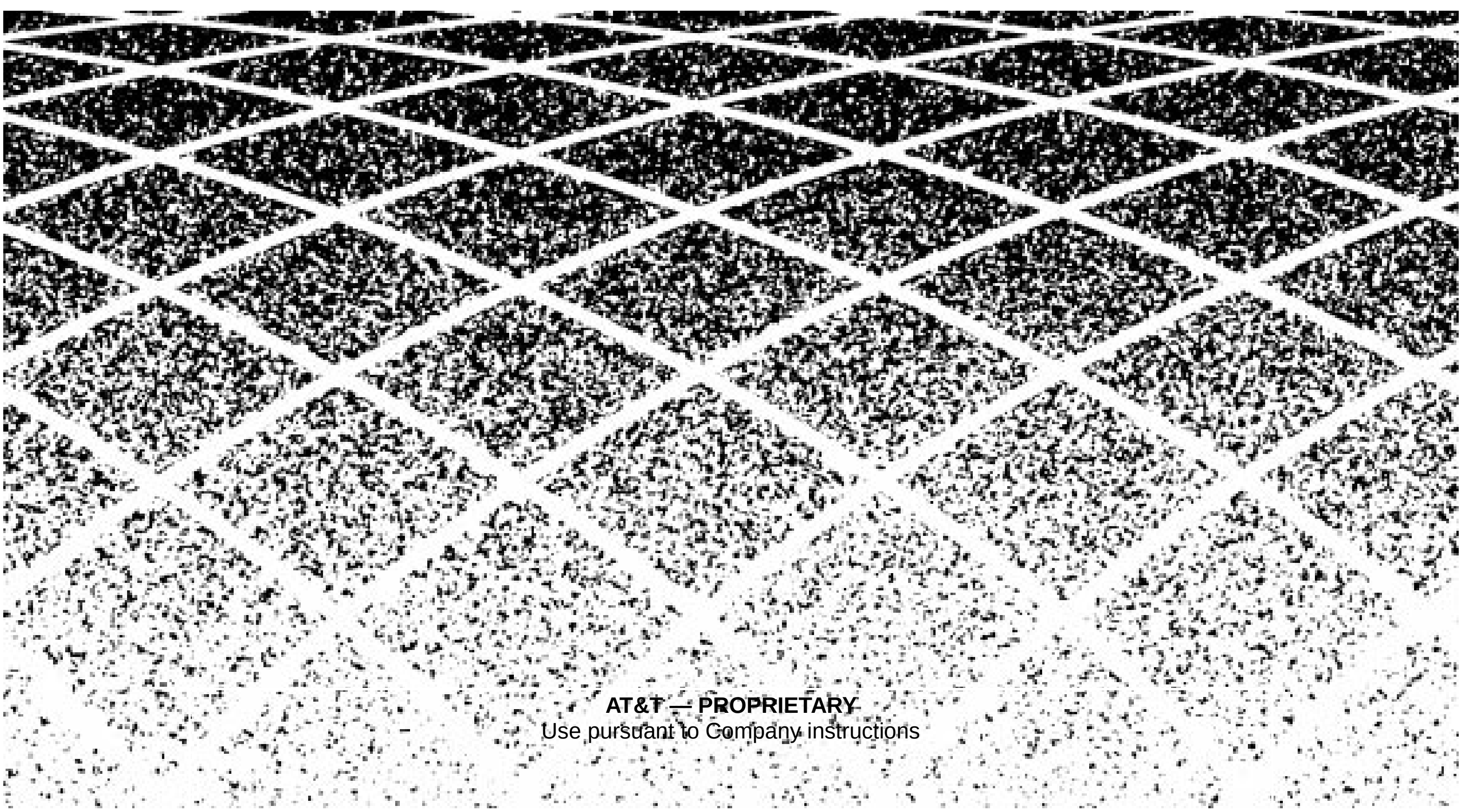
Document Number:	AT&T 803-501-100
Master List ID:	12914
Issue Date:	September 1998
Issue Number:	1

Grounding and Electrical Protection for AT&T Telecommunication Buildings and Equipment



Notice

Every effort was made to ensure that the information in this document was complete and accurate at the time of printing. However, information is subject to change.

Contents

ABOUT THIS DOCUMENT

1. GENERAL DESIGN CRITERIA

2. BUILDING GROUNDING ELECTRODE SYSTEMS and GROUND TERMINALS

3. BUILDING LIGHTNING PROTECTION SYSTEMS

4. AC POWER EQUIPMENT GROUNDING and SURGE PROTECTION

5. DC POWER EQUIPMENT GROUNDING

6. CENTRAL OFFICE INTEGRATED GROUND SYSTEM

7. CENTRAL OFFICE ISOLATED GROUND PLANE GROUND SYSTEM

8. RADIO SYSTEMS and TOWER GROUNDING

9. LIGHTGUIDE HUT and SMALL POP GROUNDING

10. TABLES and FIGURES

11. RAISED ACCESS FLOOR (RAF) GROUNDING REQUIREMENTS

12. GROUNDING ACCEPTANCE CHECKLISTS

About This Document

Purpose

The purpose of this document is to establish the minimum Grounding and Electrical Protection for facilities housing telecommunications equipment to protect personal and equipment from the effects of over-voltage due to lightning, line surges, electrical faults and unintentional contact with higher voltage circuits.

Intended Audience

This document is intended for use by AT&T engineering personnel as well as engineering consultants to these groups.

Reason for Reissue

This is the initial issue of this practice. Whenever this practice is reissued the reason for reissue will be found in this paragraph.

How to Obtain a Copy of This Document

To obtain a copy of this document, contact the Customer Information Center at:

TOLL FREE:	1-800-432-6600 (USA)
	1-800-255-1242 (Canada)
TOLL:	1-317-352-8557 (Worldwide)

Use the document numerical identifier and issue number (AT&T 803-501-100, Issue 1) when ordering this document.

A PDF (Portable Document Format) copy of this document can be obtained online by accessing the MLDB (Master List Database) via the NCS Home Page. Search for this document by using the document numerical identifier (AT&T 803-501-100).

How to Comment on this Document

To suggest changes to the information in this document or to notify the authors of errors in this manual, please submit a comment form. The comment form is located at the beginning of this manual, immediately after the title page. If the comment form is missing, send your comments and recommendations to:

AT&T Power Documentation Manager

1600 Osgood Street

30-MZB-40

N. Andover, MA 01845

ATT Mail !powerdoc

Related Documentation

See Chapter 1, General Design Criteria for related codes and standards.

Reference Documentation

The following documents are referenced within this document and shall be used with this document.

760-400-101	AC Power Distribution System Design Criteria (Master List #3674)
633-020-209	2400 Series Lightguide Grounding Closure Description and Installation (Master List #9657)
636-299-111	AT&T Nsd Osp Lightguide Cable Bonding and Grounding – Electrical Protection (Master List #5102)

1

Contents

1. GENERAL DESIGN CRITERIA

General Design Criteria

1

This section consists of AT&T information pertaining to the requirement for effective protective grounding of telecommunications equipment and structures housing telecommunications equipment. Specific engineering requirements and design information for the various types of grounding systems are covered in the following SECTIONS of this practice.

Grounding practices contained in this document conform to or exceed requirements defined in the NATIONAL ELECTRICAL CODE, NATIONAL FIRE PROTECTION CODE and INSTITUTE of ELECTRICAL & ELECTRONIC ENGINEERING standards for the installation of grounding and lightning protection systems. The provisions defined in these sections do not cover every unique grounding application which may encountered in a communications systems complex. Grounding arrangements may need to be devised for unique applications based on the design criteria outlined herein, and must conform to the NATIONAL ELECTRICAL CODE and local code requirements.

This practice supersedes information pertaining to grounding, lightning protection and surge protection in the following AT&T PRACTICES:

- 803-200-100
- 803-200-105
- 803-500-150
- 803-500-210
- 803-500-410
- 802-001-180
- 802-001-190
- 802-001-191
- 802-001-192

- 802-001-193
- 802-001-194
- 802-001-195
- 802-001-196
- 802-001-197
- 802-001-198
- 760-220-120
- 760-925-135
- 876-210-100

1.1 PURPOSE of GROUNDING

The primary purpose of a dependable low impedance grounding system in locations housing telecommunications equipment is to protect personnel and equipment from the effects of over-voltage due to lightning, line surges, electrical faults and unintentional contact with higher voltage circuits. See details below:

- Equipment Operation To provide an equalized ground reference throughout the ground plane for communications circuits.
- Equipment Protection To provide adequate fault current paths so that over-current devices may function efficiently and to avoid fire hazard through elimination of high impedance points.
- Noise Reduction To assist in the reduction of noise in communications circuits by ensuring that impedance is minimal between ground points throughout the communication system.
- Personal Safety To maintain low potential between equipment frames, cabinets, ironwork and other conductive components to minimize the possibility of electrical shock hazard.
- Reliability To provide a ground network that resists deterioration and inadvertent disconnection and requires minimal maintenance to retain optimal effectiveness for the life of the installation.

1.2 GROUNDING SYSTEM, GENERAL WORKMANSHIP REQUIREMENTS

All grounding system connections utilizing solid conductors shall be exothermically welded together or directly to the object being grounded. Use exothermic two-bolt tongue connectors on materials that can not be welded such as aluminum. This applies to exterior buried and above ground connections.

Mechanical connectors are not approved for grounding and lightning protection system applications.

Connections between stranded conductors and solid conductors shall be exothermically welded.

Aluminum conductors, air terminals, lugs and connecting materials are prohibited from use in any grounding system or lightning protection system.

All insulated grounding conductors shall utilize green, fire retardant insulation.

All UN-insulated grounding conductors (stranded or solid) shall be tinned copper.

All buried grounding conductors shall be NO. 2 AWG (minimum) solid, tinned copper.

Stranded copper grounding conductors used for incidental ground bonds shall be no smaller than NO. 6 AWG.

All bolted ground conductors shall be clearly labeled on both ends to indicate their function and far end terminating point and shall be equipped with DO NOT DISCONNECT tags.

All ground bars not supplied as part of a standard assembly shall be copper and pre-drilled for two-bolt tongue lugs on one-inch centers.

Individual grounding conductors shall not be run in metallic conduit and shall not be completely encircled by metallic clamps. If local codes dictate that a grounding conductor must be run in metal conduit or raceway, then the conduit or raceway must be bonded to the conductor at both ends with a NO. 6 AWG stranded conductor. This does not apply to the AC EQUIPMENT GROUND conductors run with AC circuits.

The minimum bending radius for a single grounding conductor shall be eight inches.

All communications equipment, power plant frames, metal battery stands, and other metallic objects shall be individually solidly grounded to a grounding conductor or directly to the building grounding system. *Daisy chaining*, or frame to frame connections of these conductors is not permitted.

Grounding conductors shall be routed along and secured to the side or bottom of cable racks or to the side of framing channels so that they are visible for their entire length. Grounding conductors shall never be secured to AC conduit or raceways.

All grounding must be a minimum NO. 6 AWG stranded copper cable. This does not apply to AC EQUIPMENT GROUND conductors run with AC circuits, which shall be sized in accordance with NATIONAL ELECTRICAL CODE requirements.

The reliability of a grounding system is dependent on careful, proper installation and choice of materials. Improper preparation of surfaces to be joined to make an electrical path, loose joints or corrosion can introduce impedance that will seriously impair the ability of the ground path to protect personnel and equipment and to absorb transients that can cause noise in communications circuits. The following functions are particularly important to ensure a reliable ground system:

All connections shall be coated with a conductive, corrosion preventive compound before joining.

All copper bus bars must be cleaned prior to making connections to remove surface oxidation.

All grounding conductors shall be properly sized according to AT&T requirements in this document or per the NATIONAL ELECTRICAL CODE.

Directionalize all of the ground conductor sweeps toward the nearest main ground source, e.g., CENTRAL OFFICE GROUND BUSBAR, MAIN CENTRAL OFFICE RISER, OFFICE PRINCIPAL GROUND POINT, etc.

Metallic surfaces to be joined shall be prepared by the removal of all non- conductive material, per NATIONAL ELECTRICAL CODE ARTICLE 250-118.

Raceway fittings shall be made up tight to provide a permanent low impedance path for fault currents.

When equipment arranged in a line-up needs to be grounded, *Daisy-chaining* shall not be used because the continuity of the grounding connection might not be assured if one or more equipment bays are removed from the lineup. The required AT&T method of grounding a line-up of equipment is to provide a common frame aisle grounding conductor from which drop leads are tapped utilizing compression H-taps to individual frames.

1.3 TELECOMMUNICATIONS EQUIPMENT GROUNDING SYSTEMS

Two main types of grounding systems are utilized for the grounding of telecommunications equipment. These are the INTEGRATED and ISOLATED grounding systems and are briefly described below:

- INTEGRATED GROUND SYSTEM An INTEGRATED GROUND PLANE is one wherein the communications system grounds and equipment grounding conductors are not isolated from contact with framework, building steel, or other incidental conductive paths to earth. Equipment frameworks and superstructure may have multiple intentional and incidental contacts with other ground sources, however the battery return path shall be isolated from contact with ground except at its ground reference connection in the power plant. This type of grounding system minimizes the potential difference between energized conductors and associated-grounded metal framework when currents flow between them. This is intended to minimize the risk of arcing due to flashover in case of lightning or electrical faults.

- <u>ISOLATED GROUND SYSTEM</u> An ISOLATED GROUND PLANE is one where the communications system frameworks and superstructure in a defined area are deliberately isolated from contact with the INTEGRATED GROUND SYSTEM, building steel or any other incidental conductive path to ground except at a single point called the GROUND WINDOW. The ISOLATED grounding system is utilized with electronic switching systems such as the 5ESS and 4ESS.

1.4 SIZING of GROUNDING CONDUCTORS

AC powered equipment shall be grounded in accordance with the NATIONAL ELECTRICAL CODE TABLE 250-95. For DC Powered equipment, where over-current protection devices are expected to operate in response to over-currents produced by ground faults, size the equipment-grounding conductors in accordance to the rules below:

NOTE: The requirements listed below shall apply only to new grounding installations. Existing grounding systems installed utilizing previous requirements need not be upgraded to meet the new sizing requirements.

- To assure the prompt operation of the appropriate over-current protection device, when a short to ground occurs the path of the ground fault current should be of very low impedance.

- Although bare equipment conductors are still used in some equipment grounding applications, insulated conductors are recommended and should be used to minimize ground fault exposure.

- The size of the grounding conductor for telecommunications equipment and frames shall be calculated using the following formula:

Circular mills = (11.1 x I x L) / V.

Circular Mills	I	L	V
28906.25	225	50	48

Note:For Office 97 users only. Use the table above to automatically calculate the circular mill requirement. Enter the values for I, L & V then select the shaded box and press F9 to update the calculation.

Where I = 10x the largest over-current protection rating or setting, in amps (NOTE 1).

Where L = Length of the equipment grounding conductor, in feet (NOTE 2).

Where V = 90% of the Circuit Voltage.

NOTE 1: The largest over-current protection device is defined as the one with the highest trip setting that can be mounted within or outside the equipment frame. This is usually the feeder breaker for the bay.

NOTE 2: The length of the grounding conductor is defined as the length from the connection point on the equipment frame to the nearest central office ground bar, HORIZONTAL EQUALIZER or main aisle grounding conductor.

Calculation example 1

Breaker/Fuse size = 225 Amps
(L) Length = 50 Feet

$$\frac{11.1 \times (10\text{x}225\text{a}) \times 50\text{ft.}}{(.90 \times 48\text{v})} = \frac{1248750}{43.2} = 28906\text{cm}$$

(V) Voltage = 48Volts

28906 Cir. Mills would require the use of a NO. 4 AWG

Calculation example 2

Breaker/Fuse size = 60 Amps
(L) Length = 100 Feet

$$\frac{11.1 \times (10\text{x}60) \times 100\text{ft}}{(.90 \times 48\text{v})} = \frac{666000}{43.2} = 15416\text{cm}$$

(V) Voltage = 48Volts

15416 Cir. Mills would require the use of a NO. 8 AWG

After using the formula above, select the standard wire size that provides the calculated circular mill size. The standard wire size shall not be less than the corresponding size from the NATIONAL ELECTRICAL CODE, CHAPTER 9, TABLE 8. In order to maintain mechanical sturdiness the conductor shall not be smaller than a NO. 6 AWG.

1.5 DEFINITIONS

AC EQUIPMENT GROUND (ACEG) Alternating Current Equipment Ground (sometimes referred to as green-wire ground or safety ground). An AC EQUIPMENT GROUND conductor is required to be run with every AC circuit to provide a fault current return path for faults to ground in AC power systems.

AC NEUTRAL The dedicated current carrying conductor of an AC circuit that is called the grounded conductor.

AIR TERMINAL An air terminal is that component of a lightning protection system that is intended to intercept lightning flashes.

ARRESTOR A protection device used on incoming power lines and metallic members of communications cables to limit the line-to-ground voltage caused by lightning or surges.

AWG American Wire Gauge (a standard for measuring the size of wire).

BATTERY RETURN CONDUCTOR The return conductor of a DC power circuit.

BONDING The permanent joining of metallic parts to form an electrical conductive path that will assure electrical continuity and capacity to conduct safely any current likely to be imposed.

BONDING JUMPER A connection between the neutral bus and the ground bus at the Main AC Service Entrance to the building or at any newly derived source of power. The ground bus on a newly derived source shall have a connection to the floor CENTRAL OFFICE GROUND BUSBAR.

CABLE ENTRANCE FACILITY (CEF) A space in a telecommunications building where communications cables enter the building. Grounding and electrical protection measures must be applied to these cables.

CABLE ENTRANCE GROUND BAR (CEGB) A copper ground bar installed in the CABLE ENTRANCE FACILITY area for the purpose of grounding metallic components of communications cables. This ground bar shall be located within six feet of the point of entry of the communications cable into the building.

CENTRAL OFFICE GROUND SYSTEM (CO GRD) This is a system of conductors designed to provide equalization of potential between equipment and a low impedance ground path. The system consists primarily of a VERTICAL RISER, CENTRAL OFFICE GROUND buses, and HORIZONTAL EQUALIZER conductors that distribute the ground system throughout the Central Office equipment floors. The system provides a ground reference for all equipment in the building.

CONDUCTOR A metallic medium for the transfer of electrical charges.

CRIMP COMPRESSION CONNECTORS Metallic circumferential connectors required to maintain low resistance conductivity between wire connections. They shall be used on all inside grounding connections.

DO NOT DISCONNECT Tag A metallic (brass) tag with the words, DO NOT DISCONNECT embossed attached to a ground cable with a bolted connection.

EARTH RESISTIVITY The resistance of soil to a DC current. The commonly used unit of measure is the meter-ohm, which refers to the resistance measured between opposite faces of a cubic meter of soil.

EXTERIOR RING BUS SYSTEM A buried ground electrode system that is comprised of buried driven ground rods interconnected by a buried exterior ring conductor bus encircling the building and/or tower.

EXOTHERMIC WELD A welding process utilizing graphite molds for form welds. A crucible in the top of the mold holds a metallic powder which, when ignited, produces molten copper that flows by gravity into the form surrounding the joining point. The hot copper alloy melts the material of the items being welded, forming a molecular bond. This process shall be used for all solid wire connections and all exterior connections. Exceptions must be approved by BUILDING ENGINEERING or the POWER TECHNICAL SUPPORT GROUP.

FRAMEWORK GROUND The portion of the CENTRAL OFFICE GROUND system that is furnished solely to provide ground continuity to frames, cabinets, and other metallic objects in the communication system.

GROUND A “0” potential reference at a given point.

GROUND IMPEDANCE The impedance of the contact between the soil and a grounding electrode.

GROUND GRID An extensive system of bare conductors buried below the surface of the earth. A ground grid is intended to provide a low impedance connection to earth and equalize potentials within the area covered. Sometimes referred to as a ground array or mat.

GROUND WINDOW A spherical zone extending to a radius of three feet from the midpoint of the MAIN GROUND BUSBAR which is in the center of the ground window.

GROUNDING CONDUCTOR A dedicated conductor used to connect equipment to a grounding electrode.

GROUNDED CONDUCTOR A system or circuit conductor that is intentionally grounded. Current carrying conductors usually referred to as grounded are the *neutral conductor* in AC circuits and the *return conductor* in DC circuits.

GROUNDING ELECTRODE SYSTEM A system of one or more conductors buried in the earth to provide electrical connection to the earth. Examples of grounding electrodes are:

- Building structural steel ground grids
- Ground rings or grids
- Ground rods , ground rod arrays, or counterpoise systems
- Metallic water pipe
- Metallic well casings
- Supplemental ground fields

GROUNDING ELECTRODE CONDUCTOR The conductor used to connect the grounding electrode system to the equipment ground system. In the AC Service Entrance Switchgear of a building, the conductor that interconnects the insulated neutral bus with the OFFICE PRINCIPAL GROUND POINT bus bar.

GROUND PLANE A network of interconnected conductive members (frames and conductors) for providing an approximate equipotential reference.

GROUND TERMINAL The portion of a lightning protection system such as a ground rod, ground plate, or ground conductor that is installed for providing electrical contact with the earth.

HIGH RESISTANCE GROUND A grounded system with a purposely-inserted resistance that limits ground-fault current such that the current can flow for an extended period without causing equipment damage.

HORIZONTAL EQUALIZER Conductors of low impedance (usually 750 kcmil cable) that extend reference ground from the CENTRAL OFFICE GROUND VERTICAL RISER on a given floor to the equipment area.

IDENTIFICATION TAGS (PERMANENT) Fiber tags attached to all ground conductors, indelibly stamped, to identify the far end connection point. This tag is required in addition to the DO NOT DISCONNECT tag.

INCIDENTAL GROUND An unplanned grounding connection. These usually occur during the mechanical assembly and installation of frames, raceways, piping, ducts, superstructure, and other conductive objects.

NOTE: Incidental ground connections from building steel to ISOLATED GROUND PLANES are not permitted.

INDUCTION (ELECTRIC) Induced potential in a communications circuit by capacitive or inductive coupling from the electric field of a nearby power line or circuit.

INTERIOR RING GROUND An interior ring bus system used in small buildings and in radio equipment rooms to minimize the possible voltage differentials between adjacent or nearby equipment due to a lightning stroke to the tower or building.

LIGHTNING PROTECTION SYSTEMAn installation, usually roof mounted, to provide lightning currents a low impedance path to earth.

MAIN GROUND BUS (MGB) Busbar(s) located within the ground window that provide the electrical interface for connections between the building's INTEGRATED GROUND PLANE and the ISOLATED GROUND PLANE.

MOV (Metal Oxide Varistor) A device within surge protectors for shunting unwanted electric surges to ground.

OFFICE PRINCIPAL GROUND POINT (OPGP): The main copper ground busbar, installed for the termination of ground conductors and electrodes to provide a common single "0" potential point of reference for the entire building ground system.

PROTECTOR (cable) A device consisting of one or more surge protector units for limiting abnormal voltages on communications cables. These are usually located in the CABLE ENTRANCE FACILITY and grounded to the CABLE ENTRANCE GROUND BAR.

RACEWAY An enclosed channel designed expressly for holding wires, cables, or bus bars, with additional functions as permitted by the NATIONAL ELECTRICAL CODE.

SEPARATELY DERIVED SYSTEMS A newly derived AC electrical source that has electrical isolation between its input and output current carrying members.

SIDEFLASHAn electrical discharge caused by a difference of potential, occurring between conductive metal bodies or between such metal bodies and a component of the lightning protection system or ground.

SOLIDLY GROUNDED Connected directly through an adequate ground connection in which no impedance has been intentionally inserted.

STATIC CHARGE A buildup of potential difference between two objects.

STATIC DISCHARGE The electrical flash that occurs when the potential difference between two objects becomes large enough to bridge the air gap between them.

SURGE ARRESTOR A protective device to limit surge voltages and to provide a controlled path for the discharge of surge current to ground. It also prevents continued flow of holding or follow current while remaining capable of repeating these functions.

SWITCHING SURGE A transient wave of over-voltage in an electric circuit caused by the operation of a switching device interrupting load current or fault current.

TRANSIENT OVER-VOLTAGE The temporary over-voltage of short duration associated with the operation of a switching device, a fault, a lightning stroke, or during arcing ground faults.

VERTICAL RISER A vertical grounding conductor (750 kcmil cable) used to extend the CENTRAL OFFICE GROUND system from the OFFICE PRINCIPAL GROUND POINT to the CENTRAL OFFICE GROUND bar on each floor. The VERTICAL RISER is sometimes referred to as the VERTICAL EQUALIZER.

VERTICAL RISER (EQUALIZER) The 750 kcmil cables that bond multiple VERTICAL RISERS together at every third floor of a multi-story building. The only purpose of this conductor is to provide potential equalization between VERTICAL RISERS.

ZONE OF PROTECTION The space adjacent to a lightning protection system or other tall structure that is substantially immune to direct lightning flashes.

2

Contents

2. BUILDING GROUNDING ELECTRODE SYSTEMS and GROUND TERMINALS

BUILDING GROUNDING ELECTRODE SYSTEMS and GROUND TERMINALS

2

2.1 FUNCTION of GROUNDING ELECTRODES and GROUND TERMINALS

Grounding Electrodes are systems of conductors (electrodes) which provide electrical contact with the earth. A grounding electrode system is required by the NATIONAL ELECTRICAL CODE 250-81 to provide an electrical connection to earth for certain systems, circuits and equipment. The various conductors that connect directly or indirectly to a grounding electrode system, together with the grounding electrode system, constitute a grounding system.

Ground Terminals are required by the Lightning Protection Code, NATIONAL FIRE PROTECTION CODE 780, to provide a lightning protection system with an electrical connection to earth. The NATIONAL FIRE PROTECTION CODE defines a ground terminal as the portion of a lightning protection system such as a ground rod, ground plate, or ground conductor that is installed for the purpose of providing electrical contact with earth.

The function of grounding electrodes and ground terminals in conjunction with the CENTRAL OFFICE GROUNDING SYSTEM is to conduct surges, and lightning currents to earth to dissipate their energy without creating hazardous voltage gradients within the equipment building or on the earth's surface. This is accomplished by selecting an electrode configuration with the lowest resistance with respect to earth.

When separate grounding electrode systems and ground terminal systems are provided they shall be bonded together to minimize the potential difference between them.

2.2 EARTH RESISTIVITY

The peak earth potential rise at the grounding electrode system, where it enters the earth is directly proportional to the earth resistance. For example, for a twenty-thousand ampere peak lightning current flowing through ten ohms earth resistance, the earth potential rise with respect to remote ground will be two-hundred thousand volts. For five ohms of earth resistance, the peak earth potential rise will be one-hundred thousand volts. The NATIONAL ELECTRICAL CODE recommends that grounding electrodes have a resistance to ground not to exceed twenty-five ohms.

NOTE: Within reasonable economic limitations, the AT&T requirement for a grounding electrode system is a resistance to ground of five ohms or less.

This requirement can be obtained at most locations and should always be strived for, however due to soil resistivity conditions it may not be achievable at all buildings. **FIGURE 1** shows the estimated average earth resistivity for the entire USA. When difficult grounding situations are encountered a cost/benefit, and risk analysis should be performed to determine the appropriate engineering/design direction.

A soil resistivity survey should always be conducted before deciding on the location and final design of the building grounding electrode system. In stratified soil, it might be necessary to drive electrodes to a greater depth before low resistivity soil is encountered. Deeper electrodes also ensure that the system is below the permanent moisture level and is not subject to extreme variations of soil resistivity due to moisture and temperature. However, there is an economic limit to the cost/benefit ratio for long electrodes. Inductance is also directly proportional to the length of the conductor and longer electrodes are not desirable for fast rising currents such as lightning currents. To limit inductance, a larger number of relatively shorter electrodes in parallel are preferable to fewer long ones.

The procedure for measuring earth resistivity consists of measuring the mutual resistance between two pairs of ground electrodes spaced at regular intervals. Since the earth is not homogeneous, in most cases one must employ a series of tests designed according to the specific requirements of the site. The most commonly used method of measuring earth resistance is the *Fall of Potential Method*. This technique consists of applying a potential difference between the point the grounding electrode system enters the earth and a selected remote point. The potential difference causes a current to flow. The voltage drop produced by the current between the grounding electrode system and another selected point is measured. The measured value of earth resistance is the ratio of the voltage drop and the current producing it.

It is important to understand that the calculated or measured value of earth resistance does not represent the actual resistance throughout the year. Resistance will vary with changes in temperature, moisture content, chemical composition of the soil, and presence of buried metal objects. After the grounding electrode system is installed, resistance measurements should be completed at final acceptance and periodically over a long period of time. This is necessary to verify any changes that may have occurred in earth resistance conditions and to determine if the grounding electrode system has deteriorated and needs to be repaired or replaced.

Frequently, it is impossible to make a meaningful measurement of earth resistance, e.g., a metropolitan area with an extensive metal public water piping system. In such situations, it is important to monitor closely the construction of the grounding electrode system to ensure the highest possible quality and to set up a program that enables a review of the condition of the system periodically.

2.3 GROUNDING ELECTRODES

There are four types of grounding electrodes that are commonly used for AT&T buildings These are described in more detail below. The recommended grounding electrode system for AT&T use is the *Driven Ground Electrode System*. If a driven ground electrode system does not meet the five ohm or less standard described in **SECTION 2.2**, a deviation shall be agreed upon by BUILDING ENGINEERING with the support from the DC POWER TECHNICAL SUPPORT GROUP.

All metallic objects buried near the building that may act as unintentional electrodes shall be bonded together to limit potential differences between them.

It should be noted that a loss of efficiency is experienced when grounding rods are placed too close to each other. An optimum separation for an eight-foot rod is from ten to fifteen feet.

2.3.1 DRIVEN GROUND ELECTRODE SYSTEM

This is the preferred ground electrode system for AT&T equipment buildings and shall be utilized for all new construction, additions and retrofits.

A driven ground electrode system consists of a number of metallic rods driven vertically in the earth and bonded together by a closed horizontal conductor referred to as the ground ring. The ring conductor is a NO. 2 AWG solid, tinned, bare copper wire that completely encircles the building at a depth of at least thirty inches below grade or below frost depth (whichever is deeper). The ring conductor should be approximately twenty-four inches from the exterior wall. The driven rods shall be a minimum of eight feet long, 5/8 inch diameter, stainless steel or copper clad, and spaced at not less than ten feet or more than fifteen feet apart around the ring. The copper ring ground conductor shall be bonded to the top of each rod by means of exothermic welds.

The rods shall be driven by hand sledging, slide hammer, or power drivers to the ring wire depth, utilizing a grounding rod driving shield, such as manufactured by Erico Products™ to prevent mushrooming of the tops of the rods.

Where grounding 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 forty-five degrees. The depth of rod penetration is important, and the rod should penetrate to a depth of permanent ground moisture for the most effective earth connection.

Rods are to be driven into undisturbed earth or into thoroughly tamped or compacted fill areas. Rods and cables should be placed in the backfill around the foundation, only after the soil has been compacted or has had adequate time to settle. Do not drive or lay rods in gravel beds which have been installed for drainage purposes unless the rods extend through such beds far enough to provide at least eight feet of contact with the undisturbed earth underneath.

Before back filling the grounding electrode system with earth, a visual check shall be made of all joints and connections by an AT&T representative. This will:

- Ensure mechanical and electrical integrity.
- Verify the absence of voids or other indications of poor exothermic bonding.
- Verify that all required interconnections have been properly made.

A visual verification and electrical continuity check should be made at this time to ensure that all connections are intact. A written record of this check with photos shall be placed in the office records for future reference.

After covering and compacting is completed an earth resistivity measurement shall be made on the exterior ring system prior to connection to the building grounding system. The reading shall be five ohms or less per the requirement in **SECTION 2.2**. The readings obtained will be included in the office records for future reference.

In larger buildings (greater than two-thousand four-hundred square feet), a minimum of two connections from the driven ground system shall be provided from opposite sides of the building to the OFFICE PRINCIPAL GROUND POINT (see **FIGURE 2**). An exception to this is when an interior ring ground system is utilized inside smaller buildings, such as radio huts, regenerator huts and small POPS. When an interior ring ground system is installed, the interior ring shall be bonded to the exterior driven ground system in the four corners of the building, as well as a direct connection from the OFFICE PRINCIPAL GROUND POINT busbar (see **FIGURE 3**). Connection to the OFFICE PRINCIPAL GROUND POINT shall be exothermically welded directly to the ground bar or by utilizing a double-bolt, thermo-weld connector. If stranded wire is used, install a compression two-bolt tongue lug. If solid wire is used, use the exothermic welding process.

2.3.2 METALLIC WATER PIPE ELECTRODE

A metallic water piping system (forty foot minimum), mechanically and electrically continuous buried in the earth is an excellent grounding electrode. In past years a water pipe ground electrode would have been the preferred grounding electrode for a building, however due to the recent practice of replacing metallic pipe with plastic, it can no longer be depended upon as an acceptable grounding electrode. Although the metallic water pipe is no longer the preferred grounding electrode it should always be used as a supplementary electrode and bonded to the OFFICE PRINCIPAL GROUND POINT. A bonding jumper is always required across the water meter, and also shall bond across unions and valves associated with the water meter. If the water company pipe to the meter is non-metallic, the bonding jumper is not required.

2.3.3 METALLIC WELL CASING ELECTRODE

A metallic well casing (forty foot minimum), if available on site, is an excellent supplementary electrode, but should not be used as the preferred grounding electrode except in situations where a driven ground electrode system cannot be installed. The well need not be functional as a water supply to serve as a grounding electrode. If a well casing is used as a supplemental grounding electrode it shall terminate at the OFFICE PRINCIPAL GROUND POINT utilizing an exothermic two-bolt tongue connector or via a direct thermoweld connection to the OFFICE PRINCIPAL GROUND POINT ground bar. The connection to the well casing shall be by exothermic weld.

2.3.4 COUNTERPOISE GROUNDING ELECTRODE

When grounding rods cannot be driven, because of bedrock at less than four feet below grade level, a counterpoise-grounding electrode may be used. The normal building driven ring ground system should be installed utilizing shortened rods or angle driven rods. When this condition exists, a counterpoise system should be installed. Counterpoise systems consist of NO. 2 AWG UN-insulated tinned solid copper wires buried to a depth of at least thirty inches below grade radiating from the driven ring ground at four opposing corners of the building. Each wire shall be run in a straight line, to the edge of the owned property or for a maximum length of two-hundred feet whichever is lesser. It shall not be less than twenty-five feet long.

Although the counterpoise system may not be as effective as a properly installed driven rod system in producing a low earth resistance, it dissipates lightning current effectively. The counterpoise system may be used as a supplementary electrode when the driven ground system does not meet the AT&T five ohm requirement.

2.4 BUILDING STRUCTURAL GROUNDING SYSTEMS

Since there are a large variety of construction methods, a ground system must be designed to fit the unique requirements of the individual building. Shown below and in the related FIGURES are two examples of how building structural grounding may be accomplished. **FIGURE 4** & **FIGURE 5** illustrate recommended methods of establishing a ground field for the following types of buildings:

- Buildings having electrical continuity through columns via structural steel, welded or wire wrapped reinforcing bars (see **FIGURE 4**).

- Buildings not having reliable continuity through either building steel or reinforcing bars (see **FIGURE 5**).

2.4.1 LARGER BUILDINGS with BASEMENTS and STRUCTURAL STEEL CONTINUITY

FIGURE 4 illustrates a recommended under slab grounding system for a building with electrical continuity through vertical column steel and horizontal building steel. Such continuity may consist of steel sections riveted, bolted or welded to form vertical and horizontal paths or may be reinforcing bars welded or wire wrapped to form continuity. The purpose of this requirement is to ensure a conductive path to earth for lightning currents while eliminating points of high impedance or discontinuity between charged and grounded conductors which might result in a side flash or an explosion within concrete structural members. This grounding system consists of grounding rods at every column footing connected together with NO. 2 AWG bare, tinned, copper wire and connected back to the OFFICE PRINCIPAL GROUND POINT bar.

.

2.4.2 LARGER BUILDINGS with BASEMENTS and without STRUCTURAL STEEL CONTINUITY

FIGURE 5 illustrates a typical configuration recommended for use in buildings that do not have continuity through vertical columns or structural steel. The ground field driven rods and conductors are run in proximity of the column footings (within two feet) but are not bonded. The system is identical to the system described in **Paragraph 2.4.1** except that the ground conductors are not bonded to the structural steel. The under slab ground system must be connected to the OFFICE PRINCIPAL GROUND POINT along with all other grounding electrode systems.

2.4.3 SMALL or MEDIUM SIZED, SINGLE STORY BUILDINGS without BASEMENTS

These buildings can house ESS equipment, Microwave Radio Equipment, Lightguide repeaters and similar equipment. Small and medium sized Point of Presence (POP) buildings are included. For these buildings, an exterior buried driven grounding system shall be employed as the building ground field and will not require a separate grounding system under the slab.

2.5 BUILDING ADDITIONS

When building additions are provided for an existing building the following applies:

- The exterior driven ring ground system must be extended to include the building addition in one continuous ring and bonded to the OFFICE PRINCIPAL GROUND POINT.
- If a separate water supply is provided for the addition, they must be bonded to the OFFICE PRINCIPAL GROUND POINT.
- If additional lightning protection systems are installed it must be bonded to the existing system and include additional downleads to the driven electrode system.
- If a separate AC service is installed it must be bonded to the OFFICE PRINCIPAL GROUND POINT.

2.6 GROUNDING CONDUCTOR INSTALLATION and IDENTIFICATION

All above ground interior conductors shall be green insulated copper stranded, terminated with circumferential crimp connectors equipped with two-bolt tongues. Buried grounding conductors shall be NO. 2 AWG solid, tinned copper and terminated by exothermic weld or exothermic two-bolt tongue connectors. All bolted conductors must be clearly labeled to identify their function, the opposite end terminating point and equipped with DO NOT DISCONNECT tags.

3

Contents

3. BUILDING LIGHTNING PROTECTION SYSTEMS

BUILDING LIGHTNING PROTECTION SYSTEMS

3

3.1 GENERAL

Lightning is an electrical discharge from cloud to cloud or between cloud and earth. Cloud to cloud discharges are by far the more numerous but are of a minor concern. Lightning strokes to ground are much fewer but are the greatest source of concern for personnel and plant protection. Lightning occurs in practically all parts of the United States but the yearly incidence of thunderstorms and relative intensity varies greatly with location. It must be assumed, therefore that buildings will be exposed to the damaging effects of lightning to varying degrees. In rural areas, the exposure will be greater than in urban areas because little benefit can be expected from the shielding effect provided by other grounded structures. Buildings located in cities and other built-up areas benefit from the presence of high structures that intercept strokes, and from shielding provided by other grounded conducting media.

Thunderstorms are of two general types:

a) Convection storms, which are local in extent and of relatively short duration.

b) Frontal storms, which extend over greater areas and may continue for several hours.

Convection type thunderstorms account for the majority of annual thunderstorm days in the United States. Studies have shown that a frontal type storm will cause appreciable more damage than a convection type storm. These and other factors indicated below must be considered when considering the application of a lightning protection system to a new or existing building.

For the purposes of this practice, lightning protection is defined as a system comprised of air terminals, associated down leads, interconnecting conductors and a building ground terminal (ground electrode field). The lightning protection techniques described in this practice are based on the LIGHTNING PROTECTION CODE, NATIONAL FIRE PROTECTION CODE 780. Some of the requirements in this practice exceed the LIGHTNING PROTECTION CODE requirements to provide a higher level of reliability.

Related industry standards:

- NATIONAL ELECTRICAL CODE (NEC, NFPA70)
- NATIONAL FIRE PROTECTION CODE (NFPA 780)
- INSTITUTE of ELECTRICAL AND ELECTRONIC ENGINEERS (IEEE 142-1191)
- UNDERWRITERS LABORATORIES INSTALLATION REQUIREMENTS (UL 96A)
- LIGHTNING PROTECTION INSTITUTE INSTALLATION STANDARD, LPI 175

3.2 WHEN is a LIGHTNING PROTECTION SYSTEM REQUIRED?

Whether a building should be provided with a lightning protection system or not depends on the probability of lightning striking that building. This probability varies with the geographic location of the building as well as the height and location of the building with respect to other structures. Below are processes and recommendations for the engineer to assist in making the correct decision on the provisioning of a lightning protection system.

3.2.1 NEW CONSTRUCTION

The guidelines below apply only to new construction. When a lightning protection system is being considered for an existing building, refer to **SECTION 3.2.2**.

It’s important to remember that lightning cannot be prevented; it can only be intercepted or diverted to a path that will, if well designed and constructed not result in damage. Once a decision is made to provide a lightning protection system it is important to note that any compromises to the system design and installation quality can result in a situation that may put the building in greater risk of lightning damage than not having the system installed at all.

A building is considered as *lightning exposed* when either of the following conditions are met:

- Thunderstorm activity for the area exceeds twenty *thunderstorm* days per year and the building is not within the ***Zone of Protection*** of other structures.

  NOTE: A *thunderstorm* day is defined as any day during which thunder is heard at a specific observation point. The number of *thunderstorm* days are shown on the Isoceraunic map of the United States and Canada in **FIGURE 6**.

- The building is located at an elevation significantly above the average elevation of the surrounding terrain such as on hilltops and not within the zone of protection of other structures and the *thunderstorm* days are ten or more.

  NOTE: A ***Zone of Protection*** *is a space protected by taller structures so as to be essentially free from being struck by a direct lightning flash. For a detailed definition and explanation of the term* ***Zone of Protection*** *see NATIONAL FIRE PROTECTION CODE 780, SECTION 3-10*

  NOTE: The lightning risk assessment guide in NATIONAL FIRE PROTECTION CODE 780, APPENDIX I may also be utilized as an additional tool when evaluating a buildings lightning vulnerability.

3.2.2 RETROFITS to EXISTING BUILDINGS

The use of air terminals on a building or structure may increase the frequency of lightning stokes at that specific location. Retrofitting of a lightning protection system to an existing building should be given very careful evaluation and only considered where documented lightning damage has occurred. Currently the industry standards and codes listed in **SECTION 3.1** do not require a lightning protection system to be installed. When it is determined that an existing building would benefit from a lightning protection system it shall be installed per the standards and guidelines herein.

3.3 ELEMENTS of a LIGHTNING PROTECTION SYSTEM

The major elements of a lightning protection system are air terminals, down and equalization conductors, and ground terminals. Lightning protection system engineering and installation requirements are detailed below.

3.3.1 AIR TERMINALS

These are devices located at specified positions on a building that are likely to be damaged by lightning, primarily its roof, to intercept a lightning stroke. For structure and dimensions of air terminals and the number and spacing required, refer to NATIONAL FIRE PROTECTION CODE 780. Air terminals are connected together with a main bonding conductor that shall provide a two-way path to ground.

