be routed on and secured to:

- a) A cable rack or cable bracket containing only grounding conductors
- b) The side or bottom of ironwork details or cable rack containing other cable types
- c) The surface of ceilings, columns, or permanent walls

Grounding conductors may be placed on the same cable brackets used to support other cables if the grounding conductors are secured to the surface of the bracket opposite that used to secure the other cables. Grounding conductors shall not otherwise be intermixed with any other type wires or cables.

Some equipment manufacturers allow grounding conductors routed within their equipment systems to be routed with other conductors, typically dc power conductors. When a system is approved for use, the routing requirements of the equipment vendor may apply.

1.8.2.2

When grounding conductors are routed on the side or bottom of cable racks or other ironwork, or the surface of ceilings, columns or walls, the conductors shall be secured at an interval of 11 to 12 inches. When cable brackets are used for support, they shall be placed at an interval of 18 to 20 inches.

1.8.2.3

When a cable bracket or other support detail is placed under a horizontally-run grounding conductor, the conductor shall be secured to each bracket or support detail using nylon cable ties or 9-ply waxed polyester twine.

1.8.2.4

Grounding conductors up to and including #1/0 AWG may be secured to the sides of cable rack stringers, auxiliary framing bars, threaded rods and other ironwork details with nylon cable ties or 9-ply waxed polyester twine. See Figure 1-4.

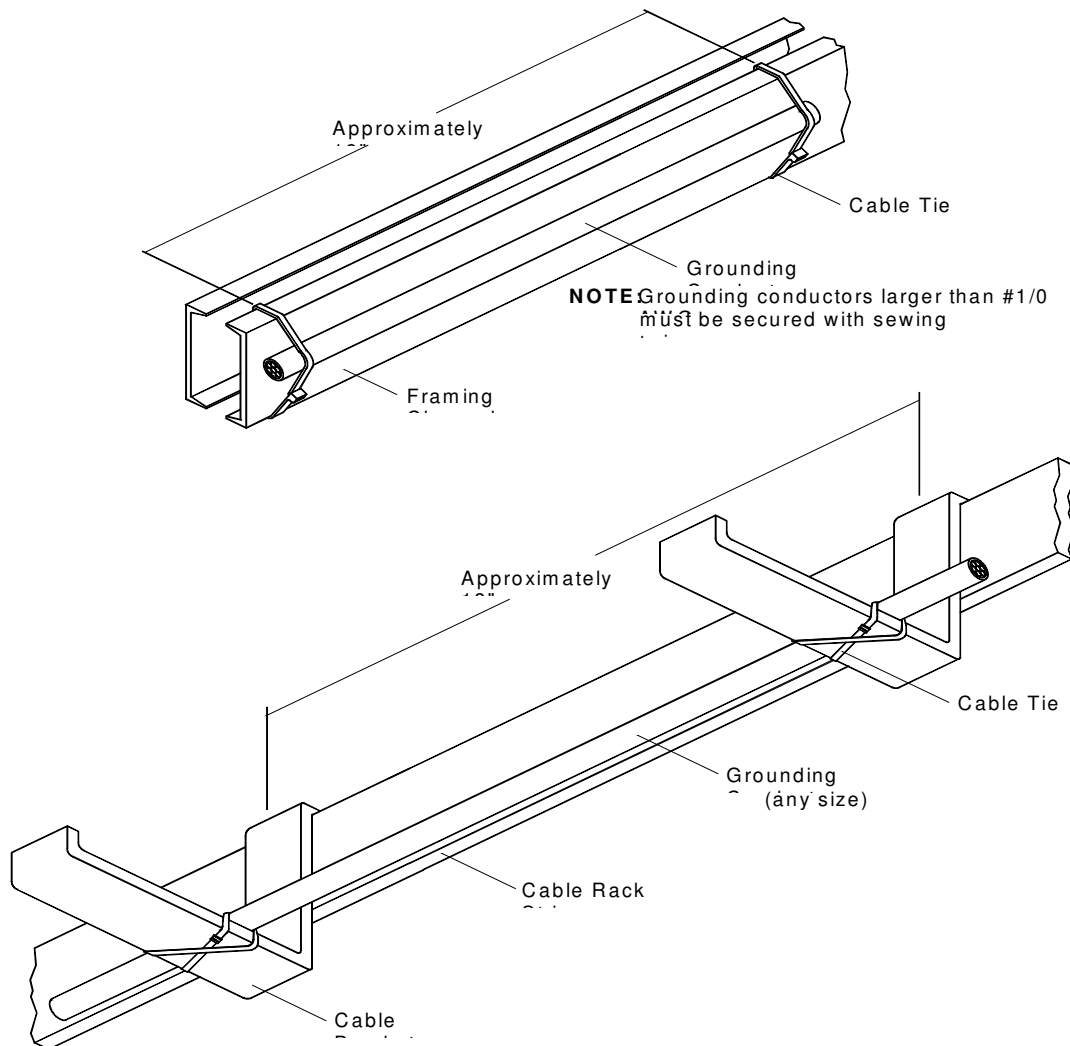


Figure 1-4
Use of Cable Ties to Secure Grounding Conductors

1.8.2.5

Grounding conductors larger than #1/0 AWG shall be secured to the sides of cable rack stringers, auxiliary framing bars, threaded rods and other ironwork details with 9-ply waxed polyester twine.

1.8.2.6

Grounding conductors secured to the underside of cable racks shall be secured to alternate cross straps with 9-ply waxed polyester twine.

1.8.2.7

The exterior surface of conduits or raceways containing ac power conductors shall not be used to support IS POP/VHO GRD system conductors.

1.8.2.8

Unless expressly required by local code, IS POP/VHO GRD system conductors (other than ACEG conductors) shall not be run in metallic or PVC conduit. If a IS POP/VHO GRD system conductor is placed in a metallic conduit, raceway or sleeve more than 3 feet in length, it shall be bonded to the conduit, raceway or sleeve at each end with a minimum #6 AWG conductor. The bond shall be placed between each end of the metallic conduit to the exposed copper conductor where it emerges from each end of the conduit.

1.8.2.9

When metal clamps are used to support or secure IS POP/VHO GRD conductors, they should not completely encircle the conductor. The metallic continuity should be interrupted by non-metallic hardware, a cable tie or 9-ply waxed polyester twine.

1.8.2.10

The phrase *completely encircle* applies primarily to ferrous metal cable clamps. It does not apply to an opening or "ring" formed by a combination of interconnected metallic objects such as cable racks, auxiliary framing, threaded rods, fire stop collars etc., unless the length (*L*) of this opening is more than 3 times its diameter (*D*). Examples of openings that **do not** create complete encirclement of a grounding conductor are:

- a) Where the conductor is routed through a metal cable hole cover instead of a floor sleeve (*L* is typically < 1/4", *D* is typically > 1 1/2")
- b) Where the conductor is on a cable rack and passes through the opening formed by the cable rack's stringers and straps (*L* is typically < 3", *D* is typically > 18")
- c) Where the conductor passes through an interior wall constructed with sheet metal studs (*L* is typically < 8", *D* is typically > 48")
- d) Arrangements similar to (a) through (c) above

1.8.2.11

Bends in IS POP/VHO GRD system conductors should be made with a minimum radius of 12 inches. If the 12-inch objective cannot be met, the manufacturer's minimum bend radius of 5 times the cable diameter shall be met. Table 1-3 provides the recommended and manufacturer's minimum bending radius, rounded up to the nearest inch for the most common grounding conductor sizes, based on the approximate diameter for rubber-covered wire (type RHH, RHW).

Grounding Conductor Size	Minimum Bending Radius (inches)	
	Recommended	Required
6 AWG	12	2
4 AWG	12	2
2 AWG	12	3
1/0 AWG	12	3
4/0 AWG	12	4
750 kcm	12	7

Table 1-3
Minimum Bending Radius for Grounding Conductors

1.8.2.12

Except for hatch plate bonding conductors described in Section 6 of this Practice, the direction of a grounding conductor's bend (e.g. towards IS POP/VHO GRD) is not restricted. The

direction of the bend should be made for ease of installation and to maintain an acceptable bending radius.

1.8.3 Connecting and Identifying Conductors

1.8.3.1

Unplated metallic surfaces shall be prepared to a bare, bright finish before joining. A thin layer of corrosion preventive compound such as NO-OX-ID "A" (electrically conductive) shall be applied to the unplated surface. If a connector is to be secured directly to a painted surface, the paint shall be removed to reveal bare metal completely around the area of the completed connection and a thin layer of a corrosion preventive compound such as NO-OX-ID "A" shall be applied to the bare metal surface.

1.8.3.2

Bolts, nuts, screws, threaded pressure devices, raceway fittings and every ground system connecting or securing device shall be free from corrosion, properly assembled, correctly tightened and accessible for inspection.

Two grounding connectors may be secured to a busbar by the same fasteners (one connector on each side of the busbar) under one or the other of the following conditions:

- a) The equipment served by both conductors will be completely de-powered before the securing hardware is loosened (e.g. connections at a bus bar or an equipment enclosure)
- b) A sufficient length of the conductor that will not be permanently disconnected is both available and accessible to attach a temporary bond around the securing hardware (e.g. connections at a IS POP/VHO GRD or other bus bar)

1.8.3.3

Within buildings, exothermic welding may be used at water pipes, connections to grounding system bus bars and bonds to building steel. Other applications may also be practical, such as connection to the peripheral ground ring in microwave stations and elsewhere. In occupied areas within a building, the use of exothermic welds should be restricted to those methods that use "smokeless" or "low smoke emitting" processes, such as the EXOLON® process from Erico Products, Inc.

1.8.3.4

The OPGP, IS POP/VHO GRD and MGB bus bars and the end of every IS POP/VHO GRD system conductor whose far end termination is not readily apparent, shall be equipped with a destination tag identifying the termination point of the opposite end of the conductor. These tags (145P or equivalent) are also allowed to be placed at other points in the IS POP/VHO GRD system.

1.8.3.5

Certain IS POP/VHO GRD system conductors shall be equipped with a brass tag with the phrase: **DO NOT DISCONNECT** stenciled on it or stamped into it. The letters shall be 3/16" minimum. The following conductors shall always be equipped with this tag:

- a) Conductors from earth electrodes
- b) Grounding conductors at a water pipe or gas pipe
- c) Grounding electrode conductors from a house service panel or other source of a
- d) Separately derived system (e.g., UPS, transformer, etc)
- e) Vertical and horizontal equalizer connections to a bus bar
- f) Both ends of a DC power plant grounding conductor
- g) Both ends of a grounding conductor between the protector frame and OPGP/COG
- h) Both ends of the conductor between the CEF and OPGP

1.8.4 Application Of Lock Washers For Grounding Connections

1.8.4.1

This section applies primarily to the use of lock washers with the securing hardware for connectors used to terminate the framework grounding conductor to equipment frameworks, cabinets and other enclosures.

1.8.4.2

These requirements apply when lock washer information has not been furnished by another part of this document, a standard drawing, a manufacturer's drawing or a detailed specification.

1.8.4.3

When used next to a nut or the head of a bolt, in order of preference, a lock washer may be an external tooth type (ETLW) or a split ring (helical spring) type. See Figure 1-5

1.8.4.4

When required between the surface of a connector and the surface to which the connector is secured, the lock washer shall be an external tooth type. See Figure 1-5.

1.8.4.5

For a bolt and nut arrangement (through-bolt) or a nut only arrangement (when a stud is used), a lock washer shall be placed between the nut and the surface to which it mates.

1.8.4.6

For a bolt only arrangement (tapped hole), a lock washer shall be placed between the bolt head and the surface to which it mates. See Figure 1-5.

1.8.4.7

For all types of lock washers, the material shall be SAE J429 Grade 2 or higher, and they shall have a zinc electroplate finish.

1.8.4.8

The lock washers used to secure equipment units to a frame, cabinet or other enclosure, shall be Type "B" or equivalent external tooth lockwashers.

Note: If the framework or bus bar surface is not painted, no washer is placed between the surface and the connector

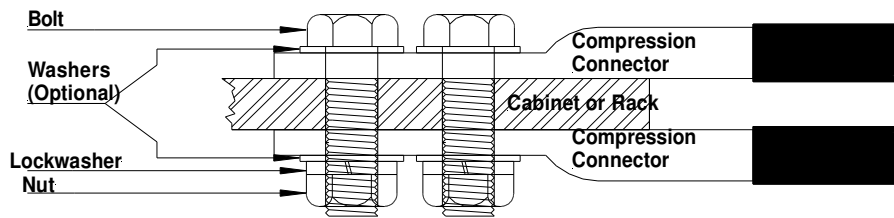
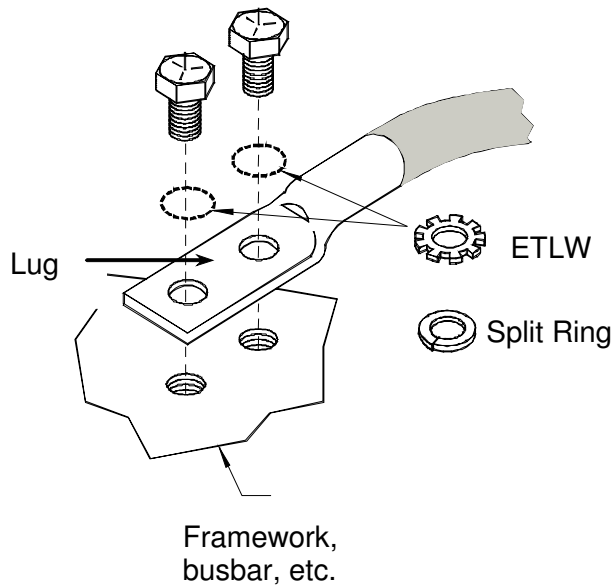
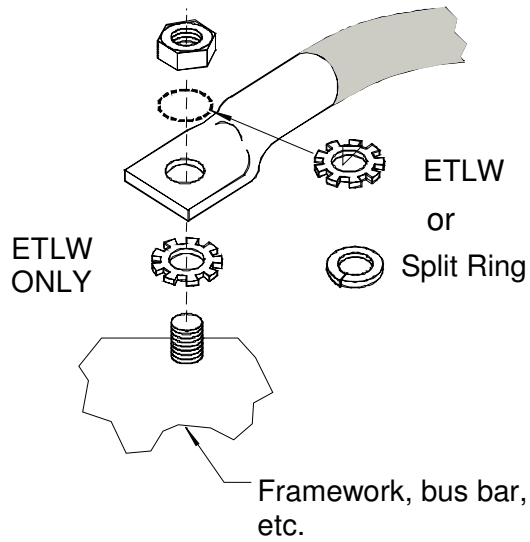


Figure 1-5
Application of Lockwashers

SECTION 2

Office Ground Electrodes, Vertical and Horizontal Equalizers, AC Service and Distribution System

2.1 SCOPE

- 1) This section provides requirements for earth electrode systems for network facility structures used by AT&T. Also provided are requirements for the Central Office Ground (CO GRD) system and the grounding of ac service and distribution systems. The requirements supplement information in the 760 and 876- series of standards and the NEC.
- 2) Section 5 provides requirements for earth electrode systems and ac service grounding for electronic equipment enclosures (EEEs) as well as other requirements specific to such installations. Section 6 contains additional requirements for earth electrodes and bonds to building components for Video sites and structures.

2.2 EARTH ELECTRODES

2.2.1 Public and Private Water Systems

2.2.1.1

In accordance with Article 250 of the NEC, a metallic underground water piping system, either private or public, shall always be used as a grounding electrode where such a system is available.

2.2.1.2

To qualify as an earth electrode, the water pipe must be an electrically continuous piping system. The NEC requires that the buried portion of the system shall be not less than 10 feet. For Company applications, it is preferred that the buried piping is electrically continuous for at least 40 feet.

2.2.1.3

When a water meter is located in the structure, the water pipe on the street side of the meter is used as the point of connection if allowed by the water utility. If a connection on the street side is not possible, and if allowed by the water utility, the pipe on the building side of the meter may be used as the point of connection when a bond is provided around the meter.

2.2.1.4

If allowed, the bond around a water meter shall be the same size as the grounding electrode conductor. See Section 2.7.1.6.

2.2.1.5

Where an internal metallic water pipe system exists, the water pipe must be bonded to the office principal ground point (OPGP) whether or not the water pipe is used as an earth electrode.

2.2.1.6

Per the NEC, a supplemental earth electrode is always required in addition to the metallic water pipe system. When a main water pipe is non-metallic, the supplemental earth electrode may serve as the grounding electrode system. Earth electrode systems installed per Section 2.2.3 satisfy the requirements in the NEC.

2.2.2 Water Well Metallic Casing

2.2.2.1

Where public water systems do not exist and a water supply is required within a structure, a drilled well with metallic casing and electrically continuous piping may be provided for an earth electrode. The well may be located on the property outside the structure or beneath the structure. While the NEC states that 10 feet of combined pipe and casing exposed to earth is an adequate electrode, a well casing that penetrates to a depth of at least 40 feet is preferred.

2.2.2.2

In special circumstances, it may be economical to install well casing and pipe as a supplementary ground system rather than a driven ground system. This may apply in areas where gravel or other earth conditions make effective grounding by means of driven rods impractical or where a driven rod system at an existing structure is economically unfeasible.

2.2.2.3

The well need not be functional as a water supply to serve as an earth electrode. Generally, a driven supplementary ground field will be more economical than a well supplied for grounding purposes only, unless special cost considerations are a factor.

2.2.3 Driven Ground Electrodes

2.2.3.1

A driven ground rod system may consist of from two to any number of rods. The preferred arrangement is one that forms a ring around the structure. This design helps equalize potential in the area of the structure.

2.2.3.2

The construction methods used in a building determine the recommended design for driven ground rod systems. The basic types of building construction used are described below and appear in Table 2-1:

- a) Building with electrical continuity through vertical and horizontal structural steel
- b) Building with electrical continuity through vertical column steel only
- c) Building without electrical continuity through vertical column steel

Continuity may consist of steel sections riveted, bolted or welded to form vertical and horizontal paths or it may consist of welded or wire-wrapped reinforcing bars.

2.2.3.3

The components of driven ground systems and their recommended application to the basic types of building construction are shown in Table 2-1 and Figures 2-1 and 2-2. In Table 2-1, an "X" in a column means that the associated component is always required to meet the minimum recommended configuration for a given construction method. An "O" means that use of the component is optional.

Driven Ground Rod System	Construction Method			Notes
	A	B	C	
#2 AWG buried perimeter ring ground	X	X	X	1
#2 AWG buried between rows of columns	X	X	O	2
#2 AWG buried bond to all perimeter columns	X	X		
#2 AWG buried bond to all interior columns	X	X		
#2 AWG grid bonded to top of all columns		X		3
5/8" x 8' ground rod at every perimeter column	X	X		
5/8" x 8' ground rod at every interior column	O	O		
5/8" x 8' ground rod at approx. 15-ft. interval			X	

**Table 2-1
Driven Ground System and Construction Method**

Note 1 - For buildings with basements, the perimeter ring should be placed within the outer walls below the concrete slab. For buildings without basements, the ring should be placed outside the perimeter of the outer walls.

Note 2 - This conductor is placed between rows of columns (in one direction only) and is connected to opposite sides of the perimeter ground ring

Note 3 - This grid should be installed so that all columns are interconnected

2.2.3.4

Metallic flashing on parapets, and metallic objects mounted on the roof shall be bonded to structural steel when continuity to ground exists through the steel.

2.2.3.5

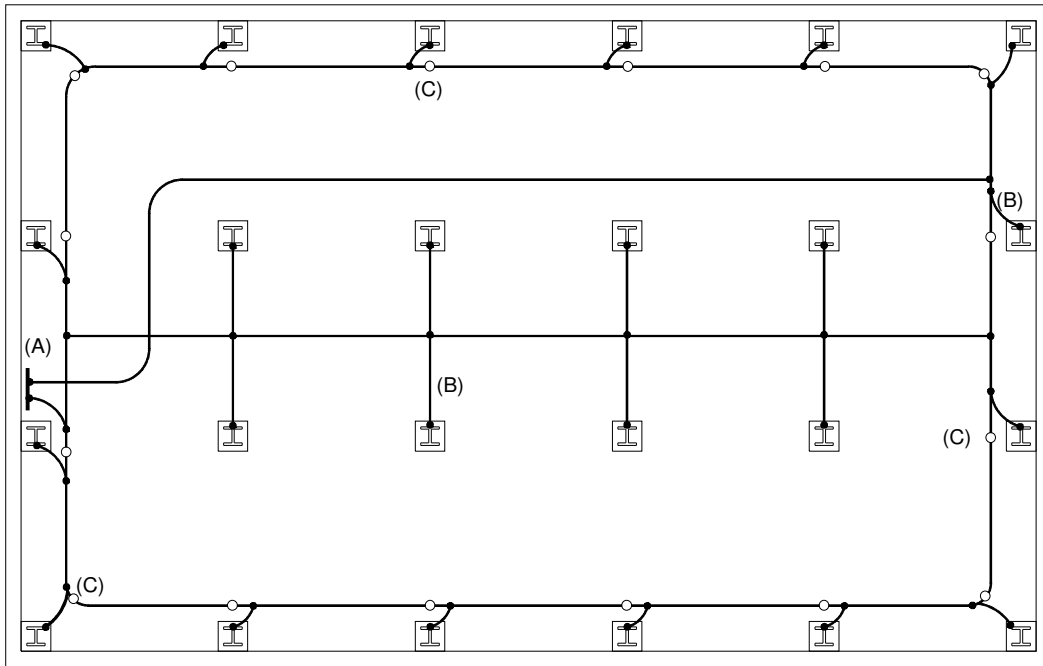
The main (interconnecting) conductor of a driven ground system shall be bare, solid copper, sized at #2 AWG minimum. Tinned wire is preferred. The conductor shall be placed at a depth of at least 30 inches below grade and 2' to 6' from the exterior wall in order to be within the building drip line. Generally, a placement 30" below the surface will protect against both frost and incidental earth disturbances.

2.2.3.6

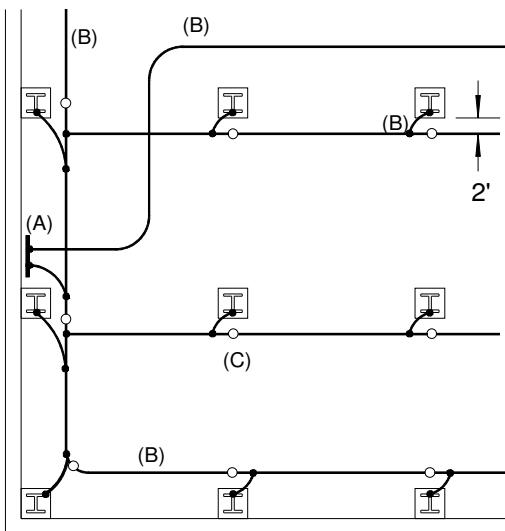
The ring formed by the main conductor shall be connected to the OPGP with at least two conductors. The preferred design uses conductors connected to opposite sides of the ring. This design is feasible for new structures only, because the conductor from the far side of the ring must be routed under or within the concrete foundation of the structure.

2.2.3.7

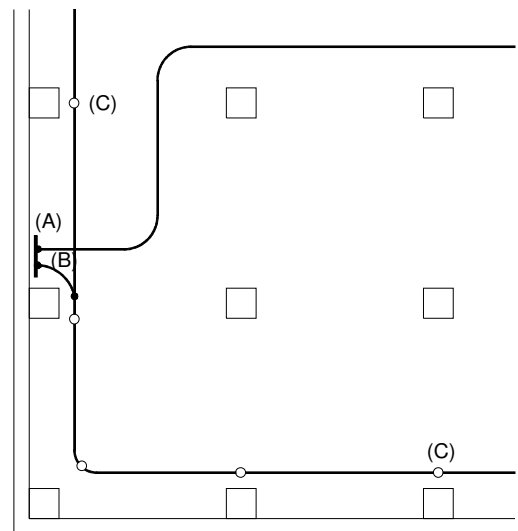
It is permissible for the two conductors terminated to the OPGP to be the ends of the ring around the structure. This design is used when a driven ground system is added to an existing structure.



Building Plan A - Supplementary ground field for building with structural steel columns or concrete columns using welded or wire-wrapped reinforcing bars



Building Plan B - Same as Plan A except that ground rods are located at every column

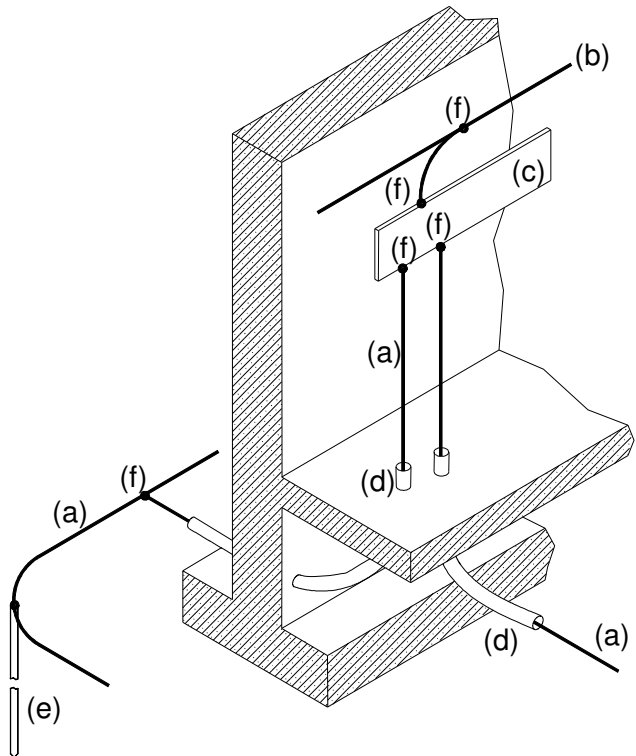
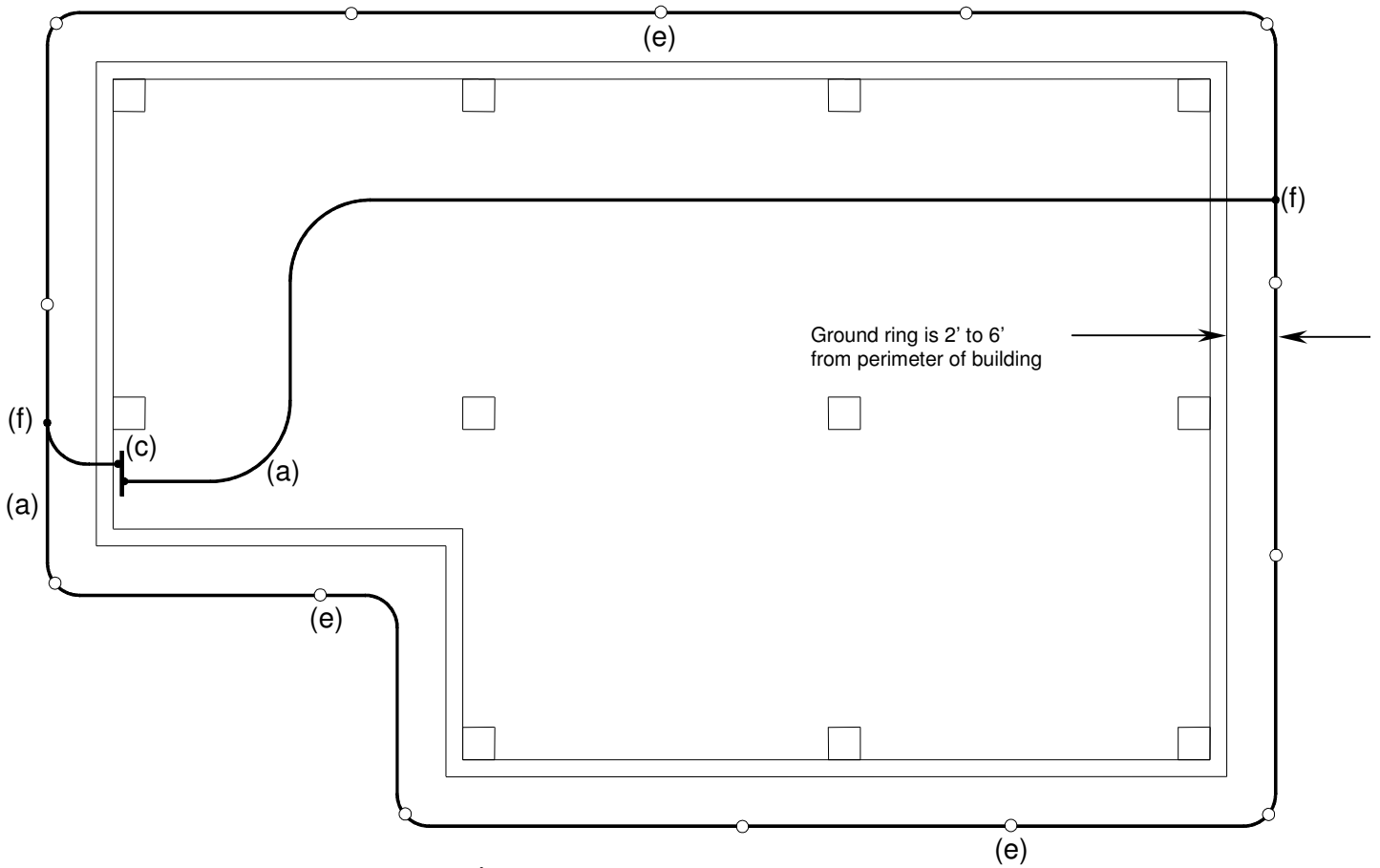


Building Plan C - Same as Plan A except that columns lack reliable electrical continuity and are not bonded to the supplementary field

- (A) OPGP Bus Bar
- (B) #2 AWG Bare Tinned Copper Wire
- (C) 5/8" x 8' Ground Rod

- Exothermic Weld to Ground Rod
- Exothermic Weld to #2 AWG, Bus Bar or Building Steel

Figure 2-1
Methods of Establishing Supplementary Ground Fields - Buildings with Basements



- (a) #2 AWG solid tinned copper conductor
- (b) Grounding Electrode Conductor run between the main house service Panel and the main cold water pipe; sized per Table 2-2
- (c) OPGP bus bar
- (d) PVC conduit
- (e) 5/8" X 8' copper clad steel ground rod
- (f) Exothermic weld connection

Figure 2-2
Typical Driven Ground System for Buildings Without Basements

2.2.3.8

Some sites, including buildings other than central offices, were equipped with a supplemental driven ground rod system consisting of 4 to 6 ground rods arranged in a straight line. These systems do not require rearrangement unless warranted by a change in conditions at the site, such as the addition of a Video antenna tower on the roof of the building or a building addition that would disturb the driven ground rod system.