3.3.2 DOWN (or MAIN) CONDUCTORS

These are stranded copper lightning protection conductors that provide a path for lightning currents down the exterior sides of a building. It is very important that they be as symmetrically arranged as practical to provide a shielding effect. Therefore, no less than two down conductors shall be used on any building. Several conductors in parallel and spaced apart have a lower inductance than a single conductor of the same size. The total number of down conductors on structures having flat or gently sloping roofs shall be such that the average distance between all down conductors does not exceed one-hundred feet. Irregular shaped structures may require additional down conductors in order to provide a two-way path for each air terminal.

Caution: ***Down conductors shall always be installed on the exterior of building walls.***

3.3.3 GROUND TERMINALS (DRIVEN GROUND ELECTRODE SYSTEM)

Down lead connections to ground rods and all connections between ground rods shall be exothermically welded. The buried ground terminals shall consist of copper clad or stainless steel ground rods a minimum of eight feet long. They shall be interconnected by NO. 2 AWG solid, tinned copper conductors that are exothermically welded to the tops of the ground rods. Ground terminals (driven ground electrode system) shall be designed and installed per requirements in **SECTION 2** of this practice.

3.4 MATERIAL and INSTALLATION REQUIREMENTS

All conductors, air terminals, and connecting material shall be copper and in compliance with NATIONAL FIRE PROTECTION CODE 780 requirements.

The lightning protection system installer shall be certified by the Lightning Protection Institute as a Master Installer/Designer.

Provide all necessary UL approved inspections to provide a UL Master Label System.

All connections in the lightning protection system shall be exothermically welded, or utilize exothermic two-bolt tongue lugs.

The lightning protection system should incorporate potential equalization connections at grade level, and at the roof level for buildings more than sixty feet in height. For buildings more than sixty feet high, intermediate equalization connectors shall be provided per NATIONAL FIRE PROTECTION CODE 780.

Down leads shall always be run on the exterior of the building.

All metallic objects on the roof shall be bonded to the roof mounted equalization loop.

Sharp bends of conductors must be avoided in the lightning protection system. No bend of a conductor shall have an included angle of less than ninety degrees, nor shall it have a bending radius less than eight inches.

Metallic material encircling grounding conductors shall not be permitted. If a grounding conductor is required to pass through a metallic conduit for mechanical protection, the encircled conductor shall be bonded to the encircling metallic material at points where it enters and where it exits the encircling metallic material.

The lightning protection system ground terminal (ground field) shall be bonded to the building exterior ring ground system and the OFFICE PRINCIPAL GROUND POINT bus bar. The connection to the OFFICE PRINCIPAL GROUND POINT shall be clearly labeled and be equipped with a DO NOT DISCONNECT tag.

4

Contents

4. AC POWER EQUIPMENT GROUNDING and SURGE PROTECTION

AC POWER DISTRIBUTION GROUNDING and SURGE PROTECTION

4

4.1 GENERAL

This section provides equipment requirements and engineering information pertaining to the provision of effective equipment grounding in the building AC distribution system. It defines the function of the AC service neutral conductor and the method of providing ground reference to the neutral, AC distribution transformers and the AC distribution system.

AC service and AC distribution grounding shall meet the following general requirements:

- AC conduits shall be electrically continuous, tightly assembled and free of insulated coupling and air gaps.
- All AC wiring shall meet or exceed NATIONAL ELECTRICAL CODE requirements.
- All connectors shall be of the circumferential compression crimp type with a two-bolt tongue. No mechanical *screw type* connectors are allowed.
- All equipment-grounding conductors shall be green insulated, stranded copper wires.
- All mounting hardware must be properly installed and tightened.
- An AC EQUIPMENT GROUND conductor shall be provided for all AC circuits per requirements in NATIONAL ELECTRICAL CODE SECTION 250-95.

- Neutral conductors and neutral buses shall be insulated from contact with the FRAMEWORK GROUND.

4.2 AC SERVICE GROUNDING REQUIREMENTS

AC service distribution systems in buildings housing telecommunications equipment utilize solid grounded or high resistance grounded systems as described below. The basic characteristic of a grounded system is that the AC secondary network is equipped with a grounding conductor that provides a low impedance bond from the AC neutral conductor to the OFFICE PRINCIPAL GROUND POINT.

The conductor provided for grounding the AC service system is defined in the NATIONAL ELECTRICAL CODE, ARTICLE 100 as follows:

Grounding Electrode Conductor The conductor used to connect the grounding electrode to the equipment ground conductor and /or to the grounded conductor of the circuit at the service entrance. This conductor is also sometimes referred to as the *AC Service Grounding Conductor*, the *Main Grounding Conductor*, the *Common Main Grounding Conductor* and the *Grounded Neutral Conductor*. In this practice, it will be referred to as the *Grounding Electrode Conductor.*

It MUST be understood that a neutral is not a common grounding conductor. It is a single point grounded current carrying circuit conductor. It is imperative that the single point grounding concept not be violated so that AC current is confined solely to the neutral conductor. In order to maintain the single point grounding concept, neutral bus bars installed in AC distribution boards and cabinets must be insulated from FRAMEWORK GROUND. Special care must be exercised during installation to ensure that an inadvertent connection between the neutral and grounded metal does not occur at any point on the load side of the service disconnect equipment. The neutral shall never be used as a source of ground for the purpose of providing equipment grounding for any equipment, except as specified by the NATIONAL ELECTRICAL CODE ARTICLE 250-61.

4.2.1 SOLIDLY GROUNDED NEUTRAL

Where the utility source is fifteen kilo-volt or less and the power transformers are owned by the utility, the main distribution system shall be solidly grounded.

4.2.2 HIGH RESISTANCE GROUNDED NEUTRAL

Where the supply source is four-thousand one-hundred sixty volts or fifteen kilo-volt and the power transformers are owned by AT&T the main distribution system shall be high resistance grounded to limit the available ground-fault current while still allowing coordination of protective devices.

Caution: This type of grounding system is not recommended and should be avoided where possible, as it requires specialized training to handle and presents a hazard to personnel. A deviation should be requested and approved by* BUILDING ENGINEERING *and the* AC POWER TECHNICAL SERVICES GROUP *prior to designing such a system.

4.2.3 NEUTRAL GROUNDING ENGINEERING REQUIREMENTS

The AC service grounding electrode conductor connects (bonds) the neutral of the secondary distribution system directly to the OFFICE PRINCIPAL GROUND POINT, or to a ground electrode provided for AC service grounding. When the service ground electrode is other than that used for equipment grounding of communications equipment, the electrodes must be bonded together to form a single electrode system. The circuit shall be terminated at the OFFICE PRINCIPAL GROUND POINT utilizing a circumferential crimp two-bolt tongue lug and clearly labeled with its function and equipped with a DO NOT DISCONNECT tag.

The grounding electrode conductor shall be a stranded green insulated copper conductor sized in accordance with NATIONAL ELECTRICAL CODE ARTICLE 250-94. It shall be run as direct as practical with a minimum of bends and no sharp bends. The conductor may be run open and visible for inspection for its entire length or run in non-metallic conduit. It should not be routed through metal that forms a ring or in metallic conduit. Where run through walls, partitions, etc., the conductor should be routed through non-metallic sleeves. It shall be routed so that no ferrous metal encircles the cable or conduit for its entire length. If it is unavoidable and the conductor must be run through metallic conduit, sleeves, or enclosures; both ends of the conduits, sleeves or enclosures must be bonded to the cable where it enters and exits.

The grounding electrode conductor, at the point of connection to the neutral, must also be bonded to the frame of the enclosure in which the service bond is made.

4.3 DISTRIBUTION TRANSFORMER GROUNDING REQUIREMENTS

Step-down transformers are included in the AC distribution system when a voltage other than the two utilization voltages supplied by the service transformer are required to power loads. Typical loads of this type are those requiring one-hundred twenty volts in buildings served with a 277/480 volt AC system. Generally, the distribution circuit powered by the transformer secondary winding must have a grounded neutral conductor (X-0 lead) as specified in NATIONAL ELECTRICAL CODE ARTICLE 200-2. Certain exceptions are listed under Exception 1.

A grounding electrode conductor shall be provided from the nearest CENTRAL OFFICE GROUND Bus on the floor and connected to the neutral point of the transformer between the transformer and the output disconnect means. A bond shall be provided between the neutral and raceway or transformer case or other metal that is part of the AC equipment grounding system, so as to complete a circuit for fault current to the transformer winding from the AC equipment grounding system. The size of the grounding conductor shall be as specified in NATIONAL ELECTRICAL CODE ARTICLE 250-94(a).

The grounding conductor shall be a stranded copper; green insulated conductor and connected with circumferential crimp type two-bolt tongue connectors. The circuit shall be clearly labeled as to its function, far end terminating point and equipped with a DO NOT DISCONNECT tag.

4.4 STANDBY AC ENGINE ALTERNATOR GROUNDING REQUIREMENTS

AC engine alternator systems provided to supply standby AC power in the case of commercial AC failure are controlled through an automatic switching means, referred to as an AUTOMATIC TRANSFER SWITCH (ATS), so that the standby engine alternator output is not connected to the commercial source. The neutral conductor of the standby AC source should be permanently grounded only to the neutral at the commercial source and is carried UN-switched though the standby switching device. The grounding electrode conductor of the commercial service system, therefore, suffices as a single point ground reference for both the standby and commercial AC systems. An exception to this arrangement is when the standby engine alternator is located in a separate building having its own ground electrode system. In this case, the standby AC system neutral shall also be connected to that ground electrode system and the transfer switch shall utilize a four pole overlapping design. Any variation from the above requirements will require approval by the BUILDING ENGINEER and the AC TECHNICAL SERVICES GROUP.

The standby engine alternator always requires an AC EQUIPMENT GROUND in the conduits that contain the phase conductors from the alternator. In addition, the engine alternator set framework or chassis shall have a connection to the CENTRAL OFFICE GROUND System. If the engine alternator is located remotely, outside of the building or on the roof, it shall have a connection to the exterior grounding system.

The following equipment associated with the standby AC plant shall also be bonded to the CENTRAL OFFICE GROUND system utilizing a NO. 6 AWG (minimum) stranded, green insulated conductor:

- All exterior engine equipment containing metallic objects (louvers, vents, etc.).
- Engine control cabinet.

- Fuel piping system.
- Metallic fuel tanks (main and day).
- Radiator (if mounted separately from the engine frame).
- Start battery rectifier.
- Start battery stand.

4.5 AC EQUIPMENT GROUNDING

This section covers the requirements for the provisioning of an AC EQUIPMENT GROUND conductor in metallic raceways of AC distribution systems and procedures to ensure proper grounding of equipment and raceways. It does not cover the installation of raceways, which shall be installed in accordance with NATIONAL ELECTRICAL CODE ARTICLE 250 and local code requirements.

The main purposes of the AC EQUIPMENT GROUND are:

- To assist in the reduction of noise in communications circuits by provision of a low impedance grounded shield throughout the AC service system.
- To maintain low potential between cabinets, conduits and other metallic enclosures of the AC service system and nearby metallic members, so as to minimize possibility of electrical shock hazard.
- To produce an adequate conductive path for current flow in ground faults, to cause over-current devices to interrupt current quickly, thereby minimizing fire hazard and equipment damage.

An AC EQUIPMENT GROUND conductor *green insulated* shall be enclosed in the same raceway with phase conductors in accordance with NATIONAL ELECTRICAL CODE requirements (TABLE 250-95). The AC EQUIPMENT GROUND conductor shall be provided for all circuits distributing AC power from a commercial AC or standby AC power source. An AC EQUIPMENT GROUND BUS, bonded to the cabinet framework, shall be provided in all house service boards, power service cabinets, lighting distribution cabinets, and other units that may be employed as a distribution point for AC service circuits. Neutral conductors shall never be connected to the AC EQUIPMENT GROUND BUS.

AC EQUIPMENT GROUND conductors shall never be connected to the AC neutral termination point in any AC distribution equipment cabinet or enclosure.

AC distribution conductors in communication buildings should always be run in grounded metallic raceways. The use of non-metallic raceways for AC distribution is prohibited, except for short runs due to vibration isolation or reasons of physical limitations. Raceways must be electrically continuous between enclosures and distribution equipment. Raceway continuity shall be maintained by means of conduit fittings, grounding straps or other raceway components designed specifically to provide such continuity.

4.6 AC POWER SURGE PROTECTION SURGE ARRESTORS

At buildings where bonding and grounding have been provided as recommended in this practice, the possibility of damage to station equipment from lightning strokes to antennas, supporting structures or the building is minimal, however equipment powered from external power facilities is susceptible to damage from over-voltage surges originating on such facilities. It is reasonable to expect that voltage spikes and surges generated by Power Company switching activities or lightning will be impressed on the AC system at least several times a year. Because of this, surge protection devices are required at the AC power service entrance facility of all AT&T buildings. These devices are designed to limit abnormal surge and transient voltages on AC power circuits by discharging surge currents, which may be induced on a phase conductor, to ground.

Distribution-class surge protection devices shall be connected to each overhead or underground primary distribution feeder (or service entrance conductor) on the utility side of the service entrance equipment. The surge protection device shall be installed not less than twenty-four inches (cable length) from the bus connection point. The leads from the bus connection to the device shall be laced together and all leads shall be run as straight as possible with a minimum bending radius of eight inches and a maximum lead length of twenty-four inches.

In order to facilitate testing and maintenance, the surge protection device shall have the capability of being safely disconnected from the energized bus.

Refer to **FIGURE 7** for a drawing of a typical lightning protection installation.

Each surge protection device shall have visible and audible status and alarm indications to indicate its condition. When the device is installed inside an equipment enclosure, it shall be equipped with a remote visual status and alarm indicator.

All surge protection devices shall conform to the requirements of and be suitable for application in accordance with ANSI C62.11, NATIONAL ELECTRICAL CODE ARTICLE 280, and AT&T PRACTICE 760-400-101.

Any electrical circuits that enter or exit the building shall have surge protection devices installed where they pass through the exterior wall.

5

Contents

5. DC POWER EQUIPMENT GROUNDING

DC POWER EQUIPMENT GROUNDING

5

This section covers equipment requirements and engineering information pertaining to the interconnections between the CENTRAL OFFICE GROUND system and DC POWER SYSTEMS.

DC power plants are generally configured to support telecommunication systems in either the INTEGRATED GROUND PLANE, or the ISOLATED GROUND PLANE. DC plants can be configured to support both the INTEGRATED and ISOLATED GROUND PLANE if certain grounding rules are followed. Following are the grounding system design guidelines to accomplish multiple DC plant configurations.

5.1 ISOLATED GROUND PLANE DC POWER ENGINEERING RULES

ISOLATED GROUND PLANES are generally required for Stored Program Control (Electronic) Switching Systems, such as, 4ESS, 5ESS, NCP, STP, and other ESS based systems. This is required due to the sensitivity of this equipment to external electrical noise, voltage spikes, and transients that can be generated from the following:

- External power faults.
- Filters that are connected from line to ground.
- Improper load connections.

- Internal and external shorts or faults.
- Lightning strikes.
- Multi-grounded AC or DC power sources.
- Power switching.

An ISOLATED GROUND PLANE is a set of interconnected equipment frames that are referenced to ground at only one point. This plane, taken as a conductive unit with all of its metallic (conducting) surfaces and grounding wires bonded together, is insulated from contact with any other grounded metalwork in the building except at the MAIN GROUND BUSBAR within the ESS GROUND WINDOW. During external fault occurrences in the AC or DC power systems or when lightning currents flow in the building, none of these currents can flow in the ISOLATED GROUND PLANE because of the single point connection to ground. **FIGURE 8** illustrates an ISOLATED GROUND PLANE in its simplest form.

POWER PLANT GROUND REFERENCE:

A DC power plant supporting an ISOLATED GROUND PLANE area shall obtain its ground reference from the nearest ESS GROUND WINDOW. This DC Reference Ground Conductor shall be run from the MAIN GROUND BUSBAR in the ESS GROUND WINDOW and terminate at the DC plant battery discharge return *chandelier bar* located above the battery stand. The cable shall be a 750 kcmil green insulated conductor. The Ground Conductor shall run outside of the cable racks, be visible its entire length and terminate utilizing circumferential crimp two-bolt tongue connectors. Both ends of the cable shall be equipped with permanent identification tags indicating its function and far end terminating point and equipped with a DO NOT DISCONNECT tag.

POWER PLANT FRAMEWORK GROUNDING:

The POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR, used for the grounding of the DC power plant equipment and framework, shall extend from the nearest CENTRAL OFFICE GROUND bar and extend down the entire power plant line-up(Refer to **FIGURE 14**). The size shall be calculated based on the largest overcurrent protection device in the power plant distribution board and the distance to the CO GROUND BUSBAR, using the calculator in **section 1.4** with minimum size of NO. 2 AWG. The cable shall be a green insulated conductor. The POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR shall terminate at the nearest CO GROUND BUSBAR utilizing circumferential crimp two-bolt tongue connectors and shall be equipped with permanent identification tags indicating its function and far end terminating point and equipped with a DO NOT DISCONNECT tag.

Equipment framework grounding conductors shall be tapped onto the POWER PLANT FRAMEWORK GROUNDIND CONDUCTOR.

The following application rules apply to DC power plants supporting an ISOLATED GROUND PLANE area:

- All framework grounding conductors for CONTROL and DC DISTRIBUTION BAYS shall utilize a conductor of the same size as the POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR.(Minimum NO. 2 AWG.)
- Framework grounding conductors for RECTIFIERS BAYS shall be sized as follows:
  - 200 amp RECTIFIERS shall be NO. 4 AWG.
  - 400 amp RECTIFIERS shall be NO. 2 AWG.
  - RECTIFLIERS FRAMES equipped with multiple RECTIFLIERS shall be NO. 2 AWG.
- Framework grounding conductors for AC DISTRIBUTION BAYS shall be NO. 2 AWG.
- Battery stand or earthquake bracing grounding conductors shall be a NO. 2 AWG and shall bond to the POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR or may be run directly to the nearest CENTRAL OFFICE GROUND bar, whichever is closer.
- All framework grounding conductors shall be a green insulated stranded copper(unless specified otherwise in the system requirements) terminated on both ends with a circumferential crimp two-bolt tongue connector with permanent identification tags indicating its function and far end terminating point. All connections to a CO GROUND BAR shall be equipment with DO NOT DISCONNECT TAGS.

CABLING REQUIRMENTS:

- Battery and return conductors shall be paired in the cable racks to minimize the field effect on adjacent cables. Minor offsets are allowed for power distribution cabinet entry, or for bonding to the MAIN GROUND BUSBAR, etc., unless system requirements dictate otherwise.
- Battery return busses in DC POWER DISTRIBUTION FRAMES(PDF) shall NOT be connected to CENTRAL OFFICE GROUND.
- Battery return conductors shall be isolated from contact with any grounded framework, or object except at the single point grounding interface at the ESS GROUND WINDOW, MAIN GROUND BUSBAR.
- When the ESS GROUND WINDOW is located in the electronic switching system area, there is no restriction on where the DC power plant must be located however, in order to reduce the complexity and cost of cabling, the plant shall always be located as close as possible to the equipment that it is supporting.
- When the power plant discharge ground bus is being used as the ESS GROUND WINDOW, MAIN GROUND BUSBAR the power plant shall be located within one floor of the electronic switching machine.

5.1.1 MULTIPLE ELECTRONIC SWITCHES SERVED by ONE DC PLANT

More than one electronic switch may be served from one DC power plant, if allowed by the system engineering parameters. The following restrictions apply when this situation exists:

- Electronic switches sharing a common power plant shall be located within one floor of the common ground window.
- Secondary Power Distribution Frames (PDF) shall be dedicated to serve only one electronic switch.
- The switches that share a common DC plant must also share a common ground window. It is preferred that the ground window be located in the power plant area.

5.1.2 DC PLANTS SUPPORTING ISOLATED and INTEGRATED GROUND PLANES

When a DC plant serving an ISOLATED GROUND PLANE area is also used to support an INTEGRATED GROUND PLANE area the following engineering rules apply:

- A common ESS GROUND WINDOW must be established (MAIN GROUND BUSBAR).
- DC battery return conductors must be routed through and bonded to the MAIN GROUND BUSBAR located in the ESS GROUND WINDOW. Due to logistical cabling problems and the cost of cabling, this should only be done when the ground window is located in the power plant area.
- The DC power distribution frames located in the equipment areas shall be dedicated to serve either the equipment in the ISOLATED or INTEGRATED PLANE but not both.

5.1.3 POWER PLANT LOCATION

For maximum protection of personnel and power equipment from lightning surges, the ideal location of the power plant equipment is as close as practical to the ESS equipment and the ground window, preferably on the same floor. In existing buildings, space restrictions or floor loading limits may require location of the power plant several floors away from the ground window. The power plant batteries and discharge ground components obtain their voltage reference from the ISOLATED GROUND PLANE ground window and the power plant framework is part of the INTEGRATED GROUND PLANE. This could result in momentary high voltage differential between active power distribution components and metal framework, relative to the distance between floors. For this reason every effort should be made to locate the power plant as close as possible to the ESS equipment and the ground window.

5.2 INTEGRATED GROUND PLANE DC POWER ENGINEERING RULES

POWER PLANT GROUND REFERENCE:

A DC power plant supporting an INTEGRATED GROUND PLANE area shall obtain its ground reference from the nearest CENTRAL OFFICE GROUND bar. This DC Reference Ground Conductor shall be run from the CENTRAL OFFICE GROUND bar and terminate at the DC plant battery discharge return *chandelier bar* located above the battery stand. The cable shall be a 750 kcmil green insulated conductor, when the battery plant is 1200 amps or larger. When the plant is less than 1200 amp, the conductor shall be calculated using the calculator in **section 1.4** with minimum size of NO. 2/0 AWG. The DC Reference Ground Conductor shall run outside of cable racks, be visible its entire length and terminate utilizing circumferential crimp two-bolt tongue connectors. Both ends of the cable shall be equipped with permanent identification tags indicating its function and far end terminating point and equipped with a DO NOT DISCONNECT tag.

POWER PLANT FRAMEWORK GROUNDING:

The POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR, used for the grounding of the DC power plant equipment and framework, shall extend from the nearest CENTRAL OFFICE GROUND bar and extend down the entire power plant line-up(Refer to **FIGURE 14**). The size shall be calculated based on the largest overcurrent protection device in the power plant distribution board and the distance to the nearest CO GROUND BUSBAR, using the calculator in **section 1.4** with minimum size of NO. 2 AWG. The cable shall be a green insulated conductor. The POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR shall terminate at the nearest CO GROUND BUSBAR utilizing circumferential crimp two-bolt tongue connectors and shall be equipped with permanent identification tags indicating its function and far end terminating point and equipped with a DO NOT DISCONNECT tag.

Equipment framework grounding conductors shall be tapped onto the POWER PLANT FRAMEWORK GROUNDIND CONDUCTOR.

The following application rules apply to DC power plants supporting an INTEGRATED GROUND PLANE area:

- All framework grounding conductors for CONTROL and DC DISTRIBUTION BAYS shall utilize a conductor of the same size as the POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR.(Minimum NO. 2 AWG.)
- Framework grounding conductors for RECTIFIERS BAYS shall be sized as follows:
  - 200 amp RECTIFIERS shall be NO. 4 AWG.
  - 400 amp RECTIFIERS shall be NO. 2 AWG.
  - RECTIFIERS FRAMES equipped with multiple RECTIFIERS shall be NO. 2 AWG.
- Framework grounding conductors for AC DISTRIBUTION BAYS shall be NO. 2 AWG.
- Battery stand or earthquake bracing grounding conductors shall be a NO. 2 AWG and shall bond to the POWER PLANT FRAMEWORK MAIN GROUNDING CONDUCTOR or may be run directly to the nearest CENTRAL OFFICE GROUND bar, whichever is closer.
- All framework grounding conductors shall be a green insulated stranded copper terminated on both ends with a circumferential crimp two-bolt tongue connector with permanent identification tags indicating its function and far end terminating point. All connections to a CO GROUND BAR shall be equipment with DO NOT DISCONNECT TAGS.

CABLING REQUIREMENTS:

- Battery and return conductors shall be paired in the cable racks to minimize the field effect on adjacent cables. Minor offsets are allowed for power distribution cabinet entry, etc., unless system requirements dictate otherwise.
- Battery return busses in Battery Distribution Fuse Bays (BDFB) and battery return splice plates external to the BDFB shall NOT be connected to CENTRAL OFFICE GROUND. The ground reference for these bays is derived at the power plant ground discharge bar.
- Battery return conductors shall be isolated from contact with any grounded framework, or object except at the single point grounding interface at the CENTRAL OFFICE GROUND Bar.

6

Contents

6. CENTRAL OFFICE INTEGRATED GROUND SYSTEM

CENTRAL OFFICE INTEGRATED GROUND SYSTEM

6

When equipment grounding is combined with circuit, system, and building grounding and is achieved by two or more connections to the grounding distribution system at different locations, the resultant system is termed an INTEGRATED grounding system. The term INTEGRATED in this usage refers to the fact that there is no attempt to separate or isolate, building ground from equipment framework and system grounding, therefore it is referred to as INTEGRATED. This type of grounding system tends to minimize the potential difference between energized conductors and associated-grounded metal work when currents flow between them, thus minimizing the risk of arching due to flashover in case of lightning.

NOTE: In an Integrated ground system the DC Battery Return is always isolated from_the framework or equipment ground.

An INTEGRATED grounding system is designed to address the following conditions:

- Coupling of conducted or radiated noise
- Lack of voltage stability
- Over-current due to ground faults
- Over-voltage due to contact with energized conductors
- Over-voltage due to lightning

- Over-voltage due to line surges

6.1 COMPONENTS of a CENTRAL OFFICE GROUND SYSTEM FIGURE 9

Generally, the CENTRAL OFFICE GROUND System consists of the following components:

- EQUIPMENT GROUNDING CONDUCTORS These are miscellaneous conductors extended from CENTRAL OFFICE GROUND buses, or HORIZONTAL EQUALIZERS for the purpose of grounding equipment frames, cabinets, transformers, and other metallic objects on equipment floors.

- HORIZONTAL EQUALIZERS These are 750 kcmil ground conductors, which extend from the VERTICAL RISER CENTRAL OFFICE GROUND buses on each floor. These conductors form supplemental CENTRAL OFFICE GROUND buses on each floor for the purpose of equipment bonding.

- OFFICE PRINCIPAL GROUND POINT This is the terminating and beginning point of the CENTRAL OFFICE GROUND System and is the common point where all building grounding and ground electrode systems come together.

- VERTICAL RISER This is a large conductor (750 kcmil) for multi-story buildings and NO. 4/0 AWG for single story buildings. The VERTICAL RISER is the backbone of the CENTRAL OFFICE GROUND system and is run vertically through all floors of the building. The riser shall be terminated on a CENTRAL OFFICE GROUND Bar on the top floor. The riser shall not extend through to the roof of the building.

In a large multi-floor central office building, the CENTRAL OFFICE GROUND system may be a complex branching network, utilizing one or more VERTICAL RISERS connected to numerous CENTRAL OFFICE GROUND busbars on various floors. In a small single floor building, the CENTRAL OFFICE GROUND system may consist of a simple network extended from a single CENTRAL OFFICE GROUND busbar.

6.2 THE VERTICAL RISER FIGURE 9 & FIGURE 10

The VERTICAL RISER is the backbone of the CENTRAL OFFICE GROUND system. It is comprised of an insulated 750 kcmil copper conductor in multi-story buildings and 4/0 AWG cable for single story buildings extending from the OFFICE PRINCIPAL GROUND to a point near the ceiling of the topmost floor of the building. The VERTICAL RISER is an electrically continuous (UN-spliced) conductor run vertically along building columns. Where the conductor passes through floors, it is protected by a flame-retardant plastic sleeve. Each VERTICAL RISER serves an area covered by a radius of one-hundred feet around the riser and additional VERTICAL RISERS may be required for larger areas. In multi-story buildings where multiple risers are employed, a VERTICAL RISER EQUALIZER (750 kcmil) is installed between risers on every third floor. Refer to **FIGURE 10**.

Besides providing low impedance, high ampacity and high strength the 750 kcmil conductor provides a large surface area, which is important for fast rising currents that flow predominantly on the surface of conductors due to *skin effect*.

Connections from the VERTICAL RISER to the CENTRAL OFFICE GROUND bars on each floor are accomplished by compression H-tap connectors and a short length of 750 kcmil cable.

The VERTICAL RISER shall be run as straight as practicable. Bends shall be gradual with a minimum bending radius of eight inches. The smallest bending angle shall not be less than ninety degrees. Extensions of the VERTICAL RISER, if necessary, shall be permitted by exothermic welding only.

VERTICAL RISERS shall be run exposed to afford visual inspection and mounted on columns or walls in the interior of the building at least six feet from outer walls and columns. Mounting and cable supporting material shall not form a closed metallic ring about the conductor. Cable supports and sleeves provided for VERTICAL EQUALIZERS shall not be utilized for the routing of any type of cable or wire other than ground wire. VERTICAL RISERS shall not be permitted on outer columns or walls.

VERTICAL RISERS shall be run between floors in two inch Polyvinyl-Chloride (PVC) pipe or other non-metallic sleeves or openings that do not form a metallic ring about the conductor.

VERTICAL RISER shall be supported every four feet in the vertical plane.

The VERTICAL RISER shall be so located that the horizontal portion of the run to the OFFICE PRINCIPAL GROUND POINT is as short as practical.

Where the physical design of the building exceeds the area allowed to be served by one CENTRAL OFFICE GROUND bar (one-hundred foot radius circle), two or more VERTICAL RISERS may be provided. Each VERTICAL RISER shall be individually terminated at the OFFICE PRINCIPAL GROUND POINT except when the horizontal portion of the first VERTICAL RISER extends from the OFFICE PRINCIPAL GROUND POINT bar in the direction of the other VERTICAL RISERS. In this case, the other VERTICAL RISERS may be terminated at the CENTRAL OFFICE GROUND bus served by the first riser or tapped to the riser conductor on the floor containing the OFFICE PRINCIPAL GROUND POINT. This may be done only if the resultant length from the OFFICE PRINCIPAL GROUND POINT to the vertical portion of the other risers is not greater than one-hundred percent of a direct run between the two points.

When more than one VERTICAL RISER is provided, they shall be bonded together at every third floor with a 750 kcmil cable referred to as a VERTICAL RISER EQUALIZER. In buildings with a basement, the bond shall occur at the third, sixth, ninth, etc. floors. Multiple VERTICAL RISERS installed in a building shall be designated VERTICAL RISER NO. 1, VERTICAL RISER NO. 2 and so on. The designation shall be stamped on the CENTRAL OFFICE GROUND buses and a permanent label installed on the VERTICAL RISER cable where it is connected to the OFFICE PRINCIPAL GROUND POINT bus RISER.

Multiple multi-story buildings separated by a building wall or an alley-way shall require a separate CENTRAL OFFICE GROUND VERTICAL RISER in each building terminating at separate OFFICE PRINCIPAL GROUND POINT's. The OFFICE PRINCIPAL GROUND POINT bars for the two buildings shall be bonded together with a 750 kcmil cable. If common infrastructure, e.g., AC power, DC power, HVAC is shared between the two buildings; a bond shall be established between the VERTICAL RISERS at every third floor utilizing a 750 kcmil cable (Refer to **FIGURE 10**).

If it can be determined that building structural steel is electrically continuous it may be used as the VERTICAL RISER. To be considered electrically continuous, column steel shall have all section butt ends of the column bridged with a welded steel plate (eight square inches minimum), or an exothermically welded or brazed 750 kcmil copper bond (Refer to **FIGURE 11**). When building steel is used as the VERTICAL RISER, the CENTRAL OFFICE GROUND floor bus bars shall be exothermically bonded to the column steel with a 750 kcmil conductor. Each structural steel column used as a VERTICAL RISER must also be bonded to the OFFICE PRINCIPAL GROUND POINT ground bar with a 750 kcmil cable run in as short a manner as practicable.

In buildings utilizing reinforced concrete and reinforcing bars the CENTRAL OFFICE GROUND buses shall not be bonded to the rebar and shall be mounted on isolators.

At locations where the building steel does not have electrical continuity, or the continuity cannot be determined, a 750 kcmil cable VERTICAL RISER shall be provided. In these locations, the VERTICAL RISER shall be bonded to the structural steel at the lowest and top-most floor.

6.3 CENTRAL OFFICE GROUND BUSBARS FIGURE 12

A CENTRAL OFFICE GROUND busbar is required on every equipment floor of an equipment building to facilitate the distribution of horizontal ground conductors. The bus bar shall be located on the same column as the VERTICAL RISER, or on a column or wall or other accessible location that serves the requirements of the physical design of the building. The CENTRAL OFFICE GROUND bar shall be connected to the VERTICAL RISER via a 750 kcmil conductor with a compression crimp H tap or exothermically welded, per **FIGURE 12**. All terminations to a CENTRAL OFFICE GROUND busbar shall be with two-bolt tongue circumferential crimp connectors or exothermically welded. Bolted connections shall be equipped with a DO NOT DISCONNECT tag and an identification tag to indicate the purpose of the conductor and its far end terminating point.

When the CENTRAL OFFICE GROUND bus is not located on the same column as the VERTICAL RISER the 750 kcmil conductor connecting it to the VERTICAL RISER shall be kept as short as practicable, so as to minimize impedance in the path. It is preferable that this length be less than twenty feet where possible.

The maximum conductor run length between a CENTRAL OFFICE GROUND busbar and the furthest grounded equipment shall not exceed two-hundred feet and shall not extend beyond the perimeter of a square superimposed on a circle of a one-hundred foot radius with the CENTRAL OFFICE GROUND bus bar at the center. (Refer to **FIGURE 13**).

- The above requirement enables a single bus bar located in the center of a two-hundred by two-hundred foot building to serve all equipment located on the same floor.

- The ideal location for the placement of CENTRAL OFFICE GROUND busbars on equipment floors is roughly in the center of the equipment layout. This should result in approximately equal run lengths of HORIZONTAL EQUALIZERS branch and associated ground conductors.

A single floor building may utilize one or more CENTRAL OFFICE GROUND buses. In a building of less than two-hundred by two-hundred foot dimension; a single OFFICE PRINCIPAL GROUND POINT bus, located near the entry point of the main ground electrode, may be used for the grounding of all equipment within the building. However, when the building dimension exceeds the two-hundred by two-hundred foot size, additional CENTRAL OFFICE GROUND buses must be installed to maintain the one-hundred foot radius rule. Connection between the OFFICE PRINCIPAL GROUND POINT and additional CENTRAL OFFICE GROUND buses shall be made with 750 kcmil green insulated conductors. HORIZONTAL EQUALIZER distribution from the CENTRAL OFFICE GROUND bus to the equipment in a single story building shall be in accordance with the requirements outlined for multi-floor building

CENTRAL OFFICE GROUND bars shall be comprised of a copper bar with dimensions of eighteen inches by four inches by ¼ inch, however the size of the bar may vary depending on the number of potential connections. Mounting holes shall be pre-drilled to accommodate two-bolt tongue connectors with 3/8" bolts on one inch centers. (Refer to **FIGURE 12**).

CENTRAL OFFICE GROUND bars shall be mounted on columns or walls in the interior of the building at least six feet from outer walls and columns. For small buildings, such as regenerator huts or small radio repeater buildings, with no interior walls or columns it is acceptable to mount the CENTRAL OFFICE GROUND bus on an exterior wall.

In multi-story buildings that do not have electrical continuity of the building structural steel and are using a 750 kcmil cable for the VERTICAL RISER, the CENTRAL OFFICE GROUND bar shall be connected to building steel on the lowest and topmost floors. On all other floors, the CENTRAL OFFICE GROUND bars are to be mounted on insulators per the method depicted in **FIGURE 12**. This method ensures that the concrete penetrating bolts will be separated from the CENTRAL OFFICE GROUND bar components by at least two inches. For single story buildings, bond the CENTRAL OFFICE GROUND bars to the structural steel or rebar.

Termination at a CENTRAL OFFICE GROUND bus bar shall be with a two-bolt tongue compression type connector. Thermally or exothermically welded connections shall also be permitted. Compression crimp connectors shall be made with tools that are approved by the listing agency as compatible with the particular connector.

Grounding conductors shall not have excessive slack and should be cut to the length required. This requirement is intended to eliminate the potentially harmful practice of coiling excess lengths of wire that contributes to excessive inductance.

When CENTRAL OFFICE GROUND buses are installed where they are not visible, e.g., in closets, above drop ceilings, behind temporary walls, below raised floors, etc., maintenance and installation access to the bars must be established and signage shall be provided to indicate the existence of the CENTRAL OFFICE GROUND bus.

6.4 HORIZONTAL EQUALIZERS and EQUIPMENT GROUNDING CONDUCTORS FIGURE 13 & FIGURE 14

HORIZONTAL EQUALIZERS are 750 kcmil cables that are extended from the VERTICAL RISER CENTRAL OFFICE GROUND bus bars into the equipment areas and terminating at the floor CO GROUND BUSBAR. The general direction of HORIZONTAL EQUALIZERS shall normally be diagonal to the walls or the building with at least one equalizer being extended into each quarter section of the building.

The maximum conductive run length between the CENTRAL OFFICE GROUND bus and the furthest grounded equipment unit shall not exceed two-hundred feet and shall not extend beyond the perimeter of a square superimposed on a circle of a one-hundred foot radius from the bus location. This restriction is based on the hypothesis that a single CENTRAL OFFICE GROUND bus located in the exact center of a two-hundred foot by two-hundred foot building may serve all equipment located on the same floor. Refer to **FIGURE 13**.

The ideal location for the placement of buses on equipment floors is approximately in the center of the equipment area, which should result in approximately equal run lengths of HORIZONTAL EQUALIZERS and conductive extensions therefrom. This also will result in maximum voltage equalization.

It is preferred that a CENTRAL OFFICE GROUND bus be located on the same column as the VERTICAL RISER and should never be more than twenty cable feet away. All runs of CENTRAL OFFICE GROUND HORIZONTAL EQUALIZER conductors which are extended from the VERTICAL RISER BUSBAR shall be routed so that cable runs are as short and direct as possible.

HORIZONTAL EQUALIZER conductors shall be run exposed to afford visual inspection of the entire system and access to connectors for maintenance purposes. Horizontal runs shall be supported along the exterior of cable rack stringers or from framing bars by means of clips or similar devices that do not form a closed metallic ring about the conductor. Cable supports and sleeves provided for the routing of CENTRAL OFFICE GROUND conductors shall not be utilized for the routing of any type of cable or wire other than ground cables. Short runs through walls shall be supported within two inch Polyvinyl-Chloride (PVC) or other non-metallic conduit.

FIGURE 13 illustrates the maximum area that may normally be served by one CENTRAL OFFICE GROUND bus. It is recognized that physical design of the building may exceed these design parameters. In these cases, two or more CENTRAL OFFICE GROUND bars per floor, served by separate VERTICAL EQUALIZERS, would be installed.

6.4.1 FRAMEWORK GROUND FIGURE 14

All equipment framework and metallic objects in a telecommunication building must be equipped with a connection to the CENTRAL OFFICE GROUND system for the purpose of personal protection and equalization. This equipment grounding process is referred to as FRAMEWORK GROUND.

All equipment frames and metallic objects will require bonding to the CENTRAL OFFICE GROUND SYSTEM. This may be accomplished by a direct connection to a CENTRAL OFFICE GROUND BUSBAR, or via connection to EQUIPMENT LINE-UP GROUNDING

CONDUCTORS or directly to the MAIN AISLE GROUNDING CONDUCTORS.

DEFINITIONS and REQUIREMENTS:

EQUIPMENT LINE-UP GROUNDING CONDUCTOR **-** This is a N0. 2 AWG green insulated grounding conductor that is run down each equipment line-up for the purpose of grounding individual equipment frameworks or cabinets. Refer to **Figure 14**.

FRAMEWORK GROUNDING CONDUCTOR **-** This is a NO. 6 AWG green insulated grounding conductor that is used for grounding individual equipment frames or cabinets. This conductor is tapped onto the EQUIPMENT LINE-UP GROUNDING CONDUCTOR. Refer to **Figure 14**.

MAIN AISLE GROUNDING CONDUCTOR **-** This is a calculated grounding conductor which is run down the main isle in the equipment areas and connected directly to the nearest CO GROUND BUSBAR. EQUIPMENT LINE-UP GROUNDING CONDUCTORS are tapped to the MAIN AISLE GROUNDING CONDUCTOR. The minimum size for a MAIN AISLE GROUNDING CONDUCTOR is a No. 2 AWG. The MAIN AISLE GROUNDING CONDUCTOR is calculated utilizing the formula in **section 4.1** based on the largest size of DC feeder breaker to be utilized in the equipment area (usually 60 to 70 amps) and the distance to the nearest CO GROUND BUSBAR. Refer to **Figure 14.**

When equipment arranged in a line-up needs to be grounded, *daisy chaining shall not be used* because continuity of the grounding connections might not be assured if one of more equipment frames are removed from the line-up. *Daisy chaining* refers to the extending of a grounding conductor from one equipment frame to the next adjacent frame. The recommended method of grounding a line-up of equipment is to provide a common EQUIPMENT LINE-UP GROUNDING CONDUCTOR from which drop leads (equipment frame grounding conductors) are tapped to individual frames. All taps are to be made utilizing compression crimp H-tap connectors. Refer to **Figure 14.**

SECONDARY DC POWER DISTRIBUTION FRAMES (BDFBs, PDs, PDFs etc.) shall have a dedicated framework grounding conductor run directly back to the nearest CO GROUND BUSBAR. Secondary distribution bays shall not utilize the EQUIPMENT LINE-UP GROUNDING CONDUCTOR as its framework grounding source. This grounding conductor shall be sized utilizing the formula in **section 4.1** based on the largest feeder breaker feeding the distribution bay and the distance to the nearest CO GROUND BUSBAR. The minimum size of the SECONDARY DC POWER DISTRIBUTION FRAME GROUNDING CONDUCTOR shall be a No. 2 AWG.

NOTE: Battery Return Bars in Secondary DC Power Distribution bays **SHALL NOT** be connected to CO GROUND.

All grounding conductors, unless specified otherwise in system documentation, shall utilize green insulated, copper stranded conductors. All connections shall be made with circumferential crimp connectors equipped with two-bolt tongues. All equipment grounding cable taps shall utilize H tap compression connectors.

7

Contents

7. CENTRAL OFFICE ISOLATED GROUND PLANE GROUND SYSTEM

CENTRAL OFFICE ISOLATED GROUND PLANE SYSTEM

7

7.1 GENERAL

An ISOLATED GROUND PLANE is one where the communications system circuit ground points (FRAMEWORK GROUND) and the DC power return conductors are deliberately isolated from contact with the central office INTEGRATED GROUND PLANE. All objects that comprise the ISOLATED GROUND PLANE are insulated from contact with other ground sources, except for a single point connection that functions to equalize potential difference between the other wise unconnected planes. This single point connection prevents current from flowing through equipment and framework located in the ISOLATED GROUND PLANE, thus isolating it from the effects of lightning strokes, ground faults, shorts and other anomalies occurring in the INTEGRATED GROUND PLANE. Refer to **FIGURE 8** for a simplified drawing of an ISOLATED GROUND PLANE.

With digital electronic switching systems, there is concern about electrical noise, voltage stress conditions and the possibility of allowing foreign currents to flow through the switching system that could cause equipment damage or malfunctions. During fault occurrences in the AC or DC power network, a large amount of current can be caused to flow in the INTEGRATED GROUND PLANE. Lightning strikes on the building, on AC power conductors or telephone cables serving the building, can cause tremendous surges of current. If these currents are allowed to flow through the electronic switch ground plane it could produce stresses that would cause malfunctions, damage or destruction of components

Due to these concerns, the ISOLATED GROUND PLANE system has become the AT&T and industry standard for the grounding of electronic switching systems. Engineering and design requirements for the provisioning of an ISOLATED GROUND PLANE system are covered in **SECTION 7.2** through **SECTION 7.10**.

NOTE: This practice covers general requirements for the provisioning of an ISOLATED

GROUND PLANE area in an AT&T telecommunications building. For specific engineering and installation requirements refer to the system documentation for the ESS system being installed.

7.2 OBJECTIVES of an ISOLATED GROUND PLANE

An ISOLATED GROUND PLANE and associated power supplies should accomplish the following:

- Assure low impedance continuity in grounding wire and bus bar connections for the lifetime of the installation.
- Control and mitigate the flow of short circuit current in susceptible frames with the ISOLATED GROUND PLANE.
- Ensure reliable operation and reduce maintenance of the equipment.
- Ground components by methods that will guard personnel from electrical shock hazards.
- Permit protection devices (fuses and circuit breakers) to clear short circuits rapidly and safely.
- Prevent external sources of foreign currents (noise currents) from flowing in and out of the ISOLATED GROUND PLANE that may upset the operation of, or cause damage to sensitive equipment.
- Provide a current free ground reference for critical data circuits.
- Reduce internal noise currents that may interfere with the proper operation of sensitive equipment.
- Reduce the voltage stress that can appear between the DC volt return conductor and the ISOLATED GROUND PLANE when lightning or short circuit current flows through the building steel.
- Reduce the voltage stress that can appear between the ISOLATED GROUND PLANE and building steel to acceptable values when lightning or short circuit currents flow through the building steel.

7.3 INTERFACE BETWEEN the INTEGRATED and ISOLATED GROUND SYSTEMS

In any building that houses communications equipment a ground plane exists throughout the structure. Continuity of the system is provided by deliberate connections such as raceways, equipment framework grounding, and the CENTRAL OFFICE GROUND system of conductors, structural steel, cable racks, water pipes and other building metal. These various components are either deliberately or incidentally interconnected to form what is called an INTEGRATED GROUND PLANE. A more detailed description of the INTEGRATED GROUND PLANE can be found in **SECTION 6**. The ISOLATED (single point) ground system is designed to work with the INTEGRATED ground system. Refer to **FIGURE 15** for a schematic diagram showing a typical ISOLATED and INTEGRATED GROUND PLANE and the interface between them.

Air ducts, electrical conduit, metal piping, cable racking, and other components of the building complex are assumed to be part of the INTEGRATED GROUND PLANE without deliberate bonding. When such members are in close proximity (within 7 feet) with equipment of an ISOLATED GROUND PLANE, they shall be bonded to the MAIN GROUND BUSBAR in the ground window. Generally, it is expected that the bonding of such objects shall be done by extending a bond wire to other bond wires having access to the ground window. It is impractical and unnecessary to run a separate bond wire from the MAIN GROUND BUS to each object. They may be grouped and assumed to be one object, requiring only one NO. 6 AWG bond wire between the MAIN GROUND BUSBAR and the equipment. Bond wires shall be kept isolated from any contact with members of the ISOLATED PLANE. There are many complex relationships that cannot be predefined. The job engineer, therefore, must assume responsibility for determining the grouping and bonding that will result in provision of conductive paths of lowest practical impedance.

7.4 The GROUND WINDOW and MAIN GROUND BUS

Unlike the INTEGRATED GROUND PLANE, which encompasses the entire building, the ISOLATED GROUND PLANE is restricted only to the electronic switching equipment area and in some cases its peripheral equipment. It interfaces with the INTEGRATED GROUND PLANE only at the MAIN GROUND BUSBAR located in the center of a three foot radius (six foot sphere) referred to as the *Ground Window*.

Grounded elements, which enter the area of the ISOLATED GROUND PLANE, must enter it within three feet of the MAIN GROUND BUSBAR and must be electrically connected to it before becoming a part of the ISOLATED GROUND PLANE. Once the grounded elements enter the ISOLATED GROUND PLANE area, they are insulated from contact with any INTEGRATED

GROUND PLANE element. Incidental ground connections from building steel or other ground planes to the equipment located in the ISOLATED GROUND PLANE are not permitted. During external AC or DC fault occurrences or when lightning currents flow through the INTEGRATED GROUND PLANE, equipment located in the ISOLATED GROUND PLANE is protected from damage due to the single point connection to the ISOLATED GROUND PLANE.

Typical bonds to the MAIN GROUND BUSBAR are shown in **FIGURE 16**.

In larger offices where a significant number of bonds must be made to the MAIN GROUND BUSBAR, additional bars may be added within the confines of the ground window three foot radius (six foot sphere) for additional cable termination purposes. Each additional bar must be bonded to the MAIN GROUND BUSBAR with a 750 kcmil cable or an equivalent busbar. Refer to **FIGURE 17** for a typical example of the ground window MAIN GROUND BUS arrangement.

Any AC conduit that enters the ISOLATED GROUND PLANE must be bonded to the MAIN GROUND BUS along with the AC EQUIPMENT GROUND conductor (see **FIGURE 18**).

The MAIN GROUND BUS shall be bonded to the closest INTEGRATED CENTRAL OFFICE GROUND bar, located on the same floor, with an appropriately sized grounding cable as indicated in the ESS system documentation. Every effort shall be made to place the MAIN GROUND BUS as close as practical to the CENTRAL OFFICE GROUND bus bar, although there are no restrictions specified for the length of the conductor.

7.5 GROUND WINDOW LOCATION

As mentioned in **SECTION 7.4**, the ground window may be located in the ESS area or at the DC power plant battery return bar. The decision of where to locate the ground window should be based on the following:

- Will the power plant be located within one floor of the ISOLATED GROUND PLANE area?

  a) If the answer is YES, the ground window may be installed at the power plant.

  b) If the answer is NO, the ground window cannot be at the power plant.

- Will the power plant be used to support equipment that is not located in the ISOLATED GROUND PLANE?

a) If the answer is YES, the ground window should be located at the power plant if it complies with the one floor rule.

b) If the answer is NO, the ground window may be located in the ISOLATED GROUND PLANE area.

The proper selection of the ground window location can optimize the length of ground conductors and help limit cable congestion at the MAIN GROUND BAR.

In multi-floor buildings, an electronic switching system may be located on several floors. When this condition exists, a common ground window must be established for the equipment. To minimize the potential difference that can exist between the INTEGRATED and the ISOLATED GROUND PLANES, the electronic switching equipment shall not be located more than one floor from the ground window. This allows the equipment to be located on three adjacent floors, with the ground window located on the middle floor.

The bonding of grounded elements to the MAIN GROUND BUS will require them to be insulated from contact with the INTEGRATED GROUND PLANE on each floor between the ground window and the equipment, and also as they pass between floors.

7.6 EQUIPMENT ISOLATION and the MOUNTING of EQUIPMENT

The equipment frames and other grounded elements within the ISOLATED GROUND PLANE area shall be one conductive unit insulated to prevent any incidental ground contact with the INTEGRATED GROUND PLANE. A violation of this insulation requirement would allow a surge current on the INTEGRATED GROUND PLANE to flow through the ISOLATED GROUND PLANE that may result in equipment malfunction or damage. Typical mechanical details requiring insulation between the ISOLATED and INTEGRATED GROUND PLANES are:

- AC raceways
- AC receptacles
- Cable racks
- End guards
- Equipment frame anchor bolts
- Lighting fixtures
- Superstructure supports
- The bottom of equipment frames

All frames that are part of the ISOLATED GROUND PLANE shall be installed in a way that insulates these frames form the INTEGRATED GROUND PLANE (building steel and all other metallic parts attached to the building steel).

The procedures and piece parts used for the isolation of equipment in the ISOLATED GROUND PLANE are specified in the specific system and supplier documentation.

Although insulating materials are used in most cases to provide the required isolation, in some cases an air gap, typically three inches, is sufficient, such as between ISOLATED and INTEGRATED cable racks. Insulation resistance and voltage breakdown are also required as specified in the individual switching system documentation.

NOTE: A megger test is required during installation of all equipment bays to ensure that there are no incidental or accidental connections made to the INTEGRATED GROUND PLANE. Before any ground window or power connections are made to the ISOLATED GROUND PLANE and after all hold down and fastening hardware is installed, the insulation resistance between the ISOLATED and INTEGRATED GROUND PLANES shall be minimum of one-hundred thousand ohms at five-hundred volts. All test measurements shall be recorded and placed in the permanent office records for future reference. Isolation of the ISOLATED GROUND PLANE from the building INTEGRATED GROUND PLANE shall be accomplished by the use of insulators. Typical fastening points include the following:

- Anchor Bolts   Anchor bolts used to hold down the ISOLATED GROUND PLANE frames will have insulating bushings installed.

- Bottom of Frames   Since there is a possibility that the bottom of frames may come into contact with structural steel or other portions of the INTEGRATED GROUND PLANE, insulating material must be placed between the frames and the floor. Raised floor applications do not require insulation.

- Lighting Fixtures, Raceways and Cable Racks   Lighting fixtures, raceways and cable racks that are part of the ISOLATED GROUND PLANE shall be insulated from the INTEGRATED GROUND PLANE.

- Superstructure Supports   Superstructure supports used in the ISOLATED GROUND PLANE area to support equipment frames shall be insulated from contact with the building steel or the INTEGRATED GROUND PLANE.

Refer to **FIGURE 19** for a typical example of supporting conduits entering the ISOLATED ground area.

Metallic shields that enclose wires, such as ABAM or coax cable shields shall be grounded at the ISOLATED GROUND PLANE equipment end only. Shielded cable used for composite clock/timing distribution shall be grounded at the timing source. The ungrounded ends shall be taped to prevent accidental grounding.

7.7 SHARED POWER PLANTS

Certain requirements must be enforced when power plants are shared between multiple electronic switching machines and/or equipment located in the INTEGRATED GROUND PLANE. These are shown below:

- Battery distribution and return feeders shall be paired to minimize the field effect on adjacent cables. Minor offsets will be allowed for connection of the return conductors to the MAIN GROUND BUS, power distribution cabinet entry, etc.

- Battery feeders and return conductors of a switching system shall not be directly linked with those of another switching system or ground system, except as permitted in system specifications. Power distribution frames shall be dedicated to serve only one electronic switch.

- Circuits or equipment located outside the ISOLATED GROUND PLANE shall be supplied by separate power feeders whose return conductors must be bonded to the MAIN GROUND BUS before extension to the INTEGRATED GROUND PLANE. This return conductor may be connected directly to the MAIN GROUND BUS or may be bonded to the MAIN GROUND BUS with a cable not exceeding three conductor feet in length. One bond conductor may multiple to several return conductors within the three foot bonding limitation. The bond conductor shall be the same size as the largest return conductor, but need not exceed NO.1/0 AWG. A supplementary MAIN GROUND BUS bar may be provided if required to accommodate the additional cables.

- Each switch shall have its own independent ISOLATED GROUND PLANE, although all the switches share one common ground window.

- Electronic switching machines sharing a common power plant shall be located within one floor of the common ground window.

- The switches that share a common DC power plant must also share a common ground window.

- When a power plant is used to support both an INTEGRATED and ISOLATED GROUND PLANE the equipment frames must be physically separated

NOTE: When a single power plant is used to support multiple ISOLATED GROUND PLANE areas and an INTEGRATED GROUND PLANE area it is highly recommended that the power plant ground return bar be designated as the ESS ground window. This will greatly reduce the length of bonding and grounding cables and eliminate much of the complexity associated with this type of installation.

7.8 POWER PLANT LOCATION

For maximum protection of personnel and equipment from lightning surges, the ideal location of the power plant equipment is as close as practical to the ground window and ESS equipment it is supporting. In existing buildings, space restrictions or floor loading limits may require location of the power plant several floors away from the ground window. Since power plant batteries and discharge ground components obtain voltage reference form the ground window this can result in momentary high voltage differential between discharge ground components and the frame metal, relative to the distance between the power plant and the ground window. While this constitutes a greater hazard to personnel than if the power plant was restricted to no more than one floor away from the ground window, personnel are not normally in contact with a discharge ground component therefore this is not considered a critical issue. Also insulators used to isolate the discharge ground bus bar from frame metal are superior to insulators used in electronic switch frame areas which minimizes the possibility of spark over. For these reasons, location of electronic switch dedicated power plants on floors other that those within one floor level of the ground window is not recommended but is acceptable.

7.9 OTHER CONSIDERATIONS

To minimize the inductive reactance and the system transient voltage exposure the ground conductors should be engineered and installed as follows:

- All connections and crimps shall be coated with an appropriate anti-oxidant compound before making connections.
- All ground conductors terminating on a bus bar shall be labeled with their purpose and far end terminating point as well as equipped with DO NOT DISCONNECT tags.
- Avoid girdling grounding cables with magnetic material.
- Directionalize all of the ground conductor sweeps toward the nearest main ground source,

e.g., CO GROUND BUSBAR, MAIN CO RISER, OFFICE PRINCIPAL GROUND POINT, etc.

- Ground conductors shall be green insulated stranded copper in compliance with UL 44, except where specified otherwise in system documentation.
- Ground conductors shall be terminated with compression crimp type connectors with two-bolt tongues.
- Metallic surfaces to be joined shall be prepared by the removal of all non-conductive material, per NATIONAL ELECTRICAL CODE ARTICLE 250-118.
- Splices and parallel taps shall be compression crimp type H taps.
- The conductor length shall be kept as short as practical.
- The conductors shall be kept as straight as possible and avoid sharp bends.

NOTE: In addition to the preceding general requirements for ISOLATED ground systems, different ESS systems (4ESS, 5ESS, etc.) have specific grounding and isolation requirements which are not included in this practice. These requirements are covered in system documentation and engineering drawings that must be considered when engineering and installing these systems.

7.10 TEST and ACCEPTANCE

The following tests are to be performed by the installation services supplier and verified by the On Site Work Force:

Each frame (or group of frames) that are part of the ISOLATED GROUND PLANE, shall undergo the following insulation tests after each frame (or group of frames) have been secured to the floor. This shall be done before any power or any grounding connections have been made to the frame or frames. The purpose of these tests is to determine that the necessary insulation has been provided between the frames and the INTEGRATED GROUND PLANE or building steel.

NOTE: All instruments used in the tests described below shall have current calibration stickers and shall have readout accuracy within plus or minus five percent.

7.10.1 VISUAL TESTS

An overall visual inspection of the ISOLATED GROUND PLANE should be made by looking for observable violations such as loose connections; improper wire size, improper connections, and grounding violations such as those listed below:

.

- Check that all conduit, cable racks, etc. that are entering, and becoming a part of the ISOLATED GROUND PLANE are properly bonded to the MAIN GROUND BUS at the ground window and are insulated from contact with the INTEGRATED GROUND PLANE throughout the ISOLATED GROUND PLANE.

- Conduits, and cable racks that have become a part of the ISOLATED GROUND PLANE by being routed through and connected to the MAIN GROUND BUS shall not be in contact with any other building steel structures or any components of the INTEGRATED GROUND PLANE. Refer to **FIGURE 19** for a typical method of isolation to be used for conduit.
- Equipment frames, cable racks, etc. which are a part of the ISOLATED GROUND PLANE shall not be in contact with building steel or the ISOLATED GROUND PLANE.

- Power for all equipment within the ISOLATED GROUND PLANE shall be supplied only from secondary distribution sources within the ISOLATED GROUND PLANE.

- Verify that all conductors are properly connected to the ground window. Things to check for are:

a) All connections have been properly cleaned and no-oxide compound applied

b) Tightness of connections

c) Use of compression crimp two-bolt tongue connectors

d) Use of stranded copper wire

7.10.2 INSULATION TESTS

Each frame or group of frames that are part of the ISOLATED GROUND PLANE shall undergo the following insulation tests after each frame or groups of frames have been secured to the floor. This shall be done before any power or grounding connections have been made to the frames. The purpose of these tests is to determine that the necessary insulation has been provided between the hold-down fasteners and the INTEGRATED GROUND PLANE.

- Low Voltage Resistance Test   This test connects a universal low voltage ohmmeter (or equivalent) between each frame or group of frames and the ground window to measure the resistance. The resistance reading shall be one-hundred thousand ohms or more.

- High Voltage Resistance Test   If the Low Voltage Resistance Test is satisfactory, connect a five-hundred volt meg-ohmmeter between the lower part of each frame (or group of frames) and the ground window to measure the resistance, The resistance shall be one-hundred thousand ohms or more.

8

Contents

8. RADIO SYSTEMS and TOWER GROUNDING

GROUNDING and LIGHTNING PROTECTION for BUILDINGS with MICROWAVE RADIO

8

8.1 GENERAL

Lightning creates a more severe protection problem at microwave radio stations and other buildings equipped with high tower structures. This is due to the presence of high tower structures, frequent difficulty in establishing an effective ground, and the high occurrence of lightning strokes. Lightning induced surges on the commercial power feeders also create problems, particularly in rural settings, where AT&T buildings may present the best ground in the area.

Providing adequate electrical and lightning protection for buildings with microwave radio requires special considerations for safety and service in the following areas:

- Antennas, waveguide and supporting structures
- Buildings and equipment enclosures
- Exterior structures such as fences, fuel tanks, storage sheds, and equipment shelters
- Power and telephone service equipment
- Radio room equipment that has direct exposure to lightning due to its connection via waveguide or coaxial cable

- Station personnel

Adequate protection in the above categories is obtained by shielding, grounding, bonding (equalization), providing supplemental conducting paths, and installing special protection for commercial AC power and communications circuits.

General requirements, processes and procedures for the electrical protection of microwave radio sites are covered in the following pages of this section. The system is essentially similar to that employed for other central offices, with some additional grounding and bonding requirements required for the purpose of equalization. The basic parts of a microwave radio site grounding system are listed below:

- AC power service entrance surge protection system (**FIGURE 7**)
- Building and tower buried ring ground system (**FIGURE 20**)
- Central office ground system
- Interior ring ground system (**FIGURE 21**)
- Supplemental ground electrode or counterpoise system (if required)

8.2 BUILDING and TOWER EXTERIOR RING GROUND SYSTEM FIGURE20

A buried exterior ring ground system establishes a station ground electrode (ground terminal) that tends to equalize potential in the earth surrounding the building and tower regardless of earth resistivity by ensuring that a low resistance current path exists throughout the area.

Generally, the ring ground system shall consist of the following:

- A NO. 2 AWG, bare, solid, tinned, copper wire buried at a depth of thirty inches below finished grade or below the frost line, whichever is deeper.
- The NO. 2 wire described above will be arranged in two circles, one around the building and one around the tower, forming two closed loops. The adjacent sides of the two loops will be joined at two points by conductors at opposite corners. The ring around the

building will be placed at a minimum of two feet from the exterior wall of the building, or outside the drip line of the structure.

- A number of metallic rods shall be driven vertically in the earth and exothermically bonded to the buried ring. These rods shall be 5/8 inch diameter copper clad steel or stainless steel ground rods, a minimum of eight feet in length, spaced not less than ten feet or more than fifteen feet apart. Refer to **FIGURE 20** for a simplified drawing of the building and tower external ring ground system.

a) Above ground outside conductors may be either solid, or stranded tinned copper.
b) All above ground connections for solid conductors shall be exothermically welded or utilize thermo-weld two-bolt tongue connectors.
c) All buried connections shall be exothermically welded.
d) Connectors used with stranded wire shall be circumferential compression crimp two-bolt tongues (Above ground only). Mechanical *screw type* connectors are not acceptable.
e) Directionalize all ground wire connections toward the nearest main ground source.
f) Ground rods shall be 5/8 inch diameter, with a minimum length of eight feet. Only Copper clad steel or stainless steel rods may be used.
g) Solid wire to stranded wire transitions shall be exothermically welded.

Where grounding 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 forty-five degrees from the vertical. It is important that the rod penetrate to a depth of permanent ground moisture (below the frost line) for the most effective earth connection.

Where ground rods cannot be driven more than four feet below grade level because of bedrock, an alternate method may be required. Approval for any deviation must be obtained from BUILDING ENGINEERING and the DC POWER TECHNICAL SUPPORT GROUP. Alternate methods include:

- Chemical rods

- Counterpoise System The counterpoise system consists of NO. 2AWG bare, tinned solid copper wires buried to a depth of at least thirty inches below grade, radiating from the ring at four opposing corners of the building. Each wire shall be run in a straight line to the edge of the owned property or for a maximum length of two-hundred feet, whichever is the lesser. It shall never be less than twenty-five feet long.

- Well (metal casing) drilled or driven to the water table.

All metallic objects outside the building within six feet of the exterior ring ground system shall require bonding to the exterior ring ground system.

8.2.1 INSTALLATION REQUIREMENTS

The installation of the grounding electrode system should be scheduled so that any excavation, such as hole or trench digging, can be performed while other excavating, clearing and earth moving operations associated with construction of the facility are in progress. If the grounding electrodes system is installed prior to completion of other earth moving operations, take the precautions necessary to assure that the components of the grounding electrode system are not damaged or broken.

All metallic lines and conduits entering the building shall be bonded to the outside ring ground prior to entering the building.

Before back-filling the grounding electrode system, a visual check shall be made of all joints and connections by an AT&T representative. This will:

- Ensure mechanical and electrical integrity.
- Verify the absence of voids or other indications of poor exothermic bonding.
- Verify that all required interconnections have been properly made.

A visual verification and electrical continuity check should be made at this time to ensure that all connections are intact. A written record of this check with photos should be placed in the office records for future reference.

After covering and compacting is completed, and before the ring ground is connected to the building ground system, an earth resistivity measurement shall be made using the *Fall of Potential* method to ensure a reading of five ohms or less per requirements in **SECTION 2.2**. These tests shall be recorded and retained as a part of the office records for future reference.

NOTE: The detail design requirements for the building and tower ring ground systems shall be in accordance with requirement in ***SECTION 2*** *of this practice. Refer to FIGURE 20 for an example of a ring ground system for a small building.*

8.3 ROOF MOUNTED TOWER RING BUS SYSTEM

A roof mounted ring bus system is required when a tower is roof mounted on a relay station or central office building. A ring shall be formed around the tower legs in a manner similar to a buried tower ring with bonds to the legs. Bonds shall also be extended to all other metallic objects on the roof to ensure equalization. Down leads from this ring shall extend over the outside of the building and be attached to the buried ring ground system or ground terminal. This system with its down leads and buried ground terminal will be used as the main discharge path for lightning.

On a steel frame building, the ring shall also be bonded with at least two bonds at opposing points on the ring to building steel. On reinforced concrete buildings or other types of construction where continuity to earth through the building steel is not assured the four connections to the roof mounted lightning protection system will suffice.

8.4 BONDING of EXTERIOR METALLIC OBJECTS

For the purpose of equalization of potential during a lightning stroke, it is necessary to bond a large variety of exterior metallic objects to the outside building and tower ring ground system. These objects may be stand-alone structures, attached to the building, or buried. Listed below are examples of objects that will require bonding. Please note that this list is not all-inclusive. All metallic objects within six feet of the exterior ring ground system shall be bonded to the ring. These bonds are made to NO. 2 AWG bare, tinned, solid, copper conductors exothermically welded or utilizing two-bolt tongue exothermic lugs.

- Buried Metallic Objects

    a) Conduits, pipes (multiple bonds are required every twenty-five feet (minimum) to fifty feet (maximum) when run parallel to earth on exterior walls)

    b) Fuel tanks

    c) Other buried ground fields or electrodes

- Other Stand Alone Metallic Objects

    a) Air Conditioning Compressors

    b) Antennas

    c) Fences (including a bond across gate openings, and multiple bonds at twenty-five foot intervals if run continuously within six feet of the ring) Refer to **Figure 22** for a typical detail for the bonding of fences and gates.

d) Fuel Tank Vent Pipes

e) Pad Mounted Engine Alternators

f) Shelters

g) Storage Sheds

- Metallic Objects Mounted On The Building (**Figure 37**)

  a) Aluminum or similar exterior wall siding

  b) Door Frames

  c) Down Spouts

  d) Exhaust Hoods

  e) Handrails

  f) Ladders

  g) Parapets (at each corner of the building when parapets are electrically continuous) otherwise at least one bond to each section in addition to the corners

  h) Vents and Louvers

Generally, a *tree* grounding system provides the most efficient and economical method of grounding groups of objects located in the same general direction from the grounding point. Individual bonding wires run to each unit is not only expensive and unnecessary but can be potentially hazardous when units so bonded are located close together. If, during a discharge, one bond wire is conducting lightning current and another used to ground a neighboring unit is not, the voltage drop across the conducting wire can cause an extreme difference of potential to occur between the two units. This build-up of potential can cause spark-over of current and is hazardous to personnel interposed between such objects.

A *tree* grounding system consists of a single conductor run from a ground point in the general direction toward a group of units requiring grounding. Branch conductors are extended to individual units from points on the main or *trunk* conductor. Sub-branches may also be extended from branch conductors. This method provides minimal impedance and reduces the probability of high potential difference caused by individual ground paths. It is recommended that branch conductors be limited to about twenty feet so that the inter-unit bond length does not become excessively long. Where units bonded to different trunk conductors are located within six feet of each other, the branch conductor should be bonded together.

8.5 AC POWER GROUNDING and SURGE PROTECTION

The neutral conductor of the AC service shall be bonded to the building buried exterior ring bus. This connection shall be in accordance with **SECTION 4** of this practice and ARTICLE 250 of the NATIONAL ELECTRICAL CODE.

Surge protection devices (lightning arrestors) shall be provided at the service entrance on the commercial service side of the main disconnect per requirements in AT&T PRACTICE 760-400-101, and **SECTION 4** of this practice. Surge protection devices shall also be installed on any branch circuit that is extended outside the building walls. This is especially true for AC branch circuits that may be extended to the tower for lights or other purposes. Refer to **FIGURE 7** for a typical wiring diagram for a surge protection device.

8.6 MICROWAVE TOWER STRUCTURE GROUNDING

The tower and antenna structure is a prime target for lightning, and although antennas are unlikely to be damaged by a direct lightning stoke, the entire structure constitutes an excellent transmission path for conducting high current into the equipment building. The grounding requirements listed below should mitigate most damage from lightning currents.

Lightning will seek a path to ground via tower footings and guy anchors. At these points, explosive damage may occur unless alternate paths are provided to by-pass the current and reduce voltage differences. Shown below are methods for accomplishing this for guyed and self supporting towers:

Guyed Towers Grounding is accomplished by installing two, eight foot, copper clad or stainless steel, ground rods alongside the concrete foundation of each anchor block. The ground rods are located within twelve inches of the anchor block and at the mid-point on either side. The guy cables are to be bonded to the ground rods with NO. 2 AWG solid bare-tinned copper wire as indicated in **FIGURE 23** and **FIGURE 24**. The tower base is to be grounded by exothermically welding a NO. 2 AWG solid, tinned, copper conductor to the tower base and to two copper clad or stainless steel eight foot ground rods installed not more than twelve inches from the concrete foundations. This grounding detail is shown on **FIGURE 25**.

Self Supporting Towers Each leg of the tower is to be bonded from the tower leg to the tower buried ring utilizing a NO. 2 AWG solid, tinned copper conductor exothermically attached to the tower leg and to the ring ground. Refer to **FIGURE 26** & **FIGURE 27**.

Waveguide Supports One grounding connection is required for each leg of the waveguide support structure. One end of a NO. 2 AWG bare, tinned, copper wire is to be exothermically welded to the waveguide support leg and the other end exothermically welded to the building or tower buried ring ground system. Refer to **FIGURE 28**.

8.7 WAVEGUIDE and HATCHPLATE GROUNDING

Since the waveguide hatchplate is the most probable focal point for lightning surges entering the building, its proper grounding is critical. Each waveguide is bonded to the hatchplate by the mounting flanges furnished with the pressure window section that passes through the hatchplate. Following are other requirements for waveguide and hatchplate grounding and bonding:

- All flexible waveguide sections associated with a microwave system shall be parallel bonded. In addition, when two or more flexible sections are in close proximity to each other, they shall be serially connected. One flange of a flexible waveguide shall then be bonded with a NO. 6 AWG wire to the closest grounded structural metal.

- Conduit entering the building, when in proximity to the hatchplate, shall be bonded to the hatchplate exterior and if run on the building exterior before entering the building, shall be bonded to the exterior ring bus. The conduit shall also be bonded to the interior ring bus system immediately on entry into the area served by the ring bus.

- Metallic supportive framework, if not mechanically connected to establish continuity, shall be bonded with a NO. 2 AWG stranded bond to the hatchplate exterior surface.

- The hatchplate shall be bonded directly to the exterior ring ground system on both the inside and outside of the hatchplate. The bonds are to be completed utilizing a NO. 2 AWG solid, tinned, copper wire utilizing an exothermic two-bolt tongue lug for fastening to the hatchplate. The bond on the inside of the hatchplate shall be extended to the exterior ring ground via a non-metallic conduit. Both bonds are to be exothermically welded to the exterior ring ground system. Refer to **FIGURE 28**.

NOTE: When the waveguide hatchplate is on an upper floor of a multi-story building the waveguide hatch bonds shall be made to the CENTRAL OFFICE GROUND system.

- The waveguide hatch plate also requires two connections to the interior ring bus system, utilizing green insulated NO.2 AWG stranded conductor equipped with two-bolt tongue crimp connectors. Refer to **FIGURE 30**.

- When coaxial cable or elliptical cable passes through a hatchplate, it shall be bonded with an appropriate grounding kit to the exterior side of the hatchplate per **FIGURE 33**.

- When flexible rectangular waveguide sections do not pass through a hatchplate, but are fastened to an exterior pressure window, as shown in **FIGURE 33**, all serial waveguide grounding shall be on the exterior side of the opening. In this case, no weatherproof boot is required.

- When flexible rectangular waveguide sections pass through a hatchplate to an inner support plate all serial waveguide grounding wires shall be extended and terminated on the inside of the hatchplate per **FIGURE 31** and **FIGURE 32**. A rubber weatherseal boot shall be added on the exterior side of the hatchplate. The serial loops shall consist of a section of NO. 6 AWG wire and two compression type connectors. The waveguides shall be bonded to the hatchplate in two places as shown in **FIGURE 32**.

- When the CENTRAL OFFICE GROUND system is used for the primary bonding and current path between the interior ring bus and earth, a primary bond to earth is not required for the interior ring ground system. The interior ring ground system shall be referenced to ground at the nearest CENTRAL OFFICE GROUND busbar. Roof mounted hatchplates shall be bonded to the interior ring bus or to a CENTRAL OFFICE GROUND bus. Waveguide shall require no inter-bonding or wire bonds to the interior ring bus system when the interior ring bus system is within twenty-five feet of the hatchplate. When the hatchplate is located further away than twenty-five feet, as when antennas are roof mounted and radio equipment is on a lower floor, the waveguide shall be bonded to the interior ring bus system. Waveguide within six feet of each other shall also be bonded together by means of metal wire clamps fastened under waveguide flange bolts and a NO. 6 wire. The point of bonding to the interior ring bus shall be at the entry point of the waveguide into the area protected by the interior ring bus system.

- When the hatchplate is not located in the same area as the interior ring bus, as in roof mounted antennas and the radio room located on a lower floor, the hatchplate shall be bonded to the nearest CENTRAL OFFICE GROUND bar.

8.8 INTERIOR RING BUS SYSTEM

An interior ring bus system is provided in the radio room area to act in series with the exterior ring bus system and with the CENTRAL OFFICE GROUND system. The interior ring bus system will act as the primary low impedance path for current between the hatchplate(s) and earth. The bus shall be constructed of a NO. 2 AWG, stranded green insulated copper wire supported from walls, cable rack stringers, or framing channels at a convenient height form the floor for the purpose of bonding to equipment and supplementary ground buses. The recommended height above the tops of frames shall be eight inches. Refer to **FIGURE 21** for a typical application of an interior ring ground system.

- The interior ring ground system gives easy access for grounding of equipment frames and miscellaneous metallic objects within the building, and is actually less costly to provide and install than providing multiple radial grounding conductors run back to the CENTRAL OFFICE GROUND bus.

- The interior ring ground system provides superior voltage equalization and surge dissipation than a normal radial grounding system. It therefore offers greater personnel and equipment protection from lightning surges that may be induced into the facility on Lightguide cable, the AC service entrance, or from a direct hit on the building.

8.8.1 INTERIOR RING BUS INSTALLATION REQUIREMENTS

In a building or floor used primarily for housing of radio equipment, the interior ring bus is routed on outer walls around the entire building or floor and the two ends are joined to form a ring. This ring is connected to the OFFICE PRINCIPAL GROUND POINT bar or the nearest CENTRAL OFFICE GROUND bar. When a radio area is part of a floor (less than half) in a central office, the ring shall surround the radio area only.

Circumferential compression crimp type parallel connectors or exothermic welding is the only acceptable method of bonding to the interior ring bus. Such connections need not be insulated. A standoff support assembly using nylon ties, as shown in **FIGURE 34**, is recommended for support of the wire on walls. Supports shall be provided at approximately two foot intervals. Additional supports at points that tend to distort the bus, such as at bonding points, may be provided on basis of need. When the bus wire is not run on walls, it is generally supported form cable racks or framing channels.

For the purpose of minimizing impedance and the incidence of arcing, the interior ring bus shall be installed with a minimum number of bends, and such bends shall be made with the greatest practical radius. In general, the nominal bend radius shall not be less than eight inches. The probability of arcing may be significantly increased by unnecessary bends. Unnecessarily small radii and severe bends may result in over voltages, producing ionization and spark-over.

Any closed ring of metallic material around a ground conductor increases its inductance to the flow of rapidly rising current. For this reason, routing of ground buses and grounding conductors through metallic objects that form a ring around the bus is prohibited. Use of non-metallic material such as Polyvinyl-chloride (PVC) plastic conduit is recommended where allowed by code. Where use of magnetic conduit is unavoidable, the ground conductor shall be bonded to each end of the metal conduit or enclosure.

The interior ring bus shall be run exposed so that visual inspection of the system may be made and any point is available for future bonding. Routing of the ring bus through conduit for the purpose of support shall be avoided for these reasons.

The interior ring bus will be installed using stranded green insulated wire and exothermic or compression crimp type parallel connectors. The interior ring bus need not be installed as a single continuous run of wire, however unnecessary splices should be avoided. In existing locations utilizing solid wire for the bus, all new splices must be made by exothermic weld. All connections between stranded wire and solid wire must be made by exothermic weld.

8.8.2 INTERFACE between EXTERIOR and INTERIOR RING BUS SYSTEMS

The interior ring ground system must be bonded to the exterior ring ground system as follows:

NOTE: The following bonding requirements for interfacing between the interior ring ground system and the exterior ring system are for single story buildings. In multi-story buildings, the interface point for the interior ring ground system, and waveguide hatch bonding is the CENTRAL OFFICE GROUND system.

- At each corner of the building a NO.2 AWG bare solid tinned copper wire bond between the external ring ground and the internal copper stranded ring ground shall be provided at a minimum of four points on the internal ring bus. The recommended location for these bonds is at the corners of the building. Refer to **FIGURE 20**. The solid tinned wire extended from the exterior ring ground shall be brought into the building through a non-metallic sleeve and bonded to the stranded copper interior ring ground using an exothermic weld. The connection to the interior ring ground shall be completed utilizing a bi-directional splice per **FIGURE 35**. To simplify the bi-directional splice connections it is recommended that the splice from solid to stranded be made below the bi-directional splice which will allow the use of stranded wire and parallel crimp connectors.

- At each waveguide hatchplate there will be two bonds to each hatchplate (one inside and one outside). These are depicted in **FIGURE 29** and **FIGURE 30**. As shown in the FIGURE the bond wire for the interior bond is NO. 2 AWG bare solid tinned copper wire extended from an exothermic connection at the exterior ring bus. This conductor is run in Polyvinyl-chloride (PVC) conduit through the exterior wall to the hatchplate where it is bonded to the inside of the hatchplate using a two-bolt tongue thermoweld lug. The exterior of the hatchplate is bonded to the exterior ring ground system in the same fashion using the same materials.

8.8.3 BONDING of INTERIOR METALLIC OBJECTS

Metallic objects in the radio area must be bonded to the interior ring bus system. Additionally, metallic objects within six feet of the interior ring bus must also be bonded. **FIGURE 21** & **FIGURE 36** illustrate the interior unit bonds required to ensure equalization of potential between neighboring units and to establish a low impedance path between units, the waveguide hatchplate and earth. Communications equipment, building heating, air conditioning, and similar facility units, building steel and numerous other metallic units require bonding. The bonding of each metallic object to the interior ring bus via supplementary buses ensures that the voltage generated by current flow is also impressed on the neighboring bonded object. This voltage equalization reduces the possibility of spark-over of current from one object to another.

The descriptions and requirements included herein do not cover all of the unique conditions of metallic structures and equipment inter-relationships to be found in a building. The intent is to provide general bonding recommendations that will aid in recognizing conditions that may require deliberate bonds to ensure continuity throughout the structure and all equipment within the structure. The old grounding adage, *if it's metal and doesn't move "bond it"*, holds true in most instances for radio buildings or radio equipment rooms.

The interior ring bus as well as all supplementary buses run into the equipment area shall be NO. 2 AWG green insulated stranded copper conductors. Supplementary buses are the trunk for the *tree* grounding system used for bonding all metallic objects in the radio room area. Refer to **FIGURE 21** & **FIGURE 36**. Individual unit bonds to equipment frames, cabinets, metal framework, battery stands, etc. shall be NO. 6 AWG green insulated stranded copper. Connections between the interior ring bus and supplementary buses shall be provided using parallel compression crimp H taps. Connections between frames and cabinets (unit bonds) to supplementary buses or the interior ring ground shall be made with parallel compression crimp H taps with compression crimp two-bolt tongue lugs used for termination to the equipment.

Examples of equipment inside the building or radio room that will require bonding to the ring bus or supplementary bus follows: This list may not be all-inclusive.

- All communications equipment frames
- Conduits, pipes
- DC power plant framework
- Door frames
- Electrical apparatus cabinets, such as AC service distribution, control and lighting
- Engine alternator and all associated equipment
- Floor mounted cabinets
- Hand rails

- HVAC equipment and ductwork
- Metal bookcases
- Metal grates, grill works, louvers
- Metal storage cabinets
- Metallic building support structure (metal support columns, I beams, metal roof structure, etc.)
- Wall mounted cabinets

Electrical units of the communication system that may be installed on the same floor but are outside the radio area are considered to be adequately protected from lightning damage by their connection to the CENTRAL OFFICE GROUND system per requirements in **SECTION 6** of this practice. Such electrical units that are located outside the ring ground area but within six feet of the ring bus shall be unit bonded to the ring bus for equalization and to establish ground system continuity between the CENTRAL OFFICE GROUND and ring ground systems.

8.8.4 GROUNDING of COMMUNICATIONS CABLES

When a radio station is properly grounded for protection of equipment from lightning strokes on the tower and building, as described in the preceding portions of this practice, the most common cause of damage to communications equipment by lightning discharge is that introduced into the station by hits on telecommunication cables or electrical conductors that enter the building. For this reason communications circuits entering the building shall be protected from lightning and other occurrences of high voltage on the conductors by the proper application of grounding and surge protection. Lightguide cable shall be grounded utilizing the 2400 LG grounding closure and proper grounding techniques as indicated in AT&T PRACTICES 633-020-209 & 636-299-111. Properly grounded surge protectors shall be installed on all communications circuits entering the building.

9

Contents

9. LIGHTGUIDE HUT and SMALL POP GROUNDING

LIGHTGUIDE HUT and SMALL POP GROUNDING REQUIREMENTS

9

Lightguide regenerator buildings and small POP buildings (less than twenty-four hundred square feet), due to their remote locations, are very susceptible to lightning induced surges on the AC power service and Lightguide cable strength members. Due to a history of lightning related problems at these locations it is imperative that proper grounding and bonding techniques be adhered to. The following will describe grounding requirements for these and similar small structures housing telecommunications equipment. Buildings larger than twenty-four hundred square feet should utilize a normal CENTRAL OFFICE GROUND system and would not require an interior ring ground system to be installed except in the radio equipment area as described in **SECTION 8** of this practice.

Detailed below are grounding requirements for the following:

- AC service entrance grounding and surge protection
- Equipment grounding requirements
- Interior ring ground system
- Outside ring ground electrode system

9.1 EXTERIOR RING GROUND ELECTRODE SYSTEM

A buried exterior ring bus system establishes a station ground electrode that tends to equalize potential in earth surrounding the building regardless of earth resistivity.

Generally, the ring ground system shall consist of the following:

- A NO. 2 AWG, bare, solid, tinned, copper wire buried at a depth of thirty inches below finished grade or below the frost line, whichever is deeper.
- A number of metallic rods shall be driven vertically in the earth and exothermically bonded to the buried ring. These rods shall be 5/8 inch diameter copper clad steel or stainless steel ground rods, a minimum of eight feet in length, spaced not less than ten feet or more than fifteen feet apart.
- All buried connections shall be exothermically welded
- The NO. 2 wire described above will be arranged in a circle around the building in a losed loop and placed at a minimum of two feet from the exterior wall, or outside the drip line of the structure.
- Where grounding 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 forty-five degrees from the vertical. It is important that the rod penetrate to a depth of permanent ground moisture (below the frost line) for the most effective earth connection.
- Where ground rods cannot be driven more than four feet below grade level because of bedrock, an alternate method may be required to meet the five ohm requirement. Approval for any deviation must be obtained from BUILDING ENGINEERING and DC POWER TECHNICAL SUPPORT GROUP. Alternate methods must be installed per requirements in **SECTION 2.3**. Alternate methods include:

a) Chemical rods

b) Counterpoise

c) Well (metal casing)

9.1.1 ADDITIONAL REQUIREMENTS

Above ground outside conductors shall be solid, tinned copper.