2.2.3.9

The separation between driven ground rods should be approximately twice their length. With closer spacing, the rods will be discharging into the same volume of earth and their effectiveness will be diminished.

2.2.3.10

Rods shall be driven to the depth of the ring conductor. A ground rod driving-shield is recommended to prevent damage to the top of the rod. Inspection boxes with removable covers may be placed at ground rod locations. This not only facilitates inspection, but also allows access to the driven ground rod system if it must be rearranged.

2.2.3.11

All connections to ground rods and all buried connections to the #2 AWG conductor shall be made using an exothermic weld.

2.2.3.12

Where ground rods cannot be driven vertically to the desired depth below grade, they may be driven at an angle away from or parallel to the exterior wall. When driven parallel to the wall, the angle shall not exceed 45 degrees.

2.2.4 Other Electrodes

2.2.4.1

Certain earth electrodes recognized by the NEC are either not recommended or are prohibited for Company structures.

2.2.4.2

Normally, a concrete encased electrode (sometimes referred to as a *Ufer ground*) is not recommended. However, if the site's geological conditions preclude the use of a driven ground rod system, a concrete encased electrode may be used. It shall:

- a) Be a continuous minimum #2 AWG solid copper conductor
- b) Be placed in the footing around the perimeter of the structure
- c) Have both ends of the #2 AWG loop connected to the OPGP using exothermic welds
- d) Be placed in a footing that is in direct contact with the earth with no moisture barriers interrupting the contact

2.2.4.3

If a concrete encased electrode system is available at any site, such as a leased building, it must be bonded to the structure's earth electrode system.

2.2.4.4

A second option for an earth electrode system when ground rods cannot be driven is a counterpoise system. The horizontal counterpoise system consists of minimum #2 AWG bare copper conductors, with rods if they can be driven, buried at a depth of at least 18 inches below grade, radiating from the ring ground system from a minimum of four corners of the structure.

2.2.4.5

The counterpoise conductors shall be run in a straight line, to the edge of owned property or for a maximum length of 125 feet, whichever is the lesser. They shall not be less than 25 feet long.

2.2.4.6

Gas service pipe, tanks, pipes (other than water pipes or well pipes) or plate electrodes are prohibited. Interior gas pipe systems must be bonded to the OPGP with a conductor sized per Table 2-3 (using the rated amperage of the circuit most likely to make contact with the pipe) system.

2.2.5 Interbonding of Earth Electrodes

2.2.5.1

Each ground rod of a driven ground system and every other intentional driven ground rod or buried object in the vicinity of a structure that may act as an unintentional electrode shall be bonded together to limit potential difference between them.

2.2.5.2

Placement of any type of electrode at less than 6 feet to any other is not desirable and it is recommended that such occurrences be avoided where practicable.

2.2.5.3

When a driven ground system is installed around a structure equipped with lightning protection, the lightning protection system's down conductors shall be connected to the driven ground system rather than to separate lightning protection system ground rods.

2.2.5.4

Most above ground fuel tanks will have grounding electrodes installed with the tank. In order to insure voltage equalization and improve the effectiveness of the building grounding electrode system, these electrodes should be bonded to the building grounding electrode system or to the OPGP at the time of installation.

2.3 DRIVEN GROUND SYSTEM FOR VIDEO SITES

The general requirements for a driven ground system at a Video site are the same as those for a central office. Additional requirements appear in Section 6.3 of this Practice. They apply to Video sites as well as central offices that contain switching and Video equipment.

2.4 CENTRAL OFFICE GROUND SYSTEM

The Central Office Ground System provides:

- a) Grounding of communication systems equipment units
- b) Earth potential reference for ac and dc power systems and communications circuits
- c) Lightning and 60 Hz current discharge paths for communication system entrance cable protectors
- d) Current paths for equalization of dc voltages

The IS POP/VHO GRD system includes conductors that extend from:

- a) The OPGP to IS POP/VHO GRD bus bars located on each floor of a building
- b) IS POP/VHO GRD bus bars on each floor to the battery return systems of dc power plants, other principal dc distribution components and if present, other vertical risers
- c) IS POP/VHO GRD bus bars to equipment frames, cabinets and other metallic objects on equipment floors, and are referred to as framework or equipment ground, and by other names derived from the served equipment or the function of the conductor.

A IS POP/VHO GRD system shall be provided in every new building and equipment area in other structures.

2.4.1 Office Principal Ground Point (OPGP)

2.4.1.1

The office principal ground point serves as a central connecting point for grounding conductors from within the structure and from all earth electrodes. The most common conductors terminated at the OPGP are:

- a) The ac service Grounding Electrode Conductor
- b) A bond to the Cable Entrance Facility
- c) A bond to the interior gas and/or water pipe system in the structure
- d) Bonds to structural steel
- e) Bonds to supplementary ground fields
- f) A IS POP/VHO GRD system vertical riser
- g) A bond to the earth electrode system in an adjacent structure
- h) Bonds to equipment requiring an earth ground reference
- i) Bonds to all earth electrodes

2.4.1.2

New structures or those undergoing significant reconstruction should employ a design that places the OPGP and the main ac service equipment and the cable entrance facility as close together as practicable. In new structures and existing structures where an OPGP is being added or relocated, a location should be chosen that remains accessible.

2.4.1.3

The former practice of locating the OPGP directly on the main water pipe is no longer recommended. This applies to both central offices and commercial buildings.

While the main water pipe is not recommended as a location for the OPGP, it is still a requirement to provide a bond from the metallic water pipe to the OPGP. See Section 2.7.1 and Figure 2-3 for a discussion of routing and connecting this conductor.

2.4.1.4

The size of the OPGP bus bar shall accommodate the initial conductors plus a 50 percent growth factor, and in no case shall it be smaller than the minimum size for a IS POP/VHO GRD bus bar: 3/8" x 6" x 16". In small structures such as remote switch locations, the OPGP may also serve as the only bus bar in the structure.

2.4.1.5

The OPGP bus bar should be mounted horizontally. If warranted by local conditions, the initial OPGP bus bar or extensions to it may be mounted vertically. Extensions of bus bars may be made by mechanical means; an exothermic weld is not required.

2.4.1.6

Where practicable, the OPGP bus bar shall be mounted on minimum 3/4" studs welded to structural steel. If such an arrangement would place the OPGP in a less centralized or less accessible location, the bus bar's location can be altered provided a bond is provided between the OPGP and structural steel using a conductor sized per Section 2.7.1.6.

2.4.1.7

If structural steel is not available for bonding, insulators providing at least 2" of separation shall be placed between the OPGP and its mounting surface.

These insulators may also be used if the mounting studs are not used as a means to bond the OPGP to building structural steel. In any case, the 2" separation is required to provide working access between the bus bar and the mounting surface.

2.4.1.8

When the OPGP lies in the path of the grounding electrode conductor between the House Service Panel (HSP) neutral bus bar and the main cold water pipe or other primary earth electrode, the connections to the OPGP should be made using exothermic welds. See Figure 2-3 (a). This satisfies the NEC requirement for an unspliced grounding electrode conductor, and has the added advantage of transforming the OPGP bus bar into a part of the grounding electrode conductor.

An alternative method to bond a grounding electrode conductor to the OPGP is shown in Figure 2-3 (b). In the alternative arrangement, the grounding electrode conductor passes near the OPGP and a bond of equal size is placed between the OPGP bus bar and the grounding electrode conductor. All terminations for either arrangement must be made with exothermic welds, compression type connectors, or a combination of methods.

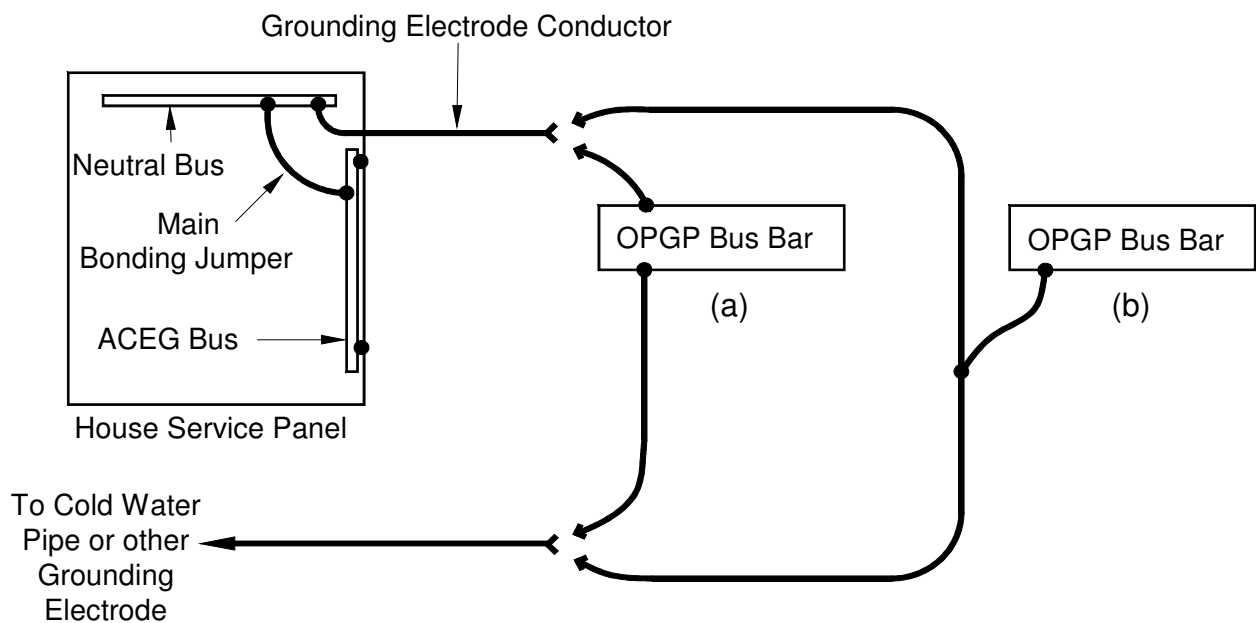


Figure 2-3
Two Methods for Bonding a Grounding Electrode Conductor to the OPGP

2.4.1.9

At the OPGP, an exothermic weld is the preferred method for terminating the two #2 AWG solid conductors from the driven ground system. Where local conditions prevent the use of an exothermic weld, a compression type two hole connector is an acceptable alternative, but only when the connector is listed for use on a solid conductor and the compression tool die set used is one specified by the connector manufacturer.

2.4.1.10

If a building addition is abutted to an existing structure and is provided with a new and separate ac service, a separate OPGP may be established. A bond shall be provided between the two principal ground points using a conductor sized as follows:

- a) For buildings with less than 4 floors (including a basement), the conductor shall be the same size as the largest grounding electrode conductor provided for either the existing building or the building addition.
- b) For buildings with 4 or more floors, the conductor shall be a 750 kcmil

2.4.1.11

When a common communication installation is housed in two closely adjacent structures (i.e., separated by an alley) having individual earth electrodes, the OPGPs shall be bonded together. The bond shall be the same as described for abutted buildings above.

2.4.1.12

With the exception of gas pipe systems, metal pipes and other buried objects having entry to the structure may act as unintentional earth electrodes. These electrodes shall be made common with the intentional electrode(s) using a minimum #2 AWG bond between their entry point and the OPGP. A single #2 AWG conductor may be branched to bond two or more of these objects.

2.4.2 Interbonding

2.4.2.1

Interbonding should be included in the building ground system design for any new structure without regard to its intended use. It should also be added to equipment buildings when any significant renovation is performed on the building ground system or a main house service panel or during a major building construction project.

2.4.2.2

At minimum, interbonding must always include three general elements within a structure. These are the utility power service entrance, the communication cable entrance and the earth electrode entrance. The points of connection for the interbonding conductors are shown in Figure 2-4. Interbonding exists when these points are connected together with conductors so that a loop is formed with any one element connected to at least two others.

2.4.2.3

In structures with more than one OPGP, HSP and/or CEF, bonds shall be placed between any one of these points and at least two other points in the interbonding system.

2.4.2.4

In structures other than central offices, a copper bus bar must be provided in the CEF area. It must be:

- a) A minimum size of 6" wide, 12" long and 1/4" thick
- b) Equipped with a permanent label: CABLE ENTRANCE GROUND BAR
- c) Mounted on insulators that provides at least 2" of clearance from its mounting surface
- d) Located at a convenient point to serve the cable shield bonding conductors, and if required, protector unit grounding conductors.

2.4.2.5

In an equipment building, the conductor from the HSP to the CEF must terminate in the CEF using either a compression type parallel tap to the #1/0 AWG conductor originating at the OPGP, or a two hole compression type connector on the same bus bar used to terminate the #1/0 AWG conductor originating at the OPGP.

2.4.2.6

On the OPGP, the preferred connection point for the conductors from the HSP and the CEF is nearest the point of connection of the conductors from the driven ground system, building structural steel or the main water pipe. The connection between the CEF and the OPGP may

be either a direct connection or it may be made by way of a connection to a IS POP/VHO GRD bar or protector frame ground bar. See section 3.7.

2.4.2.7

In the HSP, it is essential that the conductor from the CEF is connected to the ac equipment ground (ACEG) bus bar as close as possible to the point of connection of the main bonding jumper from the neutral bus bar. Terminating this cable on a neutral bus bar is prohibited.

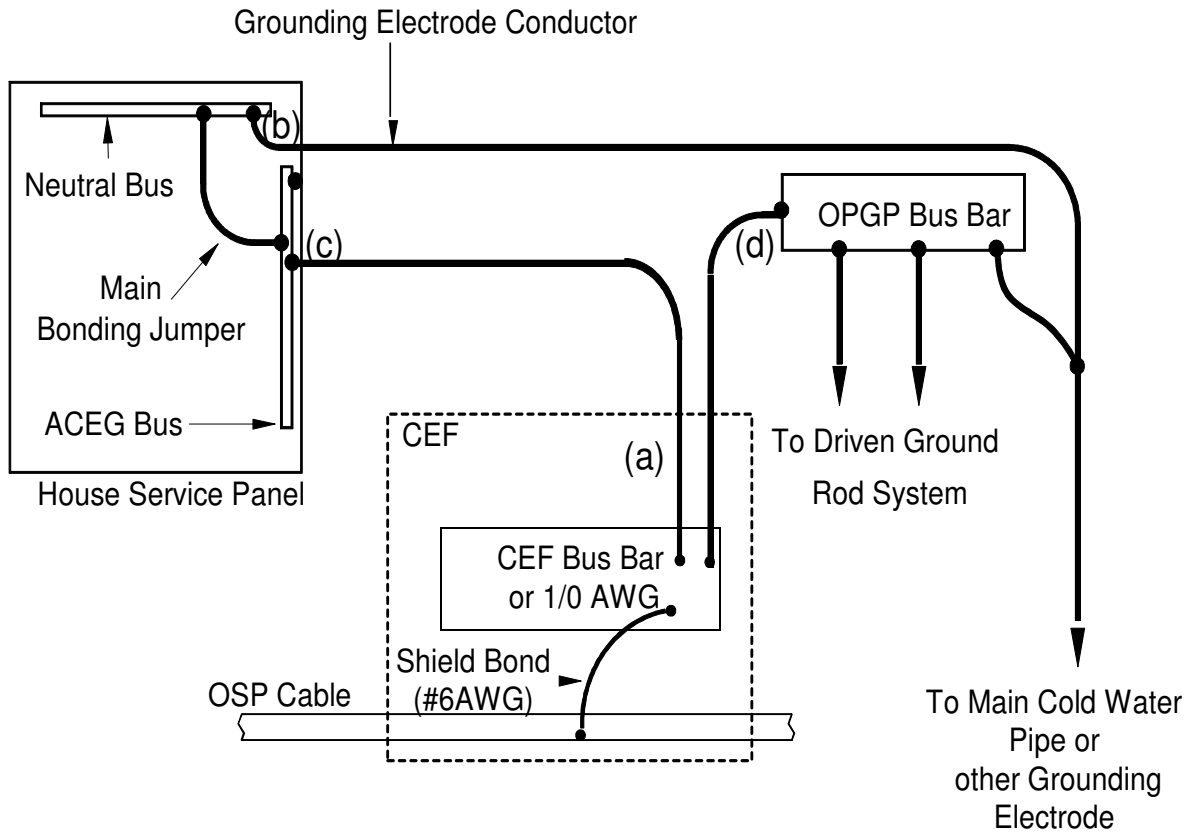


Figure 2-4
Typical Interbonding Arrangement

2.4.2.8

The points of connection for the interbonding conductors in Figure 2-4 are as follows:

- a) A point at or near the communication cable's entrance into the structure - the cable entrance facility (CEF). This may be a bus bar or 1/0 AWG conductor used to collect bonds from the individual cable shields;
- b) A point on the neutral bus bar in the HSP for the conductor to the OPGP (grounding electrode conductor);
- c) A point on the HSP's equipment ground bus bar close to the connection of the main bonding jumper from the neutral bus bar for the conductor to the CEF;
- d) A point of access to the structure's primary earth electrode, most often the OPGP

2.4.3 Design Parameters - Vertical Riser

2.4.3.1

In a single story building, a vertical riser is the conductor between the OPGP and a IS POP/VHO GRD bus bar. In multifloor buildings it also bonds the IS POP/VHO GRD bus bars together. It provides a low impedance path to the earth electrode system via its connection to the OPGP.

Equipment that requires a connection to the earth electrode system for proper operation and/or protection can use the connection to a floor's IS POP/VHO GRD bus bar because it is considered an appearance of the grounding electrode. Also, the vertical riser serves as a current path for battery return current interchange between circuits on different floors and as a low impedance fault current path. On each floor, the IS POP/VHO GRD bus bar is generally located at the vertical riser but, for logistical purposes, may be located up to 20' away.

2.4.3.2

The location of a vertical riser shall be such that the maximum conductor length between an IS POP/VHO GRD bus bar and the furthest grounded equipment unit does not exceed 200 feet (measured from where the IS POP/VHO GRD bus bar attaches to the vertical riser). This means that the equipment served may not be located outside the perimeter of a square (200' x 200') superimposed on a circle with a 100' radius, centered at the location where the IS POP/VHO GRD bus bar attaches to the vertical riser. This is shown in 2-5.

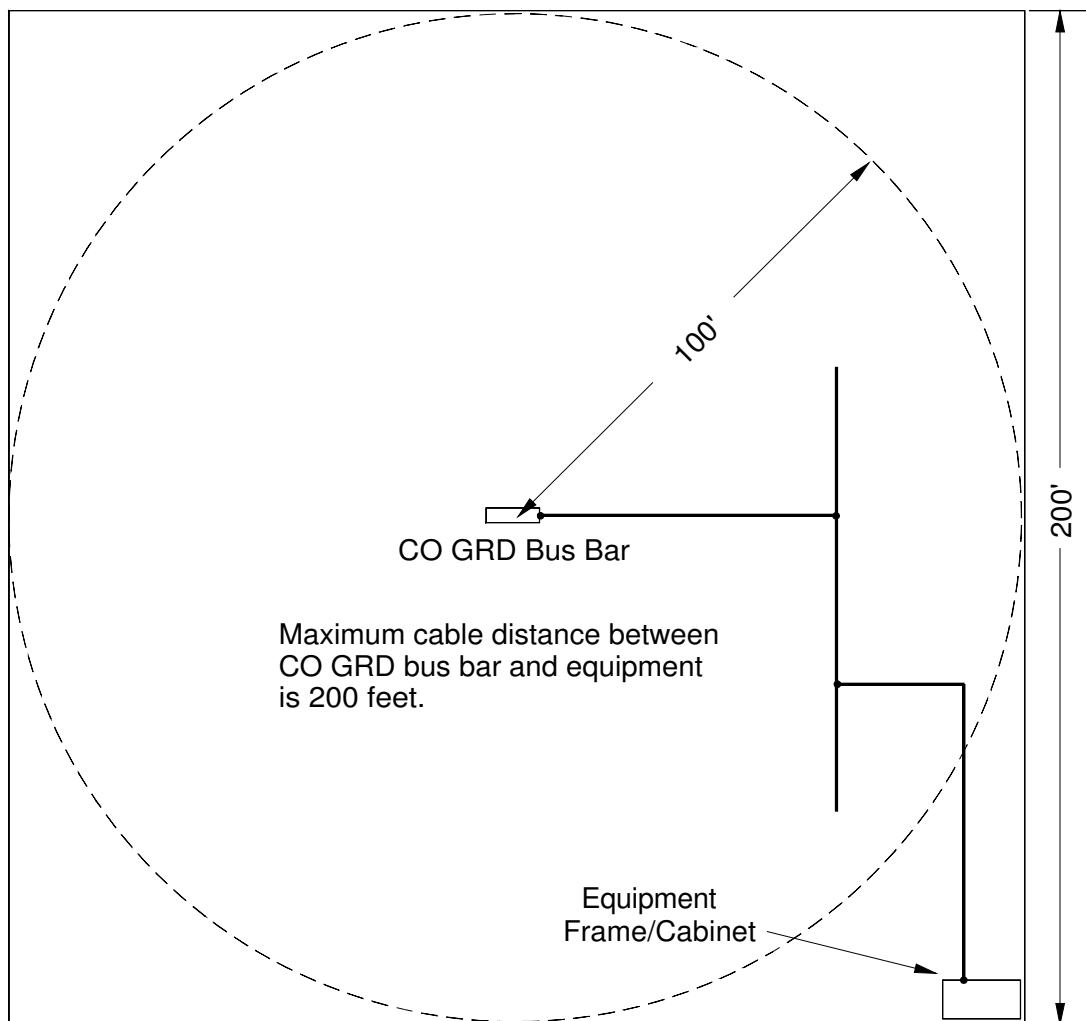


Figure 2-5
Maximum Floor Area Served by a Vertical Riser

2.4.3.3

The vertical riser shall be located so that the horizontal portion of the run to the OPGP is as short as practical.

2.4.3.4

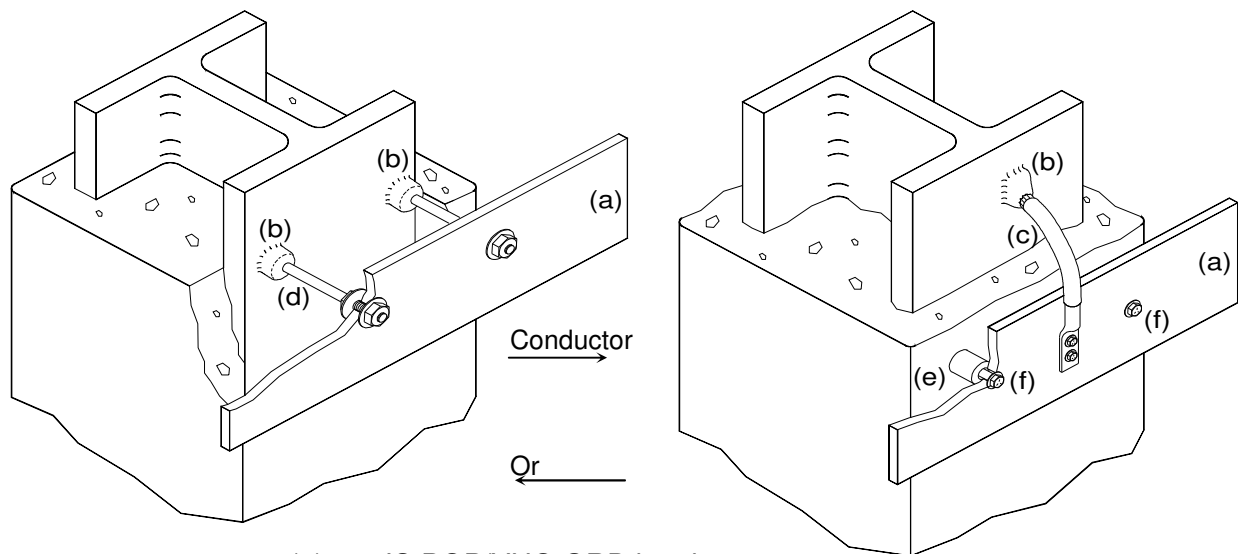
A vertical riser shall consist of a continuous 750 kcmil copper conductor or it may be a steel building column. When a 750 kcmil conductor is used, the vertical run shall be as straight as practicable, preferably with only minor bends to avoid obstructions such as floor beams.

2.4.3.5

Splices in a 750 kcmil vertical riser shall be made using an exothermic weld. A 750 kcmil vertical riser conductor may also be extended using a compression type parallel connector tapped onto an existing vertical riser conductor.

2.4.3.6

Certain types of building columns may be used as a vertical riser. Other types cannot be used for this purpose but require bonding to floor IS POP/VHO GRD bus bars to insure equalization of lightning induced voltage between building and equipment conductive components. When column steel consists of structural steel sections, and all section butt ends of the column are bridged with a weld, a welded steel plate or an exothermically welded or brazed 750 kcmil copper bond, the column may be used as a IS POP/VHO GRD system vertical riser. Bonds between IS POP/VHO GRD bus bars and column steel shall be made using a 750 kcmil copper conductor, two 3/4" studs (long enough to allow 2" access to both sides of the COG) welded to the steel column or an equivalent means. These bonds are illustrated in Figure 2-6 where the building steel is electrically continuous to earth.



- (a) IS POP/VHO GRD bus bar
- (b) Welded connection
- (c) 750 kcmil bonding conductor
- (d) 3/4" stud (e/w nuts, washers, lock washers)
- (e) 2" spacer (to allow access to both sides of the bus bar)
- (f) Standard masonry anchor assembly (1/2" or 3/4")

Figure 2-6
Bonding IS POP/VHO GRD Bus Bar to Building Steel

2.4.3.7

When vertical sections of structural steel columns are not welded or bonded, it may not be used as a vertical riser but is considered effective in discharging lightning current. For this reason, an equalizing bond shall be provided between the column steel in closest proximity to each bus bar. The bond shall be made using one of the methods used when the column steel is used as a IS POP/VHO GRD vertical riser, except that when a conductor is used to bond building steel, it need be no larger than #3/0 AWG.

2.4.3.8

When columns are reinforced concrete and reinforcing bars are not welded or wire wrapped, it is assumed that continuity to earth does not exist. For this reason, column-reinforcing bars not known to be electrically continuous to earth shall not be bonded to the IS POP/VHO GRD bus bars.

2.4.3.9

When a vertical steel column is used as the IS POP/VHO GRD conductor, that column must be connected to the OPGP with a 750 kcmil copper conductor.

This conductor should be as short as practicable, and shall be exothermically welded or brazed directly to the column steel, or connected to a ground bar arranged similar to that described in Section 2.4.3.6.

2.4.3.10

A vertical riser may serve an area which does not exceed 200 conductor feet from the vertical riser to the furthest equipment frame, as explained above. When this distance will be exceeded, a second vertical riser with associated IS POP/VHO GRD bus bars and horizontal equalizers is required.

2.4.3.11

When multiple vertical risers are required, they shall be located within 200 feet of each other so that horizontal equalizers can serve a contiguous floor area.

2.4.3.12

Multiple vertical risers shall be bonded together at the lowest floor and at every third floor with a 750 kcmil conductor. For example, bonds would be made in the basement, at the third, sixth, ninth, etc., floors.

2.4.3.13

The second vertical riser shall terminate at the OPGP except when the horizontal portion of the first vertical riser extends from the OPGP in the direction of the second vertical riser. In this case, the second vertical riser may terminate at a IS POP/VHO GRD bus bar served by the first equalizer or tapped to the equalizer conductor on the floor containing the OPGP if the resultant run length from the OPGP to the vertical portion of the second equalizer is not greater than 120 percent of a direct run between the two points.