All above ground connections for solid conductors shall be exothermically welded or utilize thermoweld two-bolt tongue connectors

All buried conductors shall be NO. 2 AWG bare, tinned, solid copper

All buried connections shall be exothermically welded.

All metallic objects outside the building, within six feet of the ring, (above or below grade) shall require bonding to the exterior ring ground system. Refer to **FIGURE 37** for examples of exterior building grounding.

Connectors used with stranded wire shall be circumferential compression crimp two-bolt tongues. (above ground only)

Ground rods shall be 5/8 inch diameter, with a minimum length of eight feet. Only

Copper clad steel or stainless steel rods may be used.

Solid wire to stranded wire transitions shall be exothermically welded

9.1.2 INSTALLATION

The installation of the outside ring grounding electrode system should be scheduled so that any excavation, such as hole or trench digging, can be performed while other excavating, clearing, and earth moving operations associated with construction of the facility are in progress. If the grounding electrode system is installed prior to completion of other earth moving operations, take the precautions necessary to ensure that the components of the grounding electrode system are not damaged or broken.

All metallic lines and conduits entering the building shall be bonded to the outside ring ground prior to entering the building.

Before backfilling, the grounding electrode system with earth a visual check shall be made of all joints and connections by an AT&T representative. This will:

- Ensure mechanical and electrical integrity
- Verify the absence of voids or other indications of poor exothermic bonding

- Verify that all required interconnections have been properly made

A visual verification and electrical continuity check should be made at this time to ensure that all connections are intact. A written record of this check with photos shall be placed in the office records for future reference.

After covering and compacting is completed, and before connection to the building grounding system, an earth resistivity measurement shall be made on the exterior ring system to ensure a reading of five ohms or less per requirements in **SECTION 2** of this practice.

9.2 INTERIOR GROUNDING REQUIREMENTS

Due to the susceptibility of regenerator huts to lightning induced voltages and surges on the AC service and Lightguide cable strength members, special grounding and bonding requirements above and beyond those provided in most central offices is required. The requirements for interior and equipment grounding and bonding are show below.

9.2.1 INTERIOR RING GROUND SYSTEM FIGURE 3 & FIGURE 21

The interior ring ground system, as described below, was originally developed for use in radio rooms or in small buildings housing radio equipment where exposure to lightning was high. The interior ring ground system, in addition to being an excellent voltage equalization and lightning dissipation system, also offers other advantages that makes its use in small buildings such as regenerator huts and POP's beneficial. These are listed below.

- The interior ring ground system offers better voltage equalization and surge dissipation than a normal radial grounding system. It therefore offers greater personnel safety and equipment protection from lightning surges that may be induced on Lightguide cable, the AC service entrance, or from a direct hit on the building.

- The interior ring ground system gives easy access for grounding of equipment frames and miscellaneous metallic objects within the building. Such systems are less costly to provide and install than providing multiple separate grounding conductors run back to the OFFICE PRINCIPAL GROUND POINT bus.

- The interior ring ground system gives better access for the bonding of building steel to the ground system.

- The interior ring ground system gives better access for bonding to the exterior ring ground system from each corner of the building. This method is preferred for small buildings exposed to lightning.

For the reasons listed above an interior ring ground system is recommended for small (less than twenty-four hundred square feet) single story buildings housing telecommunications equipment. This will include Lightguide huts and small POP buildings.

The interior ring system is to be installed as described in the following requirements:

Any closed ring of metallic material around a ground conductor increases its inductance to the flow of rapidly rising current. For this reason, routing of ground buses and grounding conductors through metallic objects that form a ring around the bus is prohibited. Use of non-metallic material such as Poly-vinyl Chloride (PVC) conduit is recommended where allowed by code. Where use of magnetic conduit is unavoidable, the ground conductor shall be bonded to each end of the metal conduit or enclosure

- Circumferential compression crimp type parallel connectors or exothermic welding is the only acceptable method of bonding to the interior ring bus. Such connections need not be insulated. A standoff support assembly using nylon ties as shown in **FIGURE 34** is recommended for support of the wire on walls. Supports shall be provided at approximately two foot intervals. Additional supports at points that tend to distort the bus, such as at bonding points, may be provided on basis of need. When the bus wire is not run on walls, it is generally supported form cable racks or framing channels.

- For the purpose of minimizing impedance and the incidence of arcing, the interior ring bus shall be installed with a minimum number of bends, and such bends shall be made with the greatest practical radius. In general, the nominal bend radius shall not be less than eight inches. The probability of arching may be significantly increased by unnecessary bends. Unnecessarily small radii and severe bends may result in over voltages, producing ionization and spark-over.

- The interior ring bus shall be run exposed so that visual inspection of the system may be made and any point is available for future bonding. Routing of the ring bus through conduit for the purpose of support shall be avoided for these reasons.

- The interior ring will be installed using stranded green insulated wire and exothermic or compression crimp type parallel connectors. The interior ring bus need not be installed as a single continuous run of wire, however unnecessary splices should be avoided. In existing locations utilizing solid wire for the bus, all new splices must be made by exothermic weld. All connections between stranded wire and solid wire must be made by exothermic weld.

- Directionalize all of the ground conductor sweeps toward the nearest main ground source, e.g., CENTRAL OFFICE GROUND BUSBAR, MAIN CENTRAL OFFICE RISER, OFFICE PRINCIPAL GROUND POINT, etc.

9.3 INTERFACE between EXTERIOR and INTERIOR RING BUS SYSTEMS

The interior ring ground system must be bonded to the exterior ring ground system as follows:

A NO.2 AWG bare solid tinned copper wire bond between the external ring ground and the internal copper stranded ring ground shall be provided at a minimum of four points on the internal ring bus. The recommended location for these bonds is at the corners of the building. Refer to **FIGURE 3**. A solid tinned NO. 2 AWG copper wire shall be thermowelded to the exterior ring bus, extended into the building through a non-metallic conduit, and bonded to the stranded copper interior ring ground. The connection to the interior ring ground shall be completed utilizing a bi-directional splice as shown in **FIGURE 35**.

9.4 CABLE ENTRANCE GROUND BAR

A single ground bar shall be provided at each cable entrance point into the building for the grounding of Lightguide cables entering the building. The ground bar shall be ¼" thick solid, hard drawn copper pre-drilled to accommodate two-bolt tongue lugs with 3/8" bolts on one inch centers and mounted on two inch minimum insulated standoffs. The bar shall be sized to accommodate the application but should not be less than thirteen inches by four inches. The cable entrance ground bar shall be installed adjacent to the cable entrance location and located on the wall as close to the floor as possible and still accommodate cable connections.

The CABLE ENTRANCE GROUND BAR will have a direct connection to the interior ring ground system.

The CABLE ENTRANCE GROUND BAR shall have a direct connection to the outside ring ground system. This connection shall be completed using a NO. 2 AWG solid, tinned, copper conductor brought into the building through a non-metallic sleeve to the ground bar. One end of the conductor shall terminate with a thermowelded connection to the outside ring bus and the other end shall terminate on the CABLE ENTRANCE GROUND BAR with a thermoweld connection directly to the bar or via a two-bolt tongue thermoweld type connector.

NOTE: All Lightguide cables, with metallic components, entering the building shall be equipped *with 2400LG grounding closures per requirements in AT&T PRACTICE 636-299-111. Refer to this practice for requirements and procedures for the proper grounding of Lightguide cables.*

9.5 OFFICE PRINCIPAL GROUND POINT BAR FIGURE 3

In larger buildings, it may be appropriate, due to logistics and cable lengths, to establish a separate OFFICE PRINCIPAL GROUND POINT bar for the grounding of the AC service, communications equipment frames, and miscellaneous grounds. This bar shall be comprised of ¼" solid copper with recommended dimensions of eighteen inches by four inches with pre-drilled mounting holes to accommodate two-bolt tongue connectors with 3/8" bolts on one inch centers. When a separate OFFICE PRINCIPAL GROUND POINT bar is provided it shall comply with the following requirements:

- The OFFICE PRINCIPAL GROUND POINT bar shall be wall mounted on two inch minimum insulators.
- The OFFICE PRINCIPAL GROUND POINT shall have a direct connection to the outside ring ground system per the same requirement as the CABLE ENTRANCE GROUND BAR above.
- The OFFICE PRINCIPAL GROUND POINT shall be the connecting point for all equipment and building grounding conductors such as the:

  a) AC service grounding conductor.

  b) Any miscellaneous ground conductors not terminated on the interior ring ground conductor.

  c) DC power plant ground reference conductor.

  d) Interior ring ground conductor.

  e) The exterior ring ground

- The OFFICE PRINCIPAL GROUND POINT bar shall have a direct connection to the CABLE ENTRANCE GROUND BAR utilizing a minimum 2/0 AWG conductor.
- Water pipe grounding conductor

9.5.1 GENERAL REQUIREMENTS

Ground bars shall be labeled with their function, e.g., OFFICE PRINCIPAL GROUND POINT or CABLE ENTRANCE GROUND BAR. These signs should be installed directly adjacent to or above the bar and in plane view. If the bars are installed below a raised floor, the signs should be installed above such floor.

All conductors terminating on ground bars shall be equipped with DO NOT DISCONNECT tags, and a permanent label indicating the function of the conductor and its far end terminating point.

All lugs used to terminate conductors shall have two-bolt tongues.

Solid conductors shall be exothermically welded to the bus or use thermoweld lugs.

Stranded conductors shall use compression crimp type lugs.

Connections between stranded wire and solid wire shall use exothermic weld.

9.6 AC POWER GROUNDING and SURGE PROTECTION

At buildings where bonding and grounding have been provided as recommended in this practice, the possibility of damage to station equipment from lightning strokes is minimal, however equipment powered from external power facilities is susceptible to damage from over-voltage surges originating on such facilities. It is reasonable to expect that voltage spikes and surges generated by Power Company switching activities or lightning will be impressed on the AC system at least several times a year. Because of this, surge protection devices are required at the AC power service entrance facility of all AT&T buildings. These devices are designed to limit abnormal surge and transient voltages on AC power circuits by discharging surge currents that may be induced on a phase conductor, to ground.

Distribution-class commercial/industrial type surge protection devices equipped with phase indicator lamps, alarm contacts, and fused for the purpose of maintenance, shall be connected to each overhead or underground primary distribution feeder (or service entrance conductor) on the utility side of the service entrance equipment. The surge protection device shall be installed not less than twenty-four inches (cable length) from the bus connection point. The leads from the bus connection to the device shall be laced together and all leads shall be run as straight as possible with a minimum bending radius of eight inches and a maximum lead length of twenty-four inches.

Reference **FIGURE 7** and AT&T PRACTICE 760-400-101

The neutral conductor of the AC service shall be bonded to the OFFICE PRINCIPAL GROUND POINT. This connection shall be in accordance with ARTICLE 250 of the NATIONAL ELECTRICAL CODE.

9.7 BONDING of INTERIOR METALLIC OBJECTS

Communications equipment, building heating, air conditioning, building steel and numerous other metallic units require bonding to the interior ring ground. Refer to **FIGURE 21** & **FIGURE 36** for an example of the bonding in miscellaneous equipment. The bonding of each metallic object to the interior ring bus ensures that the voltage generated by current flow is also impressed on the neighboring bonded object. This voltage equalization reduces the possibility of spark-over of current from one object to another.

The descriptions and requirements included herein do not cover all of the unique conditions of metallic structures and equipment inter-relationships to be found in a building. The intent is to provide general bonding recommendations that will aid in recognizing conditions that may require deliberate bonds to ensure continuity throughout the structure and all equipment within the structure.

The interior ring bus as well as any supplementary buses run into the equipment area shall be NO. 2 AWG green insulated, stranded copper conductors. Supplementary buses are the trunks for the *tree* grounding system used for bonding all metallic objects in the equipment area. Refer to **FIGURE 21**. Individual unit bonds to equipment frames, cabinets, metal framework, battery stands, etc. shall be made using NO. 6 AWG (minimum) green insulated stranded copper conductors. Connections between the interior ring bus and supplementary buses shall be provided using parallel compression crimp H taps. Connections between frames and cabinets (unit bonds) to supplementary buses or the interior ring ground shall be made with parallel compression crimp H taps with compression crimp two-bolt tongue lugs used for termination to the equipment.

Examples of equipment inside the building that will require bonding to the interior ring bus or supplementary buses follows. This list is not all-inclusive.

- All communications equipment frames
- Conduits, pipes
- DC power plant framework

- Door frames
- Electrical apparatus cabinets, such as AC service distribution, control and lighting
- Engine alternator frame and all associated equipment
- Floor mounted cabinets
- Hand rails
- HVAC equipment and ductwork
- Metal bookcases
- Metal grates, grill works, louvers
- Metal storage cabinets
- Metallic building support structure (metal support columns, I beams, metal roof structure, etc.)
- Wall mounted cabinets

9.8 BONDING of EXTERIOR METALLIC OBJECTS FIGURE 37

For the purpose of equalization of potential during a lightning stroke, it is necessary to bond a large variety of exterior metallic objects to the outside building buried ring ground system. These objects may be stand-alone structures, attached to the building, or buried. Listed below are examples of objects that will require bonding. Please note that this list is not all inclusive. All metallic objects within six feet of the exterior ring ground system shall be bonded to the ring. These bonds are to be made with No. 2 AWG bare, tinned, solid, copper conductor exothermically welded or utilize two-bolt tongue exothermic lugs.

Buried Metallic Objects

a) Conduits, pipes. Multiple bonds are required every twenty-five feet (minimum) to fifty feet (maximum) when run parallel to earth on exterior walls.

b) Fuel tanks

c) Other buried ground fields or electrodes

Other Stand-Alone Metallic Objects

a) Air Conditioning Compressors

b) Antennas

c) Fences (including a bond across gate openings, and multiple bonds at twenty-five foot intervals if run continuously within six feet of the ring) Refer to **FIGURE 22** for a typical detail for the bonding of fences and gates.

d) Fuel Tank Vent Pipes

e) Pad Mounted Engine Alternators

f) Shelters

g) Storage Sheds

Metallic Objects Mounted on the Building **FIGURE 37**

a) Aluminum or similar exterior wall siding

b) Door Frames

c) Down Spouts

d) Exhaust Hoods

e) Handrails

f) Ladders

g) Parapets (at each corner of the building when parapets are electrically continuous, otherwise at least one bond to each section in addition to the corners)

h) Vents and Louvers

Generally, a *tree* grounding system provides the most efficient and economical method of grounding groups of objects located in the same general direction from the grounding point. Individual bonding wires run to each unit is not only expensive and unnecessary but it can be potentially hazardous when units so bonded are located close together. If, during a discharge, one bond wire is conducting lightning current and another used to ground a neighboring unit is not, voltage drop across the conducting wire can cause an extreme difference of potential to occur between the two units. This build-up of potential can cause spark-over of current and is hazardous to personnel interposed between such objects.

A *tree* grounding system consists of a single conductor run from a ground point in the general direction toward a group of units requiring grounding. Branch conductors are extended to individual units from points on the main or *trunk* conductor. Sub-branches may also be extended from branch conductors. This method provides minimal impedance and reduces the probability of high potential difference caused by individual ground paths. It is recommended that branch conductors be limited to about twenty feet so that the inter-unit bond length does not become excessively long. Where units bonded to different trunk conductors are located within six feet of each other, the branch conductor should be bonded together.

10

Contents

AT&T 803-501-100

FIGURE 1

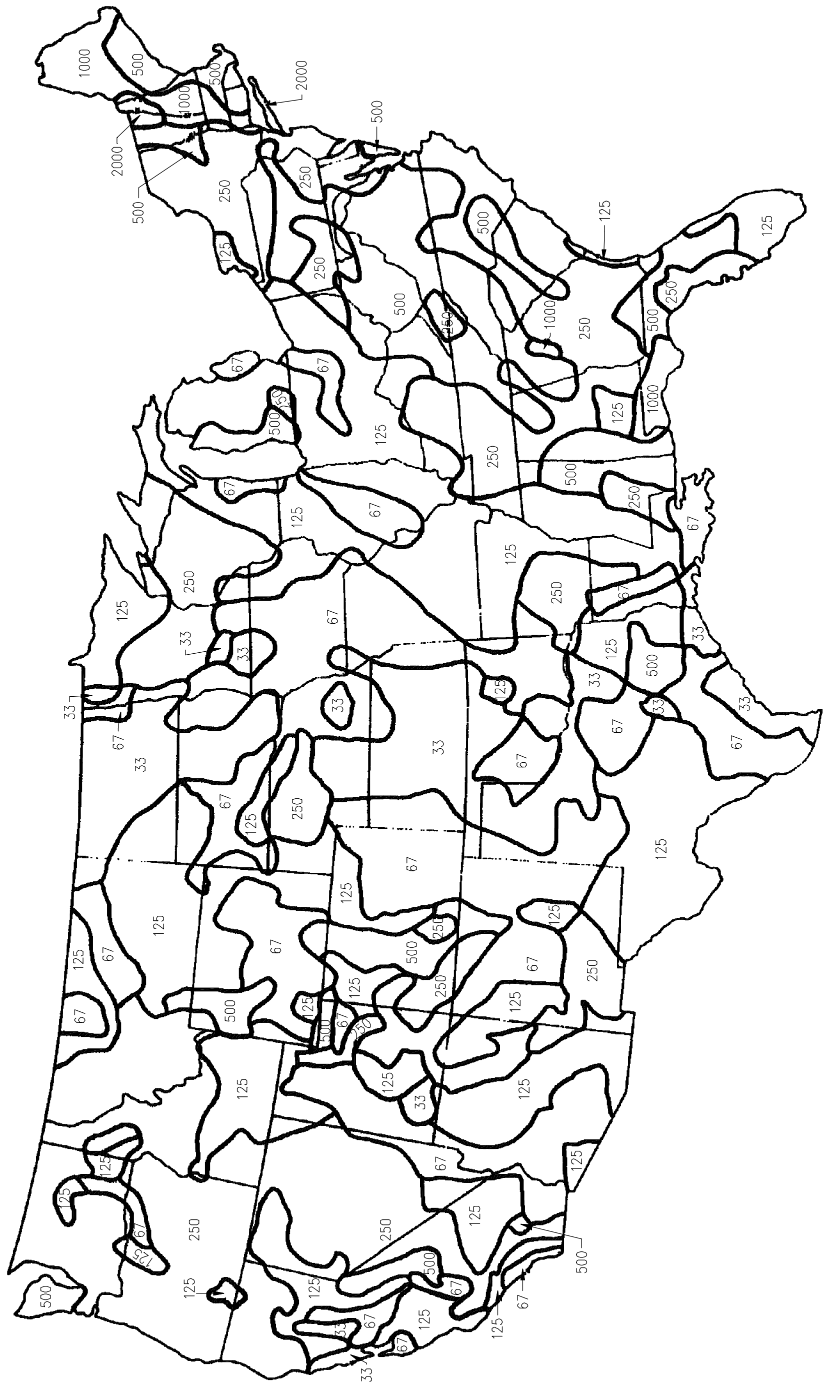


FIGURE 1
ESTIMATED AVERAGE EARTH RESISTIVITY IN THE U.S.
(METER – OHMS)
NO SCALE

AT&T 803-501-100

FIGURE 2

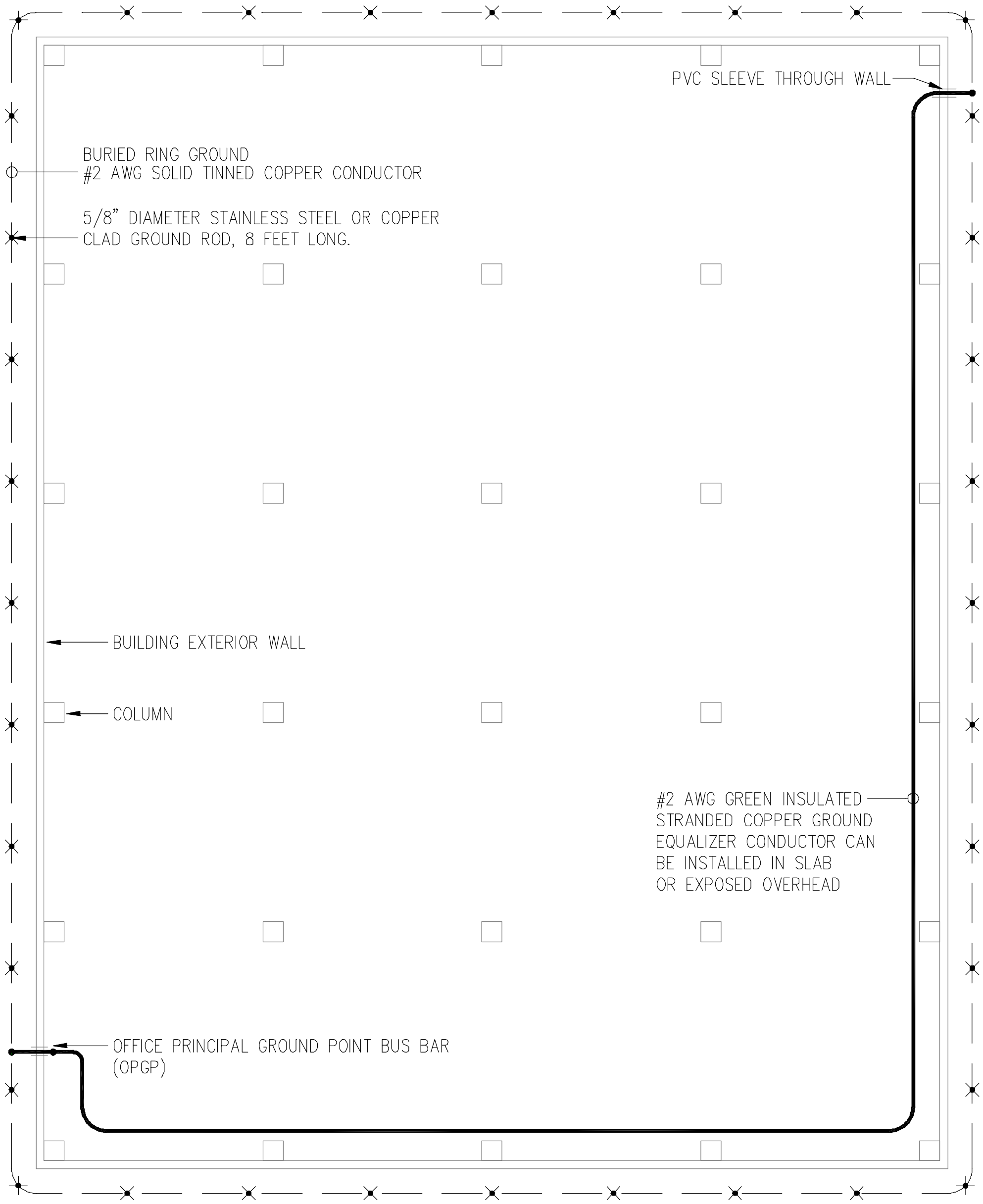


FIGURE 2

LARGE BUILDING (>2400 SQ FT) INTERFACE BETWEEN EXTERNAL BURIED RING GROUND SYSTEM AND THE OFFICE PRINCIPAL GROUND POINT (OPGP) NOT UTILIZING AN INTERIOR RING GROUND SYSTEM

NO SCALE

AT&T 803-501-100

FIGURE 3

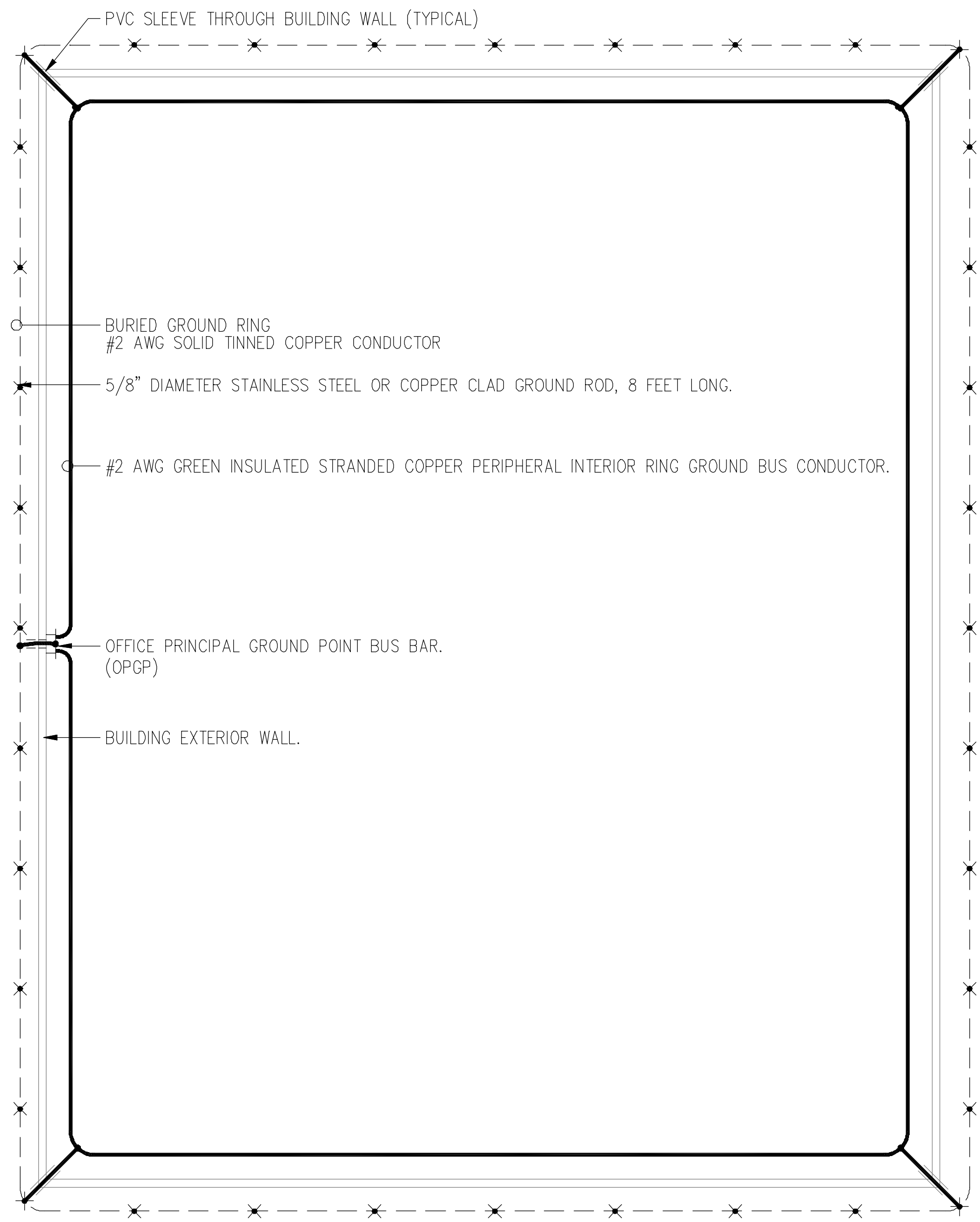


FIGURE 3
SMALL BUILDING (2400 SQ FT ≤)
UTILIZING INTERIOR
RING GROUND SYSTEM
NO SCALE

AT&T 803-501-100

FIGURE 4

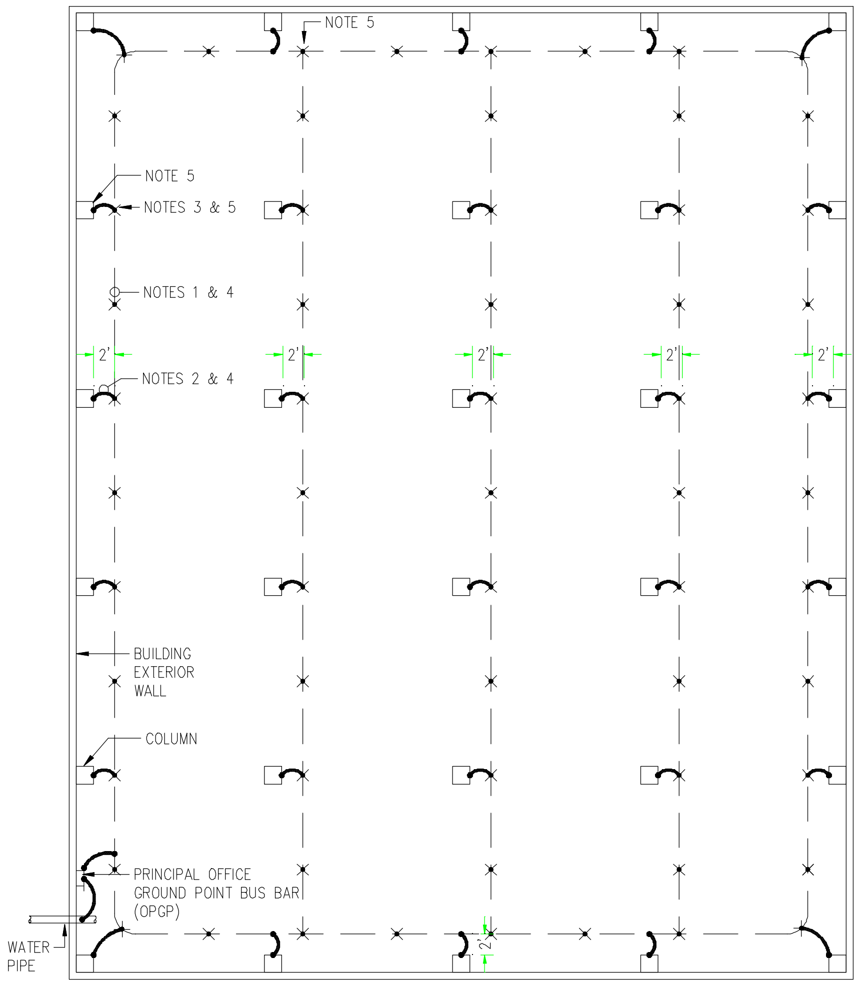


FIGURE 4

UNDER SLAB GROUNDING ARRANGEMENT FOR BUILDINGS WITH ELECTRICAL INTEGRITY THROUGH VERTICAL COLUMN STEEL OR REINFORCED CONCRETE WITH WELDED OR WIRE WRAPPED REINFORCEMENT BARS

NO SCALE

NOTES:

1. THE GROUND FIELD CONDUCTORS SHALL BE INSTALLED AT LEVEL OF COLUMN FOOTINGS.
2. RODS AND CONDUCTORS SHALL BE LOCATED WITHIN 2 FEET OF COLUMN FOOTINGS.
3. 5/8" DIAMETER STAINLESS STEEL OR COPPER CLAD GROUND RODS, 8 FEET LONG.
4. #2 AWG BARE SOLID TINNED COPPER CONDUCTOR.
5. PROVIDE THERMOWELDED CONNECTIONS.

AT&T 803-501-100

FIGURE 5

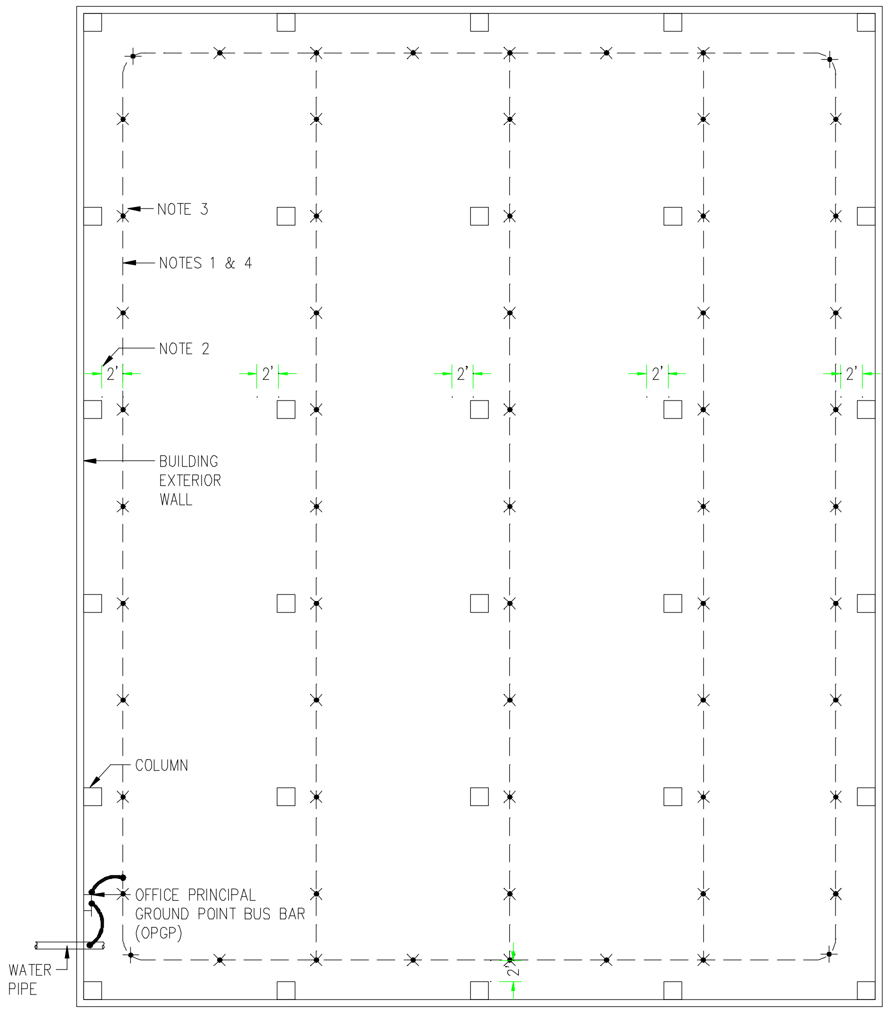


FIGURE 5

UNDER SLAB GROUNDING ARRANGEMENT FOR BUILDINGS WHICH DO NOT HAVE ELECTRICAL INTEGRITY THROUGH VERTICAL COLUMN STEEL OR REINFORCING RODS (THIS IS BASICALLY THE SAME SYSTEM AS IN FIGURE 4) EXCEPT THAT THERE IS NO CONNECTION TO THE COLUMNS)

NO SCALE

NOTE:

1. GROUND FIELD CONDUCTORS SHALL BE INSTALLED AT LEVEL OF COLUMN FOOTINGS.
2. RODS AND FIELD CONDUCTORS SHALL BE A MINIMUM OF 2 FEET OR LESS FROM COLUMN FOOTINGS.
3. 5/8" INCH DIAMETER STAINLESS STEEL OR COPPER CLAD GROUND RODS, 8 FEET LONG. PLACE NOT LESS THAN 10 FEET AND NO MORE THAN 15 FEET APART.
4. #2 AWG UNISULATED SOLID TINNED COPPER CONDUCTOR.

AT&T 803-501-100

FIGURE 6

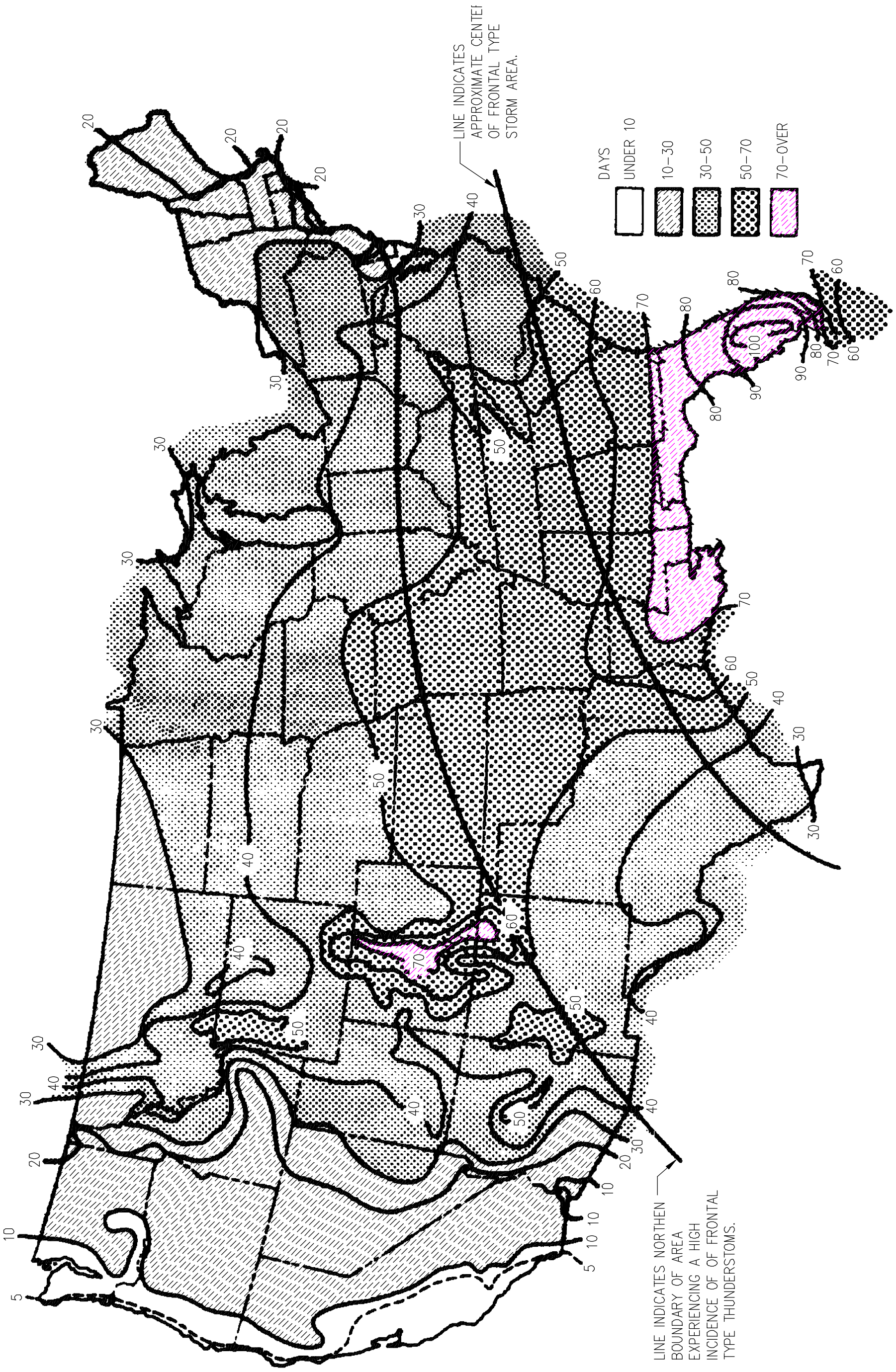


FIGURE 6
ANNUAL NUMBER OF DAYS WITH THUNDERSTORMS
(UNITED STATES)
NO SCALE

AT&T 803-501-100

FIGURE 7

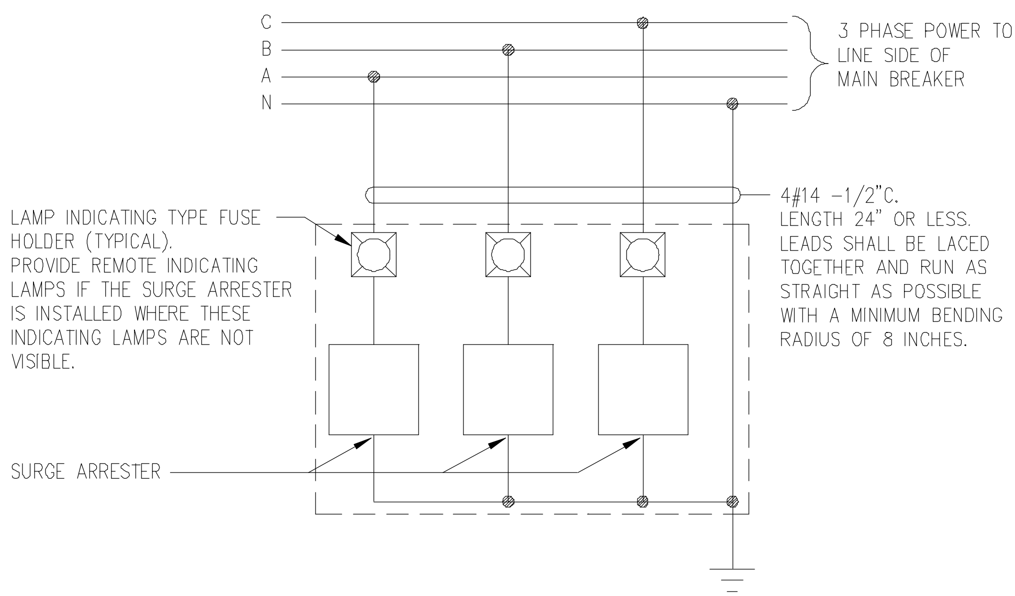


FIGURE 7

WIRING DIAGRAM
SURGE ARRESTERS
NO SCALE

AT&T 803-501-100

FIGURE 8

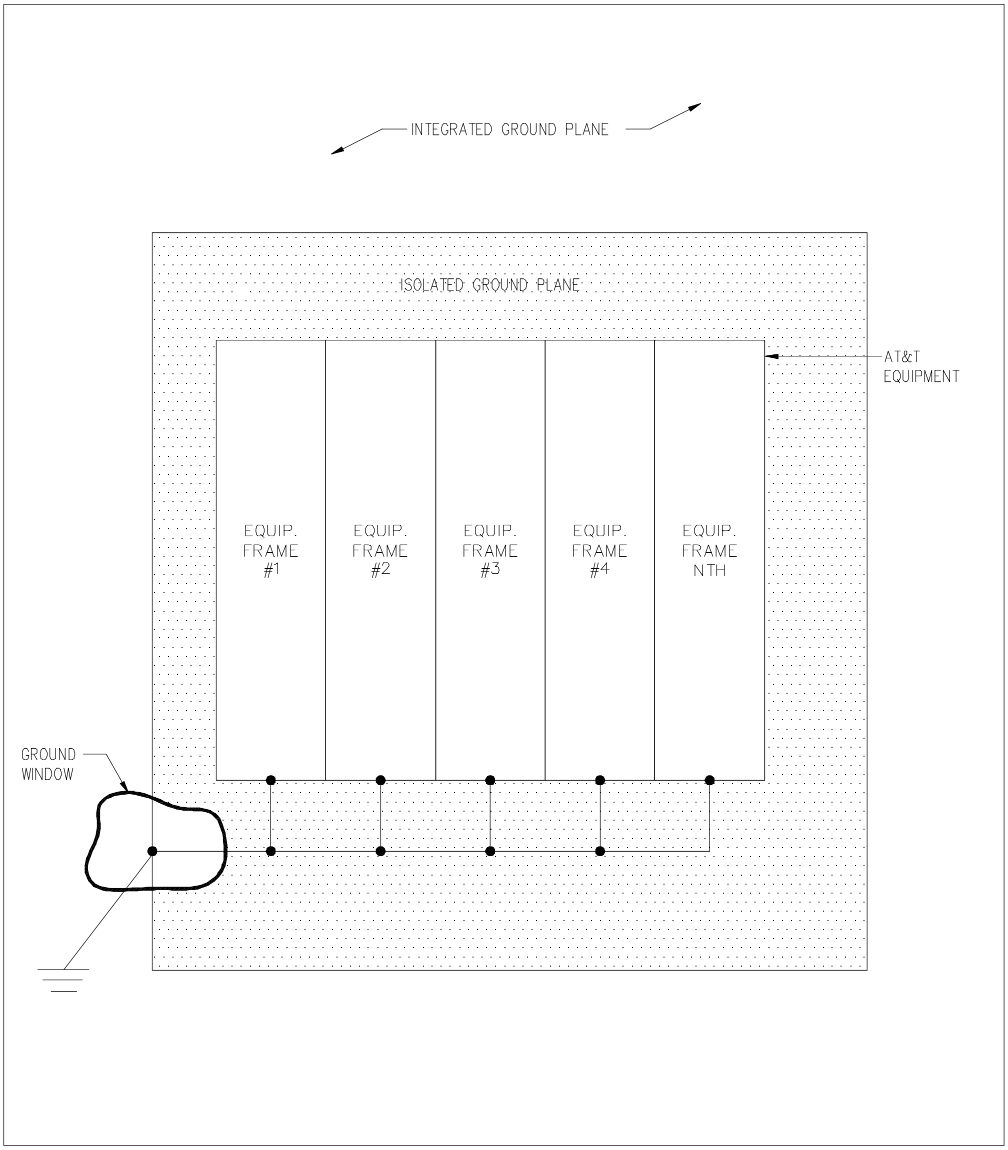


FIGURE 8

SIMPLIFIED ISOLATION GROUND PLANE GROUNDING – CENTRAL OFFICE AND REMOTE EQUIPMENT ENVIRONMENT

NO SCALE

AT&T 803-501-100

FIGURE 9

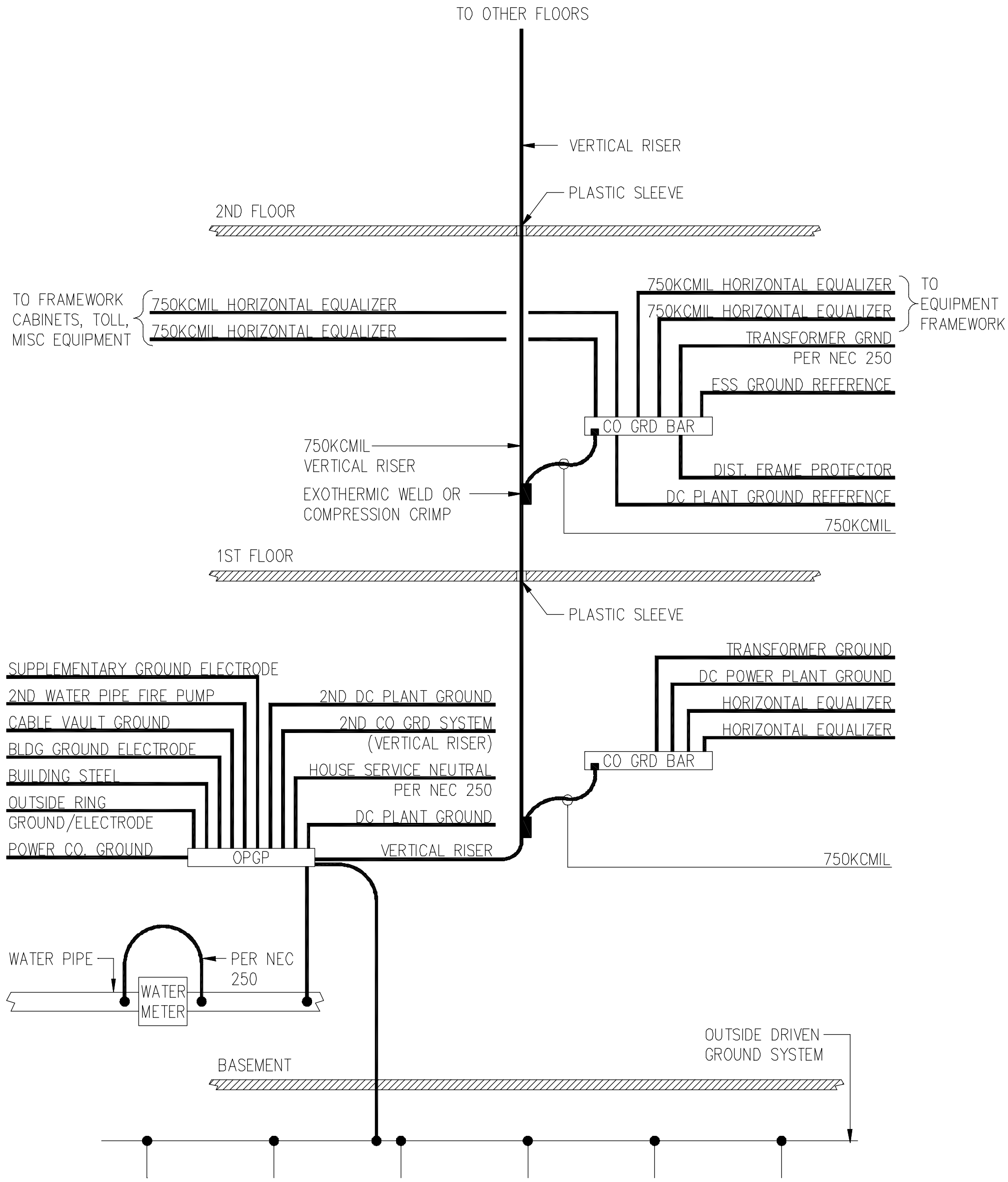


FIGURE 9
TYPICAL CO GROUND SYSTEM
NO SCALE

AT&T 803-501-100

FIGURE 10

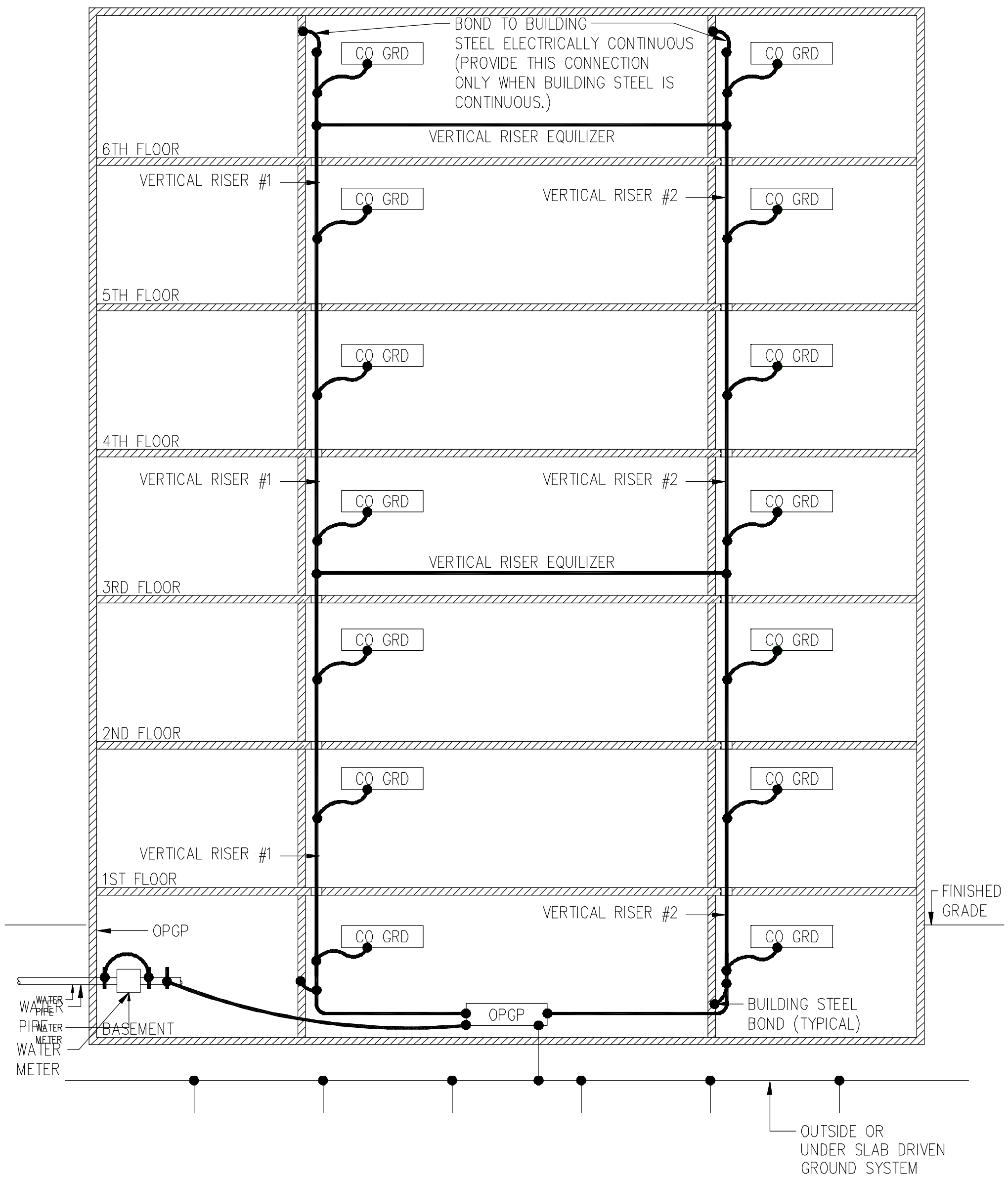


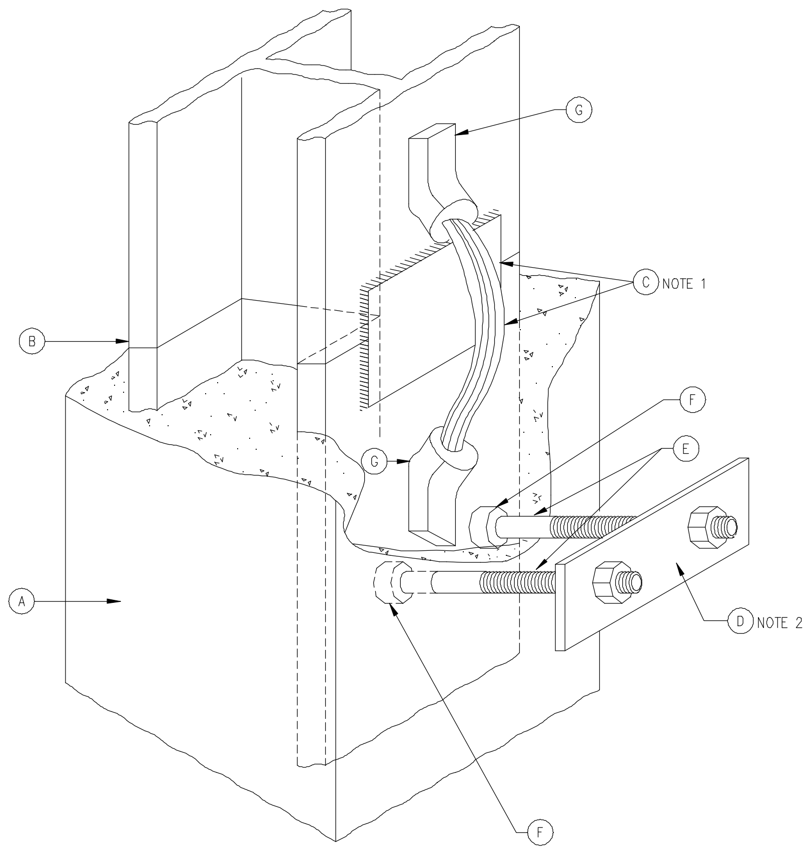
FIGURE 10
MULTIPLE VERTICAL RISER CONFIGURATION
NO SCALE

NOTES:

1. ALL CONNECTIONS TO THE VERTICAL RISER SHALL BE EITHER COMPRESSION CRIMP OR EXOTHERMIC WELDS

AT&T 803-501-100

FIGURE 11



LEGEND:

- (A) BUILDING COLUMN
- (B) STEEL SECTION
- (C) WELDED BOND BETWEEN SECTION JOINTS
- (D) BUILDING STEEL BONDING PLATE
- (E) 3/4" OR 1" STEEL THREADED ROD OR STUD
- (F) THERMOWELD STUD TO COLUMN STEEL
- (G) THERMOWELD CONDUCTOR TO COLUMN STEEL

FIGURE 11

TYPICAL COMBINED SECTION BOND AND BONDING PLATE FOR STRUCTURAL STEEL COLUMN

NO SCALE

NOTES:

1. BOND BETWEEN STEEL SECTION JOINTS MAY BE WELDED STEEL PLATE OR 750KCMIL COPPER WIRE THERMOWELD ACROSS JOINT.
2. 1/4 X 4 X 10" MINIMUM BUS RECOMMENDED. MAY BE MOUNTED VERTICALLY.

AT&T 803-501-100

FIGURE 12

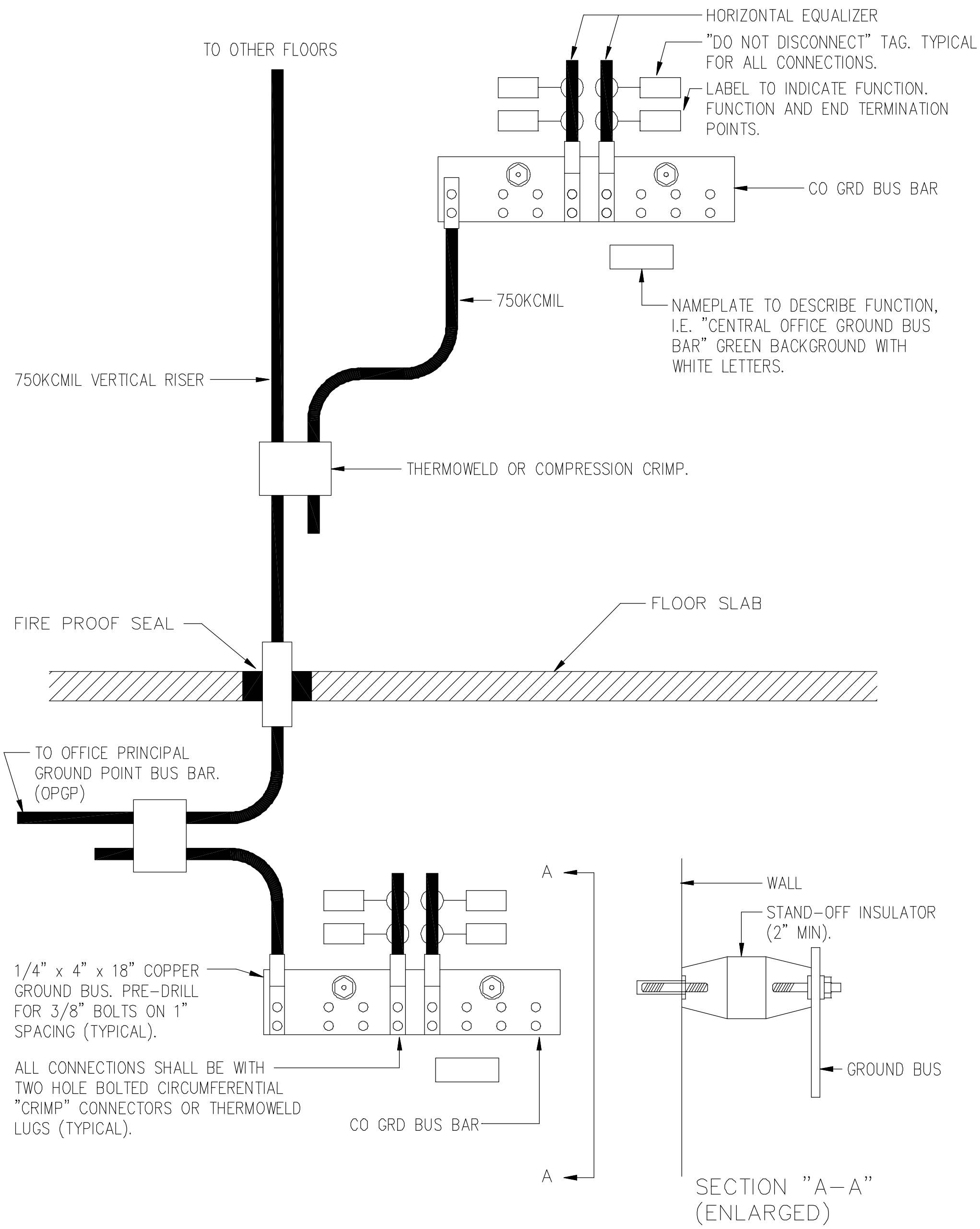


FIGURE 12

CONSTRUCTION OF C.O. GROUND RISER SYSTEM

NO SCALE

AT&T 803-501-100

FIGURE 13

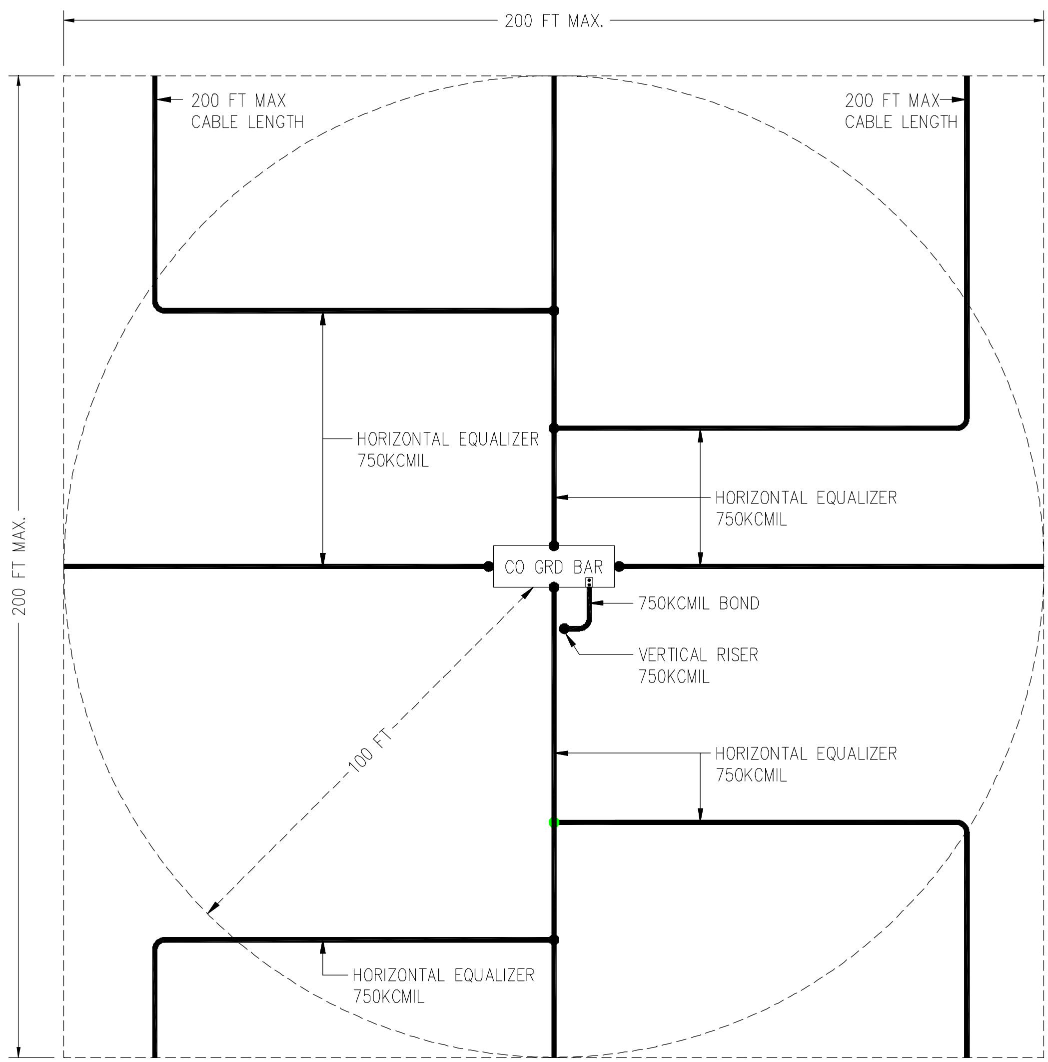


FIGURE 13

REPRESENTATION OF MAXIMUM AREA TO BE SERVED BY A SINGLE CO GRD BUS

NO SCALE

AT&T 803-501-100

FIGURE 14

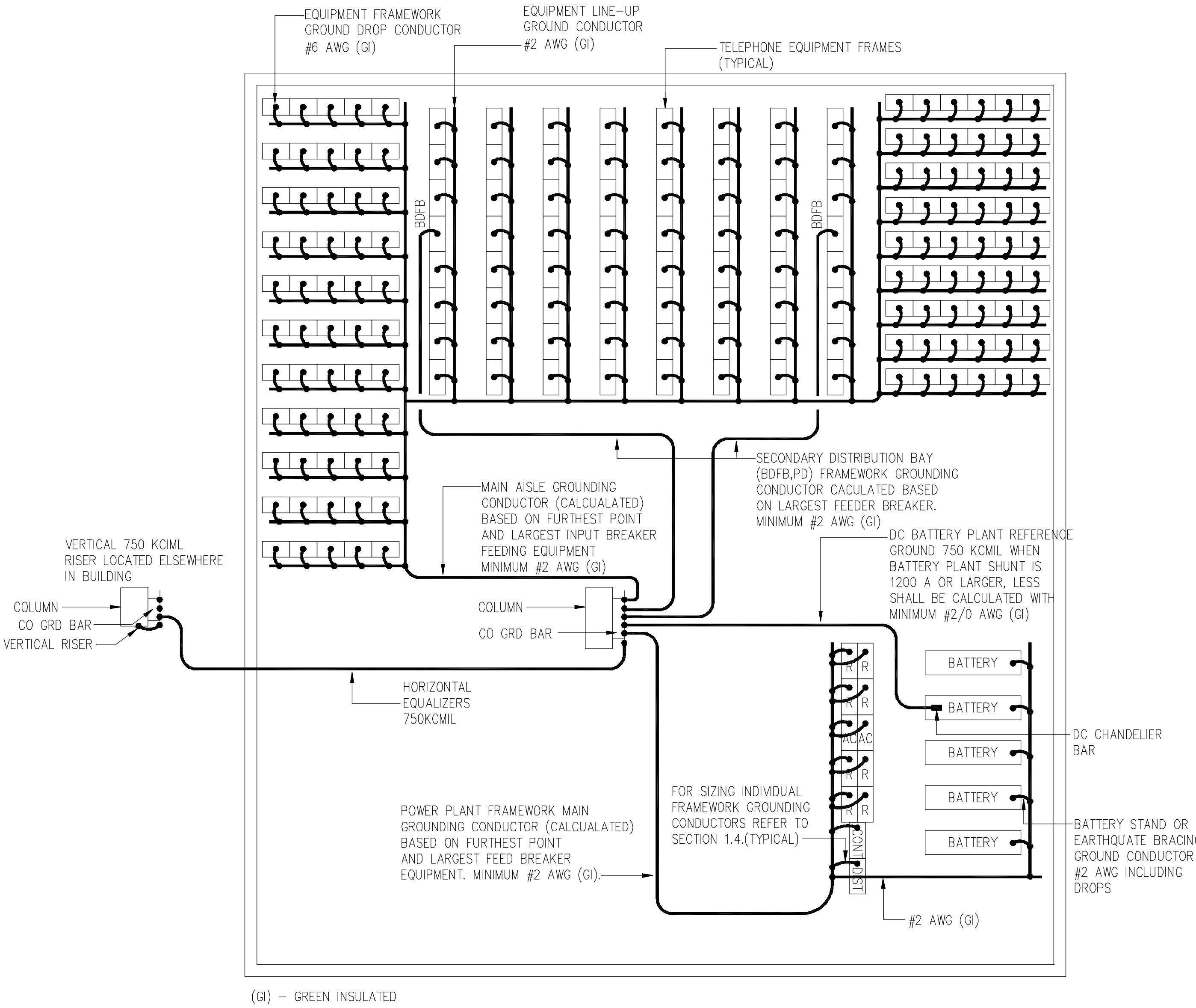


FIGURE 14
TYPICAL CO GRD HORIZONTAL EQUALIZER
SYSTEM – EQUIPMENT FLOOR
NO SCALE

AT&T 803-501-100

FIGURE 15

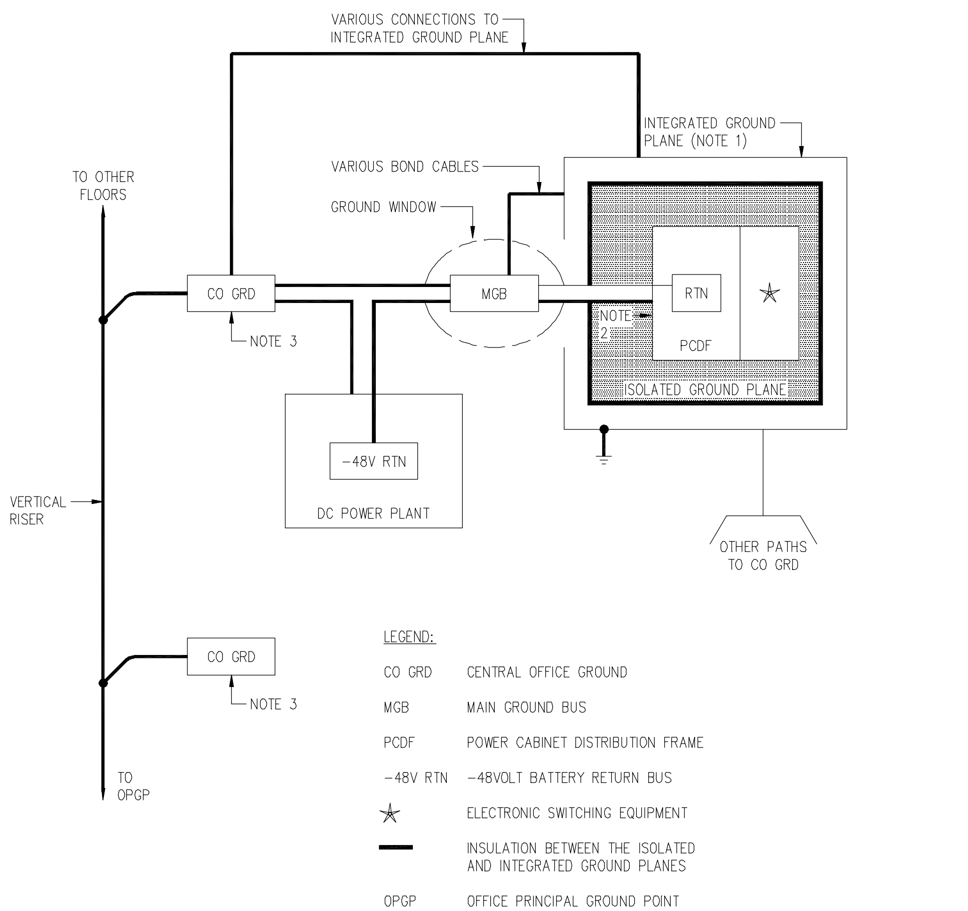


FIGURE 15

SCHEMATIC DIAGRAM SHOWING TYPICAL ELECTRONIC SWITCH, THE ISOLATED AND INTEGRATED GROUND PLANES AND THE INTERFACE BETWEEN THEM VIA THE MGB

NO SCALE

NOTES:

1. THE INTEGRATED GROUND PLANE SHOWN IS THAT WHICH IS IN CLOSE PROXIMITY TO THE ELECTRONIC SWITCHING EQUIPMENT LOCATED IN THE ISOLATED GROUND PLANE AREA. NOTE THE INTEGRATED GROUND PLANE BOND(S) TO THE MGB.
2. ANY GROUNDED ITEM ENTERING THE ISOLATED GROUND PLANE AREA MUST BE BONDED TO THE GROUND WINDOW BAR. A -48V RETURN AND A FRAME GROUND ARE TYPICAL EXAMPLES SHOWN.
3. SEE FIGURE 9 FOR EXAMPLES OF TYPICAL EQUIPMENT CATEGORIES AND BONDS REQUIRED TO THE CO GRD SYSTEM.

AT&T 803-501-100

FIGURE16

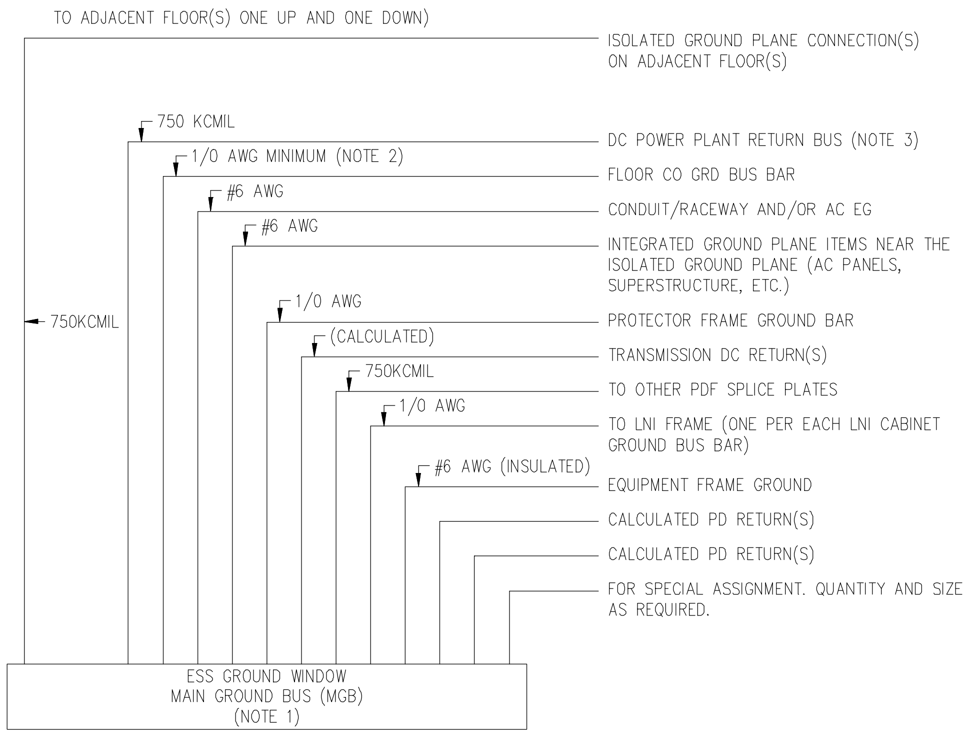


FIGURE 16

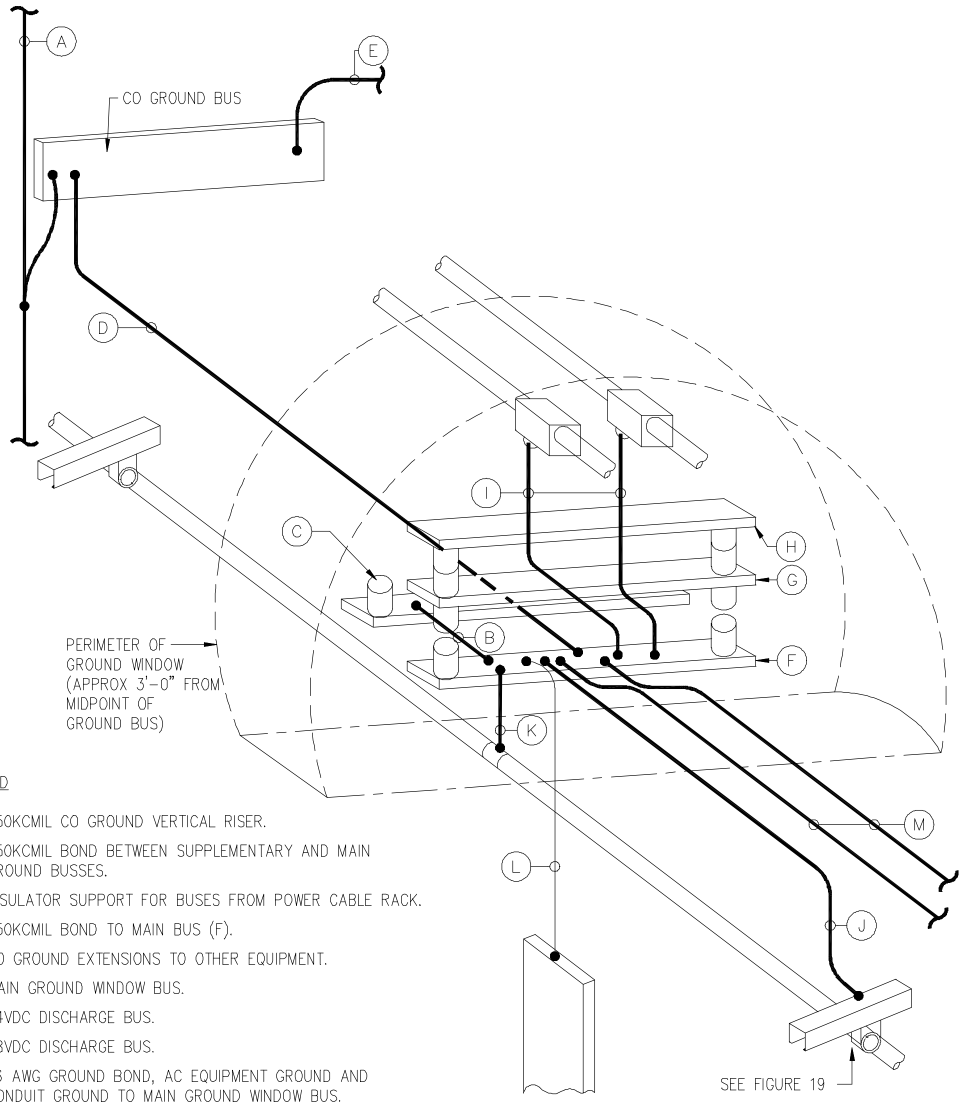
ESS GROUND WINDOW
MAIN GROUND BUS—TYPICAL BONDS
NO SCALE

NOTES:

1. THE BUS BAR USED IN THE GROUND WINDOW IS THE MAIN GROUND BUS (MGB). THE MGB GROUND WINDOW MAY BE THE INSULATED OR GROUNDED RETURN BAR OF A −48V POWER PLANT, OR THE BAR ABOVE A POWER DISTRIBUTING FRAME (PDF), OR A SEPARATE REMOTE BAR WHOSE LOCATION IS SELECTED TO OPTIMIZE THE ROUTING AND BONDING OF THE VARIOUS GROUNDED ELEMENTS TO THE GROUND WINDOW.
2. MINIMUM CABLE SIZE IS SHOWN. LARGER SIZES MAY BE REQUIRED FOR SPECIFIC SYSTEMS. REFER TO THE REQUIREMENTS OF THE SPECIFIC SYSTEM BEING USED.
3. THIS CABLE IS NOT REQUIRED WHEN THE RETURN BUS OF THE −48V POWER PLANT IS USED AS THE THE GROUND WINDOW (MGB).

AT&T 803-501-100

FIGURE 17



LEGEND

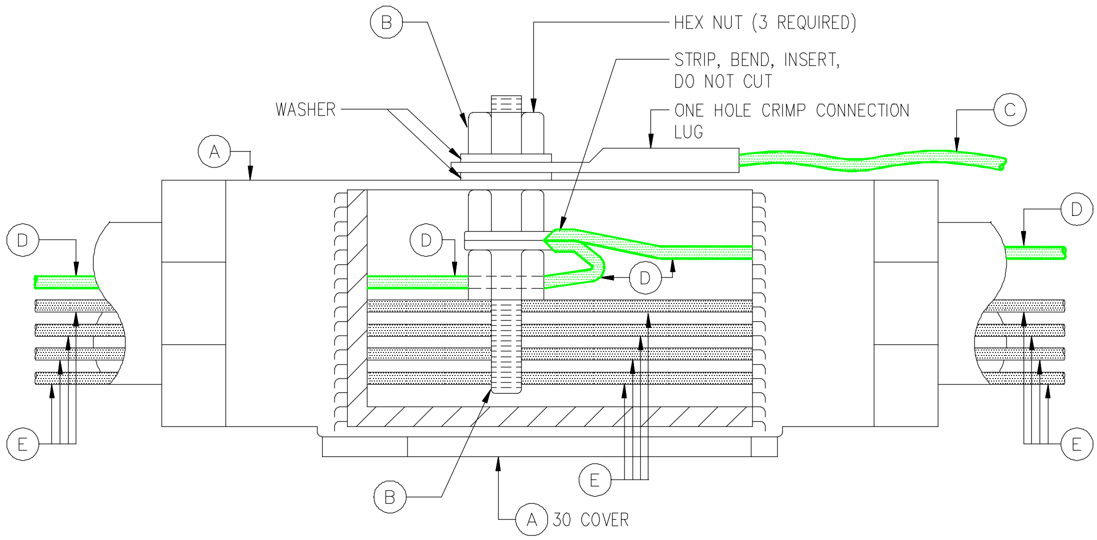
- (A) 750KCMIL CO GROUND VERTICAL RISER.
- (B) 750KCMIL BOND BETWEEN SUPPLEMENTARY AND MAIN GROUND BUSSES.
- (C) INSULATOR SUPPORT FOR BUSES FROM POWER CABLE RACK.
- (D) 750KCMIL BOND TO MAIN BUS (F).
- (E) CO GROUND EXTENSIONS TO OTHER EQUIPMENT.
- (F) MAIN GROUND WINDOW BUS.
- (G) 24VDC DISCHARGE BUS.
- (H) 48VDC DISCHARGE BUS.
- (I) #6 AWG GROUND BOND, AC EQUIPMENT GROUND AND CONDUIT GROUND TO MAIN GROUND WINDOW BUS. SEE FIGURE 18.
- (J) #6 AWG BOND TO UNISTRUT SUPERSTRUCTURE.
- (K) #6 AWG BOND TO CONDUIT STRAP.
- (L) 350KCMIL PD FRAME DISCHARGE BOND TO MAIN BUS (F).
- (M) GROUND BONDS AS REQUIRED TO OTHER CONDUCTIVE OBJECTS IN ESS AREA NOT PART OF ESS GROUND SYSTEM.

FIGURE 17

TYPICAL MAIN GROUND BUS (MGB) ARRANGEMENT
INTERFACE AT GROUND WINDOW BETWEEN ELECTRONIC OFFICE
(SINGLE POINT) AND CENTRAL OFFICE GROUND SYSTEM
NO SCALE

AT&T 803-501-100

FIGURE 18



LEGEND:

- (A) SPLICE BOX – KONDU C3 FITTING AND 30 COVER OR SIMILAR FTS, NOTE 1
- (B) BURNDY GROUND CONNECTOR
- (C) NO.6 GROUND BOND TO MAIN GROUND BUS
- (D) AC EQUIPMENT GROUND CONDUCTOR (GREEN WIRE)
- (E) AC WIRE RUNS (3 PHASE & NEUTRAL) THRU SPLICE BOX

FIGURE 18

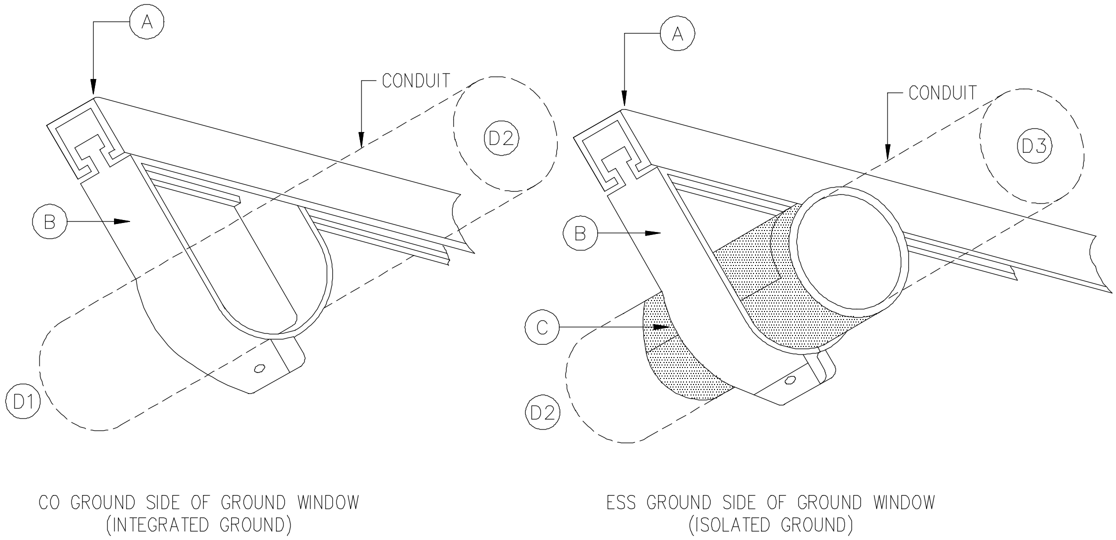
TYPICAL METHOD OF CONNECTING CONDUIT & GROUND CONDUCTOR TO MAIN GROUND BUS (GROUND WINDOW)
NO SCALE

NOTES:

1. BOX SHALL BE DRILLED AS REQUIRED TO MOUNT GROUND CONNECTION STUB AND 1 HOLE CONN LUG ON OUTSIDE OF BOX.
2. A TYPICAL METHOD OF CONNECTING AC CIRCUIT EQUIPMENT GROUND CONDUCTOR AND CONDUIT TO SUPPLEMENTARY AND/OR MAIN GROUND BUS AT GROUND WINDOW AS SHOWN. OTHER TYPES OF FITTING AND/OR JUNCTION BOX CAN BE UTILIZED.

AT&T 803-501-100

FIGURE 19



LEGEND:

- (A) FLUORESCENT LIGHTING UNISTRUT SUPPORT CHANNEL OR OTHER SUPERSTRUCTURE.
- (B) PIPE CLAMP (UNISTRUT CORP) OR OTHER CONDUIT CLAMP.
- (C) DOUBLE WRAP OF GREY FIBER SHEET, 2 INCHES WIDE INSULATION.
- (D1) FROM OVERCURRENT DEVICE.
- (D2) TO GROUND WINDOW.
- (D3) FROM ESS EQUIPMENT.