2.4.3.14

An exothermic weld or compression type parallel connector shall be used when Vertical Risers are joined to share a common 750 kcmil path to the OPGP.

2.4.3.15

When multiple vertical risers are installed in a building, they shall be designated as IS POP/VHO GRD #1, IS POP/VHO GRD #2, etc.

2.4.3.16

Multistory buildings that are separated by an alleyway or permanent building wall require one or more separate Vertical Risers in each building. The risers shall be designated IS POP/VHO GRD #1, IS POP/VHO GRD # 2, etc., when ac or dc supplies of either building provide power to

equipment in the other building. The equalizers shall terminate on the OPGP of their respective building, and a bond shall be provided between the two OPGPs sized as indicated in Table 2-2 of this section.

2.4.3.17

Acceptable methods for bonding a 750 kcmil vertical riser to the IS POP/VHO GRD bus bar are shown in Figure 2-7 and described below:

- 1) A 750 kcmil conductor is exothermically welded to the edge(s) of the bus bar. On the bottom floor of a building, the conductor from the OPGP and the one to the next floor's IS POP/VHO GRD bus bar may both be welded to the top (or sides) of the bus bar.
- 2) A short length of 750 kcmil is exothermically welded to the bus bar. The other end is tapped, using a compression type H-tap, to the vertical riser. This method allows the weld to the bus bar to be made at some other location (e.g., outside).
- 3) Same as arrangement (2), but both connections are made with exothermic welds.
- 4) A "flag" type connector is crimped to the vertical riser and bolted to the bus bar.
- 5) Same as arrangement (2), but both connections are compression type.

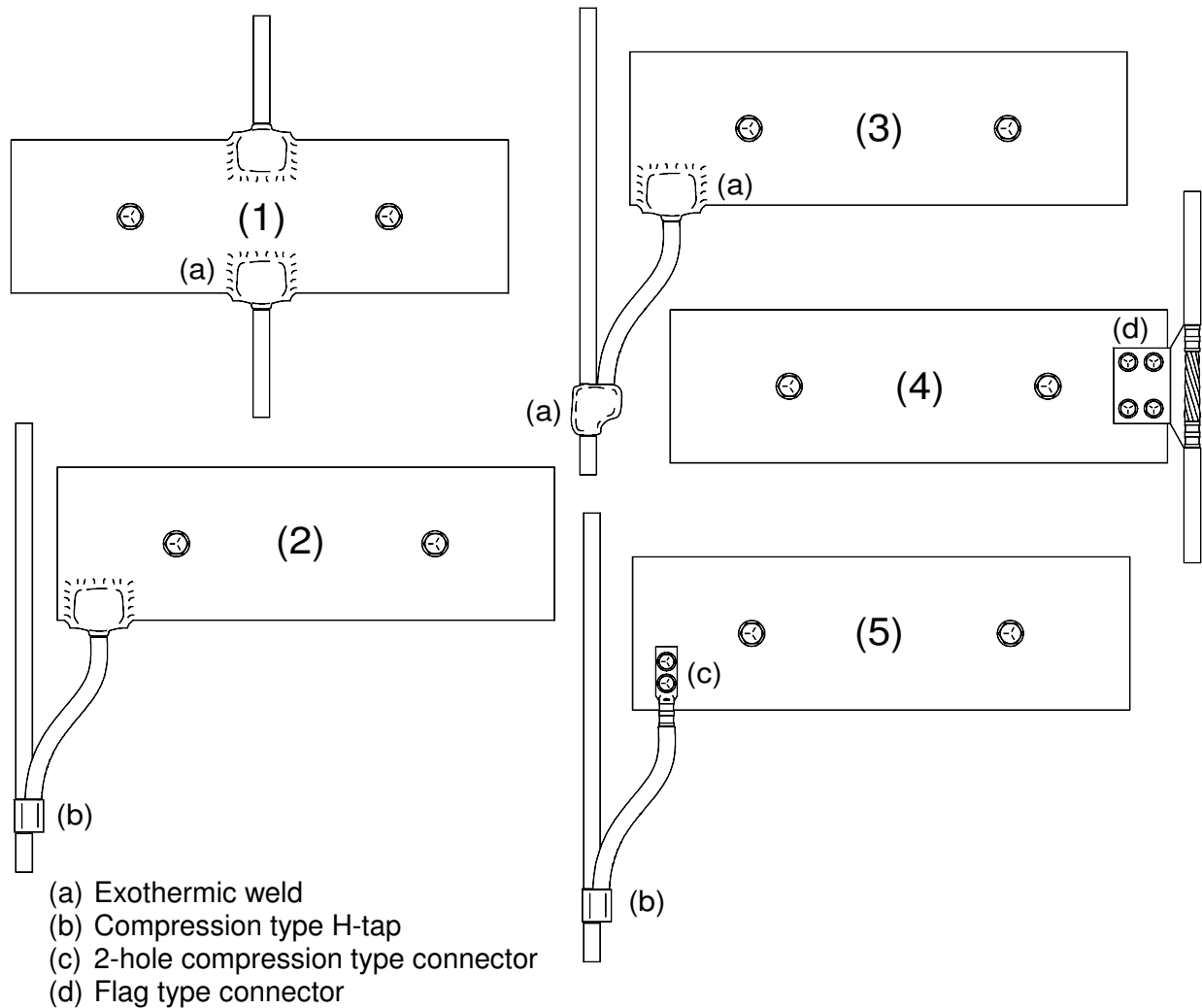


Figure 2-7
Methods of Connecting 750 kcmil Vertical Riser to IS POP/VHO GRD Bus Bar

2.4.4 Design Parameters - Horizontal Equalizer System

2.4.4.1

In the past, the recommended practice was to extend a separate 750 kcmil horizontal equalizer from a floor's IS POP/VHO GRD bus bar into each quarter section of the floor area. While this is still acceptable, the size of the building and the amount and type of equipment to be served by the IS POP/VHO GRD system should be evaluated to determine the need for this arrangement. Often, a single 750 kcmil or smaller conductor routed along a main aisle is an alternative that will provide an acceptable arrangement and will satisfy any foreseeable needs.

The conductor between IS POP/VHO GRD and an MGB or any point on a dc system grounding conductor is considered a part of the horizontal equalizer system. Any conductor normally connected to a horizontal equalizer may terminate on this conductor.

2.4.4.2

A minimum #2/0 AWG conductor shall be used between the IS POP/VHO GRD bus bar and an area containing a group of bays or miscellaneous units, or an area with more than one lineup of equipment.

Separate #2 AWG conductors may then be branched from this conductor to serve an equipment lineup or individual equipment units. The #2/0 AWG conductor may originate at an OPGP or IS POP/VHO GRD bus bar, or from another horizontal equalizer of equal or larger size.

2.4.4.3

When a BDFB is located in an area not served by a 750 kcmil horizontal equalizer, the BDFB's #1/0 AWG DCEG conductor may serve in place of the #2 AWG described above. If a BDFB has a 750 kcmil conductor between its return bus and a IS POP/VHO GRD bus bar, this is considered to be a horizontal equalizer, and may be used as such.

2.4.4.4

All extensions of, or branches from a horizontal equalizer conductor shall be made with compression type parallel connectors.

2.4.5 IS POP/VHO Ground Bus Bars

2.4.5.1

At least one IS POP/VHO GRD bus bar is required on every floor of a structure with an IS POP/VHO GRD system. The bus bar shall be located on the column that serves as the Vertical Riser, or on a column or wall when a vertical riser is a separate conductor.

2.4.5.2

The preferred location for the bus bars on equipment floors is the approximate center of the equipment area. Where a IS POP/VHO GRD bus bar cannot be centrally located, it should be located as near as practicable to the protector frames or other distributing frames equipped with protectors.

2.4.5.3

The IS POP/VHO GRD bus bar in a building's basement need not be in vertical alignment with other floor IS POP/VHO GRD bus bars. It should be located at a point along the IS POP/VHO GRD vertical riser run in the basement, and in a position that affords the shortest practical run length of the bond between the vertical riser and the predominant power plant, if one exists.

2.4.5.4

The bus bar is typically located 12"-18" below the lowest layer of ironwork. This location will generally allow access to the bus bar, help maintain an acceptable conductor bending radius and furnish an adequate rigid span for support of conductors. For low profile equipment lineups and office areas, the bus bar shall not be installed lower than 7 feet above the finished floor as this may interfere with personnel traffic patterns and access to equipment.

2.4.5.5

The bond between a vertical riser and an IS POP/VHO GRD bus bar shall be as short as practicable, and in no case shall be more than 20 feet.

2.4.5.6

In single floor buildings, more than one IS POP/VHO GRD bus bar may be provided. The additional bus bars may be connected directly to the OPGP or to the vertical riser serving another bus bar.

If the direct route to the OPGP results in a run length 25% less than the run via another bus bar, the direct route should be used.

2.4.6 Designation of OPGP & IS POP/VHO Ground Bus Bars

2.4.6.1

All IS POP/VHO GRD bus bars on all floors and all OPGP bus bars shall be designated. The designations may be stamped on the bus bar or engraved in or stamped on a separate designation plate. The plate must be securely fastened to either the bus bar or to the surface of the wall or column adjacent to the bus bar.

2.4.6.2

The preferred size for the characters used in the designation is 3/4" and in no case shall the characters be smaller than 1/2".

2.4.6.3

The terms used in designations for floor IS POP/VHO GRD bus bars are to be either "POP/VHO GRD", "POP GRD", "VHO GRD". For OPGP bus bars, the terms used in the designations are to be "OPGP", "O.P.G.P." or "Office Principal Ground Point". Terms such as "Telco Ground" or "Telephone Ground" are not to be used.

2.4.7 Office Drawings

The location of the OPGP and IS POP/VHO GRDs shall be recorded on the appropriate building plan electrical drawing. No grounding system detail is maintained.

2.5 BUILDING ENGINEERING

- 1) The exact location of vertical risers shall be determined jointly by Corporate Real Estate and Network Planning and Engineering based on expected space utilization and the requirements described in preceding paragraphs.
- 2) For buildings with structural steel, the preferred method is to use the welded structural steel as the vertical riser.
- 3) When it is intended that structural steel columns be used as vertical risers, instructions for bonding of the structural steel sections, as described in preceding paragraphs, shall be included in building specifications.
- 4) When bonding of floor IS POP/VHO GRD bus bars to building steel is required the Building Engineer shall arrange for the addition of the two 3/4" studs or the 750 kcmil conductor to building steel prior to pouring of concrete.
- 5) The installation of sleeves in floors and requirements associated with building construction should be included in construction specifications. When sleeves are placed at columns, care should be exercised to offset them from the column to miss horizontal beams while not interfering with clear equipment aisle space.
- 6) Where more than one vertical riser system is required in a building and bonding is required between them, suitably located sleeves through intervening walls that will result in shortest practical run lengths shall be provided.

2.6 AC SYSTEM GROUNDING

The AC service distribution system used in a Internet Services POP/VHO is usually a single or three-phase 120/208 or 277/480 volt grounded systems. The grounding of these systems

includes two sub-systems: the ac service grounding system, covered in 2.7, and the ac equipment grounding system, covered in 2.8.

2.6.1 Grounding Electrode Conductor (GEC)

2.6.1.1

A grounding electrode conductor (GEC) bonds the neutral of an ac power system to an acceptable earth electrode system. The preferred point of connection of the GEC to an earth electrode system is at an OPGP. For the end of the GEC terminated in the main house service panel the preferred location for the connection is the neutral bus bar. If used, any other location for this connection shall meet the applicable requirements in Article 250 of the NEC.

2.6.1.2

Figure 2-3 shows the two preferred methods for connecting the main ac service GEC to an OPGP bus bar and, in turn, to the main cold water pipe or other primary grounding electrode.

2.6.1.3

If a GEC connects to an earth electrode system that does not terminate on the OPGP, a bond equal in size to the GEC is required between the separate earth electrode system and the OPGP.

If it provides a shorter path, the conductor from the separate electrode system may terminate at a point on the earth electrode system serving the OPGP (for example to driven ground rods).

2.6.1.4

The neutral conductor of an ac system shall not be connected to a grounded object on the load side of the system's main disconnect device.

If the neutral should become open, operating current would flow over the grounding path, potentially raising the voltage on the grounded equipment.

2.6.1.5

The GEC shall be sized per Article 250 of the NEC except that conductors smaller than #2 AWG shall not be used for services, and conductors smaller than #6 AWG shall not be used for the source of a separately derived ac power system in any Company structure. See Table 2-2.

2.6.1.6

The GEC may be a bare or insulated, stranded or solid copper conductor.

2.6.1.7

The GEC should be run in the open, or in non-metallic raceway. When required to be in metallic raceway, the raceway must be bonded to the conductor at both ends. If a conductor is used for this bond, it shall be no smaller than the GEC.

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

Table 2-2
Grounding Electrode Conductor Sizing
(Table 250-66 from the NEC)

2.6.2 Main Bonding Jumper

2.6.2.1

A main bonding jumper shall be used to connect the grounded conductor of the system (the neutral) to the equipment grounding conductor and service equipment enclosure.

2.6.2.2

The main bonding jumper shall not be smaller than the sizes given in Table 2-2 above, except that sizes smaller than #2 AWG shall not be used for main house service panels in Company structures. Where the service entrance phase conductors are larger than 1100 kcmil copper or 1750 kcmil aluminum, the bonding jumper shall have an area not less than 12 1/2 percent of the area of the largest phase conductor.

2.6.3 Grounding of Separately Derived AC Systems

A separately derived ac power system is a power source that has no direct electrical connection, including a solidly connected grounded circuit conductor, to supply conductors originating in another system. Typical sources are isolation transformers, some inverters and some engine-alternators.

2.6.3.1

A GEC is required between the neutral of the source of a separately derived ac power system and an earth ground reference.

2.6.3.2

In buildings equipped with a IS POP/VHO GRD system, the preferred point of connection for a GEC is to the OPGP, a floor IS POP/VHO GRD bus bar, or building steel. In structures without a IS POP/VHO GRD system or building steel, the GEC must be connected to an approved earth electrode.

2.6.3.3

Grounding electrode conductors and main bonding jumpers for separately derived ac systems shall be installed per the requirements of 2.7.1 and 2.7.2 above, based on the size of the derived phase conductors.

2.7 AC EQUIPMENT GROUNDING

2.7.1 Feeder and Branch Circuit Equipment Grounding System

2.7.1.1

A separate ACEG conductor shall be provided in all conduits, raceways and other distribution systems containing ac circuit conductors.

2.7.1.2

A separate ACEG conductor shall be provided in all additions, rearrangements or extensions of service, feeder and branch circuit raceways. This includes distribution systems serving both communication equipment and building service equipment.

2.7.1.3

An additional insulated ACEG conductor is required for all circuits feeding isolated ground type outlets. This conductor must remain insulated from contact with any other ground reference between the circuit load(s) and its source (HSP, isolation transformer, dc-ac inverter, etc.).

See Section 4.10 4., *Special Note on Isolated Ground Type Receptacles*, for a discussion of the application of these receptacles.

2.7.1.4

A separate bonding jumper is required between a receptacle and its enclosure with the following exceptions:

- a) The receptacle is an isolated ground type
- b) The enclosure is surface mounted and direct metal-to-metal contact exists between it and the receptacle's mounting yoke
- c) The receptacle is cover-mounted and the enclosure and cover combination are listed as providing satisfactory ground continuity between the enclosure and the receptacle

2.7.1.5

Except for ACEG conductors serving isolated ground type receptacles, all ACEG conductors shall be bonded to metal enclosures to provide continuity independent of that provided by the raceway. A single bond may be used between multiple ACEG conductors and an enclosure.

2.7.1.6

An ACEG conductor shall be connected to an enclosure by one of the following means:

- a) A ground bus bar
- b) A terminal strip
- c) A grounding bushing
- d) A grounding clip
- e) A screw fastener
- f) The arrangements described in 2.7.1.4 (b) and (c)

Grounding clips are normally used only at junction boxes and receptacle enclosures. A screw fastener (machine screw, nut, bolt or stud) must be used for no other purpose than to terminate ACEG conductors.

2.7.1.7

ACEG conductors shall never be connected to an ac neutral at any point other than where the source of the system receives its ground reference.

2.7.1.8

The inclusion of an ACEG conductor in a raceway shall not be counted in determining the ampacity of conductors in accordance with 310.15(B)(2) of Article 310 of the National Electrical Code.

2.7.1.9

The ACEG conductor shall be included in calculations of allowable percentage of conduit fill defined in Chapter 9, Table 1 of the National Electric Code.

2.7.1.10

As a minimum, all ACEG conductors and bonds between them and metallic enclosures shall be sized per Table 2-3 below, which is from Article 250 of the NEC. When phase conductors are increased in size to compensate for voltage drop, the size of associated ACEG conductor(s) shall be increased proportionately.

2.7.1.11

Where conductors are run in parallel in multiple raceways, ACEG conductors shall be run in parallel. Each parallel ACEG conductor shall be sized on the basis of the ampere rating of the over current device protecting the conductors in the raceway in accordance with Table 2-3.

2.7.1.12

Insulated ACEG conductors shall be colored green or green with one or more yellow stripes. Conductors larger than #6 AWG may be identified by marking the exposed insulation with green tape or paint at each end and at every point where the conductor is accessible.

2.7.1.13

When multiple ac circuits share a common raceway, only one ACEG conductor is required for the raceway. Its size shall be based on the largest over current device serving circuits in the raceway.

2.7.1.14

The ACEG conductor in a circuit serving equipment in a frame, cabinet or other metallic enclosure that also contains dc-powered equipment may not be used in place of the required bond between the enclosure and the IS POP/VHO GRD system.

2.7.1.15

While ACEG conductors are considered part of (and bonded to) the IS POP/VHO GRD system, no other IS POP/VHO GRD conductor may serve in place of an ACEG conductor. Bonds between the IS POP/VHO GRD system and ac power distribution system components shall not be used in place of any ACEG conductor.

Rating or Setting of Automatic Over current Device in Circuit Ahead of Equipment, Not Exceeding (Amperes)	Minimum Size of Copper Equipment Grounding Conductor (AWG or kcmil)
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
2500	350
3000	400
4000	500
5000	700
6000	800

**Table 2-3
Minimum Size of Equipment Grounding Conductor
for Grounding Raceway and Equipment
(Table 250.122 from the NEC)**

2.7.2 Extending ACEG Conductors

2.7.2.1

Since ac distribution systems are of different ages, it is likely that a system not originally equipped with a separate ACEG conductor will be encountered. It is often not feasible to place an ACEG conductor in the existing upstream feeder conduit or raceway. However, the conduit or raceway may be able to serve as the ACEG conductor. The point from which an ACEG conductor is extended will usually be an enclosure such as:

- a) A distribution panel
- b) A pull box
- c) A junction box
- d) A receptacle box
- e) A lighting fixture

2.7.2.2

Before any ac distribution system is extended or rearranged from a point in a distribution system not equipped with a separate ACEG conductor, the integrity of the ACEG system between the enclosure and service panel must be verified.

This is done by determining whether an acceptable type of conduit or raceway has been used and by verifying the tightness of the fitting(s) used to fasten the conduit or raceway to the enclosure

2.7.2.3

For existing distribution systems not equipped with a separate ACEG conductor, the only types of conduit or raceway allowed to serve as an ACEG conductor are:

- a) Electrical metallic tubing (EMT)
- b) Intermediate metal conduit (IMC)
- c) Rigid metal conduit
- d) Metal raceways listed for grounding

If none of the above is present in the upstream feed to the enclosure, no circuit shall be extended from the enclosure until corrective action has been performed.

2.7.2.4

The ACEG conductors being added shall be terminated to the enclosure by one of the means in Section 2.7.1.6 above.

2.7.2.5

If more than two ACEG conductors are being added (typically at a distribution panel), it is preferable to add a ground bus to the panel. This bus may be bonded to the panel using its mounting screws provided the paint is removed from the mounting surface of the panel and an antioxidant compound is applied to the bare metal.

2.7.3 AC Power Distribution Cabinets

2.7.3.1

Every ac power distribution cabinet requires an ACEG conductor in the conduit or raceway containing the feeder conductors serving the cabinet.

2.7.3.2

ACEG conductors shall terminate on the interior of the cabinet enclosure on a bus bar bonded to the cabinet enclosure or one of the methods in 2.7.1.6 (b) thru (e).

2.7.3.3

Except for cabinets containing the service disconnecting means, the neutral bar must be insulated from the enclosure and the equipment ground bar.

2.7.3.4

The ACEG conductor provided with feeder conductors provides an acceptable extension of the IS POP/VHO GRD system to an ac distribution cabinet and ac powered equipment only when the ac system's source receives its ground reference on the same or adjacent floor to that on which the cabinet is located. Otherwise, the cabinet shall be bonded to the floor IS POP/VHO GRD system using a minimum #6 AWG conductor. This helps to minimize any difference in ground reference voltage between DC components that receive ground reference from the COG on each floor and AC components that have a ground reference from the OPGP.

2.7.4 AC Bus Duct System

2.7.4.1

AC bus duct components shall maintain equipment ground continuity throughout the bus duct system. Feeder tap boxes and plug-in units are considered to be adequately bonded through mechanical interconnection to bus duct sections.

2.7.4.2

The ACEG conductor(s) associated with bus duct feeder and distribution circuits shall be furnished in accordance with requirements above.

2.7.5 Engine-Alternator Sets

2.7.5.1

Engine-alternator and inverter derived ac supplies provided in case of commercial power failure are normally controlled through automatic or manual switching so that the phase conductors of the standby supply are never joined to the commercial supply. The neutral conductor of the standby supply is normally directly connected to the neutral of the commercial secondary service. The grounding electrode conductor (GEC) of the secondary service system serves as a ground reference for both the standby and commercial systems and such systems do not require a separate GEC. However, in some cases the use of ground fault protection will mandate that the neutral be switched.

Exception: When an engine-alternator set is located in a separate building that has its own earth electrode system, the standby system's neutral shall also be connected to that earth electrode system.

If the transfer switch does switch the neutral, then the engine-alternator or inverter is considered the source of a separately derived system and must be equipped with a GEC and a main bonding jumper.

2.7.5.2

An ACEG conductor is always required in the conduit(s) or raceway(s) containing phase leads from the alternator, and shall be furnished in accordance with the requirements above.

2.7.5.3

The ACEG conductor(s) shall terminate within the engine-alternator cabinet provided for the phase leads. Termination may be made on a bus bar or ground stud bonded to the cabinet or directly to the cabinet interior. The cabinet must be electrically connected to the engine-alternator frame by mounting bolts or by a bonding strap or equivalent means to provide continuity between the entire set and the ACEG conductors.

2.7.5.4

The neutral of the alternator shall not be bonded to the ACEG conductor or engine-alternator frame when it is located in the same building as the main ac service panel. The neutral shall be bonded to the ACEG conductor only when the set is located in a separate building equipped with its own earth electrode, or if the neutral is switched.

2.7.6 Grounding of AC Tap Boxes

2.7.6.1

Every ac tap box shall be equipped with an ACEG bus bar. This bus bar shall be bonded to the metalwork of the tap box by its mounting hardware or by a separate bonding conductor.

2.7.6.2

A separate ACEG conductor shall be furnished in the raceway serving the tap box. The ACEG conductor shall be installed per the requirements in Section 2.7.1 except that the size of the ACEG conductor shall be based on the rating or setting of the over current protective device installed in the circuit between the tap box and the system it serves.

2.7.6.3

If the transfer switch for a site's engine-alternator switches the neutral conductor, the neutral bus bar of the tap box shall be equipped with a GEC and a main bonding jumper per the requirements in 2.7.A. and 2.7.B. above.

2.7.7 Cord Connected AC Operated Equipment

2.7.7.1

Parallel polarized U ground slot receptacles(NEMA 5-15R) are standard for frame base appliance outlet and other miscellaneous ac branch circuit applications serving cord connected equipment. Such equipment, whether portable or permanently mounted, shall be equipped with a three-conductor cord and a three-conductor grounding attachment plug(NEMA 5-15P). Two conductors of the cord shall serve as circuit members. The third conductor shall serve as a grounding member, connected at the plug to the U blade, and to the equipment structural metal, so that ground continuity is established from the receptacle to the equipment structure.

2.7.7.2

When branch circuit conductors are not run in electrically continuous metallic raceway an ACEG conductor must be provided from the panel board to the receptacle. The ACEG conductor shall be bonded to the metal outlet box or other metallic enclosure mounting the receptacle as well as the EG (green) terminal screw of the receptacle.

2.7.7.3

Generally, all new ac operated portable or permanently mounted equipment units utilizing cord and plug for ac supply shall be supplied with 3-conductor cords and 2-pole, 3-conductor grounded plugs that function to ground the unit structure.

The only exceptions shall be for tools such as soldering irons that must be employed on or near circuit connection points that may have dc potential, where contact with the tool would constitute a short to ground, or for other specialized requirements of similar nature.

2.7.8 Job Drawings, Architectural

2.7.8.1

AC distribution system circuit requirements for specific job installations shall be recorded on drawings prepared by the building architect and/or the communication systems equipment engineer.

2.7.8.2

An ACEG system shall be provided, as specified in this section, in the portion of the ac distribution system controlled by architectural drawings. The ACEG conductors shall be shown on the plans in a similar manner to that of phase and neutral conductors. Methods of termination and other information necessary for proper installation shall be provided.

2.7.8.3

For the purpose of establishing a standard identification of ACEG conductors shown on circuit schematic, wiring diagram and job circuit drawing, it is recommended that lead identification at points where an ACEG lead is referenced to other circuit figures or other drawings shall use letter designation, as follows: **ACEG**

2.7.9 Rooftop Facilities

The rooftops of central office buildings may support a number of diverse components that require some degree of bonding and grounding coordination. Rooftops may include lightning protections systems, communication antennas, standby generators, air-handling units, vents, fences and metal "penthouse" enclosures. Items to consider:

- 1) Any Lightning Protection system must satisfy the requirements of NFPA 780
- 2) Lightning protection systems and communications antennas will have independent rooftop ring ground conductors, down conductors and grounding electrodes that will be bonded to the other building-related grounding electrodes at ground level.
- 3) Lightning protection systems may use building steel for down conductors if the steel is electrically continuous (welded or bonded).
- 4) Air terminals of lightning protection systems must be connected to building steel where the building steel is electrically continuous (welded or bonded).
- 5) Conductive objects that are not part of the lightning or antenna protection system and that are within 7' of a lightning or antenna conductive object shall be bonded to the lightning or antenna ground ring with a minimum #6 AWG conductor (whether or not also bonded to the CBN). Where building features do not provide adequate physical protection to the wire, cover the wire with "U" shaped metallic channel or other non-conductive cover.
- 6) Generator sets that are mounted on the rooftop shall be bonded to building steel (minimum #6 AWG) where the building steel is electrically continuous (welded or bonded), otherwise bond to the CBN.
- 7) If equipment is added to a rooftop (e.g. generators, penthouses, remote radiators, etc), these items may become the primary attractant to lightning strikes. An evaluation of conditions (height of additional equipment, height of building and surrounding buildings, incidence of lightning, etc.) should be conducted with Corporate Real Estate to determine if a lightning protection system is warranted.

2.8 COORDINATION WITH CORPORATE REAL ESTATE

The AT&T Corporate Real Estate (CRE) group has responsibility for the cost effective design and construction of central office facilities that meet network requirements. Part of the power and grounding infrastructure that is required for the safe and reliable operation of network equipment is provided by CRE and part is provided by NP&E. Table 2-4 provides a generalized listing of these responsibilities that will likely vary somewhat between the various regions. Which group has primary or secondary responsibility may not be critically important. What is important is that:

- 1) NP&E staff provide timely input to CRE regarding growth or changing infrastructure requirements.
- 2) CRE allow NP&E opportunity to review proposed designs before the start of construction.
- 3) Everyone recognize the importance of coordination.

Notes for Table 2-4:

- 1) CRE = Corporate Real Estate
- 2) P = Primary responsibility and S = Secondary Responsibility
- 3) Primary responsibility includes planning, specifying, budgeting, scheduling and implementation after consultation with those who may have secondary responsibility.
- 4) Primary responsibility is within the OSP organization.
- 5) When NP&E has secondary responsibility, they are responsible for timely delivery of any network-related specifications for use by CRE.

Item	Description	Design		Install		Maintain	
		CRE	NPE	CRE	NPE	CRE	NPE
Grounding Electrode System	Building ring, UFER, underground water pipe, building steel, OPGP and all bonds to OPGP	P	S	P		P	
Building Steel	Qualify building steel as suitable for grounding electrode / vertical riser.	P					
Building Steel	Selection of building steel as vertical riser	S	P				
Building Steel	All bonding attachments to building steel	P	S	P		P	
AC Service Bonds	Bonds from ACEG and Neutral bus to grounding electrode system	P	S	P		P	
Cable Entrance Facility	Bonds from CEF to OPGP, ACEG	P	S	P			
Cable Entrance Facility	Bonds from Cable sheath to CEF bus	S ⁴	S ⁴	S ⁴	S ⁴	S ⁴	S ⁴
AC Distribution	To facility infrastructure	P		P		P	
AC Distribution	To network line-ups		P		P		P
Ground Reference Distribution	Vertical Riser, COG	S	P	P		P	
Common Bonding Network	All connections from COG to network elements and foreign objects		P		P		P
Isolated Bonding Network	All connections to MGB, isolation from CBN		P		P		P
Ground distribution to DC Power	Ground connections to equipment frame and battery return of DC power plant		P		P		P
Evaluate the need for building lightning protection	Consideration for frequency of lightning, cone of protection, historical data	P	S				
Building Lightning Protection	Design and Install	P		P		P	
Separately Derived Power	Bonding of Generators	S	P	P		P	
Separately Derived Power	Bonding of Inverters		P		P		P
Separately Derived Power	Bonding of UPS	S	P		P		P
Grounding Electrode System – CEV	Ground rods, ring & connection to OPGP	S ⁴	S ⁴	S ⁴	S ⁴	S ⁴	S ⁴
Grounding Electrode - Radio Site	Exterior ring, interior ring, tower ring	P	S	P		P	

**Table 2-4
NP&E / CRE Responsibilities**

SECTION 3

Power Plants and Equipment, Transport and Miscellaneous Equipment

3.1 SCOPE

This section covers requirements and information about connections between a central office ground system and:

- Power equipment
- Transport equipment
- Miscellaneous equipment frames and units
- Cable entrance facilities
- Protector and distributing frames
- Power systems serving the above and other types of equipment

3.2 GENERAL

This section provides requirements for equipment that is normally installed in a common bonding network environment. It includes requirements for power plant equipment and power distribution systems that serve both common bonding network and isolated bonding network equipment.

Where requirements are specified in circuit drawings or specifications of equipment approved for use, they shall have precedence over the general requirements of this section. Where grounding requirements are not furnished in system specifications or where they have not been updated to the requirements outlined in this section, a grounding system of equal requirements covered in this section shall be provided.

3.3 DC POWER SYSTEMS

Modern DC power plants are used to provide, 48-volt power to transport, and miscellaneous equipment.

3.3.1 Battery Plants

3.3.1.1

The return side of every dc power source shall be referenced to the site's grounding system with a dc system grounding conductor. This applies to all battery plants, converter plants and all converters mounted in equipment frames, cabinets or other enclosures, whether or not the dc source serves loads located in the same enclosure.

Where two or more plants use a combined battery return arrangement, each plant should have a separate bond from its battery return to the IS POP/VHO GRD system.

3.3.1.2

For battery type plants, the default size for the system grounding conductor shall be 750 kcmil. Using Table 3-1, a smaller conductor may be allowed. Its minimum size shall be based on the maximum plant capacity specified by the manufacturer.

Power Plant Capacity (Amperes)	Minimum Size of System Grounding Conductor
up to 100	6 AWG
101 – 500	2 AWG
501 – 1199	4/0 AWG
1200 +	750 kcmil

**Table 3-1
Battery Plant System Grounding Conductor Sizing**

3.3.1.3

When approved for use, power plants and equipment with imbedded power arrangements may use conductor sizes other than those shown in Table 3-1. For such installations, the conductor should be the minimum size specified by the manufacturer of the equipment.

3.3.1.4

The dc system grounding conductor may be placed directly between a power plant's battery return bus bar and a IS POP/VHO GRD or OPGP bus bar or a point on a 750 kcmil horizontal equalizer. It may also be connected to the IS POP/VHO GRD system by a connection to a Main Ground Bus (MGB) in a ground window. The conductor between a power plant's battery return bus bar and a IS POP/VHO GRD or OPGP bus bar is considered a part of the horizontal equalizer system. Conductors normally permitted to connect to a horizontal equalizer may terminate on this conductor.

3.3.1.5

The minimum size of the system grounding conductor for dc-dc converters shall be that shown in Table 3-2, based on the output fault current rating of the converter. The fault current rating shall be the rating of the output over current protective device or the current limit inception value if no protective device is furnished.

The system grounding conductor provides the ground from the equipment to the equipment frame or enclosure and may be smaller than a #6AWG. The minimum size for an equipment frame or enclosure conductor to the IS POP/VHO GRD system is a #6 AWG.

Over current Device Rating or Current Limit Inception Not Exceeding (Amperes)	Minimum Size of System Grounding Conductor (AWG)
15	14
20	12
30	10
40	10
60	10
100	8
200	6
300	4
400	3*
500	2
600	1*

Table 3-2
System Grounding Conductor Sizing
(From Table 250-122 of the NEC)

*NOTE: Historically, #3 AWG and #1 AWG have not been readily available from suppliers and ATT has standardized on the next larger size (#2 and #1/0 respectively).

3.3.1.6

For converter plants consisting of two or more converters with outputs connected in parallel, the size of the system grounding conductor shall be based on the combined fault current available from a fully equipped converter plant as specified by the manufacturer. When the output of multiple converters embedded in equipment share a common distribution path via back plane layers, conductors or bus bars, the system grounding conductor shall be sized on the combined maximum available fault current.

3.3.1.7

Some equipment designs use dc-dc converters whose output is referenced to ground via the converter's input battery return conductor. In this case, the converter's input battery return conductor shall be no smaller than that required per 3.3.1.5, 3.3.1.6 and Table 3-2.

3.3.2 Power System Equipment Grounding

3.3.2.1

All frames, cabinets and other components of a power plant must be equipped with a minimum #6 AWG bond to the IS POP/VHO GRD system. This includes frames in a power board lineup,

rectifier bays, metal battery stands, etc. The power plant lineup conductor should be sized to accommodate the maximum expected primary distribution. For 600A distribution, the power plant lineup conductor shall be a #1/0 AWG minimum and shall be connected to the nearest:

- a) DC System Grounding Conductor (when MGB is part of the power plant battery return)
- b) MGB (when MGB is part of the power plant battery return)
- c) Horizontal Equalizer of equal or greater size
- d) IS POP/VHO GRD or OPGP bus bar

DCEG conductors for power plant frames, cabinets and other equipment shall be branched from a power plant lineup conductor. A typical power area grounding arrangement is shown in Figure 3-1.

3.3.2.2

The DC system Grounding Conductor extends from the battery return bus bar to the IS POP/VHO GRD (or OPGP) for all power plants except shared power plants with a remote MGB. This is a 750 kcmil conductor.

3.3.2.3

For any equipment frame, cabinet or other enclosure containing rectifiers, the minimum size for a DCEG conductor shall be #6 AWG. Table 3-3 shall be used to determine the size of the framework ground conductor based on the size of the output rating of the largest rectifier in the framework. The current limiting or over-current protection feature of rectifiers may not activate until 110% of the rated current output is reached. For example, a 400-ampere rectifier may not shut down until reaching 440 amperes. The conductor size in Table 3-3 is based on Table 250-122 from the NEC.

Rectifier/Inverter Output Rating (Amperes)	Rectifier/Inverter Current Limit (Amperes)	DCEG Conductor Size
up to 100	up to 110	6 AWG
200	220	4 AWG
400	440	2 AWG

**Table 3-3
Rectifier/Inverter DCEG Conductor Sizing
(From Table 250-122 of the NEC)**

3.3.2.4

The DCEG conductor for any dc-to-ac inverter shall be a minimum #6 AWG. Table 3-3 shall be used to determine the minimum size for the DCEG conductor based on the rating or setting of the dc input circuit's over current protective device. This requirement applies to all stand-alone inverters and to all bay-mounted inverters. This DCEG conductor is required in addition to the ACEG conductor for the ac input and/or output circuits. If the inverter is the source of a separately derived system, this conductor is also required in addition to the Grounding Electrode Conductor.

3.3.3 Engine Alternator Equipment

3.3.3.1

For engine rooms located within a structure, the grounding system shall be the same used for equipment in a power room: minimum #6 AWG bonding conductors shall be branched from a minimum #2 AWG main conductor extended from the IS POP/VHO GRD system and routed through the engine room. The actual conductor size is based on the requirements of Table 2-3. Certain objects must always be bonded to this extension of the IS POP/VHO GRD system. These include:

- a) The frame of any engine-alternator set
- b) A metallic engine start battery stand
- c) A metallic day tank (by a bond to its support/hold down structure)
- d) If not electrically or mechanically joined to an object that is bonded, a point on the overhead ironwork system or metallic support structure

A separate bonding conductor is not required for cabinets, enclosures or other units in an engine room that are equipped with an ACEG or other bonding conductor extended from an object already bonded to the engine room grounding system.

For items not mentioned above, a separate bonding conductor is only required for objects that are likely to become energized, such as a metal radiator shroud equipped with a load bank. A bond is not required for objects not likely to become energized such as metal door and window frames, vent ducts, louvers, shrouds, etc.

3.3.3.2

A small equipment unit that is exclusively ac-powered (tank monitor, etc.) is considered effectively bonded to the IS POP/VHO GRD system via its ACEG conductor.

3.3.3.3

An engine alternator located in a separate, stand-alone enclosure outside a central office building or other structure may use the ACEG conductor(s) furnished in feeder conduits between the enclosure and the main structure as the bond to the IS POP/VHO GRD system.

If an engine alternator in a stand-alone enclosure is configured as the source of a separately derived system, a grounding electrode conductor must be used to bond the neutral of the alternator to an earth electrode. Depending on site conditions, this may be the same earth electrode system used for the IS POP/VHO or it may be a separate earth electrode system. Requirements for a grounding electrode conductor and main bonding jumper are provided in Section 2.7 AC SYSTEM GROUNDING.

3.3.3.4

Metallic objects that are part of a remotely located engine alternator enclosure must be bonded together. The preferred method is to use separate bonding conductors, but units may also be considered bonded together if joined by welds, rivets, or other adequate mechanical means.

3.3.3.5

Fuel tanks, radiators and other conductive components of the engine-alternator set that are not effectively grounded to the engine-alternator through mechanical means shall be bonded with a #6 AWG conductor to the engine-alternator skid, cabinet or to a grounding electrode system.

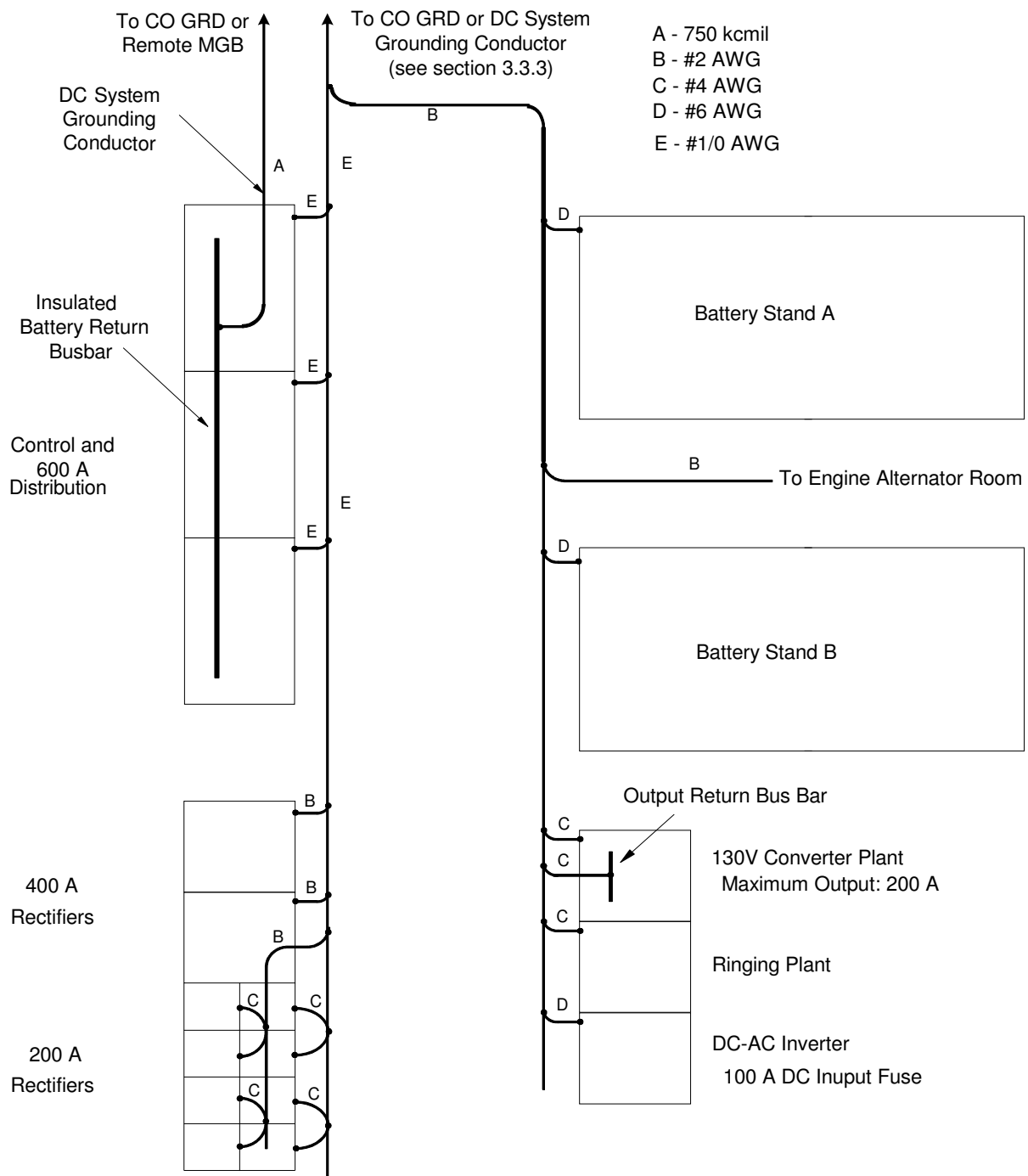


Figure 3-1
Typical Power Area Grounding Arrangement

3.4 POWER DISTRIBUTION SYSTEMS

A variety of equipment and conductor configurations have been used to ground and to distribute dc power to communication systems. While some of these equipment systems may no longer exist, all or part of their original grounding and/or power distribution systems may still be in use. Only the following shall be used for new or growth Internet Services jobs:

- a) Distribution by means of paired battery and return conductors from power plant distribution bays to power distribution frames (PD, PDC, PCFD, etc.) within electronic switching equipment or other electronic systems.

- b) From the system distribution frames, paired conductors extend to equipment bays. Refer to Section 4 of this Practice for a discussion of typical distribution systems and grounding arrangements.
- c) Distribution by means of paired battery and return conductors from power plants to battery distributing fuse boards (BDFB), by paired conductors to individual equipment bays or lineups, and to centrally located fuse boards.
- d) Direct distribution by means of paired battery and battery return from power plants to fuse panels in individual equipment bays.

3.4.1 Battery Distributing Fuse Board (BDFB)

3.4.1.1

BDFBs are used to distribute one or more dc voltages to network equipment. The battery return bus bars on early BDFBs were in electrical contact with the framework of the BDFB. All new BDFBs should have the bus bar insulated from the framework.

3.4.1.2

The DCEG conductor for BDFBs shall be a minimum #1/0 AWG conductor, and shall be connected directly to a IS POP/VHO GRD bus bar or tapped to a horizontal equalizer of equal or greater size.

3.4.1.4

When a #1/0 AWG conductor is added between the BDFB framework and a IS POP/VHO GRD bus bar, it may serve other BDFBs as well as other equipment lineups. If more than one BDFB is in a lineup, a single #1/0 AWG conductor may serve every BDFB in the lineup. Where applicable, this conductor may also serve in place of the #6 AWG lineup grounding conductor.

3.5 INTERNET SERVICES UNINTERRUPTIBLE POWER SYSTEMS

3.5.1 UPS Power

3.5.1.1

A significant portion of the Internet Services equipment is AC powered. For reliability UPSs are used for service continuity. The UPSs may be redundant and may have redundant combination Power Distribution Unit (PDU) / Static Transfer Switches STS. A simple configuration would look like Figure 3-2.

3.5.1.2

In this example, the AC service is a 480V, 3Ø, 4W and the UPS is a 480V, 3Ø, 3W with equipment ground. There is a maintenance bypass module which permits isolation of the UPS for maintenance or to replace the UPS if necessary.

3.5.1.3

The Maintenance Bypass module is connected to the Main Service which is grounded per NEC 250-24. The UPS input power, output power and ground is through the Maintenance Bypass Module. Output of the Bypass Module is still 480V, 3Ø, 3W.

3.5.1.4

The Power Distribution Center is 480V, 3Ø, 3W on the input and 120/208V, 3Ø, 4W on the output. The output WYE transformer must be grounded as a separately derived source per NEC 250-30.

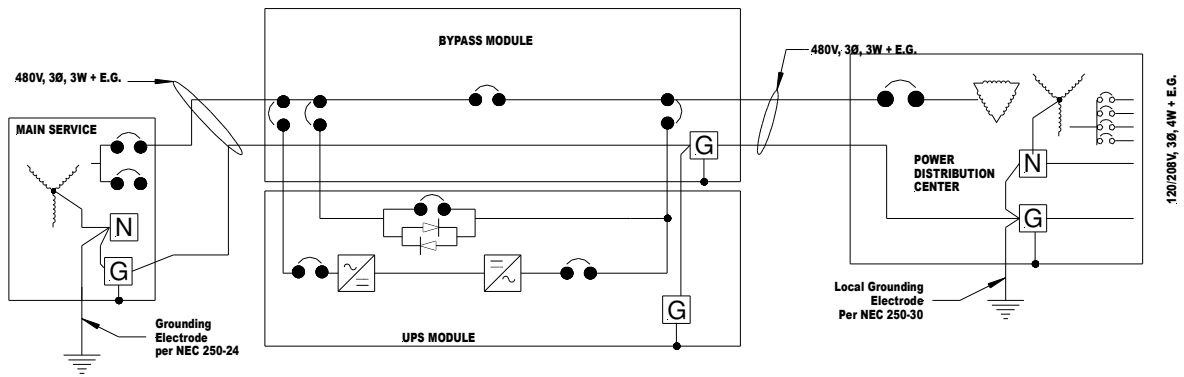


Figure 3-2

UPS Power e/w internal static bypass switch and Maintenance Bypass Module

3.5.1.5

Redundant systems are no more complicated from a grounding perspective. The AC power design proposed for Internet Services is two parallel independent UPSs similar to the above. The power distribution center of the second system requires grounding exactly as the first.

3.5.1.6

If the separately derived source is grounded to the building steel, it is crucial that the bond is verified between building steel and the closest IS VHO/POP GRD, CO GRD, OPGP.

3.5.1.7

Adequate grounding for the system modules is provided by the NEC required green wire Equipment Grounds. The battery stands auxiliary framing and disconnect hardware do require grounding.

Early VHO AC power systems are more complicated electrically but should have very similar grounding requirements.

3.5.2 AC POWER DISTRIBUTION EQUIPMENT

3.5.2.1

Most Internet Services equipment is served by AC branch circuits from two general types of distribution equipment:

- a) AC distribution panel - these are standard AC distribution panels (also called sub-panels) of various designs mounted on walls or columns that contain branch circuit connection hardware and over current protective devices
- b) Power distribution unit (PDU) - these are separate floor mounted cabinets located in the Internet Services equipment area that contain an isolation transformer and branch circuit connection hardware and over current protective devices

3.5.2.2

Grounding and power arrangements are interdependent, and must make provision for the equipment vendor specifications. Most grounding and ac power arrangements will require an ACEG and standard grounded receptacles.

3.6 INTERNET SERVICES, TRANSPORT AND MISCELLANEOUS EQUIPMENT

3.6.1 Equipment Enclosure and Unit Requirements

3.6.1.1

Nearly all Internet Services equipment, whether in a company-owned structure or on customer premises, is located in an area that is part of the common bonding network. These areas contain an assortment of equipment, often in a variety of frames, cabinets, and other enclosures. Any given equipment area may contain technology from a wide assortment of vendors.

While some Video equipment may be classified as transport equipment, it is covered in Section 6 of this Practice.

3.6.1.2

All bonds to the IS POP/VHO GRD system mentioned in paragraphs 3.6.1.3 - 3.6.5.4 shall be made to the nearest point on the horizontal equalizer system that is of equal or larger size, or if no horizontal equalizer exists, to the nearest IS POP/VHO GRD or OPGP bus bar.

3.6.1.3

There are four requirements that apply to transport, information technology and any other equipment:

a) The equipment enclosure must be equipped with a bond to the IS POP/VHO GRD system that is capable of safely conducting any fault current likely to be present at the enclosure.

b) Every bond to the IS POP/VHO GRD system, both from and within equipment frames, cabinets or other enclosures, must consist of electrical conducting paths that are intentionally designed and provided for the purpose. Unit or enclosure metalwork may be used in place of a bonding conductor to the IS POP/VHO GRD system if the chassis of an equipment unit, shelf, etc., has been made electrically continuous with the frame, cabinet or other enclosure metalwork (see 3.6.1.5 and 3.6.1.6).

c) The bond from the equipment to the IS POP/VHO GRD system shall not be used in place of a dedicated return conductor to conduct normal load current. It is important to be aware, however, that even though frame grounding conductors are not designed to carry load current, industry standards allow some current flow between the battery return conductor and the equipment frame for equipment located in the Common Bonding Network (CBN). This can result in less than 100% of the load current returning over the battery return conductor.

d) As of May 2003, there is no industry standard that limits the amount of current flow between the battery return conductor and the equipment frame. When such current flow over grounding conductors does occur, it should not exceed the maximum current flow allowed for power conductors of the same size (reference ATT 790-100-656). In order to limit this current to the rated capacity of the grounding conductors, it may be necessary to increase the capacity of the grounding conductor, limit the deployment of offending equipment in a lineup or validate the integrity of the battery return path.

3.6.1.4

Every metallic frame, cabinet or other enclosure in an equipment area equipped with dc-powered equipment shall be bonded to the IS POP/VHO GRD system with a separate DCEG conductor. This does not include minor units mounted where they are not normally contacted by personnel (e.g., wall mounted clocks).

An enclosure containing only ac-powered equipment is considered effectively bonded to the IS POP/VHO GRD system via the ACEG conductor in the circuit serving the equipment provided the requirements of Section 2.7.3.4 have been met.

Where such an enclosure may eventually contain dc-powered equipment (e.g., a miscellaneous relay rack) or when it is so located that it may become energized during a fault from a dc source, a separate bonding conductor shall be provided.

3. 6.1.5

In order to provide an adequate fault current path to operate an upstream over current protective device, equipment units mounted in frames, cabinets or other enclosures shall be provided with one or more (or an equivalent) of the following:

- a) For an equipment unit fused at ≥ 30 amps shall be grounded per 3.6.1.6.
- b) For an equipment unit fused at < 30 amps:

For an equipment unit with plated mounting flanges, thread-turning, thread-forming or similar type mounting screws (*Taptite*) that provide adequate contact between the unit's chassis and the metalwork of the frame, cabinet or other enclosure.

For an equipment unit with painted mounting flanges, thread-turning, thread-forming or similar type mounting screws and at least one mounting screw on each side of the unit equipped with a Type "B" external tooth washer ("star washer").

3. 6.1.6

When the manufacturer of an equipment unit requires a grounding conductor between the unit and the IS POP/VHO GRD system, it shall be sized per Table 3-2 and it shall be connected to one (or more) of the following:

- a) A compression type parallel tap to a grounding conductor of equal or larger size within the rack/cabinet
- b) Two hole compression connector bolted to the internal ground bus or rack/cabinet upright.
- c) The same point of connection on the rack/cabinet's metalwork as the DCEG conductor if of equivalent or larger size
- d) A grounding terminal (wire-wrap, solder, etc.) within the rack or cabinet.
- e) A compression type parallel tap to a grounding conductor of equivalent or larger size outside the enclosure

3. 6.2 Insulation

3. 6.2.1

Insulating material shall be installed between metallic objects requiring isolation from incidental grounds and material securing or fastening it to a metallic object that is part of the grounded common bonding network.

3. 6.2.2

Insulating material shall have a minimum dielectric strength of 400 volts/mil and shall have sufficient mechanical strength to withstand physical forces likely to be applied during installation.

3. 6.2.3

Floor and wall anchoring material is often in contact with concrete and may touch structural metal. An insulator shall be used between anchor bolt heads (or stud nuts) and frame or cabinet metalwork requiring isolation from incidental grounds.

3. 6.2.4

Insulating material shall be placed between the floor and the bottom of all frames, cabinets or other metallic objects requiring isolation from incidental grounds. The material shall be of sufficient size and strength that isolation is maintained when the securing hardware is tightened.

3. 6.2.5

Any metal detail extended above the equipment requiring isolation from incidental grounds to support an object that is part of the common bonding network shall use insulation material to maintain separation.

3. 6.3 Special Note on Isolated Ground Type Receptacles

3. 6.3.1

This type of receptacle should only be used when expressly required by an equipment manufacturer or because of other system considerations as determined by the equipment system engineer. This type of receptacle shall not be used as a means to identify an ac power system's source or backup feature, such as "inverter power."

Most equipment manufacturers only require that an ac receptacle serving their equipment be of the grounded type, also referred to as a standard receptacle.

3. 6.3.2

From a noise mitigation standpoint, an isolated ground type receptacle is usually only effective when it is installed as part of a system-wide single point ground design that includes consideration of both the entire power system and all communication circuits between system components. By itself, this type of receptacle provides little protection against electrical transients.

3. 6.4 Main Aisle and Lineup Conductors

3. 6.4.1

A lineup conductor shall be provided for each side of an equipment aisle that contains, or will contain, equipment frames, cabinets or other enclosures.

When a new equipment aisle is established, lineup conductors should be installed along the entire length of the aisle to avoid future splicing of the lineup conductors.

3. 6.4.2 The minimum size for a Main Aisle conductor shall be #2/0 AWG. See Table 3-4.

3.6.4.3

The minimum size for a lineup conductor serving one or more frames, cabinets or other enclosures shall be #2 AWG. See Table 3-4

Length (feet)	Main Aisle Conductor (AWG or kcmil)	Lineup Conductor (AWG or kcmil)
<50	2/0	2
51-100	250	2/0
100-150	350	4/0
151-200	500	250
>200	750	350

**Table 3-4
Main Aisle and Lineup Conductor Sizing**

3. 6.4.4

When a #1/0 AWG DCEG conductor is furnished for a BDFB, this conductor may serve in place of the #2 AWG.

3. 6.5. Bonds to Ironwork and Other Metallic Objects

The following requirements are intended to ensure that a fault current path exists because of a fault from a dc power source.

3. 6.5.1

When an area contains dc-powered equipment in frames, cabinets or other enclosures that are not equipped with top support details that provide adequate mechanical interconnection with the overhead ironwork, a bonding conductor shall be provided between the ironwork and the IS POP/VHO GRD system. The most common example of adequate mechanical interconnection is the support detail that physically joins (via bolts, clamps, clips, support pipes, etc.) an equipment frame, cabinet or other enclosure to the overhead ironwork system of cable racks, framing channels, threaded rods, earthquake braces, etc.

In the case of an equipment lineup that uses bonds to an aisle conductor and also has pipe support with mechanical connections between pipe support and the equipment frames, the pipe support has a reliable fault current path through the frames and the associated multiple bonds to the aisle conductor and does not need separate bonds.

For the purposes of this section, a metallic ac conduit or raceway does not constitute adequate mechanical interconnection.

3. 6.5.2

The area being evaluated for a supplemental bond shall be considered exempt from these requirements if the ironwork over the area is contiguous with ironwork over an area that does contain adequate mechanical interconnection. A common example of this is ironwork located above both an older, top-supported 11' 6" environment and a new, freestanding 7' environment.

3. 6.5.3

When a supplemental bond is required, it shall be made using a conductor connected between a point on the overhead ironwork (framing channel, cable rack stringer, etc.) and the nearest point on the IS POP/VHO GRD system of equal or larger size.

3. 6.5.4

The bonding conductor shall be sized per the following criteria:

a) If a BDFB or other dc power distribution bay is located within the area in question, the bonding conductor shall be a minimum #1/0 AWG.

(b) If criteria (a) is not applicable, the bonding conductor shall be a #6 AWG.

3. 6.5.5

When an ungrounded, floor-mounted metallic object of significant mass, such as a wire security partition system, is located in an area containing dc-powered equipment but is not bonded to the IS POP/VHO GRD system or mechanically joined to the overhead ironwork, the object shall be bonded to the closest of either the IS POP/VHO GRD system or the overhead ironwork system with a minimum #6 AWG conductor. Multiple objects such as wire security partitions are considered a single object if they are adequately joined using bolts, rivets or other metallic junction details.

3. 6.6 Other Systems

The preceding descriptions of IS POP/VHO GRD requirements cover the majority of configurations used in power, transport and miscellaneous equipment systems. Other systems and equipment units not mentioned may also require connection to the IS POP/VHO GRD system. This may be accomplished by comparing the physical arrangements to that of the systems described above, and devising comparable arrangements.