FIGURE 19

TYPICAL METHOD OF SUPPORTING CONDUITS
ENTERING THE ISOLATED GROUND AREA THROUGH GROUND WINDOW
NO SCALE

AT&T 803-501-100

FIGURE 20

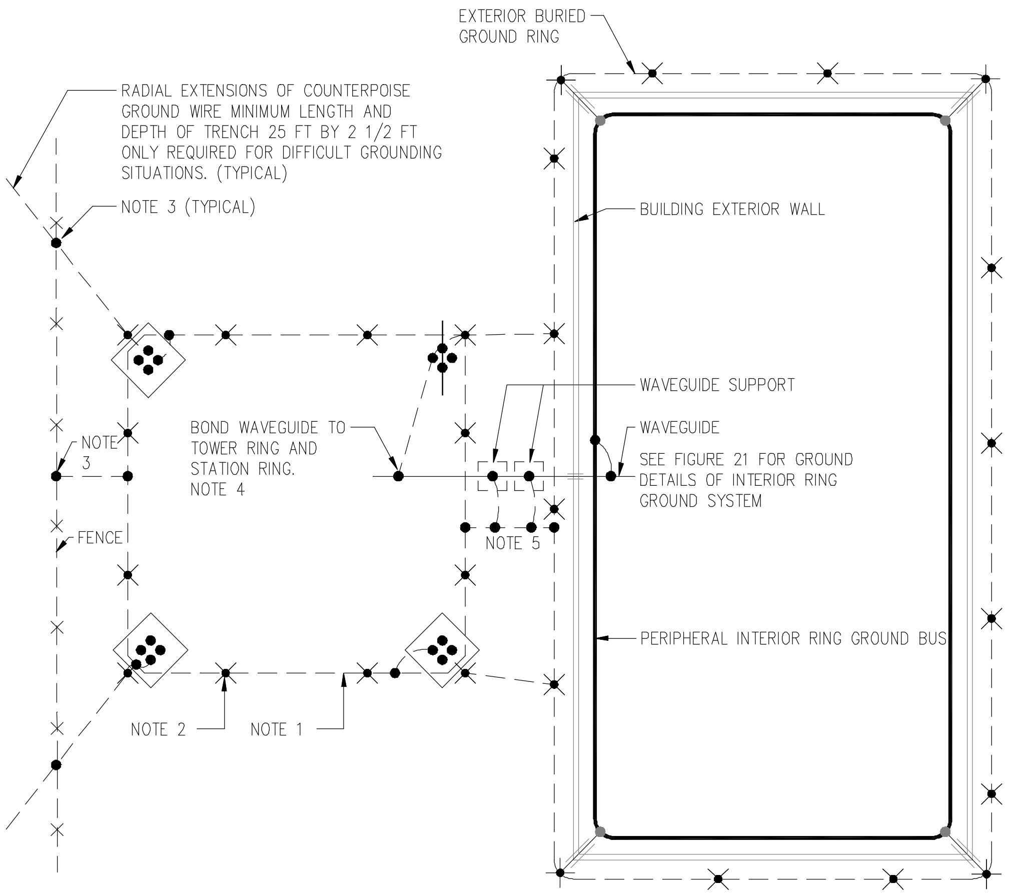


FIGURE 20
GROUNDING NETWORK FOR TOWERS
STANDING BESIDE RADIO STATIONS
NO SCALE

NOTES:

1. #2 AWG BARE SOLID TINNED COPPER WIRE FOR BONDING AND GROUNDING.
2. STAINLESS STEEL OR COPPER CLAD RODS 5/8 IN. DIA., 8 FT LENGTH. SPACING BETWEEN RODS 10 – 15 FT. DEPTH 2 1/2 FT GRADE.
3. BOND RING TO FENCE IF WITHIN 6 FT OF EACH OTHER. WHEN RADIAL EXTENSIONS ARE USED, BOND FENCE TO RADIAL CONDUCTORS. THIS WILL PRECLUDE THE NEED FOR INTERMEDIATE BONDS.
4. BOND WAVEGUIDE AT BOTTOM OF VERTICAL RUN DIRECT TO NEAREST GROUND RING CONNECTION AT BASE CORNER OF TOWER FOOTING, USE #2 AWG STRANDED OR SOLID TINNED COPPER CONDUCTOR, INSULATED OR UNINSULATED.
5. BOND WAVEGUIDE SUPPORT STRUCTURE TO BURIED RING GROUND SYSTEM.
6. ALL OUTSIDE AND BURIED CONNECTIONS SHALL BE EXOTHERMIC WELDED.

AT&T 803-501-100

FIGURE 21

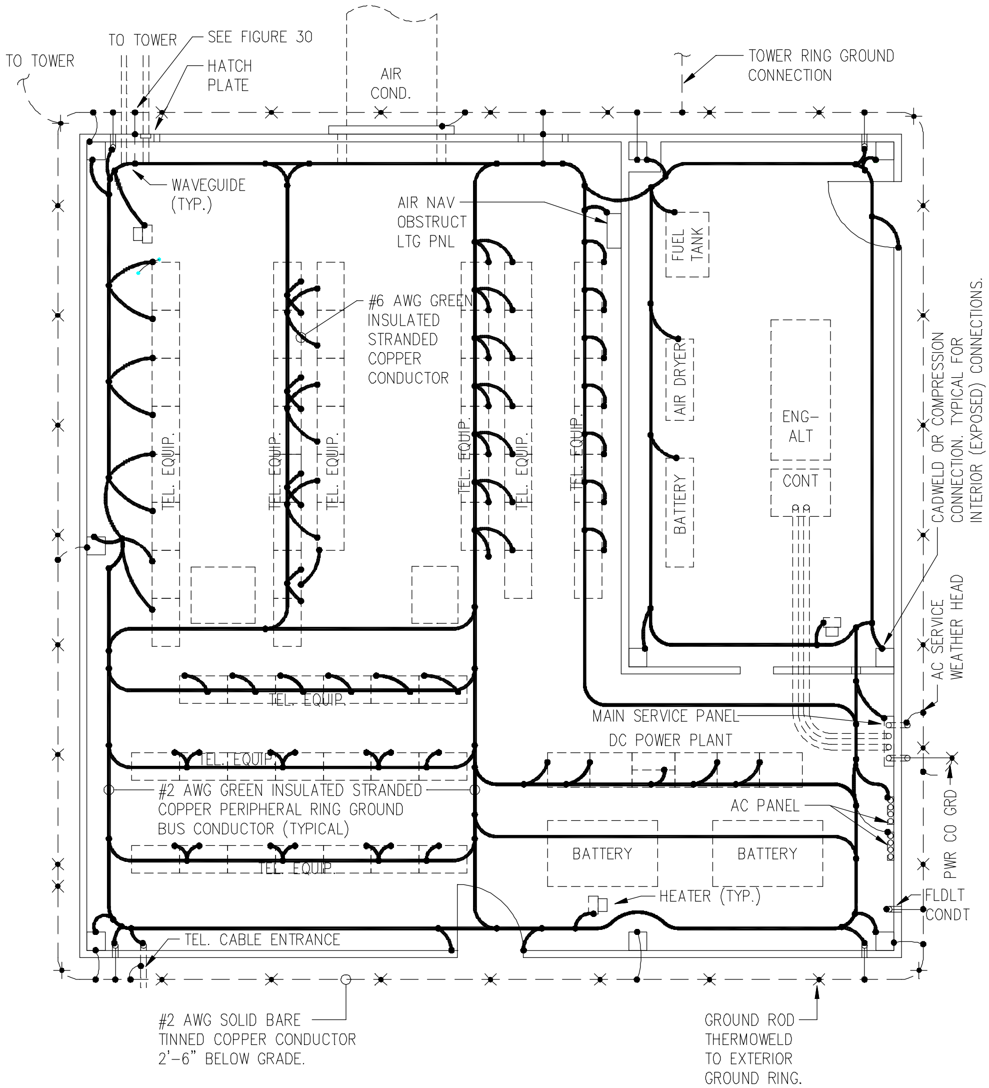


FIGURE 21
TYPICAL GROUND INSTALLATION
IN MICROWAVE STATION
NO SCALE

NOTES:

1. EXTERIOR RING SYSTEM AND EVERY GROUND BOND REPRESENTS A POTENTIAL PATH PATH TO GROUND.
2. WAVEGUIDE REPRESENT OPTIMUM CURRENT PATH TO POINT OF LIGHTNING STRIKE.
3. INTERIOR BUS SHALL BE ROUTED TO PROVIDE MINIMUM IMPEDANCE BETWEEN POTENTIAL GROUND POINTS AND WAVEGUIDE HATCHES.
4. WALL SUPPORTS SEE FIGURE 34. CRIMP CONNECTION FOR INTERIOR RING GROUND BUS SEE FIGURE 34.

AT&T 803-501-100

FIGURE 22

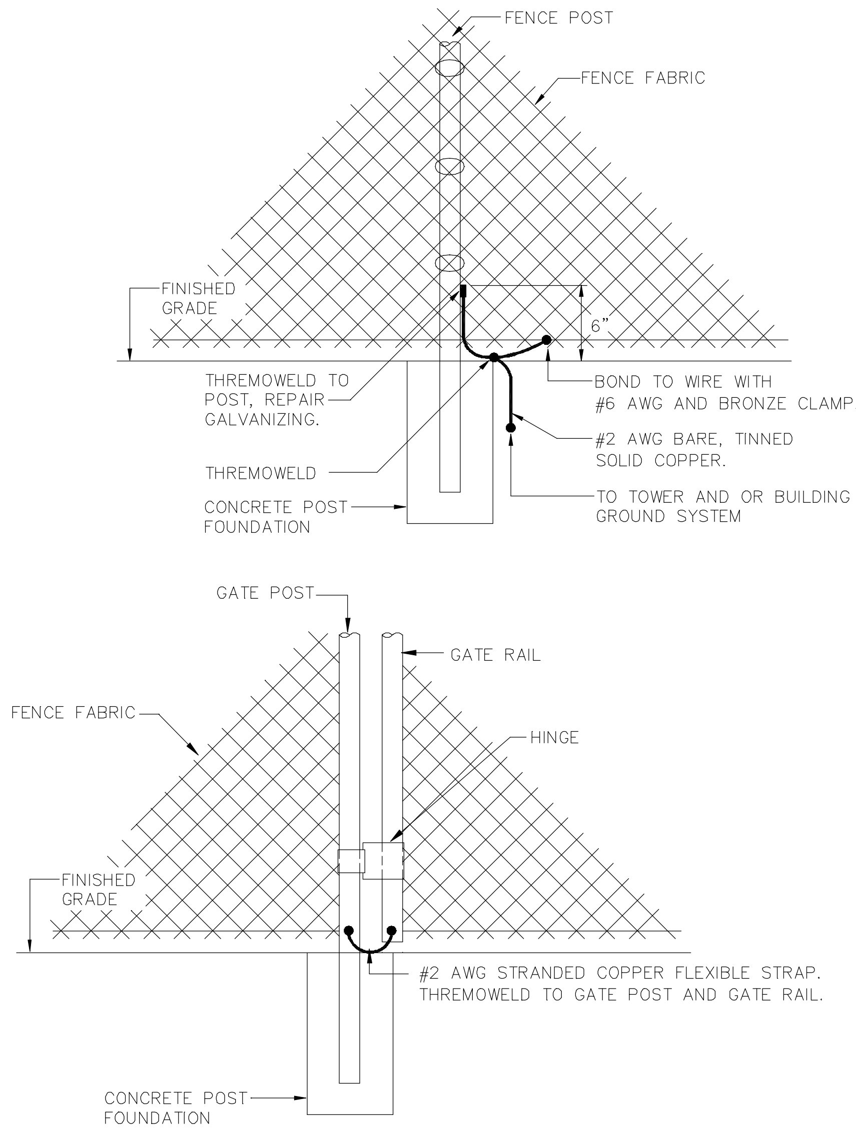


FIGURE 22

TYPICAL GROUNDING OF FENCE AND
TYPICAL BONDING OF GATE TO GATE POST
NO SCALE

AT&T 803-501-100

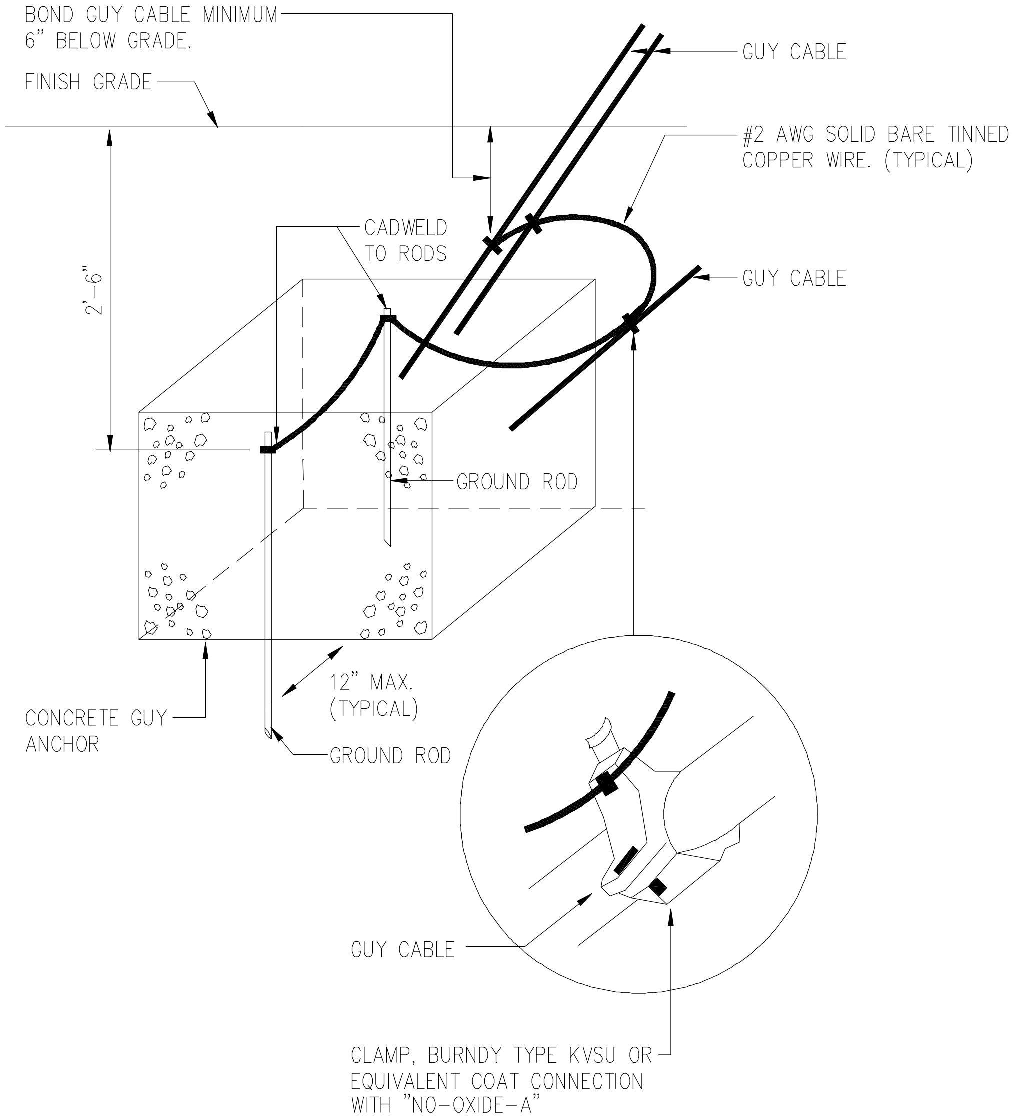


FIGURE 23
TYPICAL GROUNDING OF EMBEDDED
GUY ANCHOR
NO SCALE

AT&T 803-501-100

FIGURE 24

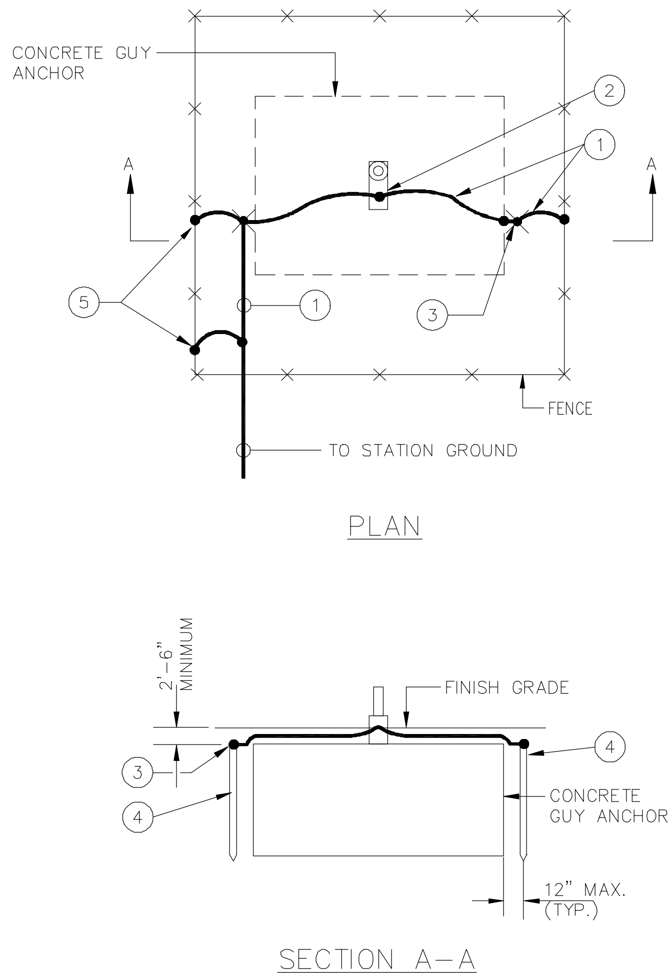


FIGURE 24
TYPICAL GROUNDING OF EXPOSED
GUY ANCHOR
NO SCALE

LEGEND:

1. #2 AWG SOLID BARE TINNED COPPER WIRE.
2. CONNECT GROUND WIRE TO GROUNDING PLATE AT GUY ANCHOR WITH THERMOWELD CONNECTION. REPAIR GALVANIZING.
3. CONNECT GROUND WIRE TO GROUND RODS WITH THERMOWELD CONNECTION
4. GROUND RODS. TOP OF RODS SHALL BE 2'–6" BELOW GRADE MINIMUM.
5. CONNECT NEAREST FENCE POST TO GROUND WITH #2 AWG SOLID COPPER WIRE. CONNECTION TO POST TO BE 6" ABOVE GROUND.

AT&T 803-501-100

FIGURE 25

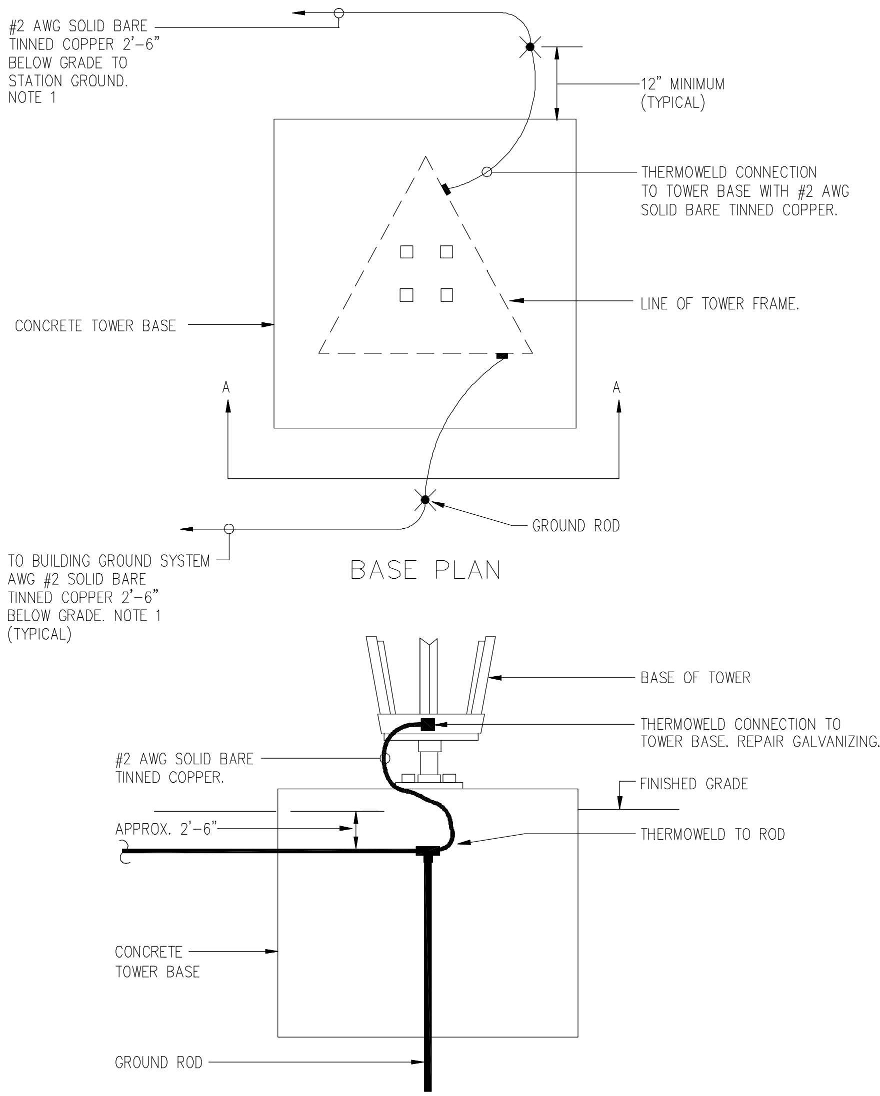


FIGURE 25

TYPICAL GROUNDING OF
GUY TOWER BASE
NO SCALE

NOTES:

1. CONNECT TO NEAREST GUY ANCHOR GROUND.

AT&T 803-501-100

FIGURE 26

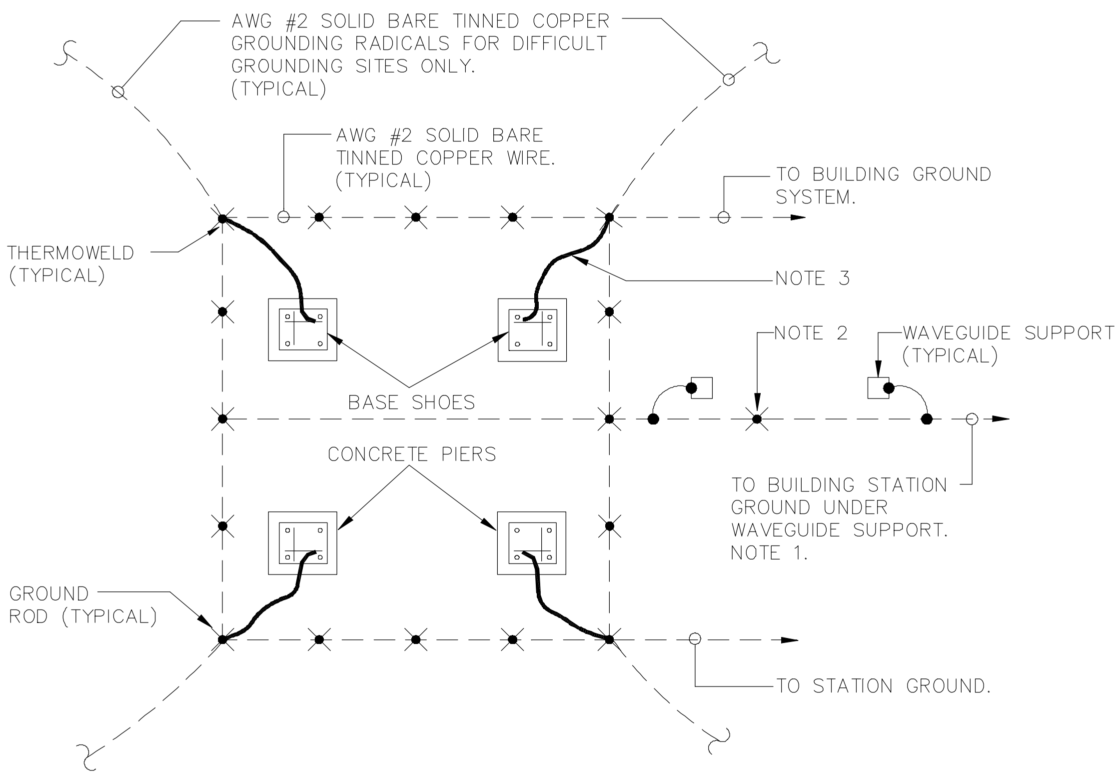


FIGURE 26

BASE PLAN

TYPICAL GROUNDING PLAN FREE STANDING TOWER

NO SCALE

NOTES:

1. BOND TO EACH WAVEGUIDE SUPPORT BASE AS REQUIRED.
2. GROUND RODS SHALL BE STAINLESS STEEL OR COPPER CLAD STEEL A MINIMUM OF 8 FEET LONG, SPACED 10 FEET MINIMUM AND 15 FEET MAXIMUM.
3. #2 AWG BARE SOLID TINNED COPPER, THERMOWELD CONNECTED TO TOWER BASE AND GROUND ROD. SEE FIGURE 27.

AT&T 803-501-100

FIGURE 27

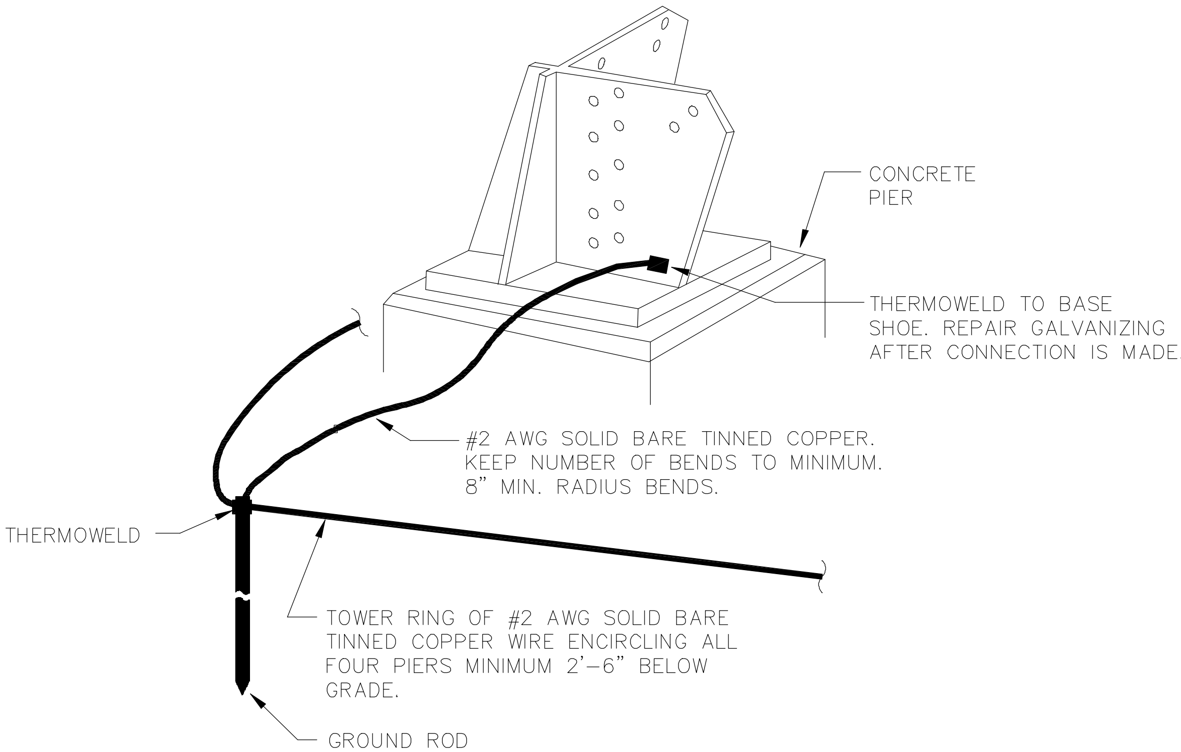


FIGURE 27

TYPICAL CONNECTION TO TOWER BASE
NO SCALE

NOTES:

1. BASE SHOE (ANCHOR BOLTS AND HOLES OMITTED FOR CLARITY).

AT&T 803-501-100

FIGURE 28

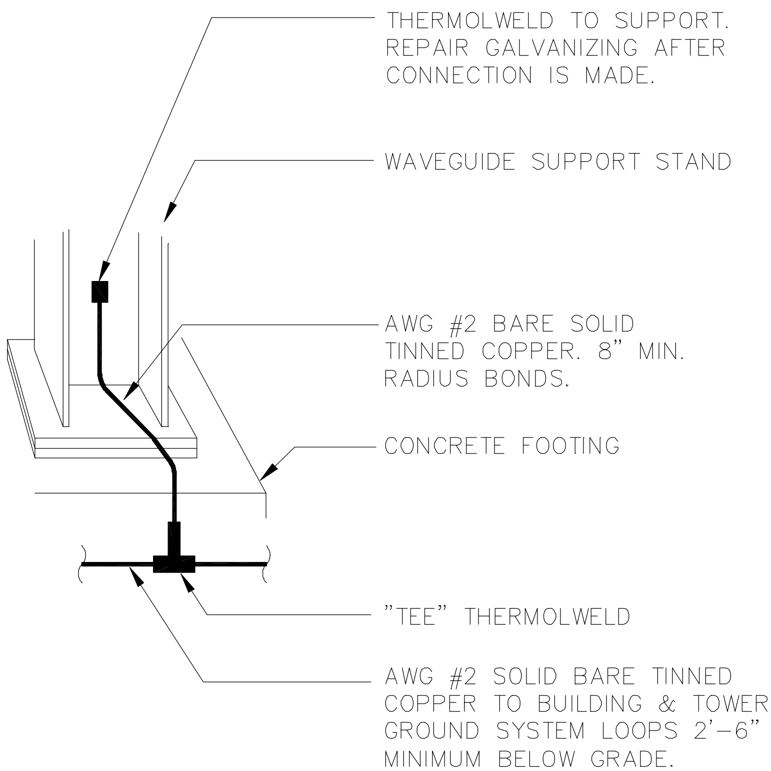


FIGURE 28

TYPICAL GROUNDING OF WAVEGUIDE STAND
NO SCALE

AT&T 803-501-100

FIGURE 29

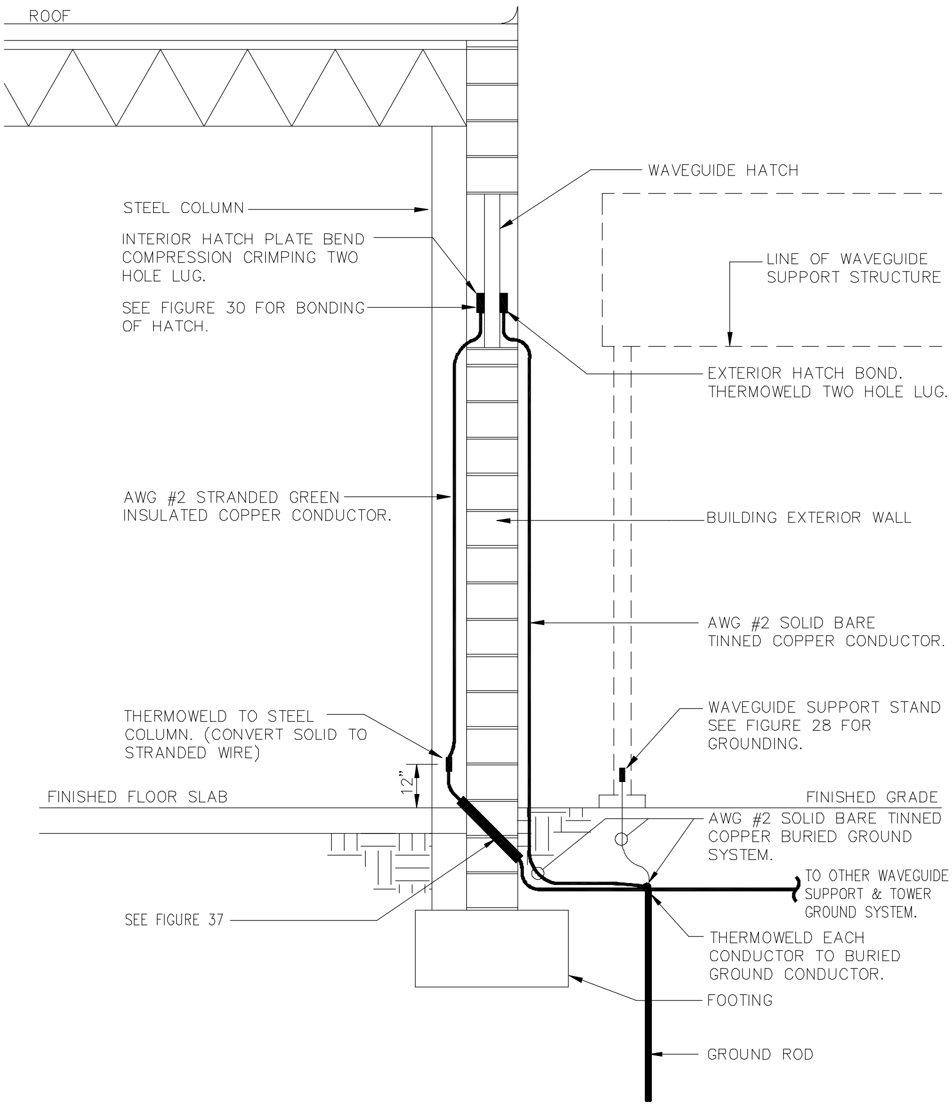


FIGURE 29

BONDING OF WAVEGUIDE HATCH & CONNECTION OF INTERIOR GROUND RING WHERE HATCH IS LOCATED ADJACENT TO COLUMNS
NO SCALE

AT&T 803-501-100

FIGURE 30

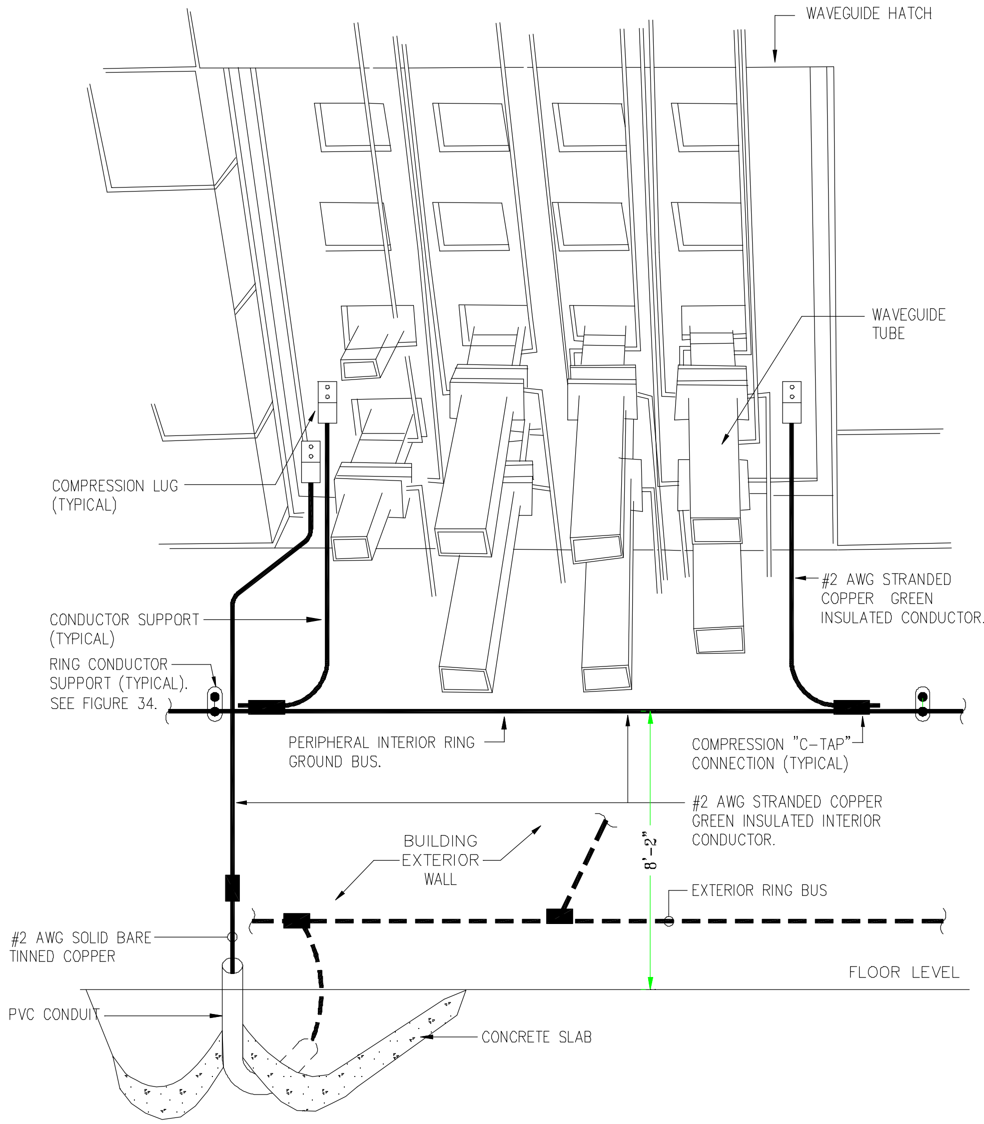


FIGURE 30

TYPICAL ARRANGEMENT OF PERIPHERAL AND EXTERIOR RING BUS BONDS AT WAVEGUIDE HATCHPLATE
NO SCALE

AT&T 803-501-100

FIGURE 31

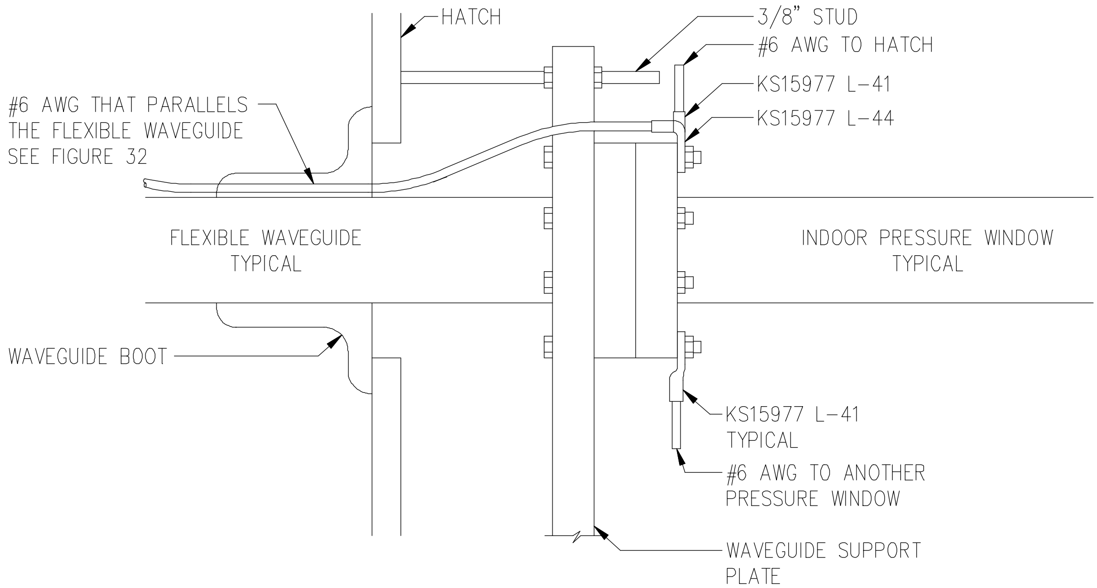


FIGURE 31

WAVEGUIDE HATCHPLATE GROUNDING
NO SCALE

AT&T 803-501-100

FIGURE 32

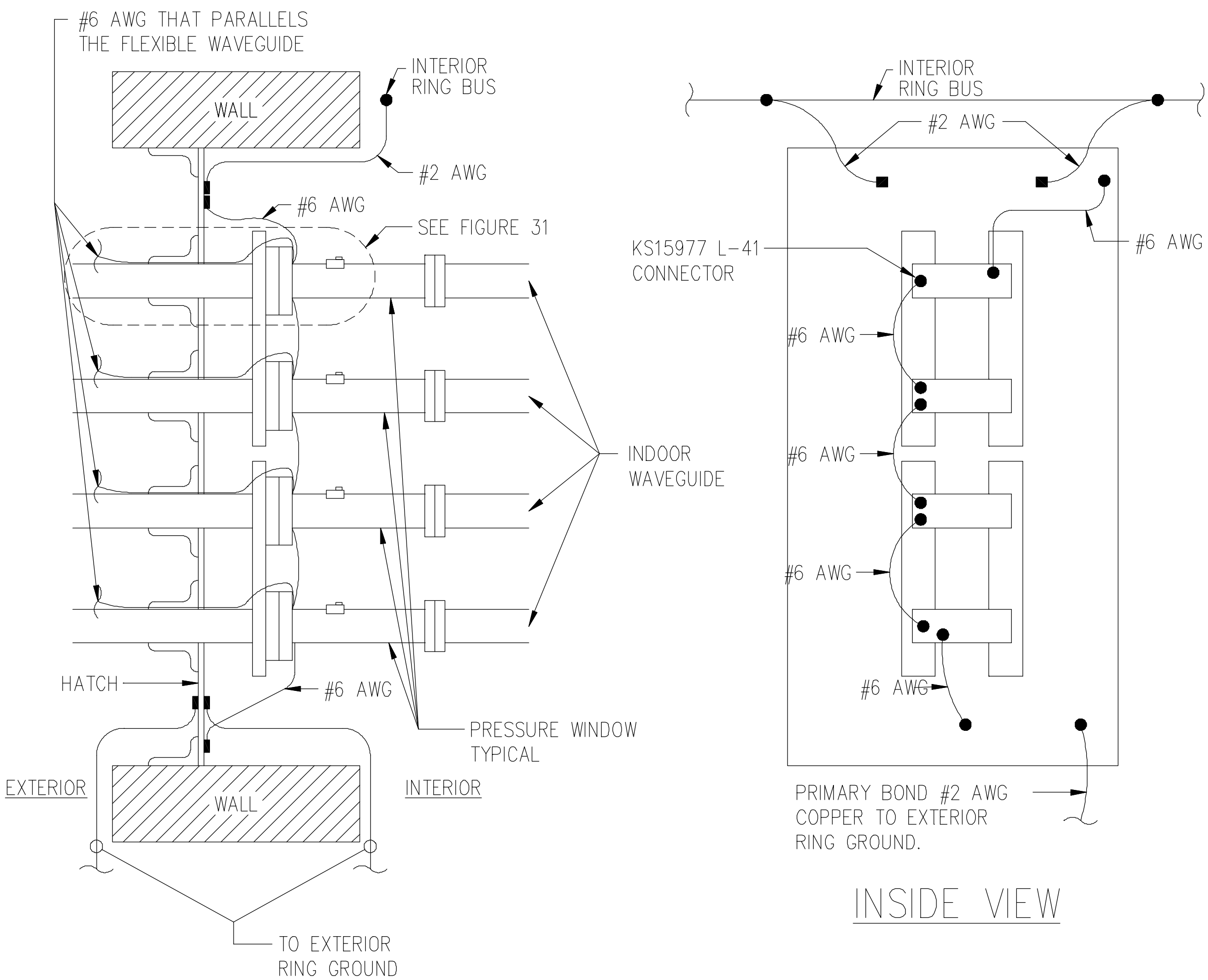


FIGURE 32

MULTIPLE WAVEGUIDE
HATCHPLATE GROUNDING
NO SCALE

AT&T 803-501-100

FIGURE 33

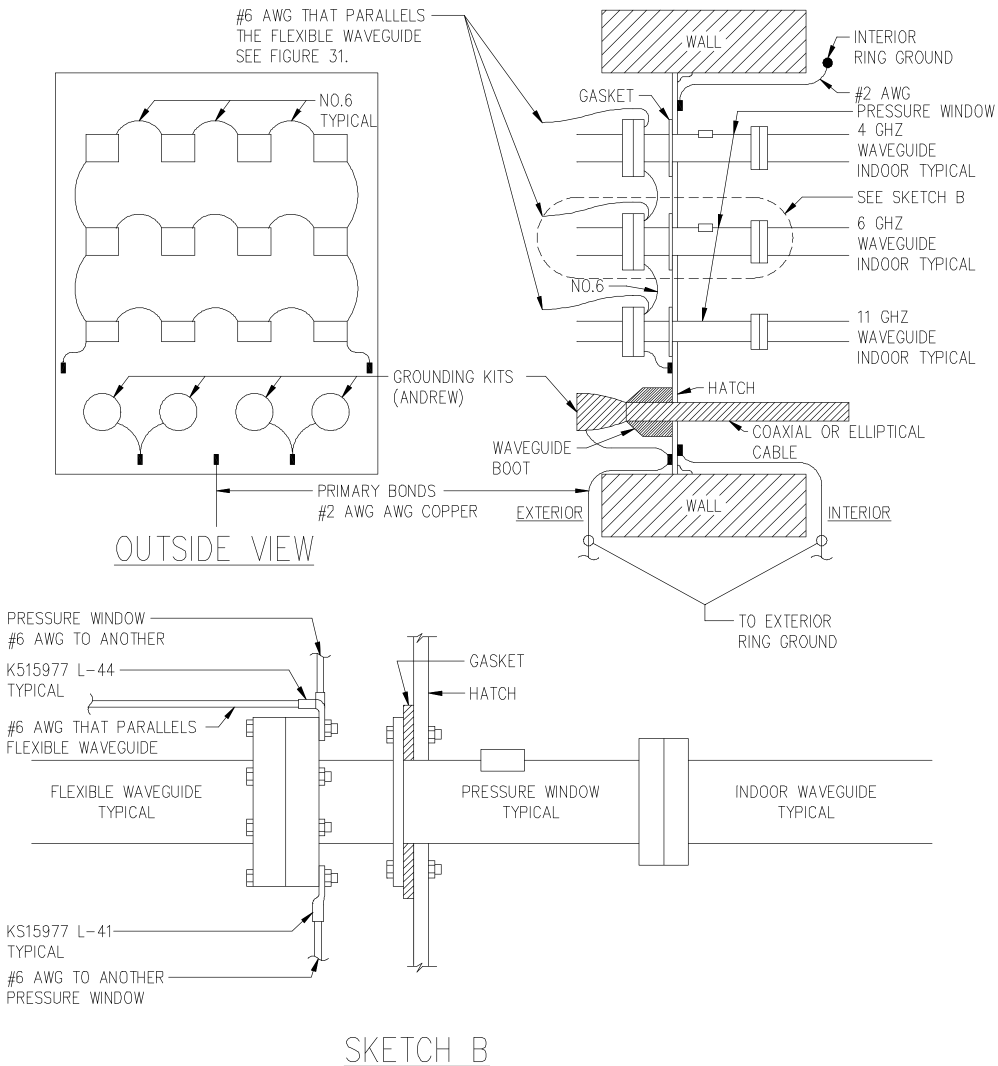
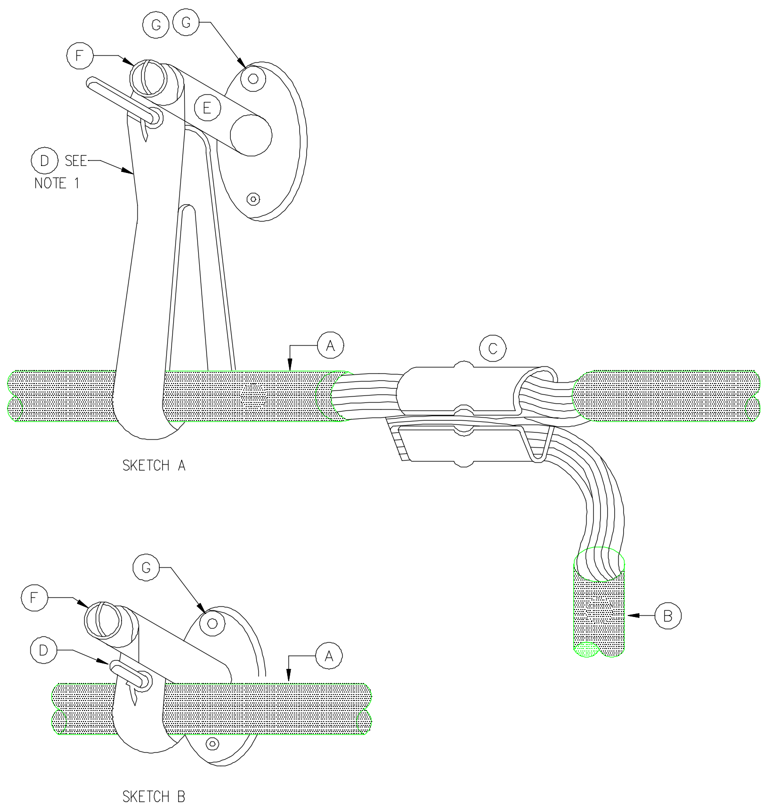