3. 6.7 Bay Ground Lead

3. 6.7.1

A bay ground lead is one method to extend IS POP/VHO GRD into frames, cabinets and other enclosures. It provides a means to terminate grounding conductors, primarily from cable shields. An approved bay ground lead may be a or stranded conductor, bus bar, or other conductive path specifically designed as a grounding conductor.

3. 6.7.2

When a bay ground lead system depends on a portion of the equipment enclosure's metalwork for a path to IS POP/VHO GRD, it may do so only if the enclosure is equipped with a minimum #6 AWG DCEG conductor.

3. 6.7.3

The bay ground lead shall not be used to conduct load (battery return) current.

3. 6.7.4

Bay ground lead components may be ordered per PBSB-ED-6501. Depending on the group ordered, they permit termination of #26 through #6 AWG conductors by means such as crimp connectors, wire wrapping, or wrapping and soldering.

3. 6.7.5

A bay ground lead should be provided for equipment that requires (but does not provide) a means to terminate bonds from cable shields.

3.6.8 Conduits, Armored Cable, Shielded Wire for Other Than AC Service

3.6.8.1

The grounding of raceways is covered in Section 2 of this TP. Application of inductive shielding of other Communication conductors is covered below.

3.6.8.2

Rigid conduit or other metallic raceway used solely for support or protection against mechanical damage to communication conductors (i.e., extension from cable rack to a unit) need not be grounded when at least one point of the run is fastened to metal objects such as equipment frames, cable rack, or framing channels that have continuity to ground.

3.6.8.3

Rigid or flexible metallic conduit or armored cable, when used to reduce the transference of inductive energy shall be bonded to the IS POP/VHO GRD system at least at both ends. Bonds shall be provided across any intermediate points of shield discontinuity unless system specifications provide other bonding instructions.

3.6.8.4

When cables or conductors are equipped with a metallic shield used to reduce the transference of inductive energy, the metallic shield shall be bonded to the IS POP/VHO GRD system at least at one end.

3.6.8.5

Rigid or flexible conduit, armored cable, or other metallic raceway used for inductive shielding is considered adequately bonded when terminated at both ends with fittings approved for ac equipment grounding (ACEG). When such raceway is not so terminated, it shall be bonded from the point of discontinuity to a suitable ground bus, frame, or other point of assured continuity with the IS POP/VHO GRD system. The bond shall be a minimum #6 AWG conductor, except where the shielding raceway is small (1" conduit or less) and not subject to possible physical damage. In such cases, it may be reduced to a reasonable size, but not less than #14 AWG. Several shielding raceways may be bonded together and grounded with a single conductor.

3.6.9 Peripheral Equipment

3.6.9.1

Computer terminals, printers, and other peripheral units of less than cabinet size shall be grounded and powered per vendor specifications, as long as a fault current path is provided to the source of power for the peripheral. Where possible, it is a good practice to use the same ac circuit to power both the CPU and peripheral equipment.

3.6.9.2

If required, metallic isolation between Internet Services equipment may be accomplished using current loop, back-to-back modems, or fiber optic communication links.

3.7 DISTRIBUTING AND PROTECTOR FRAMES

1) Conventional type distributing frames containing protectors shall be equipped with one or more bus bars having a cross-sectional area no less than that equivalent to a #1/0 AWG conductor (105.6 kcmil or .083 in.²). The bus bar(s) shall be spliced as required to extend to every vertical equipped with protectors. The most common size bus bar in use is 1/2" x 1/4" (.125 in.²).

2) Bus bars shall be mounted directly to the metalwork of the protector frame, with no insulators placed between the bus bar and the mounting surface.

3) All modular distributing frames equipped with protectors shall have a minimum #1/0 AWG conductor routed along the top and/or bottom of the module lineup, and each module shall be bonded to the IS POP/VHO GRD system as follows:

4) If the module consists of or is equipped with only one vertical of protectors, a minimum #6 AWG conductor shall be tapped, using a compression type parallel connector, to the #1/0

AWG lineup conductor and connected to the module with a two hole compression type connector.

5) If the module has more than one vertical of protector units, a minimum #1/0 AWG shall be tapped, using a compression type connector, to the #1/0 AWG lineup conductor and connected to the module with a two hole compression type connector. A copper bus bar may be used in place of the #1/0 AWG lineup conductor if it has a cross sectional area at least that of a #1/0 AWG conductor.

6) A minimum #1/0 AWG conductor shall be extended from a frame ground bus bar, be tapped to or be a continuation of a #1/0 AWG protector frame lineup conductor. This conductor shall terminate at the OPGP, or if on a floor other than that containing the OPGP, to a IS POP/VHO GRD bus bar. The length of this conductor shall be as short as practicable.

7) A distributing frame equipped with a bus bar connected to the IS POP/VHO GRD system requires no additional grounding unless a bond to the MGB is specified by the equipment vendor. When a grounded bus bar is not provided, the frame shall be bonded to the IS POP/VHO GRD system with at least one minimum #6 AWG conductor.

8) When all or part of a distributing frame not having a ground bus bar exceeds 25 feet in length, additional bonds to the IS POP/VHO GRD system should be made at 25-foot intervals. The bonds may be connected to the ground conductor serving a nearby protector frame, or may be terminated at any extension of the IS POP/VHO GRD system within the common bonding network. Multiple bonds may be branched from a single minimum #2 AWG conductor extended from a point on the IS POP/VHO GRD system.

3.8 CABLE ENTRANCE FACILITY (CEF)

1) The metallic shield of a cable entering a structure shall be bonded to the structure's ground system. In central office cable vaults, this bond is usually made at the point designated as the protection bay.

2) The Main conductor serving a CEF shall be #1/0 AWG minimum. Branch conductors between the Main conductor and cable shields are typically a minimum #6 AWG conductor or a conductor of equivalent cross-sectional area.

3) The far end of the #1/0 AWG Main conductor shall terminate on the nearest of either an OPGP bus bar, a IS POP/VHO GRD bus bar or a protector frame ground bus bar.

4) A second #1/0 AWG conductor, bonded to the #1/0 AWG Main conductor, is needed to satisfy requirements for Interbonding in Section 2.4 2. This conductor, terminated at the ACEG bus, shall be supplied for all new structures, and added to existing structures during additions or upgrades to the building ground system.

5) The metallic shield of cables entering a structure shall be bonded to CEF bus and the metalwork of the protector or distributing frame at which the cable conductors terminate.

6) Each lineup of cable rack in the cable vault shall be equipped with a bus bar (CEF bus bar). The bus bar will normally be mounted on the conductive cable support structure in a manner that provides approximately 2 inches of clearance to the underside of the bus bar. This spacing can be accomplished with conductive mounting hardware or with bus bar insulators.

If insulators are used, the bus bar must also be bonded to the cable support structure with a #6 AWG wire. If the CEF bus bar is wall-mounted to a non-conductive surface, no bond is required from the bus bar to the wall.

7) If metallic raceway is used to route a cable from a CEF to another location, the raceway shall be bonded to IS POP/VHO GRD at both ends. At the CEF end, the bond from the raceway should terminate on the #1/0 AWG serving the CEF or to an extension of this conductor. The other end should be bonded to the nearest appearance of IS POP/VHO GRD in the common bonding network.

3.9 CABLE REARRANGEMENT FACILITY

1) The grounding requirements for Cable Rearrangement Facility (CRF) cabinets are similar to the requirements in Section 3.7. The requirements apply to all CRF cabinet installations, including those in CEVs, huts and Central Offices.

2) Where no more than a single CRF cabinet will be installed, a minimum #6 AWG conductor is required between the cabinet and the structure's principal ground point.

3) Where multiple CRF cabinets are (or will be) installed, a minimum #1/0 AWG conductor shall be provided from the structure's principal ground point to the area above or below the CRF cabinets. If the CRF cabinets are located on a floor above or below the floor containing the principal ground point, the #1/0 AWG conductor may terminate on the floor ground bar if a direct route to the principal ground point is not available.

4) In a Central Office or other structure that also contains a protector frame, it is permitted to terminate the #1/0 AWG conductor at the protector frame if it is in the cable path between the CRF cabinet area and the OPGP. If the protector frame is used, the #1/0 AWG from the CRF cabinet area can terminate on the bus bar usually located at the top and/or bottom of the frame, typically at Vertical 1. The #1/0 AWG conductor from the CRF area may also be tapped to the #1/0 AWG conductor routed between the protector frame and the principal ground point.

5) When multiple CRF cabinets are installed, a separate minimum #6 AWG conductor is required between each cabinet and the #1/0 AWG conductor. The design of the CRF cabinet will determine the point(s) available to terminate the #6 AWG. Some CRF cabinets will have a ground bus bar at the top of the cabinet and an auxiliary ground bar located midway down the front of the cabinet. Others will only have the ground bar at the top of the cabinet. Either location is acceptable.

6) When interbonding is applied to a structure, a minimum #1/0 AWG conductor shall be connected between the main house service panel and a point on the #1/0 AWG conductor serving the CRF area.

3.10 FIBER OPTIC CABLE TERMINATION EQUIPMENT

1) The metallic shield and, if present, metallic strength member of all fiber optic cables shall be bonded at the CEF per 3.7 above. If the cable entering the CEF is spliced to a cable with no metallic members, no additional grounding of the cable is required at the fiber optic terminating equipment. If a fiber optic cable with any metallic member is extended to the fiber optic terminating equipment, supplemental bonds to the IS POP/VHO GRD system shall be installed as described in Section 3.9.2) thru 3.9.5) and as shown in Figure 3-3.

2) A minimum #1/0 AWG insulated conductor shall be routed along the lineup(s) containing fiber optic cable terminating equipment. The conductor may be routed, spliced, or tapped to serve more than one lineup. It shall originate at the nearest of either:

- a) An OPGP bus bar
- b) A IS POP/VHO GRD bus bar

c) A protector frame ground bus bar

d) A point on the #1/0 conductor connected between a protector frame and an OPGP or IS POP/VHO GRD bus bar

3) A #6 AWG insulated stranded copper conductor shall be tapped to the #1/0 AWG conductor and extended down the rear of the frame containing fiber optic terminating equipment. This conductor may be placed on either side (or both sides) of the rear of the frame and should extend to a point approximately 18" up from the floor. This conductor shall be routed near and tapped to the #6 AWG DCEG conductor using a compression type connector.

4) All fiber optic cable metallic shields and metallic strength members shall be bonded to the vertical #6 AWG conductor using a #6 AWG bond.

5) As an alternative, the vertical #6 AWG conductor bonded to the #1/0 conductor may terminate on a bus bar mounted in the frame. Bonds from metallic cable shields and strength members may terminate on this bus bar.

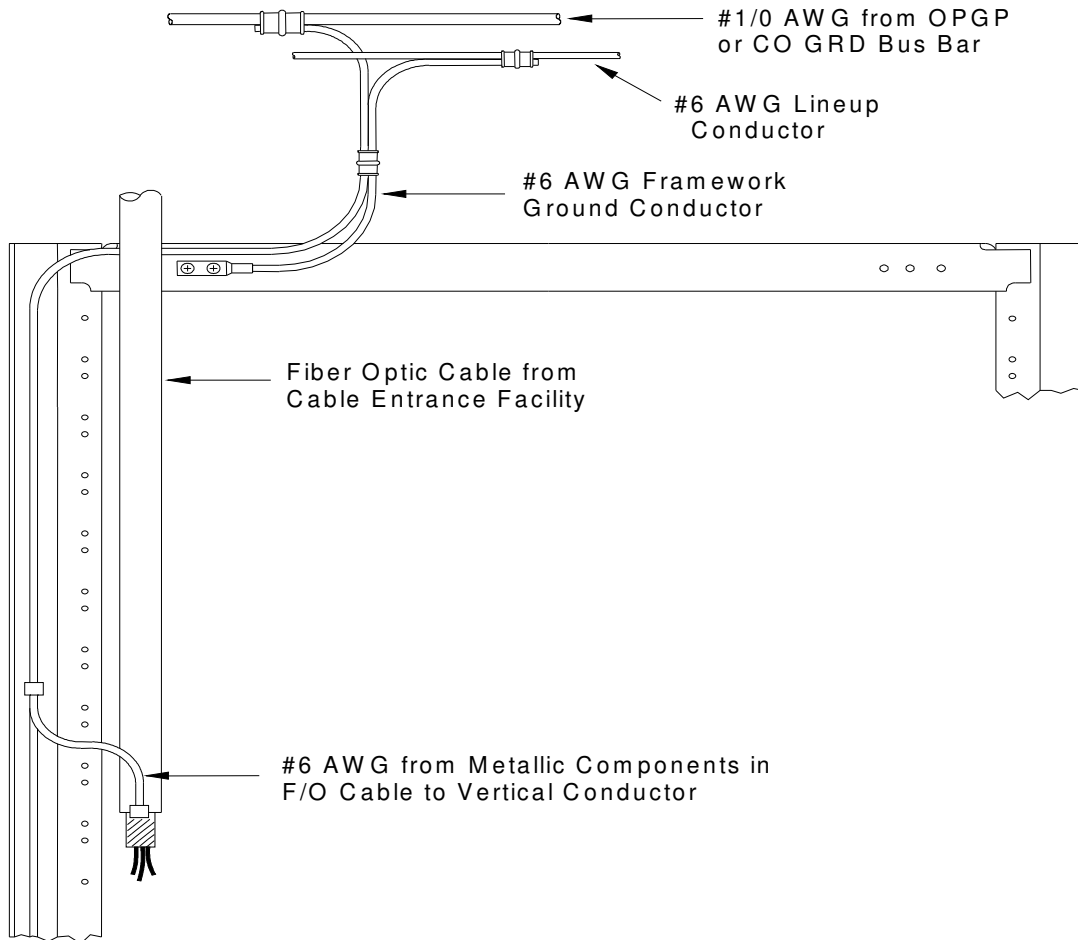


Figure 3-3
Bonding of Metallic Components in Fiber Optic Cable

SECTION 4

Raised Floor Environments for Internet Services

4.1 RAISED FLOOR APPLICATIONS

4.1.1 General

All components of a raised floor system are considered part of the common bonding network. When required by equipment vendor specifications, insulation as described in Section 4.7 6., shall be installed between the surface of raised floor tiles and equipment enclosures.

4.1.2 Design

The preferred design for a raised floor support system uses metal struts between adjacent support pedestals. The raised floor support system in a Internet Services environment shall be equipped with a ground system that consists of:

- a) Bare copper main conductors, sized at #4 AWG minimum
- b) A main conductor routed around the perimeter of the raised floor area
- c) Main conductors bonded to pedestals and formed into a grid system consisting of squares with sides no longer than 20 feet and H tapped to the perimeter conductor at each end. Covers are not required for H-Taps on bare conductors used below the floor.
- d) Intersecting main conductors shall be bonded with a #6AWG bonding conductor.
- e) The grid system shall be bonded to an IS POP/VHO GRD or OPGP bus bar with a #2/0 AWG conductor. The conductor shall be connected to the approximate center of the grid
- f) A minimum #6 AWG bond from the grid system to metal conduits entering the grid area if no IS POP/VHO GRD, OPGP bus bar or MGB is available

4.1.3 Incidental Contact

There is no restriction on contact between the grid assembly and conduits, ducts, pipes, and other conductive materials installed under the floor, or extended through the floor, that are part of the common bonding network.

4.1.4 Connections

All connections shall use compression connectors and H-taps, or grounding clamps listed for the application to connect to the pedestal upright.

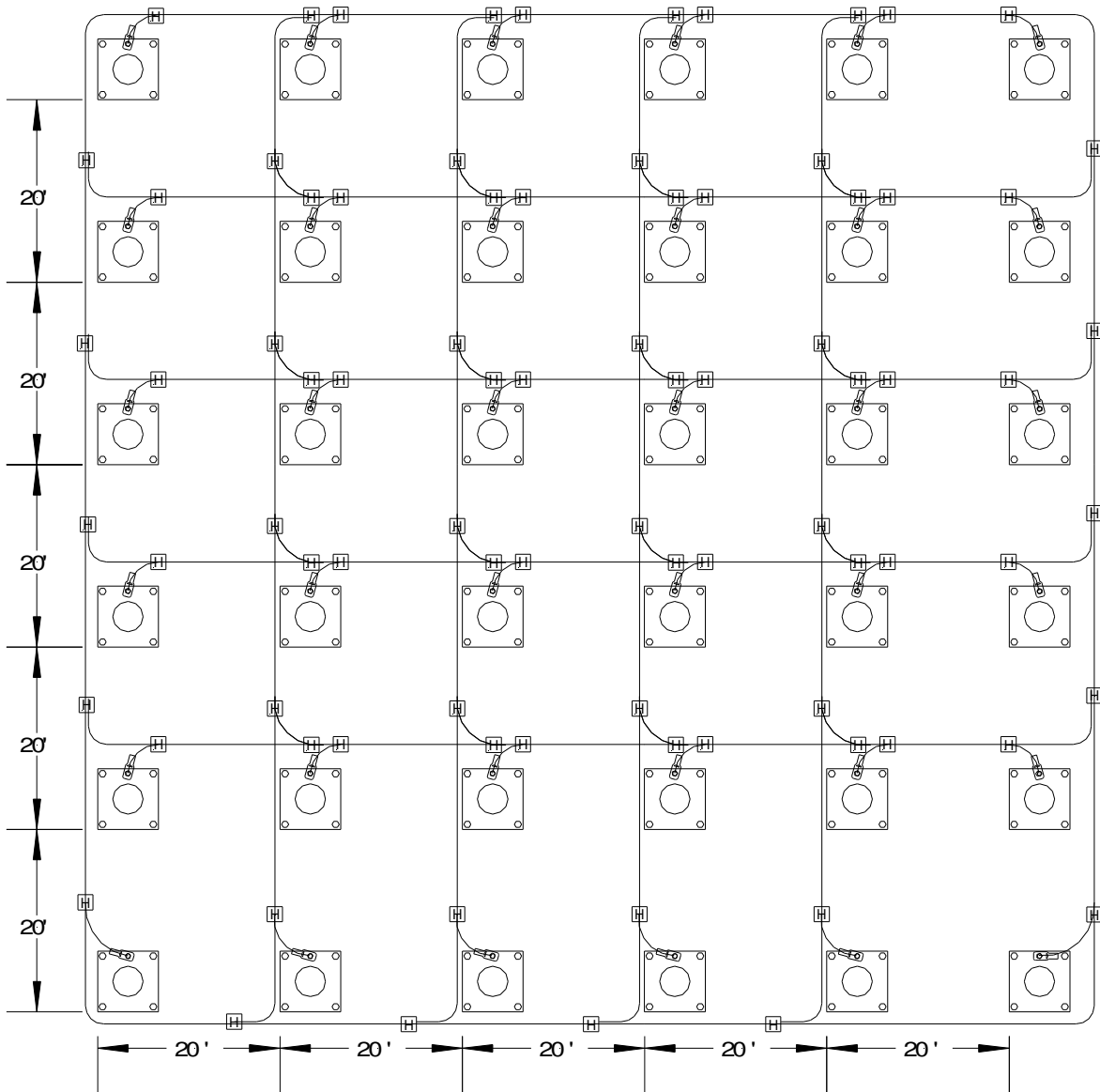


Figure 4-1
Raised Floor Grounding

SECTION 5

Commercial/Leased Locations

5.1 SCOPE

This section provides grounding requirements for a variety of structures and equipment types that are often located in a structure other than a central office. This section also describes earth electrode system requirements that, while based on the same protection principles, differ in detail from those typically used at a central office.

5.2 COMMERCIAL/LEASED LOCATION EQUIPMENT

5.2.1 General

5.2.1.1

The grounding requirements in Section 5.2 apply to Internet Services located on Commercial/Leased Location. The term "network equipment" applies to any piece of ac or dc powered Company-provided equipment that is located between the primary over-voltage protectors and equipment owned by the customer. For information on grounding and bonding of primary over-voltage protectors, refer to 876-300-100.

5.2.1.2 The Company usually does not design or control systems in Commercial/Leased structures to which connections must be made, such as power and earth electrode systems. When network equipment is installed at these sites, adjustments may be needed to some of the grounding requirements that would normally be applied to the same equipment if located in a Company-owned structure. A CRE representative should confer with the property manager to obtain the most preferred arrangement as described below and in associated documents.

5.2.1.3

Except as modified by the contents of Section 5.2, the engineering, material and installation requirements in all other sections of this Practice should be applied to network equipment at Commercial/Leased Property. Grounding specifications from the equipment vendor should also be reviewed.

5.2.1.4

The grounding systems shown in Figures 5-1 and 5-2 are examples of the maximum and minimum arrangements likely to be the responsibility of the Company when Internet Services equipment is placed at a Commercial/Leased site.

5.2.1.5

Several items will affect the design of the grounding system that must be furnished with the Internet Services, regardless of the amount of equipment provided. The following are addressed in Section 5.5 and should be evaluated early in the provisioning process:

- a) Appearance of site's earth electrode system in Internet Services equipment room
- b) Presence of equipment grounding system in Internet Services equipment room
- c) Location of cable entrance(s)
- d) Type(s) of power required by net Internet Services work equipment
- e) Type(s) of power provided by customer
- f) Equipment and framework/cabinet grounding

As used in Section 5.2, "equipment grounding system", "Internet Services Ground" and "IS POP/VHO GRD" should be considered equivalent terms.

5.2.2 Access to a Site's Earth Electrode System

5.2.2.1

A metallic path to the site's earth electrode system must be available in the area where the network equipment is located.

Using either a direct connection to Internet Services equipment or a connection to the equipment grounding system, a bond must be made, in order of preference, to one or more of the following:

- a) A dedicated grounding conductor extended from the site's earth electrode system (see Figure 5-1) - this conductor may or may not be terminated at a bus bar; either arrangement is acceptable.
- b) Building structural steel, provided it is bonded to the site's earth electrode system
- c) A continuous metallic water pipe, provided it is accessible along its entire length to the point where it is bonded to the site's earth electrode system

Any conduit bonding hardware (bushings, clamps, etc.) must be listed for the purpose.

5.2.3 Property Owner Furnished Equipment Grounding System

Installation of Internet Services equipment may be planned for an area served by a property owner -furnished equipment grounding system. This system may also serve Internet Services equipment if the following two conditions are met:

- (1) The grounding system must be connected to the site's earth electrode system by at least one of the methods describe above.
- (2) The minimum size for the conductor serving frames, cabinets or other enclosures containing network equipment is #6 AWG. Refer to table 3-1.

A property owner may have equipment grounding system requirements that specify conductors larger than the minimum sizes specified in Section 5.2.

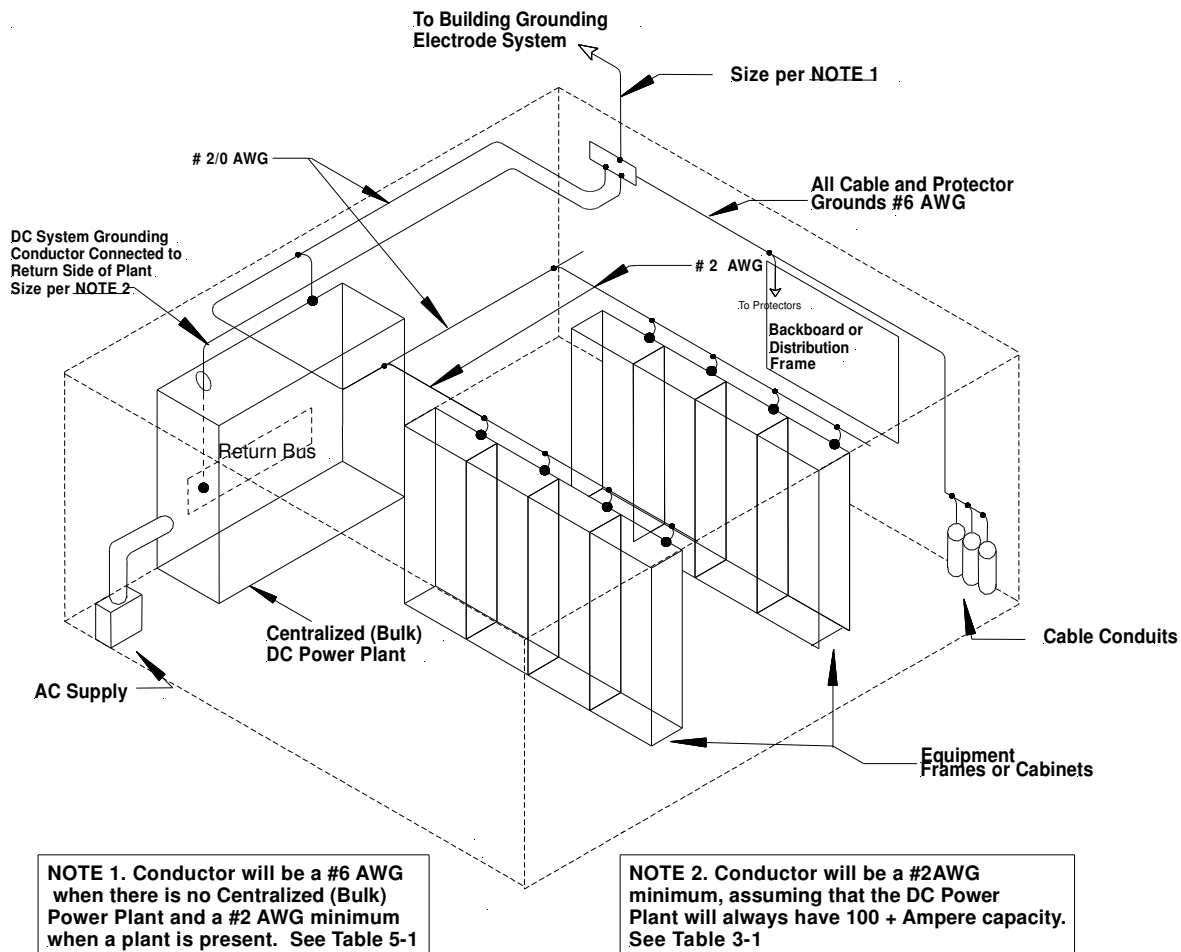


Figure 5-1
Typical Grounding Arrangement for Commercial Leased Property Internet Services Room

5.2.4 Cable Entrance

The cable entrance(s) may or may not be located in the same area as the Internet Services equipment. This document does not cover cable entrance grounding and bonding. Refer to 876-300-100.

Figure 5-1 shows a single conductor from the site's earth electrode system serving the cable entrance and the equipment area.

5.2.5 DC Power Systems Provided with Network Equipment

5.2.5.1

If a centralized dc power source is provided with Company-owned Internet Services equipment, it shall have the return side of the dc system grounded to the site's earth electrode system. The return conductor shall be independent of any equipment grounding conductor and shall be sized per Table 3-1. The conductor shall be a minimum of #6 AWG (See Figure 5-1). Also, its framework must be bonded to the equipment grounding system serving frames, cabinets or other enclosures containing network equipment served by the power source.

5.2.5.2

If an embedded dc power source is provided with Company-owned Internet Services equipment, it shall have the return side of the dc system grounded within the equipment it serves. Figure 5-6 shows an embedded dc system grounding conductor bonded to the bay ground lead, which, via the framework ground conductor, is connected to an appearance of the site's earth electrode system.

5.2.5.3

For dc power systems with a rated capacity of no more than 100 amperes, a minimum #6 AWG conductor must be used for the dc system grounding conductor. For dc systems with a capacity larger than 100 amperes the default size for the system grounding conductor shall be 750 kcmil. Using Table 5-1, a smaller conductor may be allowed. Its minimum size shall be based on the maximum plant capacity specified by the manufacturer.

5.2.5.4

If a battery plant has been assembled from discrete components (batteries, rectifiers, fuse panels, etc.) and has no maximum capacity value, the system grounding conductor shall be based on the combined output rating of all installed rectifiers.

Power Plant Capacity (Amperes)	Minimum Size of System Grounding Conductor
Up to 100	6 AWG
101 – 500	2 AWG
501 – 1199	4/0 AWG
1200 +	750 kcmil

**Table 5-1
Battery Plant System Grounding Conductor Sizing**

5.2.5.5

The point of connection within the dc power system for the system grounding conductor will depend on the type of components used. If a bus bar is used to terminate battery return conductors from the batteries, rectifiers and fuse panels (or directly from the equipment), it is the most preferred point. If a bus bar is not used, the next preferred point is the battery return terminal on the output of the rectifier.

5.2.6 Power System(s) Provided by Customer

5.2.6.1

All ac receptacles serving network equipment must be of the grounding type. While verification is beyond the scope of this document, that portion of a customer's ac power system serving network equipment should be equipped with an ac equipment ground (ACEG) system in compliance with Article 250 of the latest edition of the NFPA 70, *The National Electrical Code*.

5.2.6.2

In the event that an ac branch circuit is to be hard wired (not cord-connected) to network equipment, the serving conduit or raceway must be equipped with a separate ACEG conductor routed with the other circuit conductors. The metallic raceway alone may not be used as the ACEG. See Section 2 of this Practice.

5.2.7 Grounding and Bonding within Frames, Cabinets & Enclosures

5.2.7.1

Internet Services frames and cabinets may be equipped with a vertical ground bar. The ground bar shall be insulated from the frame or cabinet. The ground bar will be connected to the ground system by one of the following methods:

- A. A #6 AWG conductor connected to the ground bar and to the underneath side of the connection between the aisle ground conductor and the framework with two hole compression connectors.
- B. A #6 AWG conductor connected to the ground bar with a two hole compression connector and to the frame or line-up grounding conductor with a compression H tap.
- C. A #6 AWG conductor connected to the ground bar and to new holes drilled in the framework with two hole compression connectors.

5.2.7.2

The vertical ground bar shall not be used to conduct normal load (battery return) current.

5.2.7.3

Internet Services equipment (units, shelves, etc.) requiring connection(s) to the equipment grounding system may be connected to the vertical ground bar.

Figure 5-3 is a typical Internet Services Cabinet equipped with a vertical ground bar.

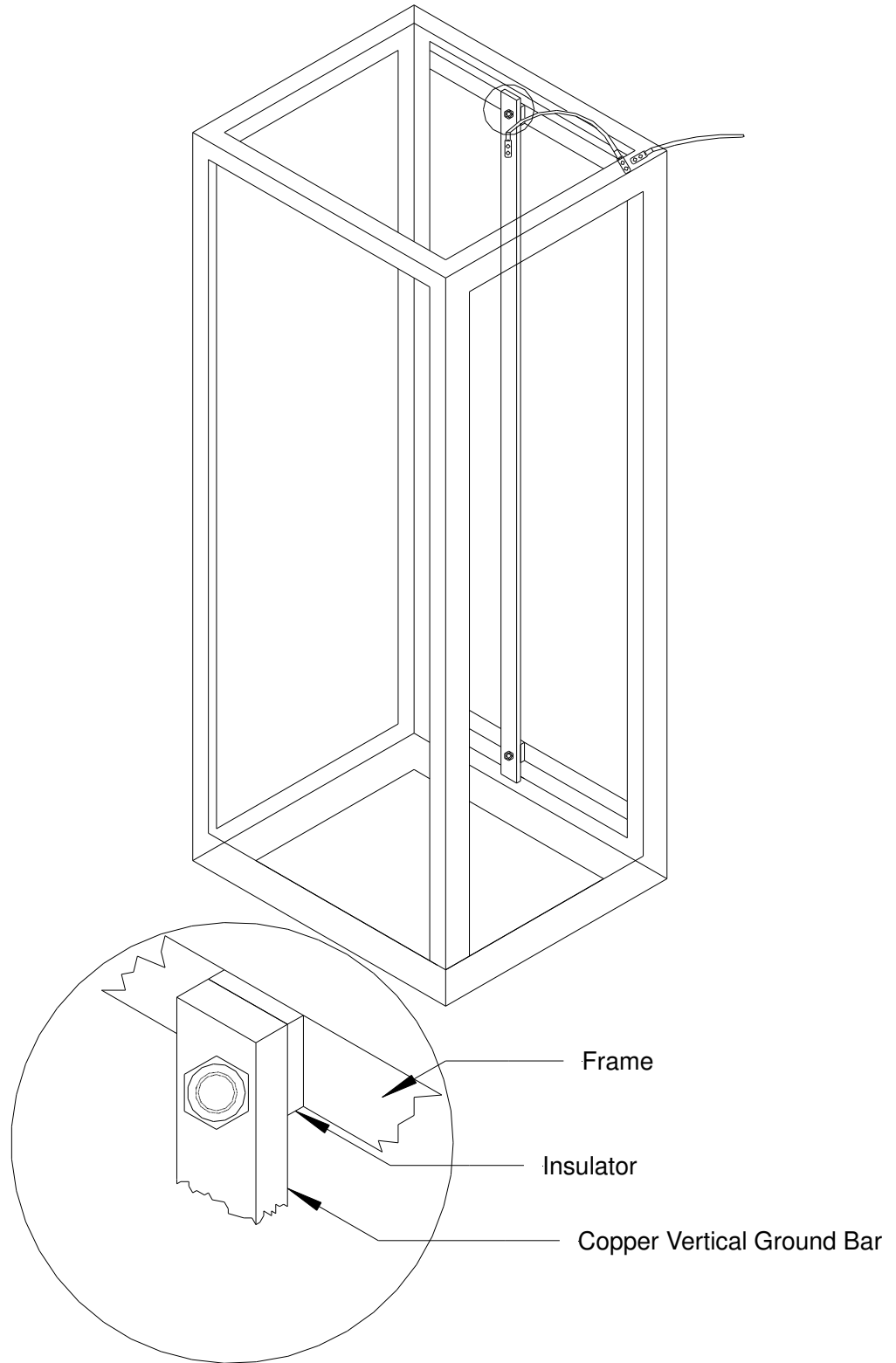


Figure 5-3
Internet Services Equipment Frame/Cabinet Grounding Details

SECTION 6

Video Sites and Equipment

6.1 SCOPE

This section provides grounding and bonding requirements for Video equipment, structures and rooms containing Video equipment, antennas, antenna towers, other antenna support arrangements, and transmission media between antennas and Video equipment. The requirements are applicable to systems used for network service, maintenance, receive only, and systems located on Commercial Leased Property.

The grounding and bonding system is a fundamental part of the protection scheme for a Video site and Video equipment. However, other elements, not covered in this Practice, must be considered including:

- a) Electrical protection of the ac service
- b) Electrical protection of all other copper and fiber optic cables (with metallic components) entering the structure by either aerial or underground means

6.2 GENERAL

The intent of a grounding and bonding system for a Video site and its equipment is to establish low impedance paths to earth and low impedance bonds between nearby metallic objects. This reduces the voltage differential between objects and the earth, and between nearby objects within a structure during a lightning strike.

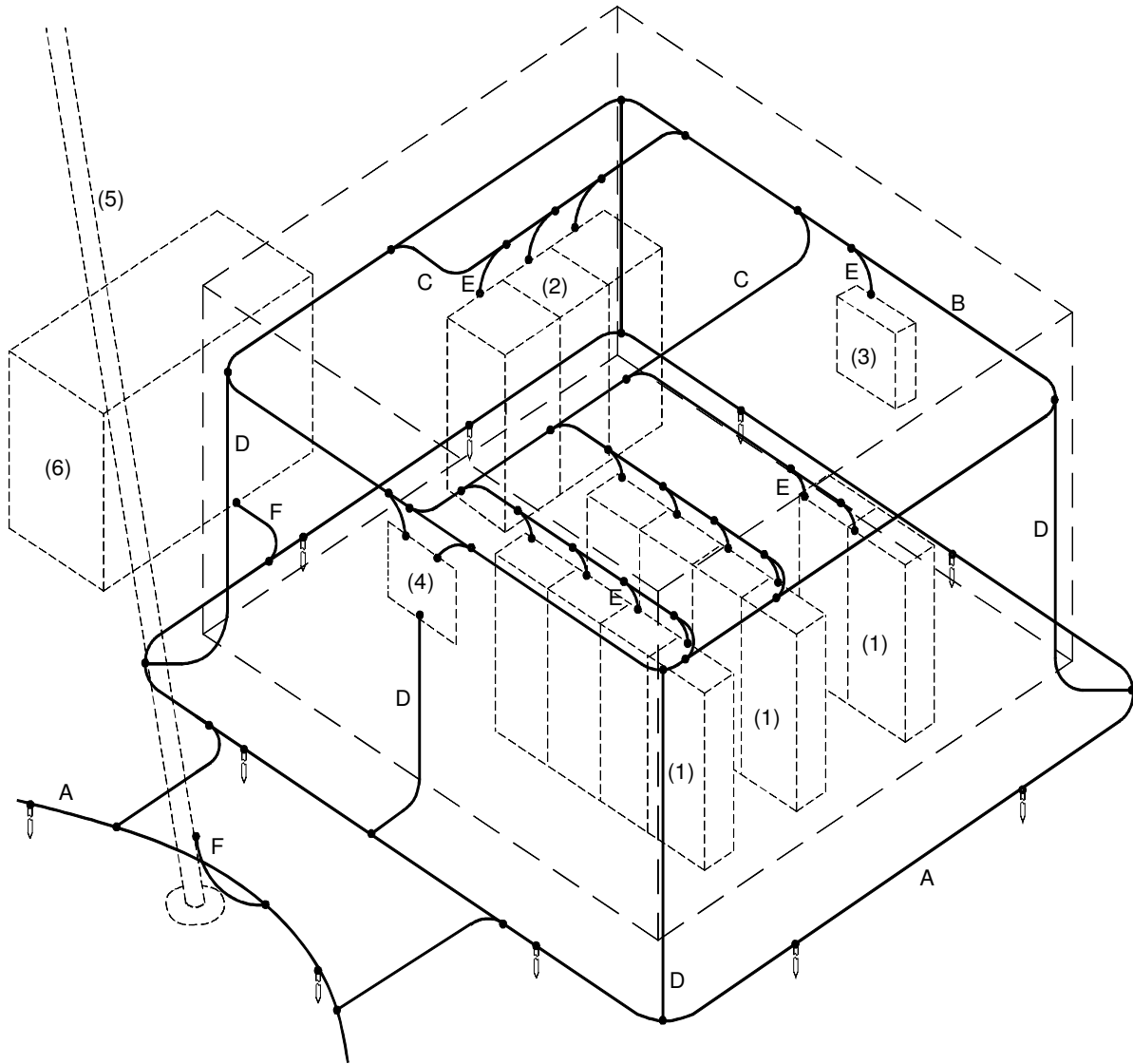
During a strike, extreme voltage differential may develop between points on a conductor. Inductive reactance is the major component of the impedance of a lightning current path. An increase in the size of a conductor will reduce its dc resistance but will not significantly reduce the voltage differential between points along this path. Reducing a path's dc resistance by using conductors larger than #2 AWG results in little reduction in impedance. A #2 AWG conductor will carry substantial current without thermal damage, and it is resistant to mechanical damage.

Voltage differential can be minimized by ensuring that the path is of lowest practical impedance and/or by providing parallel paths of minimum impedance. A straight conductor of shortest possible length is the path of lowest impedance.

Every type of transmission media between an antenna tower and a structure housing Video equipment consists of one or more conductive paths that can carry current during a lightning strike to the tower. The designs described in this Practice are intended to conduct lightning current on conductors external to the building and, to the greatest extent possible, dissipate the current into the earth before it enters the Video equipment structure.

Figure 6-1 depicts a typical Video site grounding and bonding system and consists of:

- a) An exterior ring ground system
- b) A peripheral conductor
- c) Supplementary conductors
- d) Interior-exterior ring ground bonds
- e) Interior unit bonds
- f) Exterior unit bonds



- | | |
|-----------------------------|-----------------------------------|
| A - Exterior Ring Ground | (1) - Equipment Lineup |
| B - Peripheral Conductor | (2) - Power Plant |
| C - Supplementary Conductor | (3) - Miscellaneous Unit |
| D - Interior-Exterior Bond | (4) - Waveguide Hatchplate |
| E - Interior Unit Bond | (5) - Antenna Tower Leg |
| F - Exterior Unit Bond | (6) - Engine-Alternator Enclosure |
| ⌚ - Ground Rod | |

Figure 6-1
Typical Video Site Grounding System

6.3 EXTERIOR RING GROUND SYSTEM

6.3.1 Earth Electrode System

6.3.1.1

The exterior ring ground conductor is the main element of the earth electrode system. It shall be a minimum #2 AWG bare solid copper conductor. Earth electrode material and installation requirements not specified in this section shall be installed as described in Section 2.2.3

6.3.1.2

The earth electrode system shall form a ring around the building and the tower, and where possible, consist of a driven ground rod system. Wherever possible, a single ring should be used to enclose both the tower and the building. When site conditions prevent the use of driven rod system, another ring type earth electrode system, or a combination of systems described in Section 2 shall be provided.

6.3.1.3

The earth electrode system shall be installed around an antenna tower's legs and/or guy anchors. Each guy anchor and tower leg shall have a driven ground rod that is bonded to the tower ring ground system and the guy anchor and/or tower leg.

6.3.1.4

Where separate ring ground systems have been provided for the tower and the building, at least two bonds shall be made between the tower ring ground system and the building ring ground system using minimum #2 AWG solid copper conductors. The bonds should be as short as possible, and should originate at two corners of the tower ring system.

6.3.2 Roof Ring Ground System

6.3.2.1

When an antenna tower is mounted on the roof of a structure, a roof ring ground system is required. The roof ring ground system shall be formed around the tower's legs similar to a buried tower ring ground system. Bonds shall be extended to tower legs and other metallic objects on the roof.

6.3.2.2

On buildings not exceeding 75 feet in height that are reinforced concrete or other type of construction, where continuity to earth through building steel is not assured, a minimum of two #2 AWG down conductors shall be extended from the roof ring ground system to the exterior ring ground system. A down conductor is required for each 100 feet of building perimeter or fraction thereof. For example, a building with a perimeter of 420 feet would require at least 5 down conductors. On buildings more than 75 in height, down conductors shall be minimum #2/0 AWG. These requirements are taken from the National Fire Protection Association Standard 780, Installation of lightning Protection Systems.

6.3.2.3

On steel frame buildings, regardless of height, building steel may serve in place of separate down conductors. At least two bonds shall be made between the roof ring ground system and building steel from opposing points on the ring. Additional bonds to building steel shall be made at an interval not exceeding that for down conductors in 6.3.2.2 above.

6.3.2.4

When structural steel serves as down conductors between a roof ring ground system and an exterior ring ground system, bonds between building steel and the exterior ring ground system shall be made at every other steel column along the building's perimeter.

6.3.2.5

When structural steel is used in place of down conductors, a bond must exist between the OPGP and a structural steel member.

The bond may be in the form of the OPGP bus bar's mounting studs, a minimum #2 AWG conductor between the OPGP and structural steel, or a connection between a driven ground rod system that is bonded to the OPGP and a structural steel member.

6.3.2.6 If any guy wires are anchored to the roof or other part of a structure, a #2 AWG down conductor shall be installed between each guy anchor on the structure and the exterior ring ground system.

6.3.2.7

All roof-mounted hatchplates (equipped and unequipped) shall be connected to the roof ring ground system with a minimum #2 AWG conductor.

6.3.3 Interior-Exterior Bonds

6.3.3.1

Primary and secondary bonds shall be placed between the interior and exterior ring ground systems. Primary bonds originate on hatchplates; secondary bonds originate at other points along the peripheral conductor.

6.3.3.2

Structures that do not require a roof ring ground system shall have roof mounted hatchplates bonded to the exterior ring ground system with a minimum #2 AWG primary bond. The bond shall be connected to the hatchplate on the interior side, routed past and bonded to the peripheral conductor, and then extended to the exterior ring ground conductor in PVC conduit.

The bonds between hatchplates and a roof ring ground system are considered primary bonds since the roof ring ground system is bonded to the external ring ground system.

6.3.3.3

Wall mounted hatchplates shall be bonded to the exterior ring ground system using a minimum #2 AWG conductor. The bond shall be connected to the hatchplate on either the exterior or interior side. If connected to the interior side of the hatchplate, it shall be extended to the exterior ring ground conductor in PVC conduit.

6.3.3.4

When the Video equipment is in a central office building, a minimum #2 AWG primary bond shall be installed between hatchplates and a Video Entrance Ground Bar

6.3.3.5

Minimum #2 AWG secondary interior-exterior bonds shall be installed between the peripheral conductor and the exterior ring ground system in at least four locations. At minimum, these bonds shall be placed at the corners of the structure. Additional bonds shall be added when the distance between secondary bonds or between primary and secondary bonds exceeds 50 feet. These additional bonds shall be evenly spaced between other bonds.

6.3.4 Bonds to Antenna Towers

6.3.4.1

A bond is required between the tower metalwork and the transmission media (coaxial cable, etc.) at the point where the media turns toward the structure. The media should make this turn as near as practicable to the tower base. See Figure 6-2.

6.3.4.2

Bonds between a tower and rigid coaxial cable may be made via the coaxial cable's mounting hardware. If the mounting hardware does not provide continuity, a minimum #6 AWG bonding conductor is required.

6.3.4.3

The outer shield of coaxial cable must be bonded to the tower structure. A convenient method for this bond is by the use of a "grounding kit" which includes a #6 AWG bonding conductor. An example is shown in Figure 6-2.

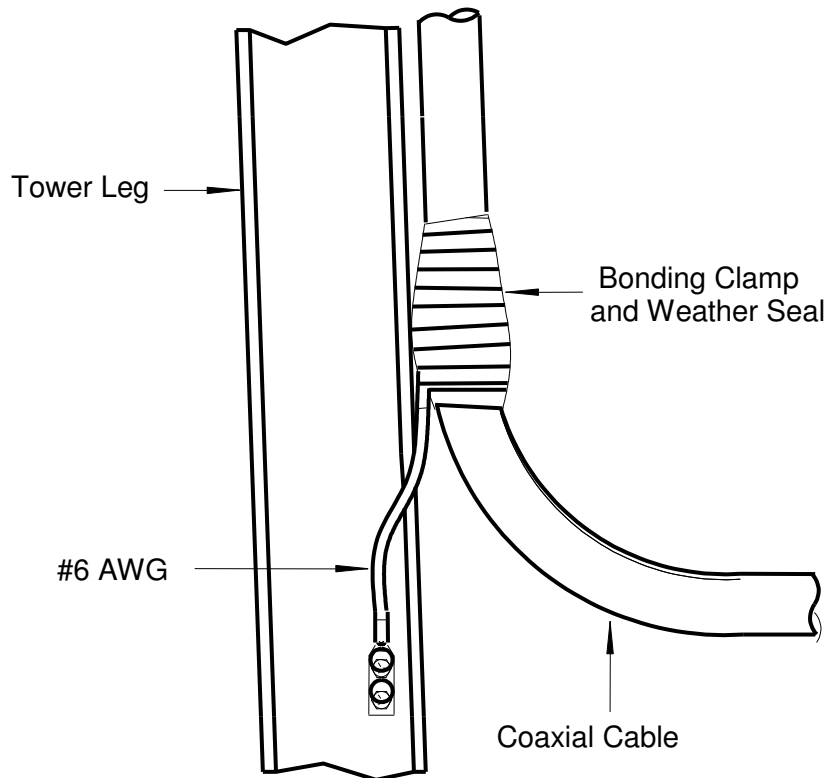


Figure 6-2
Bond to Tower Leg

6.4 INTERIOR RING GROUND SYSTEM

The interior ring ground system consists of:

- a) A #2 AWG peripheral conductor along the boundary of the Video equipment area
- b) #2 AWG supplementary conductors
- c) #2 AWG bonds between a peripheral conductor and the exterior ring ground system
- d) Unit bonds

When properly bonded to the exterior ring ground system, a connection to a peripheral or supplementary conductor is considered equivalent to a connection to an OPGP, and equipment located within the area of the peripheral conductor may obtain earth potential reference from any point on peripheral or supplementary conductors.

6.4.1 Peripheral Conductor

6.4.1.1

When a building or one of its floors is used primarily for Video and associated equipment, a peripheral conductor shall be formed into a ring around the interior of the entire building or floor. This is the primary element of the interior ring ground system.

When the Video area occupies only part of a floor area (e.g., less than half), the ring shall encircle the Video area only. If separated from the Video equipment area, power equipment associated with the Video system need not be included within a ring ground system in central office installations.

6.4.1.2

When Video equipment occupies only a part of the floor area, consideration should be given to the placement of the Video equipment so that the peripheral and supplemental conductors do not create inductive problems for the non-Video equipment during lightning strike activity. This can usually be accomplished by routing the peripheral conductor 3' or more away from the non-Video equipment.

6.4.1.3

The peripheral conductor shall be a minimum #2 AWG, and shall be, bare stranded.. Aluminum conductors shall not be used. See Annex D, Figure 6-10.

6.4.1.4

The peripheral conductor need not be installed as a single continuous conductor. Unnecessary splices should be avoided, but when installation is simplified by installing the peripheral conductor in segments, and segments are joined by an exothermic weld (preferred) or compression type parallel connector, such segmentation is permitted.

6.4.1.5

Routing of the peripheral conductor through metallic objects that form a ring around the conductor, such as ferrous metal conduits or sleeves through walls or floors, shall be avoided whenever possible. A PVC or aluminum conduit is preferred for floor or wall penetrations. If non-metallic or aluminum conduit is prohibited by local code, the peripheral conductor shall be bonded to each end of the metallic conduit.

6.4.1.6

To minimize impedance and incident of arcing, the peripheral conductor shall be installed with a minimum number of bends. Bends shall be made with the greatest practical radius, with a preferred radius of no less than 1 foot. When this is impractical, the minimum radius shall not be less than 6 inches. Use of 90-degree bends to avoid obstructions shall be avoided when lesser bends (e.g., 45-degrees) can be adequately supported.

6.4.1.7

The peripheral conductor shall be run exposed to allow inspection of the system and connection of branch conductors. PVC conduit shall not be used for support.

6.4.1.8

The peripheral conductor shall be located at a height from the floor that allows for convenient bonding of supplementary conductors

6.4.1.9

Supports shall be provided at an interval of between 18 and 24 inches. Extra supports may be provided where the peripheral conductor may be distorted, such as at bonding points. When the peripheral conductor is not located on a wall, it should be supported from cable racks or auxiliary framing channels.

6.4.1.10

Bonds to the peripheral conductor shall be made using compression type parallel connectors (H taps). H-Tap compression connectors shall be protected using fire retardant hard shell or soft shell covers with an oxygen index rating of 28 or better. Clear covers shall be used.

6.4.2 Supplementary Conductors

6.4.2.1

Supplementary conductors are also part of the interior ring ground system, and are usually needed between points on the peripheral conductor to ensure that Video and associated equipment meet the two fundamental requirements for unit bonding:

- a) All metallic objects within the area of the interior ring ground system not directly bonded to the peripheral conductor shall be connected to the peripheral conductor via a minimum of two paths.
- b) All metallic objects within 7 feet of each other must be bonded together.

6.4.2.2

The requirements (a) and (b) above are normally met via paths formed by unit bonds to the ring ground system. The following shall be used to determine maximum allowable lengths of bond paths between objects:

- a) For objects located within 1 foot of each other, the bond path between objects shall not exceed 15 feet. This distance includes the individual unit bond lengths and common peripheral conductor length between the two objects. See Figure 6-4.
- b) For objects located from 1 to 7 feet of each other, the bond path length shall not exceed 30 feet. This distance includes the individual unit bond lengths and common peripheral conductor length between the two objects. See Figure 6-4.
- c) When (a) or (b) cannot be met via connections to a peripheral conductor, the objects shall be bonded via a supplementary conductor or by a direct bond between objects.
- d) Mechanical connections between metallic objects (e.g., inter-frame bolting) shall not be considered as a bond path.

6.4.2.3

Supplementary conductors shall be installed over and between equipment lineups. To provide a parallel path, the conductors must provide two paths to the peripheral conductor. One end of a supplementary conductor may be terminated on another supplementary conductor to provide the second path.

6.4.2.4

Supplementary conductors shall be the same size (minimum #2 AWG) and material as the peripheral conductor. Aluminum conductors shall not be used.

Other conductors shall be bonded to the peripheral conductor using either exothermic welds or compression type parallel connectors. H-Tap compression connectors shall be protected using fire retardant hard shell or soft shell covers with an oxygen index rating of 28 or better. Clear covers shall be used.

Supplementary conductors may be supported from cable rack stringers or framing channels using 9-ply waxed polyester twine, cable ties, clamps or clips. If clamp or clip supports are used, a type that does not require drilling of channels and stringers is preferred. All supports shall be placed at an interval of 18 to 24 inches. Removal of paint from the channel or stringer

is not required when clamps or clips are used. Scratches in the finish shall not be painted, and clamps or clips shall not be painted. A job-fashioned detail may be used to route the conductor around obstructions at cable rack junctions or other points interfering with the conductor.

See 6.5.3 for other acceptable material for supplementary conductors over lineups.

6.4.2.5

The supplementary conductor shall be bonded to a channel or stringer at an interval not exceeding 15 feet when the conductor parallels the channel for a distance greater than 20 feet. The channel or stringer shall be drilled and a compression or mechanical type clamp shall be secured to the channel or stringer. An acceptable means is shown in Figure 6-3, using a Burndy GB26 connector or equivalent.

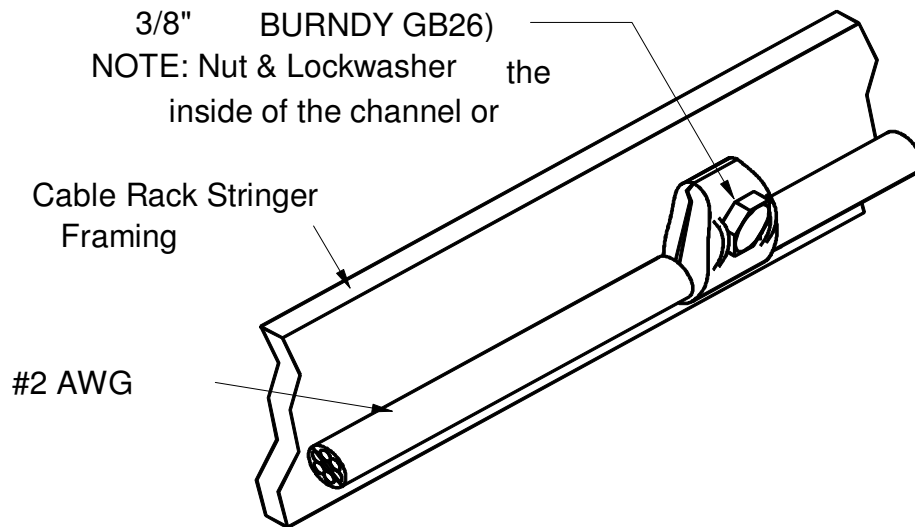


Figure 6-3
Method of Bonding Supplementary Conductor to a Framing Channel

6.4.2.6

To minimize impedance, special attention must be paid to the direction of turns at all junctions of supplementary and peripheral conductors. At the junction nearest a hatchplate, the supplementary conductor shall turn in the direction of the hatchplate. The other end of the conductor shall turn in the opposite direction, toward a bond between the exterior ring ground and the peripheral conductor more remote from the hatchplate than the connection of the supplementary conductor.

6.4.2.7

When there is no significant difference in the length of the bond paths to a hatchplate from either end of a supplementary conductor, both ends shall turn in the direction of the hatchplate.

When the building is equipped with more than one equipped hatchplate, the end of the supplementary conductor shall turn in the direction of the nearest hatchplate.

6.4.3 Coaxial Cable Bonds

6.4.3.1

Coaxial cables require no bonds to the interior ring ground system when they are bonded to a hatchplate that is located within 25 feet of the interior ring ground system.

6.4.3.2

When the hatchplate is located more than 25 feet from an interior ring ground system peripheral or supplementary conductor, coaxial cables shall be bonded to the interior ring ground system. Coaxial cables within 7 feet of each other shall be bonded together with a minimum #6 AWG. The bond shall be extended to a peripheral or supplementary conductor at a point where the coaxial cables enter the area protected by the interior ring ground system.

Primary bonds between such remotely located hatchplates and interior conductors may be omitted when coaxial cables are so bonded.

6.5 UNIT BONDS

At Video sites, every metal object that is buried or above ground on the building exterior, part of the building structure, or located inside the building should be regarded as a path for lightning current, and shall be bonded to the site's grounding system. An object is exempt from this requirement when **all** of the following conditions are met:

- 1) It would require an extraordinary expense to bond the object.
- 2) The object is not in contact with the earth.
- 3) The object is more than 7 feet from an object that is either bonded to a grounding system or in contact with the earth.
- 4) Objects assembled to provide low impedance continuity between components do not require inter-component bonding. Such objects include units mounted on a common metal frame or cabinet, air ducts (when joined to constitute a reliable electrical connection) and similar assemblies.

6.5.1 Exterior Unit Bonds

6.5.1.1

Metallic objects, external to or mounted on the building, shall be bonded to the exterior ring ground system. This includes earth supported metallic objects located within 7 feet of the exterior ring ground system or an object bonded to the exterior ring ground system.

6.5.1.2

Metal fences within 7 feet of the exterior ring ground system or objects bonded to the exterior ring ground system shall be bonded. See Figure 6-11 Fence and Gate Grounding for Antenna Towers Annex D.

- a) If the fence runs continuously within 7 feet of the exterior ring ground conductor, it shall be bonded at an interval not exceeding 25 feet. Bonds shall be made across gate openings.
- b) The #2 AWG solid, bare, tinned copper wire from the buried ground ring shall be connected to each gate post and corner post using an exothermic weld or clamp connector listed for the purpose.
- c) Each gate section shall be bonded to hinge post with a #2 AWG equivalent flexible copper braid using an exothermic welds or clamp connectors listed for the purpose.

- d) Each horizontal pole or brace shall be bonded to each other and to the vertical pole which is bonded to the buried ground ring using an exothermic welds or clamp connectors listed for the purpose.

6.5.1.3

Conduits or pipes located on a roof or exterior wall shall be bonded at an interval not exceeding 25 feet.