FIGURE 33

SERIAL WAVEGUIDE GROUNDING
NO SCALE

AT&T 803-501-100

FIGURE 34



LEGEND:

- (A) #2 AWG GREEN INSULATED STRANDED COPPER WIRE (PERIPHERAL RING GROUND BUS).
- (B) #6 AWG GREEN INSULATED STRANDED COPPER WIRE (UNIT BOND).
- (C) CRIMP TYPE PARALLEL TAP (T&B "C TAP" CAT 54730 TYPICAL).
- (D) T&B "TY-RAP" CAT TC-15 CABLE TIE OR EQUIVALENT (SKETCH A) IN INSTALLING POSITION (SKETCH B) IN FINAL POSITION.
- (E) T&B "TY-RAP" CAT SO-405A STANDOFF OR EQUIVALENT.
- (F) P.168625 RHM SCREW.
- (G) U.S. EXPANSION BOLT CO "TAP-IT" CAT NO. 463250 NYLON FASTENER OR EQUIVALENT.

FIGURE 34
TYPICAL WALL SUPPORT ASSEMBLY
FOR PERIPHERAL INTERIOR RING GROUND BUS
NO SCALE

NOTES:

1. TO FACILITATE CRIMPING OF WIRES TO (A), STRAP (F) SHALL BE INSTALLED IN POSITION (SHOWN IN SKETCH A) UNTIL ALL CRIMPS ARE MADE. THEN ALL ADJUSTED TO POSITION (SHOWN IN SKETCH B). SUPPORT ASSEMBLIES (G) SHOULD BE PROVIDED EVERY 2 FEET.

AT&T 803-501-100

FIGURE 35

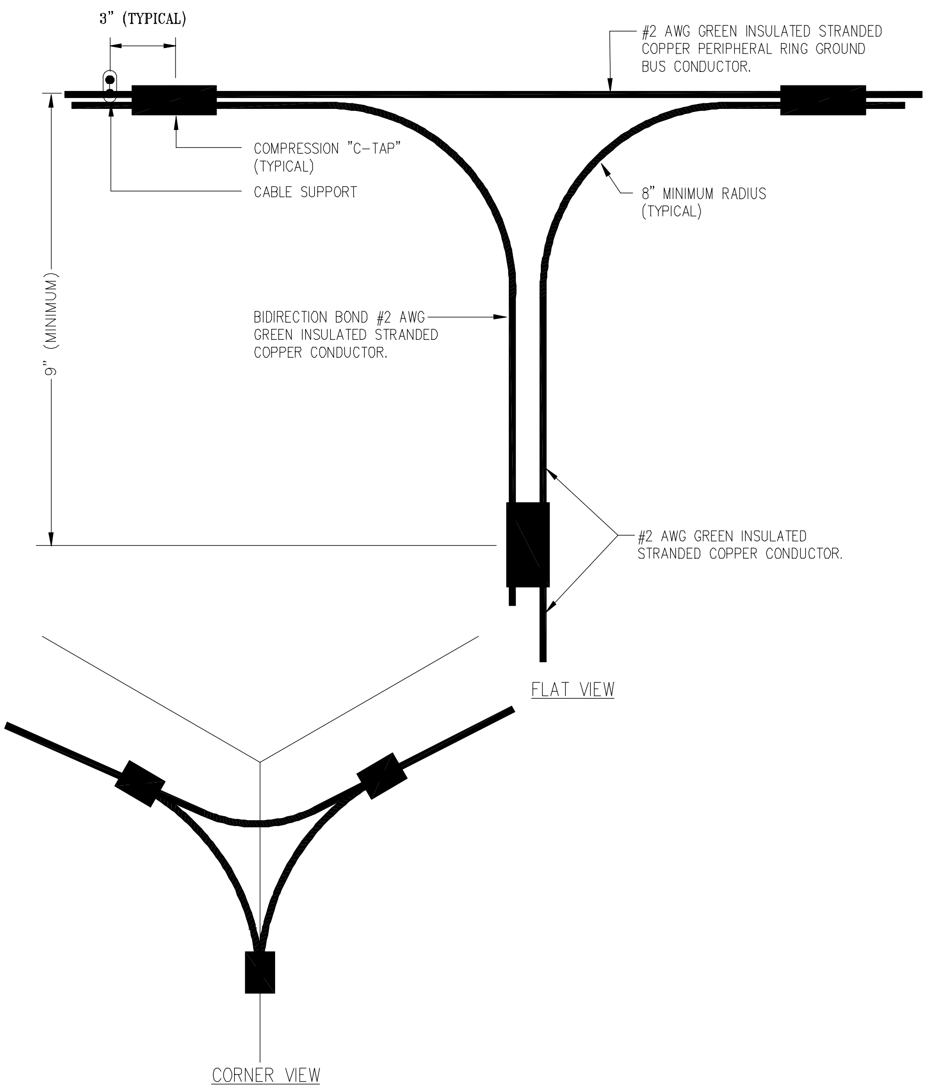


FIGURE 35

HORIZONTAL BI-DIRECTIONAL SPLICE FOR CONNECTING SUPPLEMENTARY BUS TO PRIMARY PERIPHERAL INTERIOR RING BUS

NO SCALE

AT&T 803-501-100

FIGURE 36

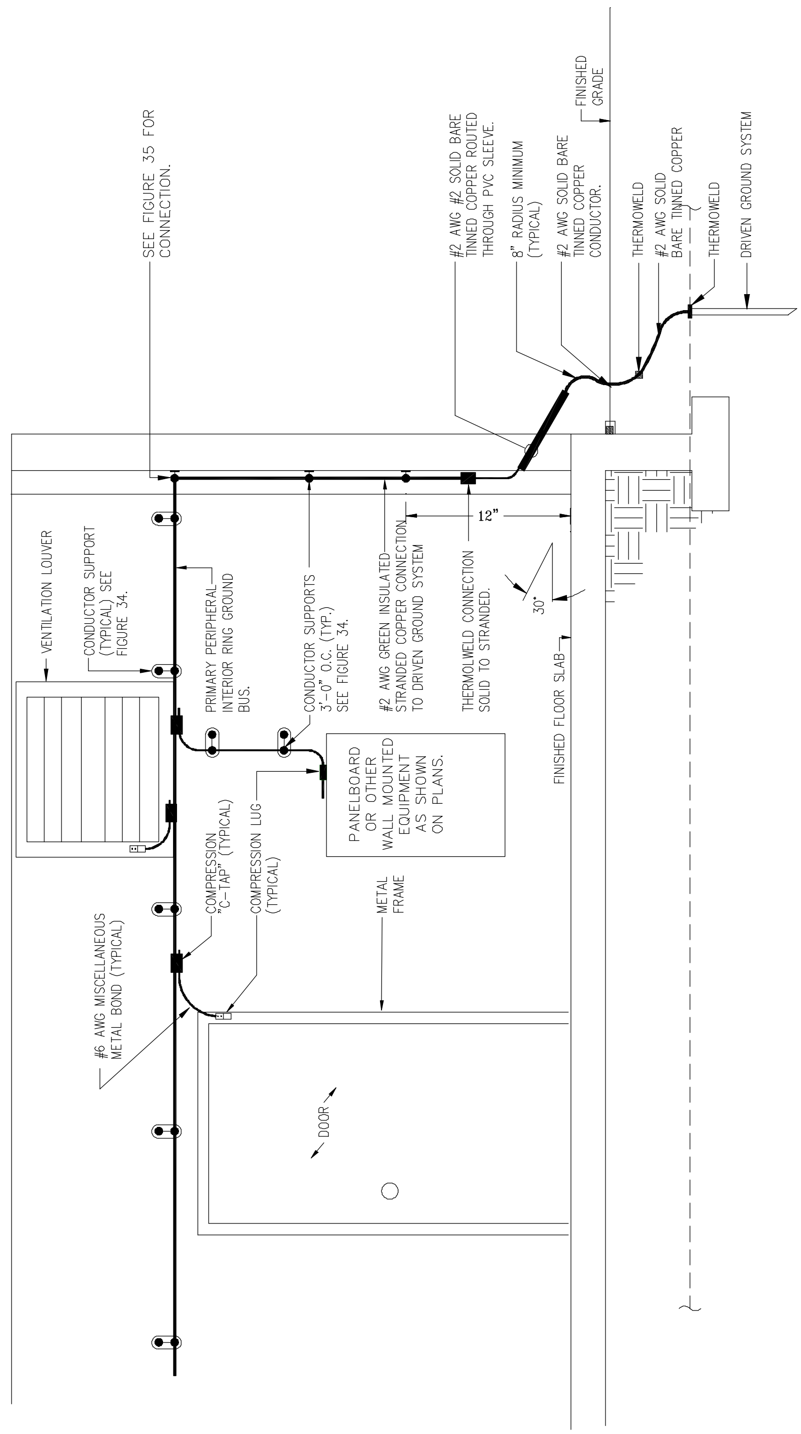
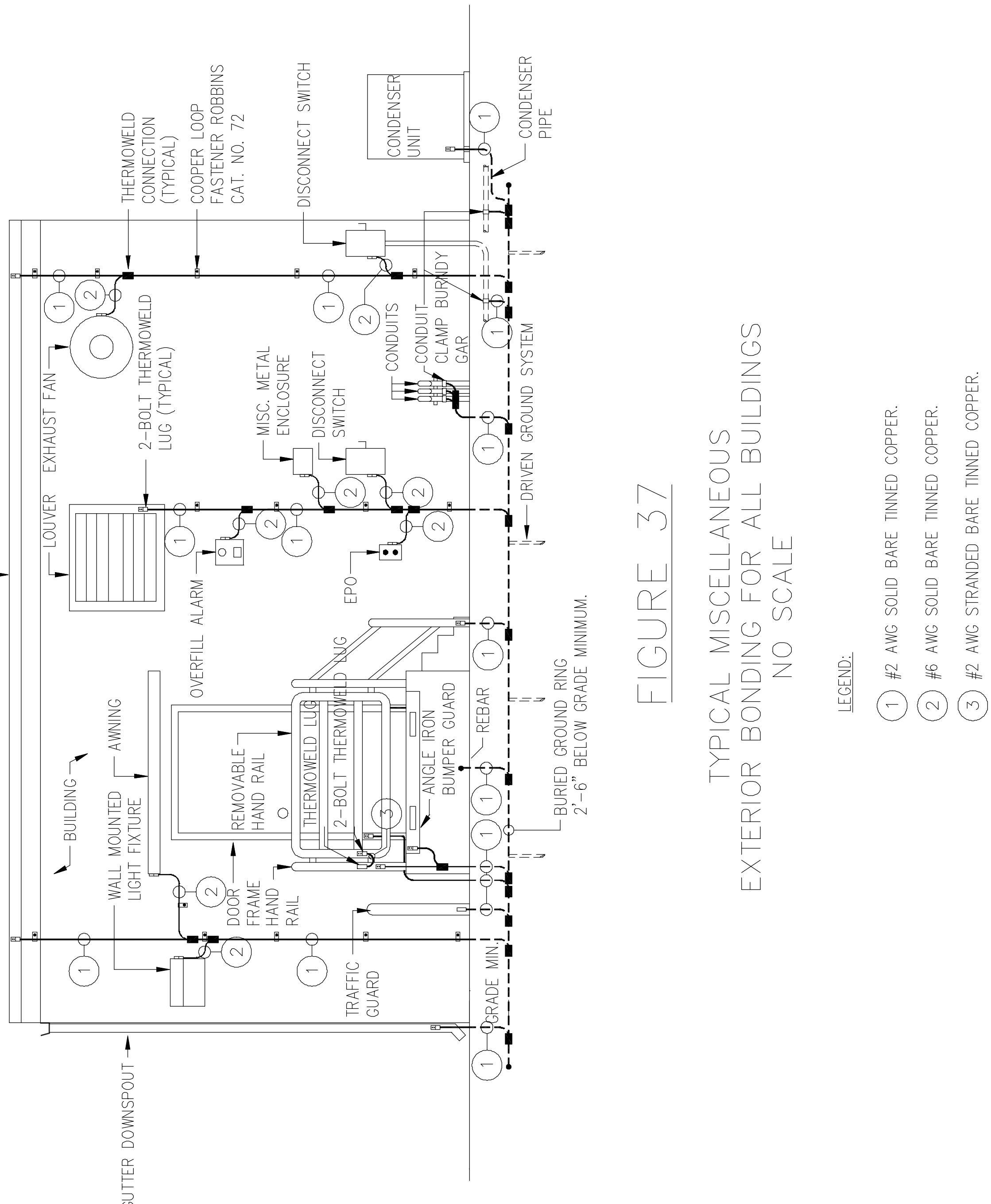


FIGURE 36
TYPICAL MISCELLANEOUS BONDING FOR ALL BUILDINGS
NO SCALE

AT&T 803-501-100

FIGURE 37



11

Contents

11. RAISED ACCESS FLOOR (RAF) GROUNDING REQUIREMENTS

RAISED ACCESS FLOOR (RAF) GROUNDING REQUIREMENTS

11

11.1 General:

NOTE: This standard is written with the intent that the Raised Access Floor grounding installation be competitively bid by the AT&T Building Engineer's General Contractor/Construction Manager to the telecommunication equipment installers (e.g., Lucent) or the electrical sub-contractor. All components are commercially available from either Lucent Technologies or other manufacturers.

The Architect/Engineer of Record shall include this Attachment in its present form or may have it typed into their Bid Package format under the Electrical Division.

- The isolated ground system used in 4ESS, 5ESS, DMS, etc., and the integrated equipment ground system is separate and distinct from the system used to ground the raised floor structure, except for the common interface at the Central Office(CO) Ground Bar.

- The conductive members of the Raised Access Floor (RAF) formally known as the SAFloor System, shall be grounded for personnel safety, system reliability and performance. This grounding path to earth is established for lightning currents, electrostatic discharge (ESD) and ground faults.

- The RAF shall not be used to conduct or carry load current from the telecommunications equipment and shall not be used in conjunction with the telecommunication equipment framework grounding conductors for carrying load current.

- The RAF ground system has been evaluated at nominal 24 and 48 volts. Cabling from the splice plate to the furthest stanchion cannot be greater than 100 ft. Provide additional splice plates if needed with 2/0 AWG insulated interconnecting cables.

- The recommended grounding arrangement is predicated on the electrical properties of the RAF pedestal to stringer connections. These connections must be torqued down to 30 in-lb. In the event of an earthquake, stringer to pedestal head connections must be re-torqued to original specifications.

- The grounding recommendations herein only apply to installations in United States of America and territories.

- The RAF metallic structure is not intended to be or function as, a signal reference grid.

11.2 Grounding Components:

11.2.1 Conductors: Conductors shall be:

- 2/0 AWG non-halogen, green insulated stranded copper conductor, Lucent Technologies Comcode No. 407406008, or approved equivalent.
- 2/0 AWG bare tinned stranded copper conductor, Lucent Technologies Comcode No. 406982066, or approved equivalent.
- No. 2 AWG bare stranded copper conductor.

All bonding and grounding conductors shall be installed without any sharp bends (min. 8”). Grounding conductors used for pedestal grounding (grids) shall rest on the building sub-floor. (See detail No. 02). All conductors will be tagged to identify their origin at the point of attachment to the CO ground bar and the RAF splice plate e.g., “COG (Central Office Ground) **-** Column D4”.

The 2/0 AWG insulated conductor which is exposed above the raised floor when run from the RAF splice plate to the CO ground bar shall be tied to the outside (not within) the network cable rack or securely fasten to the wall surface. Refer to both Layout A (Detail No. 6) and Layout B (Detail No. 07).

There shall be no girdling of bonding conductors i.e., do not encircle ground conductors with a metal clamp, or run ground conductors through metal sleeves in the floor, etc.

11.2.2 Connectors:

All termination's to the Central Office building ground bar and on the RAF splice plate require a double hole, double bolted, crimp connector per the information below;

- The 2/0 AWG crimp connector is Lucent Technologies WP 91412 List 57, Comcode No. 405348236, or Framatome Connectors **-** Burndy Electrical is component No. YA26L-2TC38, or approved equivalent.
- The paint penetrating RAF pedestal ground connector/clamp (Detail No. 01), manufactured by Framatome Connectors **-** Burndy Electrical, component No. GP1726-RT, shall be used in all installations. If removable painted tape is provided on pedestal, connector shall be Burndy Electrical component No. GP64526-G1 or approved equal.

Ordering**:** Any entity under contract with AT&T may order these ground connectors by calling:

- John Mansfield of Graybar Electric at 910-370-2804, Monday through Friday from 8am to 4pm..

The connector shall be approved under UL Standard 467 "Grounding and Bonding Equipment" when assembled to a Raised access floor pedestal using one or two copper conductors having a range of 6 AWG, stranded to 2/0 AWG, stranded.

11.2.3 Raised Access Floor Splice Plate:

The splice plate (ground bar) used to consolidate the under floor grid runs shall be copper measuring ¼ inch thick by 18 inches long by 6 inches wide and supported by two (2) Glastic, Inc., insulators (component No. 1872-3E) measuring 3 ½ inches high. These insulators are assembled to a Unistrut or Versabar channel measuring 1 5/8 inches square by 24 inches long and anchored to the building sub-floor using two (2) Hilti Kwik Con II screw fasteners (No. 00224363) per channel. Refer to Detail No. 03.

- The RAF splice plate if supplied by Lucent Technologies is identified on drawing ED4C471-30 Group 21, Comcode No. 843059981 or, or commercially approved equivalent.

The splice plate shall accommodate twenty-four (24) crimp connectors.

One end of the 2/0 AWG insulated bonding conductor shall be attached to the splice plate under the RAF and the other end shall be connected to the Central Office ground bar using the appropriate double hole crimp connector. Refer to Layouts A (Detail No. 6), Layout B (Detail

No.7), Detail No. 03 and 04.

All other conductors shall be connected to the splice plate using the appropriate double hole crimp connectors. Refer to Detail No. 03 and 04.

If a pre-drilled splice plate was not installed, the installer must drill the anchoring holes and the holes to accommodate the connectors. Refer to Detail No. 03.

11.3 Raised Access Floor Grounding Layout:

11.3.1 General:

The General Contractor/Construction Manager (GC/CM) shall provide all materials necessary to install the RAF ground system and to bond it to the Central Office ground bar as identified on the Architect/Engineer of Record drawings, or as requested by AT&T's personnel.

11.3.2 Layout:

A. Typical Layout A:

- The under floor/platform splice plate (ground bar) shall be fastened to the building sub-floor at or as close as possible to the RAF center point of the area when there is one (1) plate or equally spaced when more are required. See Detail No.6.

- Bonding the Raised Access Floor splice plate to the Central Office ground bar shall be done using a 2/0 AWG insulated conductor. The appropriate double hole crimp connector shall be used at each cable end. Refer to Detail No. 03, and 04.

- The ground grid shall be referenced to the building column designations. Each run of the ground grid shall be bare, tinned, 2/0 AWG conductor attached to every tenth pedestal using the pedestal grounding connector/clamp by Burndy Electrical. Four (4) full length stringers must be connected to each pedestal receiving a grounding clamp. Refer to Detail No. 01, 02, and 05.

- Each conductor run of the ground grid shall be connected to the RAF ground bar using bare 2/0 AWG conductor following the shortest route from the pedestal ground connector to the RAF splice plate.

B. Typical Layout B:

- For a RAF where two (2) Central Office ground risers are present (up to 120 ft apart from each other), connect to both CO ground bars with 2/0 AWG insulated conductors from the RAF splice plate which is located at or as close to the center area. These conductors shall follow the shortest route between the ground bars and the splice plate. Refer to Detail No. 03 and 04, and paragraphs 3.2.A.3 and 4.2.A.4 above. Refer to Detail No.7.

11.3.3 Additional Conductor Runs:

Where an area of more than half but less than a standard building bay of RAF remains, install an additional bare 2/0 AWG conductor run parallel to the existing conductor runs. Where odd floor shapes occur, orient conductor runs in the longest direction, and install a grounding connector to every tenth pedestal or equally spaced pedestals but not greater than every tenth pedestal.

11.3.4 Matching Existing Raised Floors:

When matching an existing raised floor installation, align grounding connectors on the existing floor pedestals with the connectors in the new installation and install a bare 2/0 AWG conductors between each of the pedestal ground connectors.

A minimum of two conductors are required for a single building bay. In cases of two or more bays, provide a conductor per bay. Refer to Detail No. 05.

11.3.5 Pedestal Ground Connector Installation:

Any RAF pedestal which receives a ground connector/clamp must be supporting four full length stringers. Pedestal ground connector clamps must not be used on pedestals supporting less than four full stringers.

Pedestal ground connector/clamps shall be positioned 6 inches above the sub-floor on the pedestal stanchion. This location will prevent interference with the network equipment isolated ground system, and provides adequate room for the Air Sampling Smoke Detection (ASSD) system. Refer to Detail No. 01 and Detail No. 02.

Where a ground conductor passes through a partition or floor, the conductor shall pass through a non-conductive sleeve (i.e, the RAF is installed on both sides of a wall partition). Provide fire seal as required when penetrating a fire rated partition.

11.3.6 Building and Raised Access Floor Expansion Joints:

To assure continuity of the ground system, structural and raised floor expansion joints shall be bonded with a bare 2/0 AWG conductor. Each end of the conductor shall be attached to a pedestal ground connector on each side of the expansion joint.

A minimum of two conductors are required for a single building bay. In cases of two or more bays, provide a conductor per bay. Refer to Detail No. 05.

11.3.7 Raised Access Floor Accessory Grounding:

All accessories, i.e., stairs, ramps, lifts of any type, and guard railings, must be grounded to the nearest pedestal supporting four full length stringers. Use a bare No.2 AWG conductor to bond all accessories to the ground system. A GP1726-RT connector must be used on the pedestal to terminate the No.2 AWG conductor. When the GP1726-RT can't be used (e.g., 7/8 inch square galvanized pedestals that support stairs and ramps per Tate Access Floor, Inc.), any commercial grounding clamp that can accommodate No.2 AWG cable may be used, i.e., Burndy raised floor grounding clamp No. GP64526G1. If the pedestal is provided with a removal 1" painted tape strip use the Burndy #GP64526-G1 instead of the GP1726-RT.

11.4 Pedestal Ground Clamp Installation Procedure:

The painted surface shall be wiped with a damp cloth to remove any dust, particles or foreign matter.

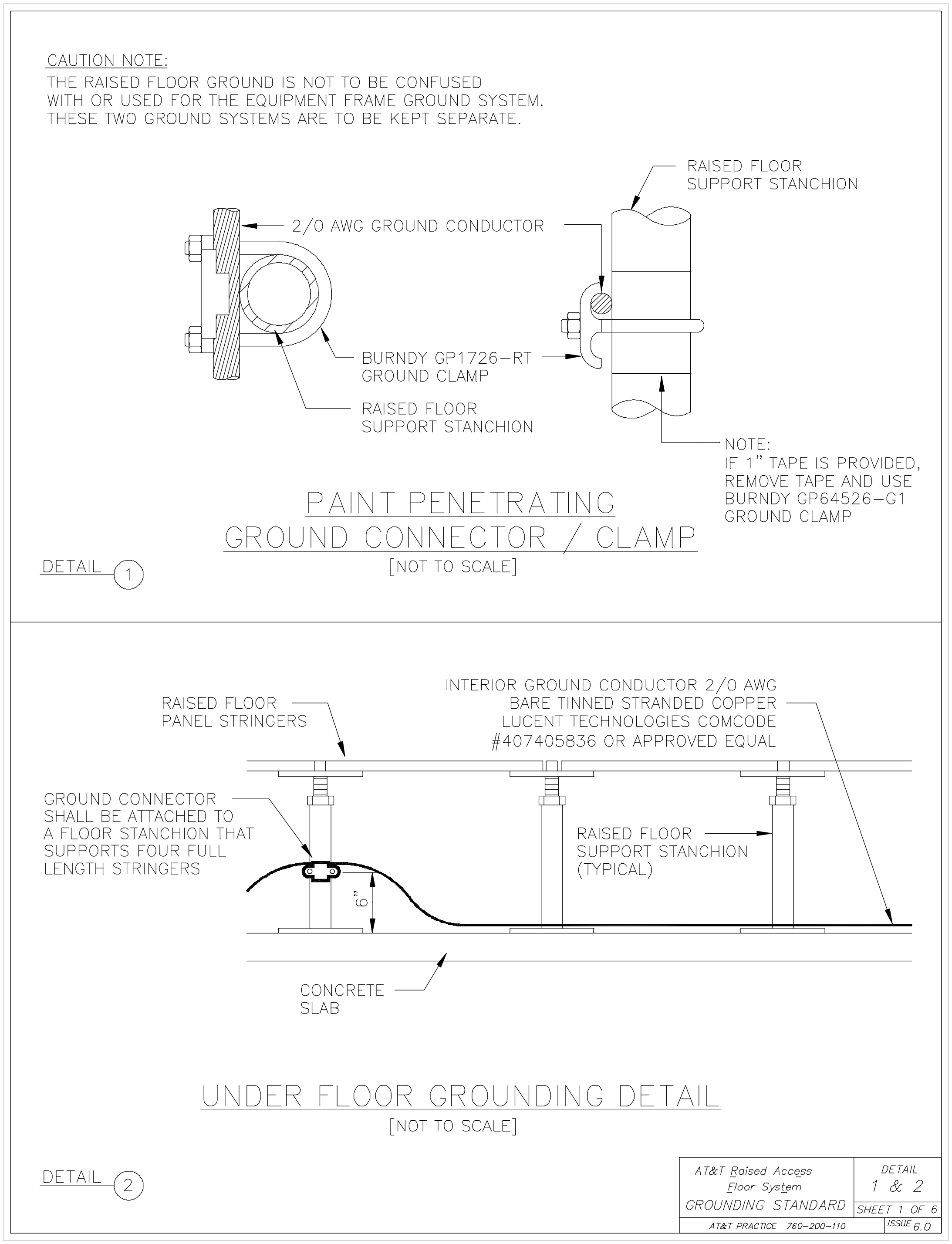
Prior to installing the clamp, apply a ¼" wide bead of FC - Burndy Electrical Penetrox ™ E oxide inhibitor or equivalent to the areas on the pedestal where the clamp will be positioned. Spread the inhibitor on the pedestal and conductor so all surfaces of the clamp contacts the inhibitor when the clamp is installed.

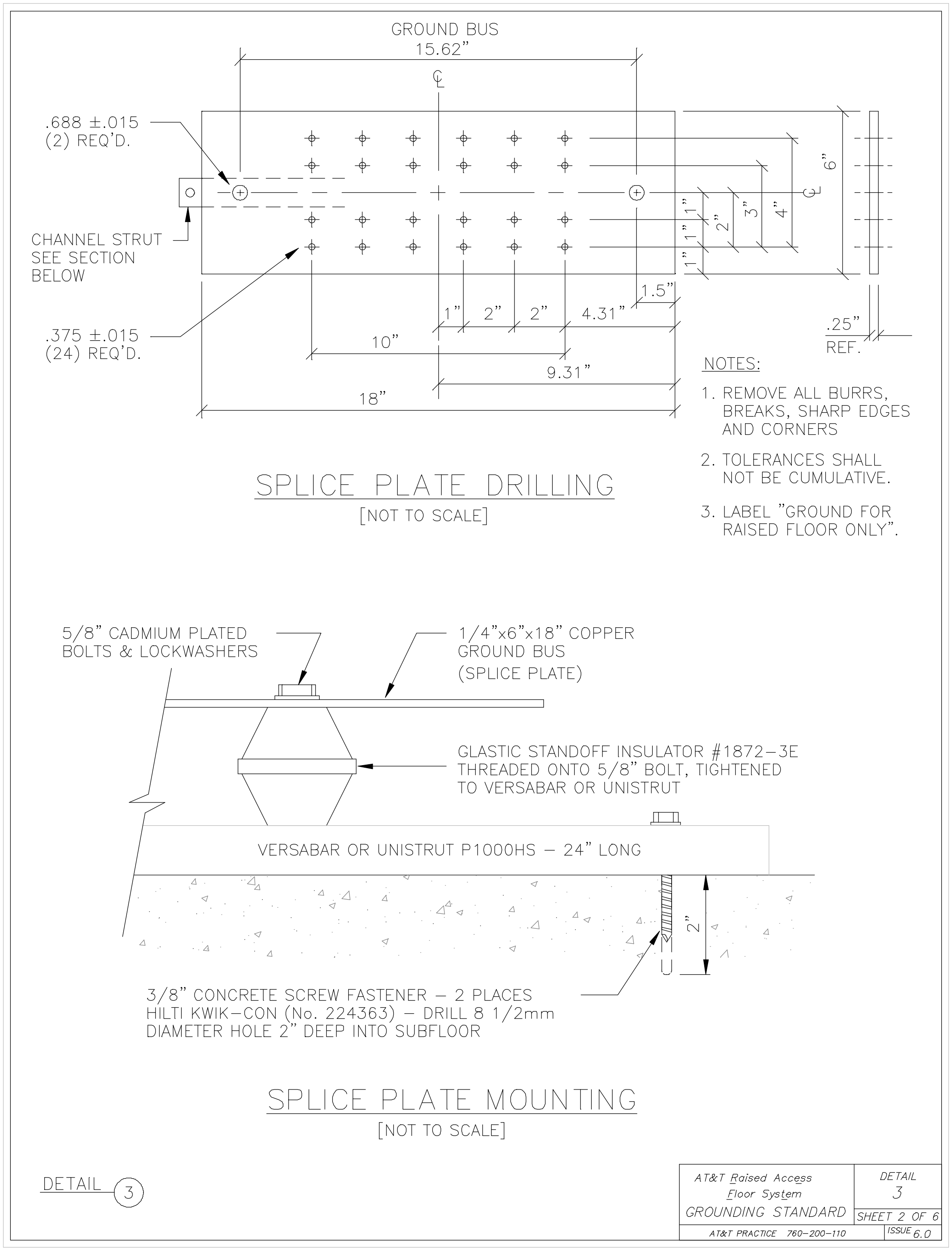
Disassemble the connector components. Place the body with sharp machined steps against the pedestal. Place the U-bolt around the pedestal and through the body of the connector. Place the cap onto the U-bolt with the conductor grooves facing the conductor grooves on the connector body.

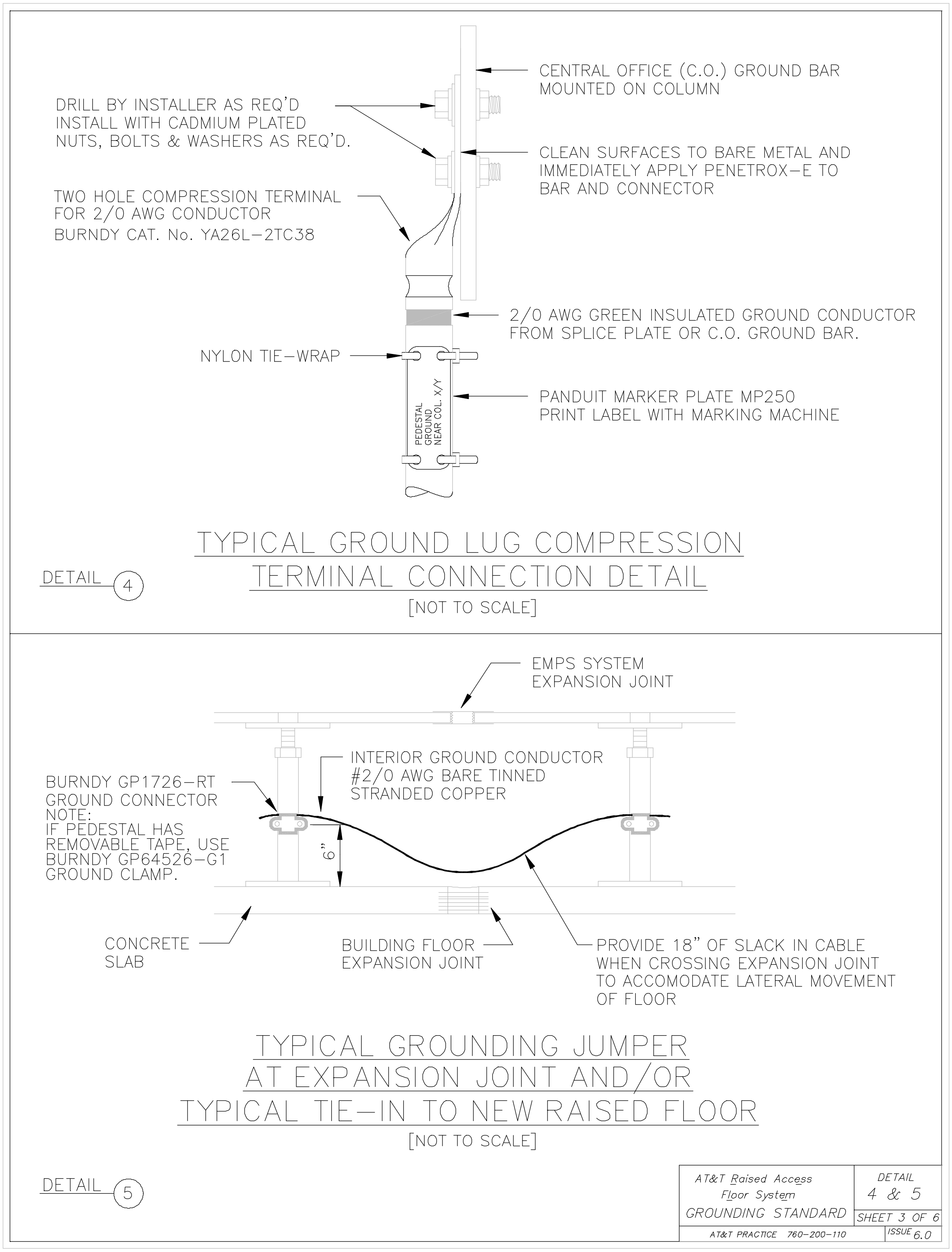
Assemble the lock washers and hex nuts onto the U-bolt with sufficient slack to permit the bare 2/0 conductor to be placed in the groove. Place the bonding conductor(s) into the conductor grooves of the loosely assembled connector assembly.

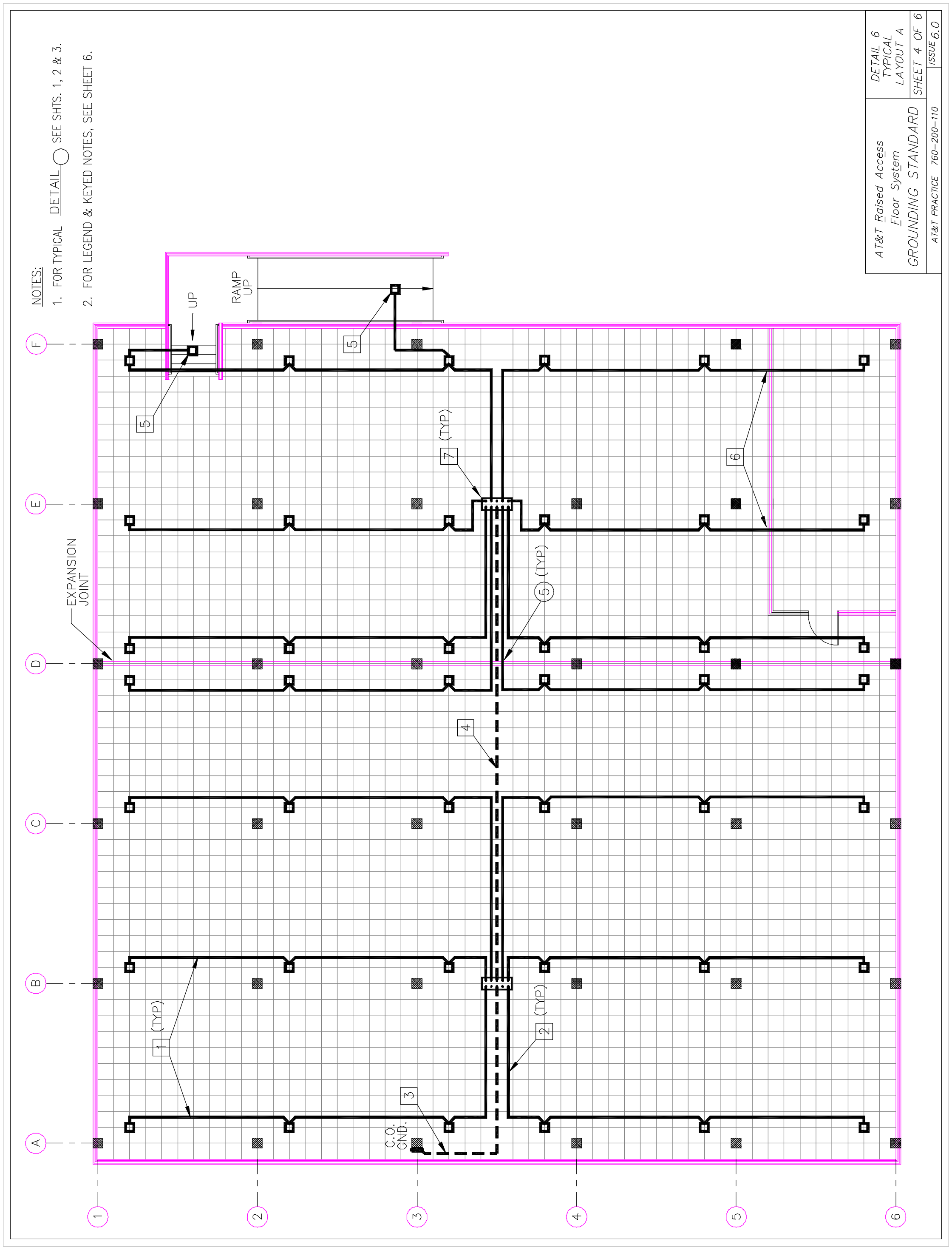
Finger tighten the hex nuts and gradually tighten them with a torque wrench to 245 nominal in-lb (240 minimum, 250 maximum) thereby securing the conductor and the connector to the pedestal assembly. The torque wrench shall have an accuracy of +/- 5 in-lb at 245 in-lb. The Burndy #GP64526-G1 grounding clamp shall not be required to be torque to 245 in-lb.