6.5.1.4

Exterior unit bonds may be connected to the buried ring ground conductor, the roof ring ground conductor, or a down conductor between the roof and buried ring ground conductors.

6.5.1.5

A tree grounding system is recommended to bond objects on the exterior of a building. This system consists of main and branch conductors. A main conductor is connected to an exterior ground conductor, and is routed toward a group of units requiring bonds, terminating on the unit farthest from the exterior ground system. Branch conductors bond individual units to the main conductor, and sub-branches may be extended from branch conductors.

6.5.1.6

Main conductors shall be minimum #2 AWG and branch conductors shall be minimum #6 AWG. Branch conductors should be no longer than 15 feet. Where units bonded to different main conductors are within 7 feet of each other, the branch conductors of the two main systems should be bonded together so that the length of a direct bond between the units is not greater than 30 feet.

6.5.1.7

All buried connections shall be made using an exothermic weld. Connections made above ground shall be made with exothermic welds or a compression type connector. Any connection other than an exothermic weld shall be located to permit periodic inspection.

6.5.2 Interior Unit Bonds

6.5.2.1

Every metal frame, cabinet, and individual metallic unit located within the area of the peripheral ring ground conductor requires unit bonding directly to the peripheral or a supplemental conductor. ***Any metal frame, cabinet, and individual metallic unit bonded to the peripheral conductor or a supplementary conductor shall have no additional connections to the ground system. Main aisle and lineup grounding conductors shall not be run within the footprint of the peripheral conductor.*** The minimum size for a unit bond is #6 AWG. The length shall be determined using the requirements in 6.4.2.1 and 6.4.2.2.

6.5.2.2

Assemblies of known low impedance such as conduits and framework shall be considered as an extension of the unit bond conductor. When assessing the total bond conductor length for compliance with 6.4.2.2, the calculation shall include the distance from the bond point on an object to the point of proximity with another object. Figure 6-4 shows two cabinets separated by 6 inches. The cabinets are 3 feet wide, and are bonded at the top center. Both unit bond conductors are 3 feet long and connect to a peripheral conductor at points 4 feet apart. The total bond length is 13 feet, which meets the 15-foot requirement.

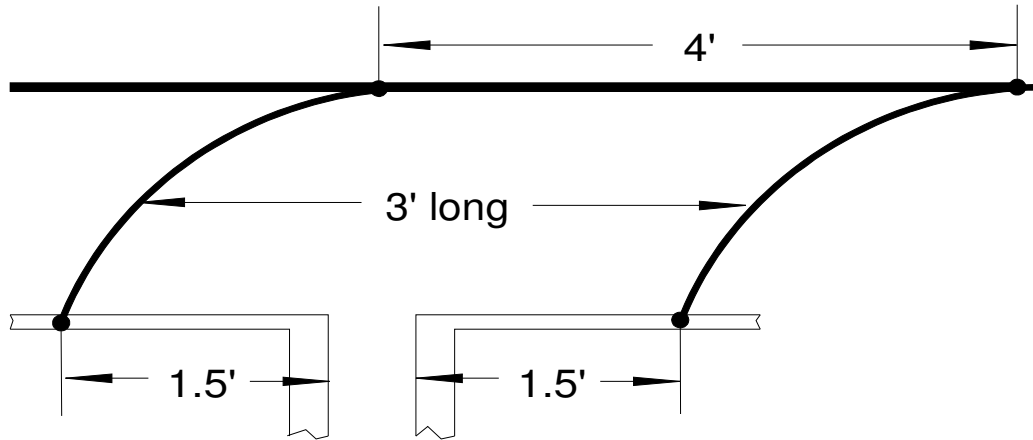


Figure 6-4
Determining the Distance Between Metallic Objects

6.5.2.3

Grounding conductors routed along interior walls and units located next to such walls may be in proximity to other conductors or units mounted on the other side of the wall. When the peripheral or supplementary conductors that run on either side of a wall are bonded together at both ends, intermediate bonds may be omitted. Bonds to conductors on both sides of a wall shall be made to objects such as conduits or pipes that penetrate the wall.

6.5.2.4

Unit bond conductors shall be installed with a minimum number of bends. Bends shall be made with the greatest practical radius. The bend radius should not be less than 1 foot, but when that radius is not practical, the minimum radius shall not be less than 6 inches.

6.5.2.5

Where unit bond conductors join peripheral or supplementary conductors, they should turn in the direction of the nearest hatchplate.

6.5.2.6

A single conductor connecting one or two units to a peripheral or supplementary conductor may be used without regard to the direction of turns as there will be no surge current flowing in the unit bond. As an example, refer to the wall mounted equipment and the two-cabinet lineup of Figure 6-1. Each has a single conductor to a peripheral or supplementary conductor.

6.5.2.7

Three or more units in a line up should have two connections via a peripheral or supplementary conductor.

6.5.2.8

All interior unit bond connections to flat surfaces shall be made with 2 hole compression type terminals. Conductors shall be joined using only exothermic welds or compression type splices or parallel connectors. Connections to pipe clamps or conduit clamps may be made using a single hole compression type terminal (preferred) or the mechanical means provided with the clamp.

Every group of frames, cabinets or other enclosures arranged in a lineup shall be equipped with a conductor that provides a means to terminate unit bonds from every frame or cabinet in the

lineup. If a peripheral conductor cannot serve in this capacity, this conductor is considered a supplementary conductor. It shall be a minimum #2 AWG copper conductor.

6.5.3.2

When a #2 AWG conductor or steel pipe is used, separate minimum #6 AWG unit bonds shall be added between each frame or cabinet and the #2 AWG lineup conductor.

6.5.3.3

AC cabinets used for distribution, control, etc., shall be unit bonded to nearby ring ground conductors. Other metal cabinets (such as tool cabinets) mounted within 7 feet of units requiring a bond shall also be bonded to the ring ground system.

6.5.3.4

Connections to frames or cabinets shall be made using two hole compression type terminals. Conductors shall be joined with compression parallel connectors.

6.5.4 Miscellaneous Unit Bonding

6.5.4.1

Metal battery stands and similarly constructed metallic units shall be bonded to the interior ring ground system. Metallic objects, not classified as bays or cabinets, such as engine-alternator sets, fuel tanks, fans and similar units require unit bonding. Some of these units are long enough to require additional bonds to meet the requirements of 6.4.2.2.

6.5.4.2

Units of similar nature to the above that are associated with heating, air conditioning, electrical toilets, metallic partitions, protective grillworks and other metallic items furnished as part of building facilities shall be unit bonded.

6.5.4.3

Portable metallic items, such as ladders, wheel mounted test cabinets and equipment of similar nature do not require unit bonds, but may be stored in a manner that alters the spacing between bonded objects. When the item placed in its storage space reduces the space between bonded objects to less than 7 feet, but not less than 1 foot, and the item is entirely isolated from incidental contact with metalwork, the item may be considered adequately protected when a bond of less than 15 feet exists between the bonded objects. If storage of an item results in a separation of less than one foot, a direct bond of shortest practical length shall be provided between the bonded objects, at or near the point of nearest proximity.

6.5.4.4

Miscellaneous unit bonds shall be minimum #6 AWG, and shall use two hole compression type terminals and/or compression type parallel connectors.

6.5.5 Conduit, Pipe and Duct Bonding

6.5.5.1

Pipes, conduits, raceways and air ducts, when permanently joined by means other than slip joints, are considered electrical conductors. When these objects are mechanically joined to bonded units within the area of the peripheral conductor, they are considered adequately bonded by that unit's bond for a distance of:

- a) 15 feet if insulated from metallic support hardware
- b) 30 feet if in electrical contact with support hardware at an interval not exceeding 15 feet

When objects exceed these length limits, additional #6 AWG bonds shall be made between the units and a peripheral or supplementary conductor. They shall be located at an interval not exceeding those in (a) or (b) above.

6.5.5.2

Fluorescent lighting system fixtures and conduit installed within the ring ground area shall be bonded in the same manner as conduit runs. Per Section 2 of this Practice, an ac equipment ground conductor shall be furnished in all conduit and raceways.

6.5.5.3

When Video equipment and its ring ground system occupy only a portion of a floor and conduits, ducts, or similar objects supported above the Video equipment extend into other areas of the floor, each object shall be bonded to the peripheral conductor at or near the point where the objects exit the ring ground system area. A tree arrangement using a supplementary conductor and unit bonds may be employed.

6.5.5.4

Points of discontinuity in conduit, raceway, pipe and duct runs shall be made electrically continuous by a minimum #6 AWG bond across a point of discontinuity.

6.5.6 Bonding of Units Outside the Ring Ground Periphery

6.5.6.1

Equipment units on the same floor as Video equipment but located more than 7 feet from the area of the peripheral conductor (or a unit bonded to it) shall be considered adequately bonded by their connection to the IS POP/VHO GRD system.

6.5.6.2

Equipment located outside the area, but within 7 feet of the peripheral conductor or units bonded to it, shall be bonded to the peripheral conductor. Such bonds may be direct bonds or a tree arrangement using a supplementary conductor and unit bonds. Unit bonds shall terminate at the same point on the unit as the DCEG conductor, or they may be tapped to the DCEG conductor using a compression type parallel connector.

6.5.6.3

A lineup of frames, cabinets or other enclosures that runs parallel to the peripheral conductor and is within 7 feet of units bonded to the peripheral conductor shall be bonded to the peripheral conductor. A bond shall be made between each end of the conductor serving as the lineup grounding conductor and the peripheral conductor.

If the length of the bonds plus the length of the lineup conductor exceeds 60 feet, a second bond is required, and shall be placed between the peripheral conductor and the approximate midpoint of the lineup.

6.6 BONDS AT STRUCTURE ENTRANCES

6.6.1 General

6.6.1.1

Transmission media from antennas and other conductive paths from towers may enter a structure through:

- a) A hatchplate
- b) A weather barrier (either metal or non-metallic, but too thin to be a hatchplate)
- c) A hole or other opening in a roof or exterior building wall

6.6.1.2

A hatchplate is the preferred point to bond the antenna media. However, a site may not be equipped with a hatchplate, or the hatchplate may not have room to terminate bonding conductors. This section provides requirements for hatchplate bonds as well as alternative methods for antenna media bonding at the structure's entrance.

6.6.2 Video Entrance Bus Bar

6.6.2.1

An Video Entrance Bus Bar can be added when a hatchplate doesn't exist, when the weather barrier supplied is too thin to be used as a hatchplate, or when there is no room to terminate bonding conductors. A bus bar may also be used to provide a more convenient means to mount a protective device required for coaxial or other multi-conductor cable. See Annex D, Fig 6-8, 6-9.

6.6.2.2

An Video Entrance Bus Bar should be mounted so that it does not interfere with coaxial or other cables and also allows access to terminate bonding conductors and/or mount protective devices.

6.6.2.3

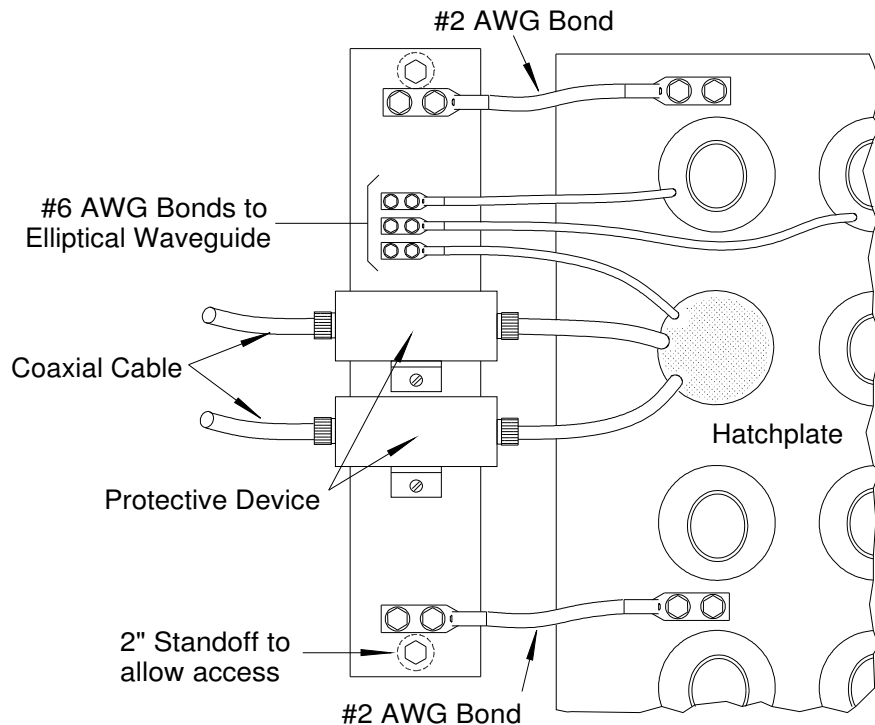
If a hatchplate exists, the distance between it and an Video Entrance Bus Bar should be kept as short as practicable, preferably no more than 18 inches.

6.6.2.4

A Video Entrance Bus Bar and any associated bus bar details should be 3/8"X6"X18" copper. The bus bar should be sized to accommodate the quantity of connections and/or protective devices likely to be used. See 6.6.5 for bonding requirements for auxiliary bus bars.

6.6.2.5

Figure 6-5 shows one possible arrangement of an Video Entrance Bus Bar located on the inside wall of a structure next to a hatchplate. The 2" standoffs at the top and bottom of the bus bar should not be insulators. They may be a threaded type or they may be brackets.



**Figure 6-5
Video Entrance Bus Bar Details**

6.6.3 Other Arrangements

6.6.3.1

The Video system's design or some other aspect of the site's structure may warrant the use of entrance hardware that does not include a conventional style hatchplate. The following characteristics should be included in the design of the entrance:

- If a metal plate is used for bonding purposes, it should be at least 1/8" thick.
- Any metallic components should provide a means to accept bonding conductors, or they should be bonded via junctioning material (bolts, rivets, welds) to objects that are adequately bonded to the site's grounding system.
- It should be bonded to both the interior and exterior ring ground systems.

6.6.4 Exterior Bonds

6.6.4.1

A means shall be provided at the point of entry into the structure to connect a bond to the structure's earth electrode system using a primary bond as described in Section 6.3.3 *Interior-Exterior Bonds*.

6.6.4.2

All conductive paths from antenna towers entering a structure shall be bonded at their point of entry into the structure. The most common paths are coaxial cables and tower lighting conduits.

6.6.4.3

Metallic support framework for coaxial cable within 7 feet of an entrance that is not mechanically joined to a hatchplate or other grounded object shall be bonded to the exterior surface of the hatchplate, bus bar or primary interior-exterior bonding conductor with a minimum #6 AWG conductor.

6.6.4.4

Any metallic conduit entering the building within 7 feet of the entrance shall be bonded to the exterior surface of a hatchplate, bus bar or primary interior-exterior bonding conductor with a minimum #6 AWG conductor.

6.6.4.5

When an entrance through the structure's roof is used, the bond to the exterior ring ground system can be completed via the bond between a hatchplate or bus bar and the roof ring ground conductor. This conductor can also be used to terminate #6 AWG bonds from other objects that must be bonded. This shown as the 2nd preferred location in Figure 6-6.

6.6.4.6

When no hatchplate exists and a bus bar is used instead, the bus bar must be bonded to the exterior ring ground system with a minimum #2 AWG conductor.

6.6.4.7

Figure 6-6 shows some acceptable points for terminating #6 AWG bonding conductors from coaxial cable. Also shown are a number of other #2 AWG bonds between:

- a) The hatchplate and the external ring ground system (only 1 bond required) - run on the inside or outside of the structure
- b) The hatchplate and the interior ring ground system (2 bonds are required) - these bonds and the bond in (a) make up one of the required interior-exterior bonds
- c) The hatchplate and the Video Entrance Bus Bar (2 bonds required)

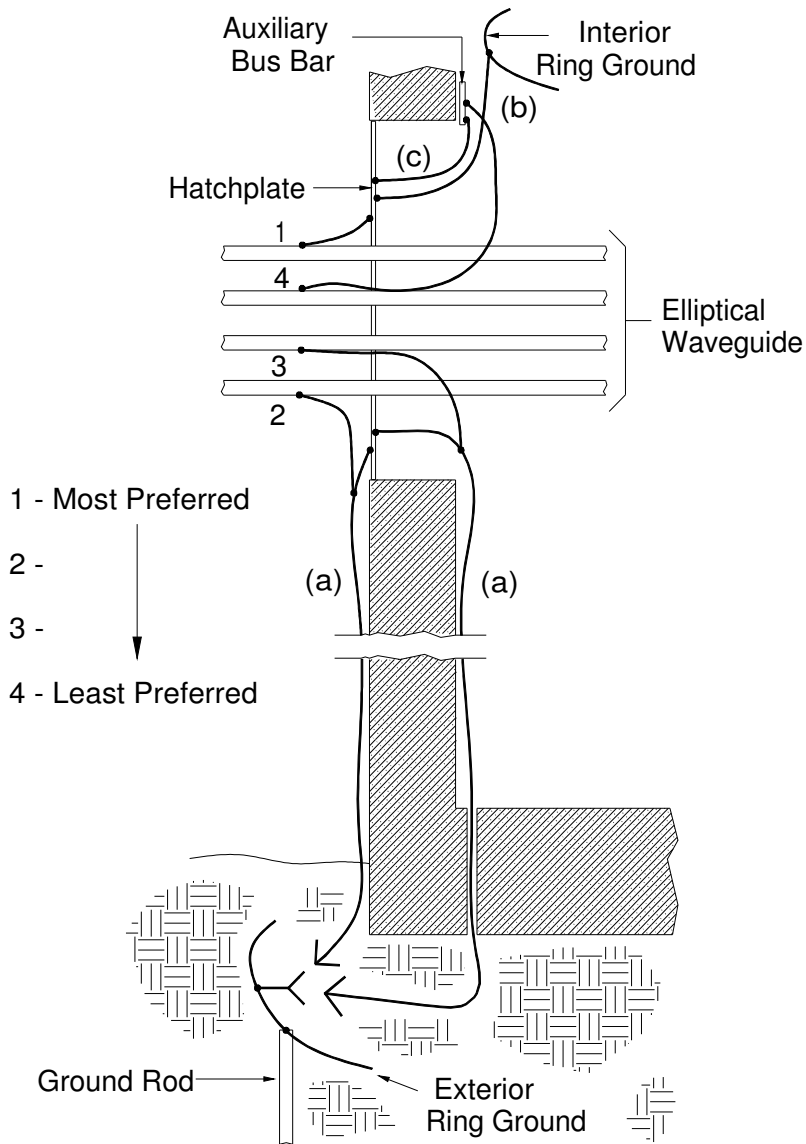


Figure 6-6
Preferred Bonding Locations

6.6.5 Interior Bonds

6.6.5.1

Wall mounted hatchplates shall be bonded to the peripheral conductor with two #2 AWG conductors. The bonds shall turn toward the hatchplate.

6.6.5.2

When no hatchplate exists and a bus bar is used instead, the bus bar must be bonded to the interior ring ground system with two #2 AWG conductors.

6.6.5.3

When a hatchplate and an Video Entrance Bus Bar are both present, the bus bar must be connected to the hatchplate or to the interior ring ground using two #2 AWG conductors or with bus bar detail(s) of equivalent cross-sectional area.

6.6.5.4

When a hatchplate and an Video Entrance Bus Bar are both present, but the hatchplate does not have room to terminate the 2 required bonds, the bus bar may be bonded to the interior ring ground system. The two #2 AWG bonds may be tapped to either the interior ring ground conductor or the bonds between it and the hatchplate.

6.6.5.5

If an interior ring ground system is not required, the hatchplate or bus bar must be bonded to the structure's grounding system with a minimum #2 AWG conductor routed directly to the nearest IS POP/VHO GRD or OPGP bus bar.

6.7 BONDING OF STRUCTURAL MEMBERS

1) Building construction methods described will not cover every arrangement likely to be encountered. The bonding requirements described below can be used as a guide when other construction techniques are used.

2) If steel mesh is used between courses of a concrete block or similar form of masonry wall, each mesh shall be provided with a minimum #6 AWG bond conductor that protrudes from the wall. This bond shall be connected to the closest of either a peripheral conductor or an interior/exterior bond conductor. If steel mesh is used in concrete block columns in outer walls, each mesh shall be bonded in the same manner as in the walls.

3) When rebars (reinforcing bars or welded steel mesh) in poured concrete walls are inter-connected, and connected to rebars or structural steel in columns by welding or conductor-wrap, they shall be bonded as follows:

(a) Rebars at the bottom of the wall shall be connected to the exterior ring ground at the midpoint of the wall between columns.

(b) Rebars at or near the top of the wall shall be connected to the interior peripheral conductor at the midpoint of the wall between columns.

(c) If it is known that rebars are not inter-connected, they shall not be bonded to exterior or interior ring ground conductors.

4) If precast concrete exterior panels are reinforced with steel bars or mesh, the reinforcement steel in each panel shall be bonded to the exterior ring ground.

5) When the rebars in concrete columns are electrically continuous but not in electrical contact with wall rebars, (e.g., knockout wall panels) the column rebars shall be bonded near the top to a peripheral or supplementary conductor. Rebars not made electrically continuous throughout the column, they shall not be bonded to the exterior or interior ring ground conductors.

6) Peripheral structural steel columns that are bare or encased in concrete or masonry, when not part of a steel frame construction, shall be bonded to the exterior ring ground conductor and to an interior ring ground conductor.

7) Structural steel beams and trusses supporting the roof of a building are generally sufficiently bonded to earth through hanger rods and other hardware that support superstructure, conduits, pipes, ducts and other metallic units above the Video equipment area. Individual beams not obviously grounded in this manner or by contact with grounded steel frame or columns of the building shall be bonded to the peripheral conductor at both ends.

8) Pre-stressed concrete beams with rebars that make no contact with grounded structural members shall be bonded to peripheral conductors at both ends.

9) Rebars of poured concrete roof beams are normally integrated with column rebars so that continuity exists throughout the structure. When such continuity exists, additional bonds to such beams are not required.

10) Metal framed openings in walls, such as door frames, may or may not be grounded through continuity with rebars or other metallic objects bonded to the exterior ring ground conductor. Such frames shall be bonded to the peripheral ring ground system.

11) Metal frames in the roof, other than those bonded through contact with bonded metal objects (hatchplates), shall be bonded to peripheral or supplementary conductors.

12) Small prefabricated buildings or huts of metallic frame and exterior surface construction are often used to house Video equipment. They shall be equipped with an interior peripheral ring conductor (sometimes called a *J-rail*) to which all unit bonds terminate. Such structures require no additional bonding other than those between the structure and the exterior ring ground system.

6.8 SMALL VIDEO ANTENNA SYSTEMS

6.8.1 Scope

6.8.1.1

The requirements of 6.8.1 – 6.8.5 apply to comparatively small equipment antenna systems. These systems may be located at central offices, remote terminals or other types of structures and typically:

- a) Provide service to a single customer,
- b) Are receive-only systems, or
- c) Are systems used by Company maintenance forces.

6.8.1.2

The Video equipment usually consists of 1-3 units designed to mount either in a miscellaneous relay rack or a separate, cabinet. The Video equipment may also be a combination of mast-mounted RF unit(s) and rack-mounted multiplexer unit(s).

6.8.1.3

The antennas/reflectors covered by the requirements in 6.8.1 – 6.8.5 are **not** mounted on towers. They are most often secured to a structure using brackets, tripods, or other hardware, or they may be mounted on poles.

6.8.1.4

Except as modified by the contents of 6.8.1 – 6.8.5, all other engineering, material and installation requirements in this section shall apply.

6.8.2 System Component Location and Other Considerations

6.8.2.1

The vertical and horizontal structural members of a building are usually made of either reinforced concrete, structural steel or a combination of the two.

Since structural steel often simplifies the addition of the grounding and bonding in 6.8.1 – 6.8.5, determining the actual type of construction is a key element in the planning process. The responsible Building Engineer should be contacted when the type of construction cannot be readily determined.

6.8.2.2

Because the length of grounding and bonding conductors is critical in any lightning protection system, the location of Video system components, especially the antenna and Video equipment, needs to be evaluated and engineered on a site-by-site basis. While locating the antennas and equipment per 6.8.2.4 and 6.8.2.5 below may result in longer runs of antenna, power and network interface cabling, the additional effort is acceptable because of the additional protection provided by these measures.

6.8.2.3

When a building is not structural steel construction, every attempt should be made to place the antenna no more than 7 feet from the edge of the roof along that portion of the structure's perimeter that is directly above the driven ground rod system.

6.8.2.4

Within the area described above, a point should be chosen that, in order of importance:

- a) Provides the shortest path for the 2 down conductors to the driven ground rod system
- b) Provides the most unobstructed path down the side of the building, avoiding windows, doors, piping, etc.
- c) Is more than 7 feet from metallic objects on the roof (A/C units, pipes, ladders, etc.)?
- d) Provides the shortest path for antenna cables

6.8.2.5

Whenever practicable, Video equipment should be located near the OPGP bus bar in one or two story buildings. In multi-story buildings, the equipment should be located on the top floor near a vertical riser. To the greatest extent possible, the equipment should be separated from other network equipment (except other Video equipment). Consideration should be given to creating and reserving a dedicated Video equipment area.

6.8.3 Down Conductors

6.8.3.1

Except for antenna mountings bonded to building structural steel, a minimum of 2 down conductors shall be provided between a structure-mounted antenna mounting and the site's driven ground rod system. These may serve more than one antenna mounting.

6.8.3.2

Down conductors between a structure-mounted antenna mounting and the structure's driven ground rod system shall be #2 AWG minimum.

6.8.3.3

For any horizontal portion of their route on the roof where the down conductors are run parallel to each other, they shall maintain a minimum separation of 1 foot.

6.8.3.4

The down conductors should maintain a separation of approximately 50 feet on the vertical portion of their runs to the structure's driven ground system.

If a driven ground array is less than 50 feet in length, the down conductors should connect to the opposite ends of the ground rod array.

6.8.3.5

When an antenna must be located outside the preferred area on a building without structural steel, the horizontal portion of the down conductors should be routed in a manner that provides the shortest path to the vertical portion of the runs, avoids unnecessary turns, and will require the fewest bonds to metallic objects.

6.8.3.6

When an antenna is placed on a building of structural steel construction, a single bond to a structural steel member (horizontal or vertical) may be used in place of the 2 down conductors. The bond between the antenna support and building steel may be made using a welded or bolted connection, or a single #2 AWG bonding conductor. Examples of these are shown in Figure 6-7.

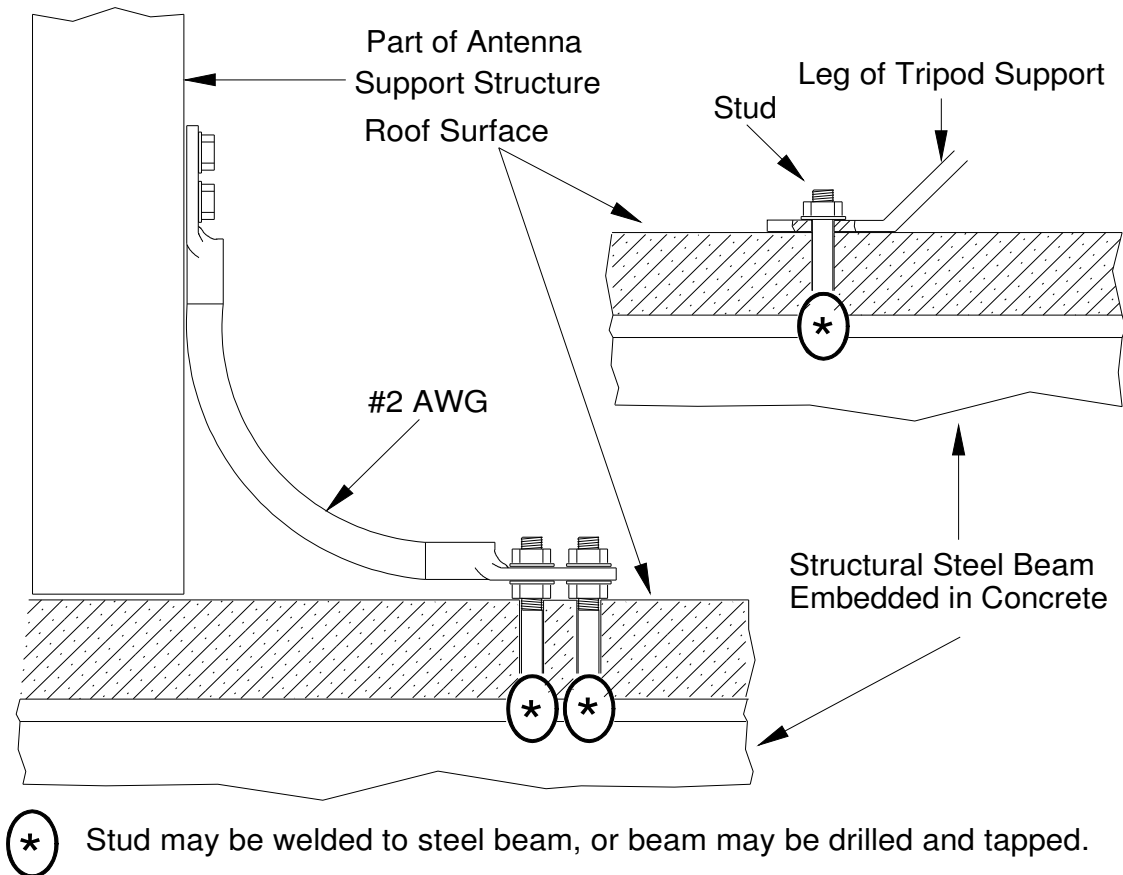


Figure 6-7
Bonds to Structural Steel

6.8.4 Bonding Conductors

6.8.4.1

Every metallic object within 7 feet of an antenna mounting or down conductor shall be bonded to the mounting or down conductor using a minimum #6 AWG bonding conductor.

6.8.4.2

When an antenna cable passes through metallic conduit or raceway, the end of the conduit or raceway on the roof shall be bonded to the closest of either a metallic antenna mounting or a down conductor with a minimum #6 AWG bonding conductor. The far end of the conduit or raceway must be bonded to the nearest appearance of the IS POP/VHO ground system

6.8.4.3

When a portion of the Video equipment is mounted on an antenna mast or pole, the unit shall be bonded to the closest of either a metallic antenna mounting or to a down conductor with a minimum #6 AWG bonding conductor.

6.9 MATERIAL

6.9.1 Protective Devices

6.9.1.1

Protective devices are required for coaxial cable, each conductor in an antenna control cable, and any other multi-conductor cable between the antenna and equipment inside the structure. Protective devices are normally included in the Video equipment specification.

6.9.1.2

Whenever practicable, the protective device should be located outside the structure, or be mounted directly to the inside of the hatchplate.

6.9.1.3

Every protective device must be bonded to a hatchplate, bus bar or to a primary interior-exterior bonding conductor. The bond may be made via the device's mounting flange, mounting stud, or by a minimum #6 AWG conductor.

6.9.2 Conductors

Except where expressly stated, Video site grounding and bonding conductors may be either stranded or solid copper.

For stranded conductors, only those with standard stranding should be used. If a flat strap or bus bar is used in place of a conductor, it must be equal in cross-sectional area to that of the cable required for a given application. See Table 6-1 for conductor information.

Cable Size	Circular Mils	Area (in. ²)	Stranding
6 AWG	26240	0.021	7
4 AWG	41740	0.033	7
2 AWG	66360	0.052	7
1/0 AWG	105600	0.083	19

**Table 6-1
Conductor Information**

6.9.3 Connectors

6.9.3.1

All terminals should be 2-hole compression type. A single hole compression type terminal should only be used at locations where only a single bolt or stud is available.

6.9.3.2

Terminals may be straight, 45° or 90° types. The type of terminal should be chosen based on the specific job conditions.

6.9.3.3

All parallel tap connectors and in-line splices shall be compression type.

6.9.3.4

Mechanical connectors should only be used:

- a) Where site conditions prevent the use of compression tools
- b) Where a mechanical connector is an imbedded part of an equipment unit
- c) Where specified in the standard drawing
- d) To bond supplementary conductors to cable rack or auxiliary framing

6.9.4 Other Material

6.9.4.1

Only material specifically intended for grounding and bonding should be used. For example, an adjustable metal hose clamp should not be used to secure a cable shield bond unless it is a component of a kit of parts that includes installation instructions.

ANNEX A

Reference Documents and Information

A.1 Replaced Practices

The list below contains the requirements of older documents that have been largely incorporated within this Practice.

802-001-180MP - Grounding and Bonding Requirements Telecommunications Equipment, Power Systems, Central Office and Other Structures

ATT 812-000-027 – Grounding and Bonding Requirements for Network Facilities

BSP 081-330-800SW - Cadweld Exothermic Ground Connections, Issue A, November, 1987

BSP 802-001-180 - General Grounding Requirements in Central Offices, Radio Stations, and Other Structures

BSP 802-001-190 - Equipment Ground Systems Material - General Equipment Requirements

BSP 802-001-191 - Office Ground Electrodes - General Equipment Requirements and Engineering Information

BSP 802-001-192 - Equipment Ground System, Central Offices - General Equipment Requirements and Engineering Information

BSP 802-001-193 - Equipment Ground System, Central Offices - General Interface Requirements for DC Power Plants and Communication Systems

BSP 802-001-194 - Equipment Ground System, Central Offices - General Interface Requirements, Manual Toll Relay Rack Ground System

BR 802-001-195 - General Grounding Interface Requirements for Electronic Switching Systems and Power Plants

BSP 802-001-196 - General Equipment Ground Requirements for Data Processing Computer System Installation

BSP 802-001-197 - General Equipment Ground Requirements for Microwave Radio Main and Auxiliary Stations

BSP 802-001-198 - General Equipment Ground Requirements for AC Service Distribution Systems in Communications Buildings

BSP 802-001-997SW - Protective Grounding Systems for Roof Mounted Antennas, Issue A, June, 1982

PBS-068-180PT - Grounding and Bonding Requirements - Telecommunications Equipment, Power Systems, Central Offices and Other Structures

PBS-068-180PT - Grounding and Bonding Requirements, Telecommunications Equipment, Power Systems, Central Offices and Other Structures, Issue B, February 1995

A.2 Other Reference Documents

The documents listed below contain a wide variety of information on the subject of grounding. The first group, labeled *Public Domain Documents*, should be readily available to anyone. The second group *Operating Company Documents*, contains documents that may not be available to non-employees because of proprietary information agreements. The third group, *Equipment Drawings*, are no longer maintained and may not be available to anyone.

MIL-HDBK-419A is particularly good. This 600-page reference is divided into two sections, one on Theory and one on Applications.

A.3 Public Domain Documents

ANSI/IEEE Std 142-1991 IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems

FAA-STD-019b – Lightning Protection, Grounding, Bonding and Shielding Requirements for Facilities

FIPS PUB 94 Federal Information Processing Standards - Guideline on Electrical Power for Automated Data Processing Installations

The IAEI Soares Book on Grounding (International Association of Electrical Inspectors)

MIL-HDBK 419A – Grounding, Bonding and Shielding for Electronic Equipments and Facilities
<http://www.uscg.mil/hq/tcpet/tpf/etsms/Mil-STDs/MILHDBK419.pdf>

MIL-HDBK 1857 – Grounding, Bonding, and Shielding Design Practices

MIL-HDBK 1004/6 – Lightning Protection

MIL-STD-188-124B – Grounding, Bonding and Shielding for Common Long Haul/Tactical Communications Systems Including Ground Based Communications-Electronics Facilities and Equipments

NFPA 70 National Electrical Code

NFPA 75 Standard for Protection of Electronic Computer/Data Processing Equipment

NFPA 780 Lightning Protection Code

Section 802 Rural Electrification Administration (REA) Electrical Protection Grounding Fundamentals

TR-NWT-000295 Isolated Ground Planes - Definition and Application to Telephone Central Offices (Telcordia)

GR-1089-CORE Electromagnetic Compatibility and Electrical Safety Generic Criteria for Network Telecommunication Equipment (Telcordia)

A.4 AT&T Company Documents

PBS-005-300PT Electrostatic Discharge Control

BSP 760-150-155 Building Planning for Operations Support Systems

BSP 760-400-510 Building Electrical Systems Grounding

BSP 790-100-660 AC Power for Telecommunication Equipment

BSP 876-000-000 Index, Electrical Protection and Bonding

BSP 876-100-100 Principles of Electrical Protection - Engineering Considerations

BSP 876-101-130MP Electrical Protection Grounding
BSP 876-200-100 Electrical Protection - Central Offices
BSP 876-210-100 Electrical Protection of Radio Stations
BSP 876-300-100MP Electrical Protection at the Customer Premises
BSP 876-700-100 Measurements of Ground
BSP 876-701-100 Earth Resistivity Measurements

A.5 Equipment Drawings

ED-3C014-51 Method of Grounding Unequal Flange Duct Type Frames
ED-4A081-10 4ESS Switching Equipment Central Office Grounding
ED-6C005-70 COSMIC I and II Grounding
ED-6C145-30 COSMIC Framework Grounding, AC Distribution, Lighting
ED-90026-01 MDF & CDF Ground Bus Bar Connections
ED-90093-01 Misc Frames & Racks
ED-90276-01 Protector Frame
ED-90484-01 Relay Rack
ED-91210-51 Relay Rack-Angel Type
ED-92465-01 Relay Rack Framework
ED-92971-70 Framework Ground for Bulb Angle or Channel Relay Racks
ED-97729-11 Protective Grounding Systems for Central Office Equipment
ED-97915-01 Guidelines, Computer System Raised Floor Systems

A.6 Conductor Information

Size	Area Cir. Mils	Area in. ²	Ohms/kft.
14 AWG	4110	0.0032	3.1400
12 AWG	6530	0.0051	1.9800
10 AWG	10380	0.0082	1.2400
8 AWG	16510	0.0130	0.7780
6 AWG	26240	0.0206	0.4910
4 AWG	41740	0.0328	0.3080
3 AWG	52620	0.0413	0.2450
2 AWG	66360	0.0521	0.1940
1 AWG	83690	0.0657	0.1540
1/0 AWG	105600	0.0829	0.1220
2/0 AWG	133100	0.1045	0.0967
3/0 AWG	167800	0.1318	0.0766
4/0 AWG	211600	0.1662	0.0608
250 AWG	250000	0.1964	0.0515
300 AWG	300000	0.2356	0.0429
350 kcmil	350000	0.2749	0.0367
400 kcmil	400000	0.3142	0.0321
500 kcmil	500000	0.3927	0.0258
600 kcmil	600000	0.4712	0.0214
750 kcmil	750000	0.5891	0.0171

Table A-1
Properties of Stranded Copper Conductors

Note: DC Resistance is for bare conductors at 75 degrees C

A.7 Conduit Information

Conduit Size	Wall Area, in. ²		DC Resistance per kft.		
	EMT	*Rigid	EMT	Rigid Steel	Rigid Alum.
1/2"	0.084	0.254	.9700	.3200	.0800
3/4"	0.127	0.337	.6400	.2420	.0605
1"	0.188	0.500	.4500	.1540	.0385
1 1/2"	0.322	0.790	.2530	.1030	.0258
2"	0.409	1.080	.1990	.0790	.0198
2 1/2"	1.236	1.710	.0659	.0476	.0119
3"	1.518	2.250	.0536	.0352	.0088
4"	2.256	3.180	.0362	.0239	.0060

Table A-2
Properties of Steel and Aluminum Conduit

Note: Rigid steel and aluminum conduit have equivalent cross-sectional areas

ANNEX C
Index to Figure and Tables

Figure or Table	Description	Page Number
Figure		
1-1	Connector with Inspection Window	15
1-2	Typical Conductor Terminations	17
1-3	Typical Ground Bar	18
1-4	Cable Ties to Secure Grounding Conductors	20
1-5	Application of Lockwashers	24
2-1	Supplementary Ground Fields	28
2-2	Ground System for Buildings w/o Basements	29
2-3	Bonding GEC to OPGP	33
2-4	Interbonding	35
2-5	Floor Area Served by Vertical Riser	36
2-6	Bonding COG to Building Steel	37
2-7	Bonding COG to Vertical Riser	40
3-1	Power Area Grounding Arrangement	58
3-2	Internet Services Uninterruptible Power System	60
3-3	Bonding Fiber Optic Cable Sheath	69
4-1	Raised Floor Grounding	71
5-1	Grounding Conductors for Commercial/Leased	74
5-3	Frame/Cabinet Grounding	77
6-1	Video Site Grounding System	79
6-2	Tower Leg Bond	82
6-3	Bonding Conductor to Framing Channel	85
6-4	Video Site Bond Distance	88
6-5	Video Site Auxiliary Bus Bar	92
6-6	Preferred Bonding Locations	94
6-7	Video Site Bonds to Steel	98
6-8	Video Entrance Grounding – Entrance Remote	109
6-9	Video Entrance Grounding –VHO Room	110
6-10	Typical VHO Frame Grounding with Peripheral (Halo) Conductor	111
6-11	Fence and Gate Grounding for Antenna Towers	112

Figure or Table	Description	Page Number
Table		
1-1	Cross Reference to Terms	11
1-2	FUTURE	
1-3	Minimum Bending Radius for Conductors	21
2-1	Driven Ground Rod System Components	27
2-2	GEC Sizing	43
2-3	Equipment Grounding Conductor Sizing	46
2-4	NP&E / CRE Responsibilities	52
3-1	Battery Plant Grounding Conductor Sizing	54
3-2	DC-DC Converter Grounding Conductor Sizing	55
3-3	Rectifier Grounding Conductor Sizing	56
3-4	Main Aisle and Lineup Conductor Sizing	64
5-1	Battery Plant Grounding – Commercial/Leased	75
6-1	Conductor Information	99
Annex A		101
A-1	Properties of Stranded Copper Conductors	104
A-2	Properties of Conduit	105
Annex B	Revisions	106
Annex C	Index to Figures and Tables	107-108
Annex D	VHO Grounding Figures	109-112

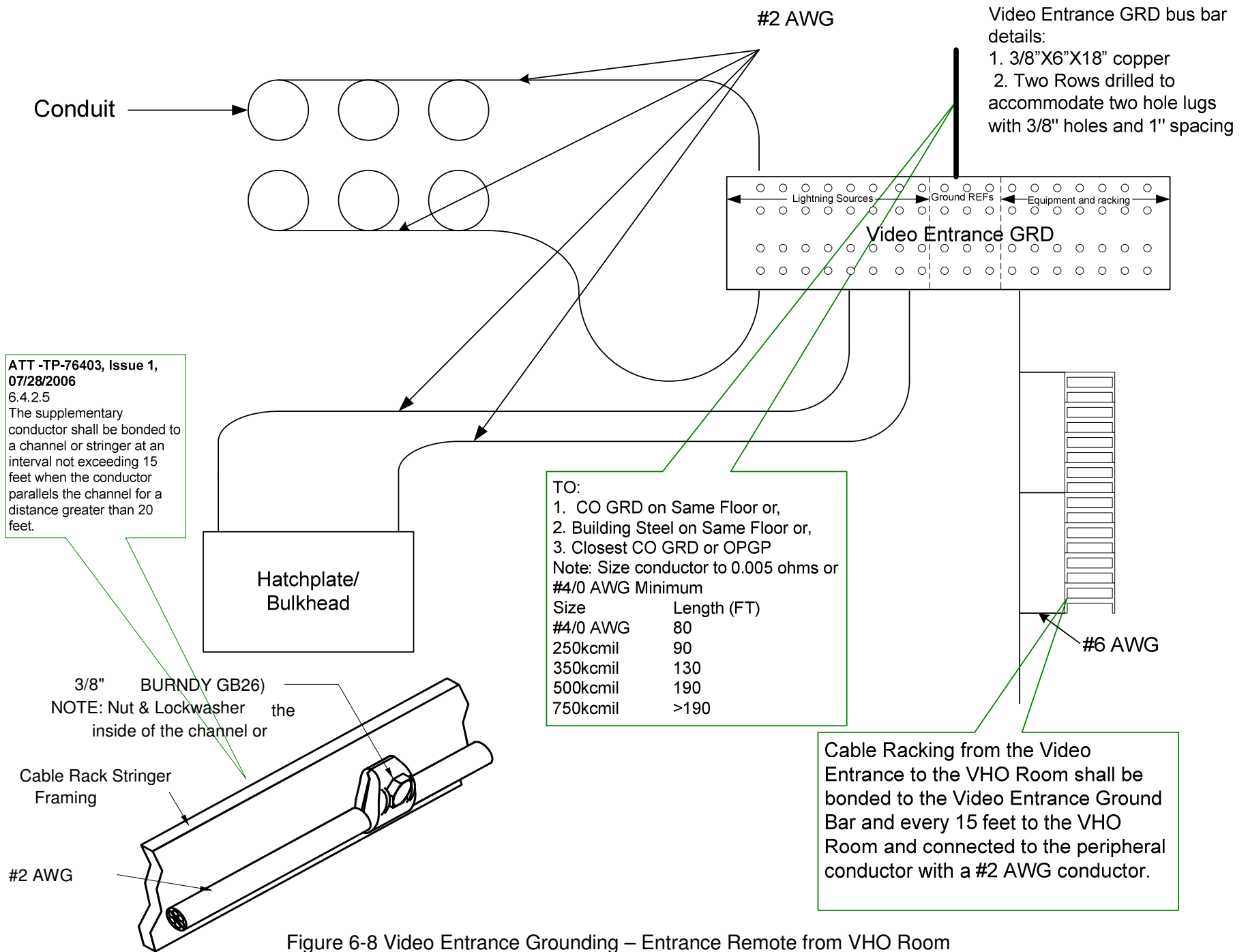


Figure 6-8 Video Entrance Grounding – Entrance Remote from VHO Room

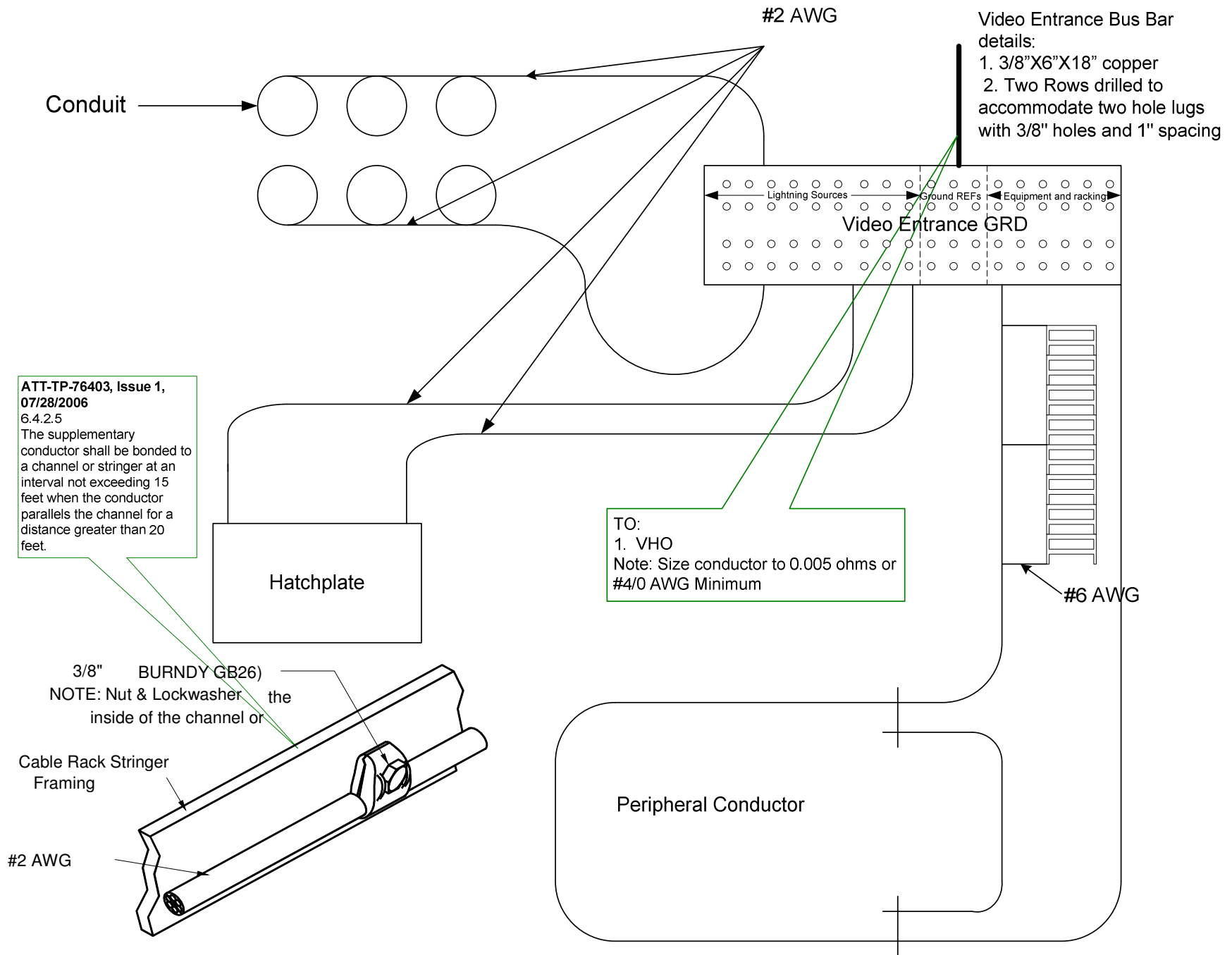


Figure 6-9 Video Entrance Grounding –VHO Room

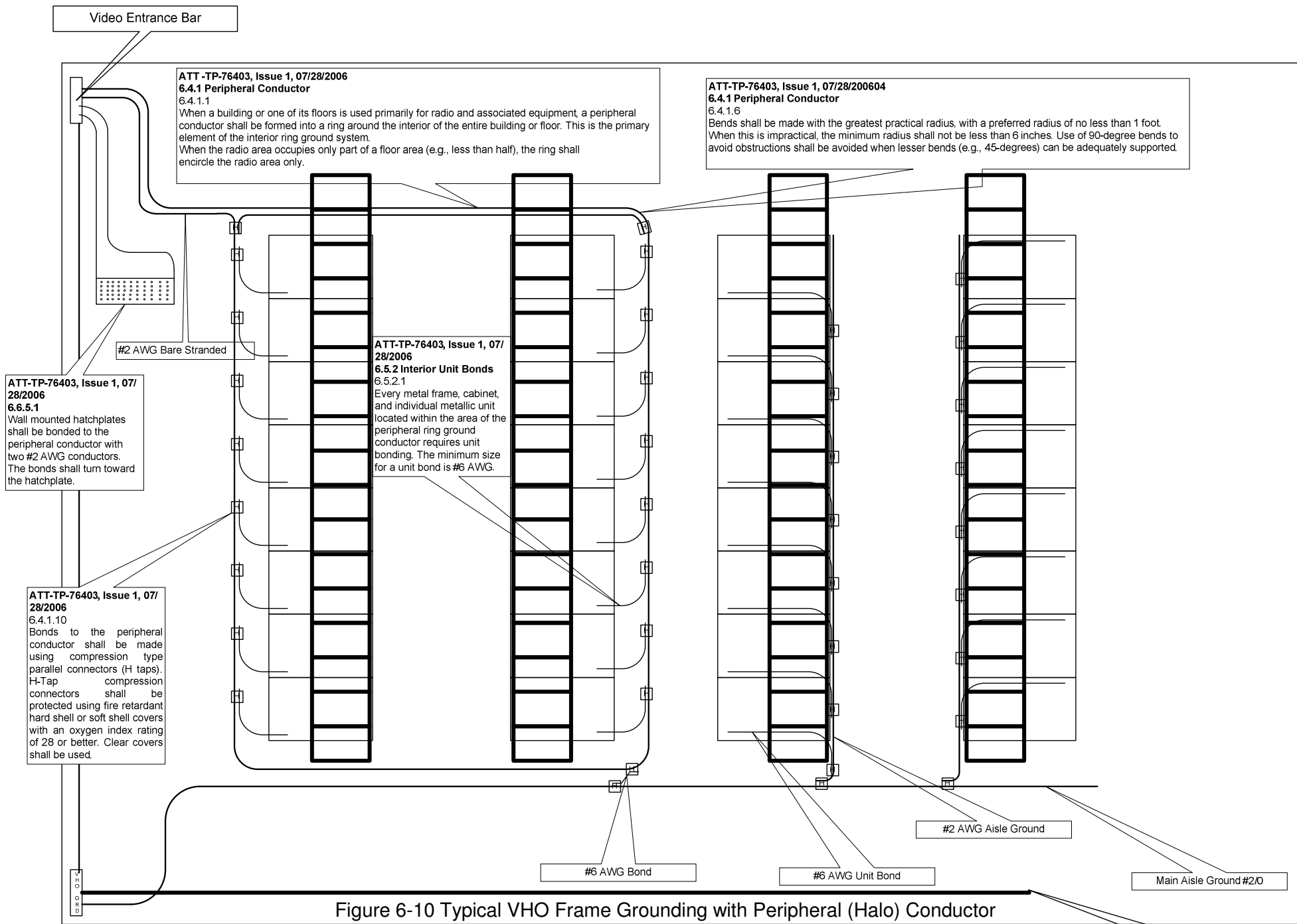
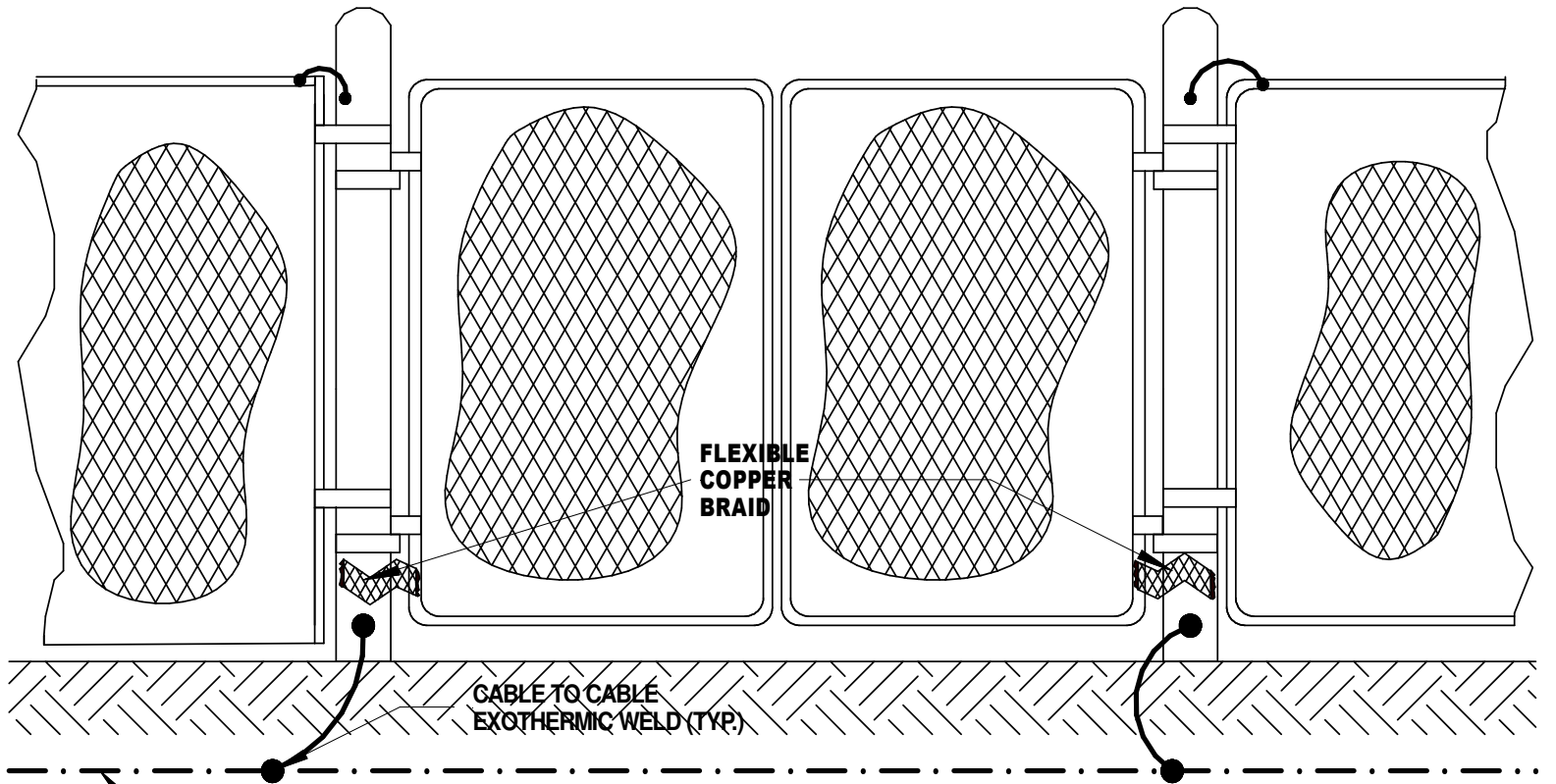


Figure 6-10 Typical VHO Frame Grounding with Peripheral (Halo) Conductor



The #2 AWG solid, bare, tinned copper wire from the buried ground ring shall be connected to each gate post and corner post using an exothermic weld or clamp connector listed for the purpose.

RING GROUND #2 AWG SOLID BARE TINNED COPPER WIRE (MIN 30" BELOW GRADE OR 6" BELOW THE FROST LINE WHICH EVER IS DEEPER.)

Each gate section shall be bonded to hinge post with a #2 AWG equivalent flexible copper braid using an exothermic welds or clamp connectors listed for the purpose.

Each horizontal pole or brace shall be bonded to each other and to the vertical pole which is bonded to the buried ground ring using an exothermic welds or clamp connectors listed for the purpose.

Figure 6-11 Fence and Gate Grounding for Antenna Towers