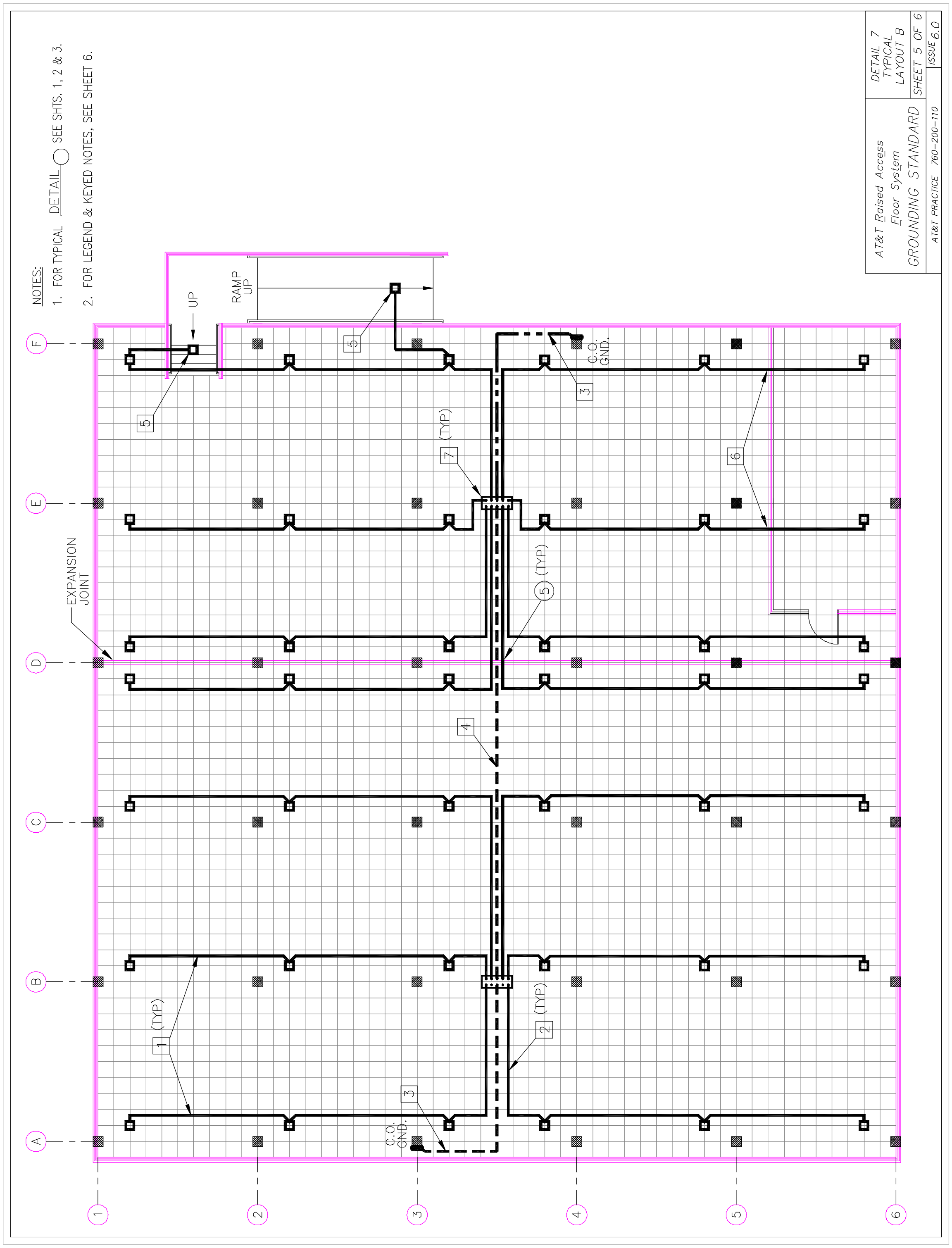
11.5 Details and Drawings:




GROUND BUS
15.62"
.688 ±.015
(2) REQ'D.
CHANNEL STRUT
SEE SECTION
BELOW
.375 ±.015
(24) REQ'D.
6"
1"
2"
3"
4"
1.5"
1"
2"
2"
4.31"
10"
9.31"
18"
.25"
REF.
NOTES:
1. REMOVE ALL BURRS, BREAKS, SHARP EDGES AND CORNERS
2. TOLERANCES SHALL NOT BE CUMULATIVE.
3. LABEL "GROUND FOR RAISED FLOOR ONLY".
SPLICE PLATE DRILLING
[NOT TO SCALE]
5/8" CADMIUM PLATED
BOLTS & LOCKWASHERS
1/4"x6"x18" COPPER
GROUND BUS
(SPLICE PLATE)
GLASTIC STANDOFF INSULATOR #1872-3E
THREADED ONTO 5/8" BOLT, TIGHTENED
TO VERSABAR OR UNISTRUT
VERSABAR OR UNISTRUT P1000HS – 24" LONG
2"
3/8" CONCRETE SCREW FASTENER – 2 PLACES
HILTI KWIK-CON (No. 224363) – DRILL 8 1/2mm
DIAMETER HOLE 2" DEEP INTO SUBFLOOR
SPLICE PLATE MOUNTING
[NOT TO SCALE]
DETAIL 3
AT&T Raised Access
Floor System
GROUNDING STANDARD
DETAIL
3
SHEET 2 OF 6
AT&T PRACTICE 760-200-110
ISSUE 6.0


CENTRAL OFFICE (C.O.) GROUND BAR
MOUNTED ON COLUMN
DRILL BY INSTALLER AS REQ'D
INSTALL WITH CADMIUM PLATED
NUTS, BOLTS & WASHERS AS REQ'D.
CLEAN SURFACES TO BARE METAL AND
IMMEDIATELY APPLY PENETROX–E TO
BAR AND CONNECTOR
TWO HOLE COMPRESSION TERMINAL
FOR 2/0 AWG CONDUCTOR
BURNDY CAT. No. YA26L–2TC38
2/0 AWG GREEN INSULATED GROUND CONDUCTOR
FROM SPLICE PLATE OR C.O. GROUND BAR.
NYLON TIE–WRAP
PEDESTAL
GROUND
NEAR COL. X/Y
PANDUIT MARKER PLATE MP250
PRINT LABEL WITH MARKING MACHINE
TYPICAL GROUND LUG COMPRESSION
TERMINAL CONNECTION DETAIL
[NOT TO SCALE]
DETAIL 4
EMPS SYSTEM
EXPANSION JOINT
INTERIOR GROUND CONDUCTOR
#2/0 AWG BARE TINNED
STRANDED COPPER
BURNDY GP1726–RT
GROUND CONNECTOR
NOTE:
IF PEDESTAL HAS
REMOVABLE TAPE, USE
BURNDY GP64526–G1
GROUND CLAMP.
6"
CONCRETE
SLAB
BUILDING FLOOR
EXPANSION JOINT
PROVIDE 18" OF SLACK IN CABLE
WHEN CROSSING EXPANSION JOINT
TO ACCOMODATE LATERAL MOVEMENT
OF FLOOR
TYPICAL GROUNDING JUMPER
AT EXPANSION JOINT AND/OR
TYPICAL TIE–IN TO NEW RAISED FLOOR
[NOT TO SCALE]
DETAIL 5
AT&T Raised Access
Floor System
GROUNDING STANDARD
DETAIL
4 & 5
SHEET 3 OF 6
AT&T PRACTICE 760–200–110
ISSUE 6.0


NOTES:
1. FOR TYPICAL DETAIL SEE SHTS. 1, 2 & 3.
2. FOR LEGEND & KEYED NOTES, SEE SHEET 6.
AT&T Raised Access Floor System
GROUNDING STANDARD
AT&T PRACTICE 760-200-110
DETAIL 6 TYPICAL LAYOUT A
SHEET 4 OF 6
ISSUE 6.0
RAMP UP
UP
EXPANSION JOINT
(TYP)
C.O. GND.


NOTES:
1. FOR TYPICAL DETAIL SEE SHTS. 1, 2 & 3.
2. FOR LEGEND & KEYED NOTES, SEE SHEET 6.
RAMP UP
UP
EXPANSION JOINT
C.O. GND.
(TYP)
A
B
C
D
E
F
1
2
3
4
5
6
AT&T Raised Access Floor System
GROUNDING STANDARD
AT&T PRACTICE 760-200-110
DETAIL 7 TYPICAL LAYOUT B
SHEET 5 OF 6
ISSUE 6.0

LEGEND:

GROUND CLAMP ON STANCHION

FLOOR SUPPORT STRINGER GRID. STANCHION LOCATED AT EACH INTERSECTION.

RAF GROUND BUS SPLICE PLATE

#2/0 AWG BARE TINNED STRANDED COPPER GROUND CABLE, UNLESS NOTED OTHERWISE. (ROUTE IN A STRAIGHT RUN ALONG SINGLE ROW OF SUPPORT STRINGERS)

2/0 AWG INSULATED, STRANDED COPPER GROUND CABLE. (ROUTE FROM C.O. GROUND BAR OR SPLICE PLATE)

KEYED NOTES:

1 PROVIDE 1–#2/0 AWG BARE CU GROUND CONDUCTOR FROM FLOOR PEDESTAL TO FLOOR PEDESTAL USING A SINGLE CONDUCTOR FOR EACH RUN. BEGIN AT PERIMETER STANCHION ON BUILDING COLUMN LINE OF RAISED FLOOR WHICH SUPPORTS (4) FULL LENGTH STRINGERS. BOND EVERY TENTH PEDESTAL ALONG THE RUN USING A BURNDY CLAMP CAT. No. GP–1726 RT, MOUNTED 6" ABOVE STRUCTURAL FLOOR AND TORQUED TO 245 IN–LB. IF THE RAISED FLOOR PEDESTAL IS PROVIDED WITH A 1" REMOVABLE TAPE TO EXPOSE THE STEEL POST, USE BURNDY #GP64526–G1 CLAMP. THE CONDUCTOR SHALL BE LAID ON THE STRUCTURAL FLOOR AND SHALL TIGHT TO CLAMP. THE CONDUCTOR SHALL NOT BE BENT OR KINKED. PROVIDE PARALLEL RUNS EQUALLY SPACED NOT GREATER THAN (10) PEDESTALS (20 FT.) APART.

2 PROVIDE 1–#2/0 AWG BARE CU GROUND CONDUCTOR FROM FLOOR PEDESTAL GROUND CLAMP BACK TO THE NEAREST RAF SPLICE PLATE (GROUND BUS). ATTACH THE CONDUCTOR TO THE SPLICE PLATE USING BURNDY CAT. No. YA26L–2TC38 TYPE CONNECTOR.

3 PROVIDE A 4"x6" HOLE IN FLOOR PANEL WITH A NON–CONDUCTIVE SLEEVE NEAR THE C.O. GROUND BUS LOCATIONS. PROVIDE 1–#2/0 AWG, GREEN NON–HALOGEN TYPE INSULATED CU CONDUCTOR FROM C.O. GROUND BUS THROUGH ACCESS HOLE IN FLOOR PANEL AND UNDER RAISED FLOOR TO RAF SPLICE PLATE. ATTACH CONDUCTOR TO THE C.O. GROUND BUS AND RAF SPLICE PLATE USING BURNDY CAT. No. YA26L–2TC38 TYPE CONNECTOR. THE CONDUCTOR SHALL NOT BE BENT OR KINKED AND SHALL NOT TOUCH THE RAF PANEL.

4 CONNECT ADDITIONAL SPLICE PLATE WITH 2/0 AWG GREEN NON–HALOGEN INSULATED TYPE CU CONDUCTOR USING BURNDY CAT. No. YA26L–2TC38 TYPE CONNECTOR AT EACH SPLICE PLATE.

5 PROVIDE 1–#2 AWG BARE CU GROUND CONDUCTOR FROM FLOOR PEDESTAL TO RAMP/STAIR SUPPORT PEDESTAL AND ANY OTHER EXPOSED STEEL. ATTACH CONDUCTOR TO THE FLOOR PEDESTAL UNDER THE STAIR/RAMP USING A BURNDY CLAMP CAT. No. GP64526G1 MOUNTED 6" ABOVE STRUCTURAL FLOOR.
BOND OTHER EXPOSED STEEL WITH 2 HOLE COMPRESSION TERMINAL LUG.

6 PROVIDE NON–CONDUCTIVE SLEEVE IN WALL UNDER RAISED FLOOR FOR ROUTING OF THE GROUNDING CONDUCTOR. FIRE SEAL ALL PENETRATIONS.

7 PROVIDE A 1/4"x6"x18" CU RAF SPLICE PLATE MOUNTED BELOW RAISED FLOOR WHERE INDICATED WITHOUT BEING PLACED DIRECTLY BELOW ANY NETWORK EQUIPMENT LINEUPS.

AT&T Raised Access Floor System GROUNDING STANDARD	LEGEND & NOTES
	SHEET 6 OF 6
AT&T PRACTICE 760–200–110	ISSUE 6.0

12

Contents

12. GROUNDING ACCEPTANCE CHECKLISTS

GROUNDING ACCEPTANCE and QUALITY CHECKLISTS

12

Included in this section are grounding and electrical protection quality and acceptance checklists for use by Engineering, the On-Site Work Force, and Technical Support to verify the quality of new installations or the relative condition of the grounding system in existing AT&T locations.

These checklists are grouped into the following categories:

- **Checklist 1** - General Requirements
- **Checklist 2** - Building Ground Electrodes
- **Checklist 3** - Building Lightning Protection
- **Checklist 4** - AC Power Equipment and Surge Protection
- **Checklist 5** - DC Power Equipment Grounding
- **Checklist 6** - Central Office INTEGRATED Ground System
- **Checklist 7** - Central Office ISOLATED Ground System
- **Checklist 8** - Radio Systems and Towers

CHECKLIST 1 GENERAL GROUNDING REQUIREMENTS

The reliability of a grounding system is as much dependent on careful and proper installation as it is on the proper choice of materials. Improper preparation of surfaces to be joined to make an electrical path, loose joints and corrosion can introduce impedance that will seriously impair the ability of the ground path to protect personnel and equipment and to absorb transients that can cause noise in communications circuits. The following functions are particularly important to ensure a reliable ground system.

NOTE: Review and become familiar with the requirements listed below prior to beginning a grounding quality or acceptance review. These requirements are generic and may or may not be repeated in the individual review sections.

- ☐ All bonds between solid and stranded wire must be exothermically welded.
- ☐ All buried ground conductors shall be NO. 2 AWG solid, tinned, copper wires.
- ☐ All connection points to frameworks, cabinets, and miscellaneous metallic objects shall be cleaned, have paint removed, and no-oxide compound added prior to connection.
- ☐ All connections to the grounding system buried in earth, as well as connections involving solid wires shall be thermowelded connections. Above ground connections to solid wires may utilize exothermic lugs with two-bolt tongues.
- ☐ All connectors utilized with stranded green insulated wire shall be circumferential crimp type lugs with two-bolt tongues.
- ☐ All copper bus bars shall be cleaned prior to making connections to remove surface oxidation and coated with a no-oxide corrosion preventive compound prior to connection.
- ☐ All grounding conductors shall be properly sized according to requirements in this practice or per the NATIONAL ELECTRICAL CODE.
- ☐ All grounding material (bus bars, conductors, lightning protection equipment, mounting hardware, etc.) shall be copper.
- ☐ All interior grounding conductors shall be stranded copper with green insulation unless system requirements (4ESS, 5ESS, etc.) specify otherwise.

Issue Date: September 1998
Issue No.: **1**
Master List ID: 12914

- ☐ All main grounding conductors shall be properly labeled on both ends to identify the function of the conductor and its far end terminating point. The conductor shall also be equipped with a DO NOT DISCONNECT tag where it terminates at a ground bus bar.

- ☐ All uninsulated grounding conductors (solid or stranded) shall be tinned copper.

- ☐ Directionalize all ground connection sweeps toward the main ground source.

- ☐ Grounding conductors shall not be run in cable racks, and shall be visible for their entire length.

- ☐ When equipment arranged in a line-up needs to be grounded, *daisy-chaining* shall not be used because the continuity of the grounding connection might not be ensured if one or more equipment bays are removed from the lineup. The recommended method of grounding a line-up of equipment is to provide a common frame aisle grounding conductor from which drop leads are tapped utilizing circumferential compression crimp connections to individual frames/bay.

CHECKLIST 2 BUILDING GROUND ELECTRODES

WHAT IS THE BUILDING UTILIZING AS ITS PRIMARY GROUNDING ELECTRODE?

- ☐ Domestic water pipe
- ☐ External Driven Rod System
- ☐ Other – Explain
- ☐ Well Casing

Domestic water pipe

☐ Is there an OFFICE PRINCIPAL GROUND POINT bar or are all connections made directly to the water pipe? OFFICE PRINCIPAL GROUND POINT bar is preferred.

☐ Verify that the water pipe is metallic and is a minimum of forty feet, mechanically and electrically continuous, buried in earth.

☐ Verify that a bonding jumper is provided across the water meter and all unions or valves.

☐ Verify that all connections to the water pipe are tight and free from corrosion.

☐ Verify that all of the following grounding systems or electrodes (if they exist) are bonded to the OFFICE PRINCIPAL GROUND POINT bar or water pipe and are properly labeled and equipped with DO NOT DISCONNECT tags:

- ☐ AC power neutral grounding conductor
- ☐ Building structural steel grounding or electrode system
- ☐ CENTRAL OFFICE GROUND System (VERTICAL RISER)
- ☐ External driven ground electrode system, or counterpoise system
- ☐ Fireline standpipe system

Well Casing

☐ All requirements for the water pipe system above will apply to a well casing used for the primary grounding electrode.

External Driven Rod Electrode System

☐ Verify that the external driven rod electrode system is extended into the building with at least two connections from opposite sides of the building to the OFFICE PRINCIPAL GROUND POINT bar.

☐ Verify that unintentional earth electrodes within six feet of the driven rod electrode system (fences, fuel tanks, storage sheds, etc.) are bonded to the driven rod system with a NO. 2 AWG solid, tinned, copper conductor.

☐ Verify that the impedance of the driven ground electrode system is five ohms or less.

NOTE: This should be checked at the time of new installation only or in a trouble situation. Personnel hazard, use extreme caution when testing an existing grounding system.

☐ Verify that the driven ground electrode system is buried a minimum of thirty inches or below the frost depth.

☐ Verify that the buried ring conductor is NO. 2 AWG a solid, tinned, copper conductor and that it is exothermically welded to the tops of the driven ground rods.

☐ Verify that the driven ground rods are a minimum of eight feet long, 5/8 inch diameter, stainless steel or copper clad steel, and are spaced not less than ten feet or more than fifteen feet apart.

☐ For new installations, before backfilling the grounding electrode system with earth a visual check shall be made of all joints and connections by an AT&T representative. This will:

- ☐ Ensure mechanical and electrical integrity
- ☐ Verify that all required interconnections have been properly made
- ☐ Verify the absence of voids or other indications of poor exothermic bonding

☐ A visual verification and electrical continuity check should be made at this time to ensure that all connections are intact. A written record of this check with photos shall be placed in the office records for future reference.

☐ After covering and compacting is completed an earth resistivity measurement shall be made on the exterior ring system prior to connection to the building grounding system to ensure a reading of five ohms or less per requirement in **SECTION 2.2**, (NOTE 1.). The readings thus obtained will be included in the office records for future reference.

- ☐ If a building structural steel driven ground electrode system is installed under the concrete slab, ensure that it is properly connected to the OFFICE PRINCIPAL GROUND POINT bar.

- ☐ When building additions are provided for an existing building complex the following items need to be verified:

  - ☐ Verify that the exterior driven rod electrode system has been extended around the building addition and that it is bonded to the existing system. Ensure that two connections to the OFFICE PRINCIPAL GROUND POINT have been extended from the completed new ring. The completed new ring should be one continuous closed loop including the original ring.

  - ☐ If a separate water supply is provided, verify that it is bonded to the OFFICE PRINCIPAL GROUND POINT

CHECKLIST 3 BUILDING LIGHTNING PROTECTION SYSTEMS

If the building is equipped with a lightning protection system, the following should be verified:

- ☐ If additional roof mounted lightning protection systems and grounding electrodes are provided, verify that the system is bonded to an existing electrode system and to the OFFICE PRINCIPAL GROUND POINT.
- ☐ On new construction verify that all connections are exothermically welded or utilize exothermic two-bolt tongue lugs. In older buildings where existing mechanical or crimp type connectors are in use, they are acceptable. It is not intended that they be retrofitted with welded connections, however any new construction shall follow the new practice.
- ☐ Verify that all air terminals, and conductors are copper
- ☐ Verify that all metallic masses on the roof are bonded to the loop.
- ☐ Verify that all metallic objects within six feet of the lightning protection driven rod ground electrode system are bonded to the system.
- ☐ Verify that the lightning protection down leads are run down the outside of the building.
- ☐ Verify that the lightning protection driven rod ground electrode system is bonded to the exterior ring ground.
- ☐ Verify that there are no sharp bends of conductors in the lightning protection system. No bend of less than ninety degrees and a radius of eight inches will be allowed.
- ☐ Verify that there is no metallic encirclement of a lightning protection conductor.

CHECKLIST 4 AC POWER GROUNDING AND SURGE PROTECTION

- ☐ Verify that all AC circuits are equipped with an AC equipment ground conductor AC EQUIPMENT GROUND (green wire ground).

- ☐ Verify that all AC distribution cabinets are equipped with a framework mounted ground bar for the termination of AC EQUIPMENT GROUND leads. Neutral leads shall not be terminated on this bar.

- ☐ Verify that all distribution transformers have their neutral point grounded to the nearest CENTRAL OFFICE GROUND bar or to a grounded structural steel building member.

- ☐ Verify that an AC power surge protection device (surge arrestor) is provided at the AC power service entrance on the commercial side of the AC disconnect.

- ☐ Verify that the AC service neutral is grounded to the OFFICE PRINCIPAL GROUND POINT or to a ground electrode provided for AC service grounding. This ground electrode must also be bonded to the OFFICE PRINCIPAL GROUND POINT.

- ☐ Verify that the grounding conductor is not routed through metallic encirclements or sleeves and that it is terminated in the AC service cabinet and at the OFFICE PRINCIPAL GROUND POINT via a circumferential crimp two-bolt tongue connector.

- ☐ Verify that the neutral conductor is grounded only on the service side of the main disconnect and is not connected to any grounded object on the load side of the disconnect.

- ☐ Verify that the standby engine alternator and all associated equipment are provided with a chassis ground back to the nearest CENTRAL OFFICE GROUND bar.

- ☐ Verify that the standby engine alternator neutral is grounded only at the commercial AC power source and is carried unswitched through the commercial to standby switching device (breaker pairs, or automatic transfer switch).

- ☐ Verify that the surge protection device is equipped with visual and audible alarms.

- ☐ Verify, in all AC distribution cabinets that have a neutral conductor extended to them, that the neutral terminating bus bar is insulated from FRAMEWORK GROUND.

CHECKLIST 5 DC POWER EQUIPMENT GROUNDING

- ☐ Verify that the DC plant is equipped with a ground reference bonded to the battery discharge return *chandelier* bar located above the battery stand per the following requirements:

  - ☐ A DC plant supporting an INTEGRATED GROUND PLANE shall obtain its ground reference from the nearest CENTRAL OFFICE GROUND bar. This conductor shall be 750 kcmil.

  - ☐ A DC plant supporting an ISOLATED GROUND PLANE shall obtain it's ground reference form the MAIN GROUND BUSBAR within the ESS Ground window, except in the case of a 415 A/B power plant. This conductor shall be 750 kcmil when connected to the ground window.

- ☐ If a DC plant is used to support both an ISOLATED GROUND PLANE and an INTEGRATED GROUND PLANE, ensure that the battery returns for those circuits run outside the ISOLATED GROUND PLANE are bonded to the MAIN GROUND BUS in the ground window.

- ☐ Verify that all power plant frameworks and battery stands are properly grounded with the ground reference obtained from the nearest CENTRAL OFFICE GROUND bar. Grounding conductors shall be sized in accordance with the requirements in **SECTION 6.4.1**.

- ☐ Verify that, when the power plant return bar is used for the ground window, the power plant is within one floor of the ESS equipment supported by the ground window.

- ☐ Verify that all grounding conductors are green insulated stranded copper, sized appropriately of the application and shall be terminated with circumferential crimp two-bolt tongue connectors.

- ☐ Verify that all grounding conductors terminating on bus bars are properly labeled to identify their function, their far end terminating point, and are equipped with DO NOT DISCONNECT tags.

- ☐ Verify that grounding conductors are not run in cable racks and are visible for their entire run.

- ☐ Verify that battery and return conductors are paired in the cable racks.

- ☐ Verify that all battery return bars in main and secondary distribution bays are insulated from contact with CENTRAL OFFICE GROUND except at the one connection at the main battery discharge return bar above the battery stand. Battery return busses in Battery Distribution Fuse Bay (BDFB) and battery return splice plates external to the Battery Distribution Fuse Bay shall NOT be connected to CENTRAL OFFICE GROUND.

CHECKLIST 6 CENTRAL OFFICE INTEGRATED GROUND SYSTEM

☐ Verify that an OFFICE PRINCIPAL GROUND POINT bar has been established for the bonding of grounding electrodes, building grounding systems, the AC service neutral and as the originating point for the CENTRAL OFFICE GROUND system.

☐ Verify that the OFFICE PRINCIPAL GROUND POINT bar is properly designated as the OFFICE PRINCIPAL GROUND POINT and that the sign is readily visible.

☐ Verify that all primary and supplementary building ground electrodes are bonded to the OFFICE PRINCIPAL GROUND POINT bar.

☐ Verify that all connections to all bus bars are made with circumferential crimp two-bolt tongue connectors, direct exothermic welds, or exothermic weld type two-bolt tongue lugs.

☐ Verify that all connections are permanently labeled with the purpose of the grounding conductor, the far end terminating point, and equipped with DO NOT DISCONNECT tags.

☐ Verify that all connections to ground bars have been treated with anti-oxide compound.

☐ Verify that ground conductors are not run through metallic encirclements or in metallic conduit. If ground conductors are run in metallic conduit, verify that the conductor is bonded to the conduit on both ends.

☐ Verify that the office is equipped with one or more VERTICAL RISERS that are run through multiple floors of the building. In a multi-story building, the VERTICAL RISER shall be comprised of a 750 kcmil cable that originates at the OFFICE PRINCIPAL GROUND POINT. In a structural steel I beam type building the structural steel may be used as the VERTICAL RISER if it meets the requirements in **SECTION 6** of this practice, but it shall also be bonded to the OFFICE PRINCIPAL GROUND POINT with a 750 kcmil cable. A single story building may use a NO. 4/0 AWG cable for extension of the ground reference into the equipment area. This cable must also originate at the OFFICE PRINCIPAL GROUND POINT.

☐ It is recommended that the 750 kcmil VERTICAL RISER be a continuous unspliced cable. When splices must be used only exothermically welded splices are acceptable.

☐ Verify that the VERTICAL RISER is not routed through metallic sleeves or small metallic enclosures through walls and floors.

☐ Verify that the material used for the supporting of the VERTICAL RISER does not encircle the cable with a metallic ring.

☐ Verify that connections from the VERTICAL RISER to the CENTRAL OFFICE GROUND bars on each floor are accomplished by compression H-taps or exothermic welds and short lengths of 750 kcmil cable (less than twenty feet).

☐ Verify that the VERTICAL RISER is run as straight as possible and does not contain any sharp ninety degree turns or U bends.

☐ Verify that the VERTICAL RISER is run exposed to afford visual inspection.

☐ Where multiple VERTICAL RISERS are utilized in a building, verify that they are bonded together at every third floor with a 750 kcmil cable.

☐ Verify that all VERTICAL RISERS originate at the OFFICE PRINCIPAL GROUND POINT per requirements in **SECTION 6** of this practice.

☐ If the electrical integrity of the structural steel is unknown, verify that the floor CENTRAL OFFICE GROUND bars are mounted on insulators.

☐ If the electrical integrity of the structural steel is verified and the structural steel is used as the VERTICAL RISER, verify that the floor CENTRAL OFFICE GROUND bars are bonded to the structural steel per requirements in **SECTION 6.2** of this practice.

☐ Verify that all terminations to a CENTRAL OFFICE GROUND bus are made with two-bolt tongue bolted circumferential crimp connectors, exothermically welded, or utilize two-bolt tongue exothermic connectors.

☐ Verify that all connections to a CENTRAL OFFICE GROUND bus are properly identified to indicate the purpose of the conductor, its far end terminating point, and are equipped with a DO NOT DISCONNECT tag.

☐ Verify that each CENTRAL OFFICE GROUND bar supports an area of the building no larger than a square superimposed on a one-hundred foot radius circle with the floor CENTRAL OFFICE GROUND bar being the center of the circle.

☐ Verify that grounding conductor lengths are no more than two-hundred feet maximum from the equipment being grounded to the floor CENTRAL OFFICE GROUND bar.

- ☐ Verify that all CENTRAL OFFICE GROUND bars are visible and accessible. If it is necessary to install a CENTRAL OFFICE GROUND bar in a closet, behind a wall, below a raised floor, etc., signage must be provided to indicate the existence of the CENTRAL OFFICE GROUND bus and access provided for future installations or maintenance.

- ☐ Verify that the HORIZONTAL EQUALIZERS run from the floor CENTRAL OFFICE GROUND bar into the equipment areas are green insulated 750 kcmil cables and are run exposed to afford visual inspection and future grounding connections.

- ☐ Verify that all equipment framework and metallic objects in the telecommunications equipment area are bonded to the HORIZONTAL EQUALIZER aisle and frame ground system in accordance with their specific design requirements.

- ☐ Verify that the process of *daisy chaining* is NOT used for equipment frame grounding. *Daisy chaining* refers to the extending of a ground conductor from one equipment frame to the next adjacent frame. The recommended method of grounding line-ups of equipment is to provide a common frame aisle grounding conductor from which drop leads are tapped to individual frames.

- ☐ Verify that all grounding conductors, unless specified otherwise in system documentation, are green insulated, copper stranded conductors. All connections shall be made with circumferential crimp connectors equipped with two-bolt tongues.

CHECKLIST 7 CENTRAL OFFICE ISOLATED GROUND SYSTEM

Stored program control systems such as NNS, 4ESS, 5ESS, NCP, STP, Packet Switch, etc., require a single point ISOLATED ground system. Refer to SECTION 7 of this practice for more detailed requirements for the provisioning of an ISOLATED GROUND PLANE. A quality and acceptance checklist for an ISOLATED GROUND PLANE follows.

☐ Verify the location of the Ground Window

- ☐ Located in the ESS area?
- ☐ Located at the power plant battery return bar?
- ☐ Other, Describe?

☐ If the ground window is located at the power plant battery return bar, verify that it is insulated from FRAMEWORK GROUND.

☐ If the ground window is located at the power plant battery return bar, verify that it is within one floor of the ESS equipment.

☐ Verify that the MAIN GROUND BUSBAR, within the ground window, is referenced to CENTRAL OFFICE GROUND per system requirements.

☐ Verify that all AC conduits entering the ISOLATED GROUND PLANE area are properly bonded to the MAIN GROUND BUSBAR within the ground window. Both the conduit and the AC EQUIPMENT GROUND conductor must be bonded.

☐ Verify that all AC conduits are insulated from contact with the INTEGRATED GROUND PLANE after entering the ISOLATED GROUND PLANE area and being bonded to the ground window.

☐ When the ground window is not located at the DC power plant, verify that the power plant CENTRAL OFFICE GROUND reference is obtained from the ground window.

☐ Verify that all ESS frames and equipment within the ISOLATED GROUND PLANE are isolated from contact with the INTEGRATED GROUND PLANE.

- ☐ Verify that all equipment, ironwork, ductwork, etc., of the ISOLATED GROUND PLANE located within seven feet of the ISOLATED GROUND PLANE is bonded back to the MAIN GROUND BUSBAR in the ground window.

- ☐ When the power plant that supports the ISOLATED GROUND PLANE area also supports equipment in the INTEGRATED GROUND PLANE, verify that the return conductors of the INTEGRATED distribution circuits are bonded to the MAIN GROUND BUSBAR at the ground window.

- ☐ When AC power is distributed to equipment from under a raised floor for miscellaneous and protected AC supplies, verify that the cable troughs, conduit and flex conduit is properly isolated from contact with the raised floor.

- ☐ If miscellaneous AC convenience outlets exist in the ISOLATED GROUND PLANE area, which are on INTEGRATED ground, verify that they have been disabled or equipped with warning labels to prevent their use as a power source for test equipment.

- ☐ Verify that all equipment bays, frames, cabinets, etc., located in the ISOLATED GROUND PLANE are equipped with FRAMEWORK GROUND connections back to MAIN GROUND BUS and ground window.

- ☐ Perform a visual inspection of the entire ISOLATED GROUND PLANE area looking for observable violations such as loose connections, improper wire sizes, improper connections, and grounding violations such as those listed below

- ☐ Conduits, and cable racks that have become a part of the ISOLATED GROUND PLANE by being routed through and connected to the MAIN GROUND BUS, shall not be in contact with any other building steel structures or any components of the INTEGRATED GROUND PLANE.

- ☐ Equipment frames, cable racks, etc. which are a part of the ISOLATED GROUND PLANE shall not be in contact with building steel or the INTEGRATED GROUND PLANE.

- ☐ Power for all equipment within the ISOLATED GROUND PLANE shall come only from secondary distribution sources within the ISOLATED GROUND PLANE.

.

- ☐ Check that all conduit, cable racks, etc. that are entering, and becoming a part of the ISOLATED GROUND PLANE are properly bonded to the MAIN GROUND BUS at the ground window and are insulated from contact with the INTEGRATED GROUND PLANE throughout the ISOLATED GROUND PLANE.

- ☐ Verify that all DMACS Nodes associated with the ISOLATED GROUND PLANE receive their power from within the ISOLATED PLANE and are grounded to the ISOLATED GROUND PLANE.

- ☐ Verify that all conductors are properly connected to the ground window. Things to check for are:

  - ☐ Ensure that all connections have been properly cleaned and anti corrosion compound applied.
  - ☐ Tightness of connections
  - ☐ Use of compression crimp two-bolt tongue connectors,
  - ☐ Use of stranded copper wire

CHECKLIST 8 BUILDINGS HOUSING MICROWAVE RADIO

Due to the susceptibility of microwave towers to attract lightning it is very critical that grounding systems associated with buildings housing radio equipment be properly engineered and installed. Use the following checklist for quality verification and acceptance of building housing radio systems

GENERAL REQUIREMENTS

- ☐ Verify that all above ground connections to solid wire are either exothermically welded or utilize exothermic type two-bolt tongue connectors.
- ☐ Verify that all buried conductors are NO. 2 AWG solid, bare, tinned copper wires.
- ☐ Verify that all connectors used with stranded wire utilize circumferential crimp two-bolt tongue connectors.
- ☐ Verify that all interior grounding conductors are green insulated, stranded copper, except where system requirements allow bare, tinned, stranded copper.
- ☐ Verify that connections on new installations between solid and stranded conductors are exothermically welded. Existing installations may have utilized a double parallel crimp.
- ☐ Verify that grounding connections buried in earth are exothermically welded.

OUTSIDE BURIED RING GROUND SYSTEMS for TOWER and BUILDING

- ☐ Verify that a buried ring ground system is installed around the Building and Tower per requirements in **SECTION 8** of this practice. Shown below are some of the specific requirements for this system. This list is not all-inclusive.
- ☐ Verify that the tower and building exterior buried ring ground systems are installed utilizing the following components and requirements:

☐ Verify that the ring is comprised of a NO. 2 AWG solid, tinned, copper wire buried at a minimum depth of thirty inches or below the frost line, whichever is greater.

☐ Verify that the NO. 2 wire described above has been arranged in two circles, one around the building and one around the tower, forming two closed loops. Ensure that the adjacent sides of the two loops are joined at two points by conductors at opposite corners. The ring around the building should be placed at a minimum of two feet from the exterior wall of the building, or outside the drip line of the structure.

☐ The NO. 2 AWG wire is buried in a circle around the building or tower in a closed loop and placed at a minimum of two feet from the exterior wall of the building, and outside the drip line of the structure.

☐ Verify that the driven rods used with the buried ring ground system are a minimum 5/8 inch in diameter, copper clad steel or stainless steel rods, a minimum of eight feet in length, and spaced along the buried ring at not less than ten foot or more than fifteen foot intervals.

☐ Verify that all connections between the NO. 2 AWG ring and ground rods are exothermically welded. Also, verify that all other buried connections are exothermically welded.

☐ For a new installation verify that the outside ring ground system has been measured and meets the requirement of five ohms or less per **SECTION 2** of this practice.

☐ Verify that all tower legs are bonded to the tower buried ring ground system utilizing a NO. 2 AWG solid, tinned, copper conductor exothermically welded to the tower legs and to the buried ring ground.

☐ Verify that the tower and building buried ring ground system are totally separate ring systems and that the tower ring ground system has a minimum of two connections to the building buried ring ground system.

☐ Verify that all incidental earth electrodes and metallic objects outside the building are bonded to the exterior ring ground system for the purpose of equalization. See **SECTION 8** of this practice for examples of the types of objects that must be bonded.

WAVEGUIDE and HATCHPLATE GROUNDING

☐ Verify that the metallic framework provided for waveguide support is bonded to the exterior ring ground.

☐ Verify that conduit entering the building when in close proximity of the hatchplate is bonded to the exterior ring ground.

☐ Verify that the waveguide hatchplate has two direct connections to the exterior buried ring ground system. One inside and one outside, per requirements in **SECTION 8** of this practice.

☐ Verify that the waveguide hatchplate has two connections to the interior ring ground per requirements in **SECTION 8** of this practice.

☐ Verify that all flexible waveguide sections are parallel bonded with grounding straps.

☐ Verify that coaxial cable from the tower entering the building through the waveguide hatch or other locations is equipped with appropriate grounding kits and bonded to the exterior ring bus.

INTERIOR RING BUS SYSTEM

☐ Verify that an interior ring bus system is provided in the building or radio equipment room per requirements in **SECTION 8** of this practice. Some of these requirements are detailed below but may not be all-inclusive.

☐ Verify that the interior ring bus for new installations is installed utilizing NO. 2 AWG green, insulated, stranded, copper conductors. For existing locations various materials may have been used including bare tinned stranded, solid tinned copper, and in some cases gray insulated stranded. All are acceptable and should not be replaced to comply with the latest requirements.

☐ Verify that all new connections between stranded conductors are made with circumferential crimp connectors. In older radio rooms, many mechanical connectors may be found. This was in compliance with the standards of that time and these connections need not be upgraded to crimp type unless documented lightning related problems have occurred at that location.

☐ Verify that connections at the interface between the exterior and interior ring ground system, solid wire to stranded wire, are made with exothermic welds. Older installations may have used two parallel crimp connectors. This was in compliance with the standards of that time and these connections need not be upgraded to exothermic welds unless documented lightning related problems have occurred at that location.

☐ Verify that new installations are equipped with bi-directional splices in the corners of the building and at the interface between the interior and exterior ring ground systems. This was not required in older installations.

☐ Verify supporting materials and stand-offs used to support the interior ring ground are adequate (one approximately every two feet) and do not encircle the ring ground conductor with a metallic ring.

☐ Verify that the interior ring ground system is free from sharp bends in the grounding conductors. In general, the nominal bend radius shall not be less than eight inches.

☐ Verify that all equipment frameworks and miscellaneous metallic objects are bonded to the interior ring ground system per requirements in **SECTION 8** of this practice.

MISCELLANEOUS GROUNDING and LIGHTNING PROTECTION REQUIREMENTS

☐ Verify that all communications cables entering the building are properly protected with surge arrestors, and grounded.

☐ Verify that the AC power service entrance is equipped with a surge arrestor and is properly grounded.

☐ Verify that all AC distribution circuits extended outside the building and in particular to the tower area are protected with surge arrestors.

☐ If a Lightguide cable enters the building, verify the existence of a CABLE ENTRANCE GROUND BAR, and the proper installation of a 2400 LG grounding closure on each cable.

BUILDINGS with ROOF MOUNTED TOWERS

☐ Verify that a ground ring is provided around the tower utilizing a NO. 2 AWG conductor and that the tower legs are attached to the ring utilizing exothermic welds.

☐ Verify the existence of a roof mounded lightning protection system and that it is installed per requirements in **SECTION 3** of this practice.

- ☐ Verify that the roof mounted tower ring is attached to the lightning protection at each corner of the ring, and that all connections are made with exothermic welds.

- ☐ Verify that all roof mounted metallic objects are bonded to the tower ring or lightning protection system conductors.

- ☐ On a building with an electrically continuous steel frame, verify that the tower ring is bonded to building steel at two points, one on either side of the ring. This path, as well as the lightning protection system downleads, will serve as the current path for a lightning stroke. Verify that connections to the building steel and the lightning protection system exist.

- ☐ On buildings which do not have electrical continuity in the building steel, or it is unknown whether continuity exists, the tower ring will utilize the lightning protection down leads for the lightning current path. Verify that these connections exist.

- ☐ In buildings with roof mounted towers the CENTRAL OFFICE GROUND system will be used as the ground reference point for the interior ring ground system, and the bonding of the waveguide and the waveguide hatch. Verify that these bonds exist.