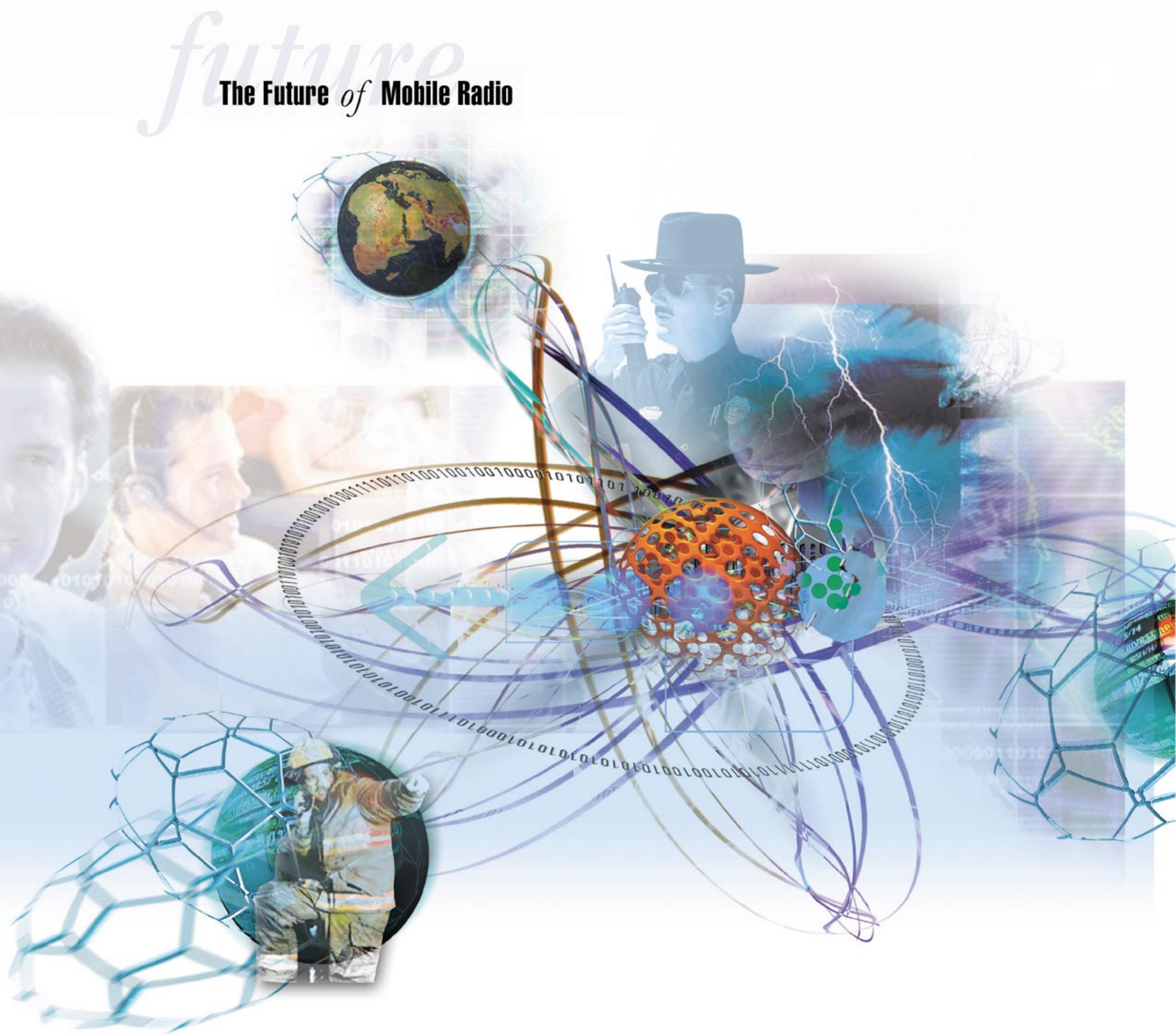
Installation Manual
AE/LZT 123 4618/1 R3A



Standards
Site Grounding and Lightning Protection

tyco
Electronics

M/A-COM

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NOTICE!

Repairs to this equipment should be made only by an authorized service technician or facility designated by the supplier. Any repairs, alterations or substitution of recommended parts made by the user to this equipment not approved by the manufacturer could void the user's authority to operate the equipment in addition to the manufacturer's warranty.

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1. OBJECTIVE

The objective of this document is to provide a standard for M/A-COM site equipment grounding. The methods recommended are essential to protect personnel, minimize component failure, and optimize performance by reducing electrical “noise”. Transient voltages introduced into a system by inadequate site grounding often exceed the operating parameters of electronic components resulting in higher equipment-failure rates. Semiconductor devices are especially susceptible to damage by externally induced transient voltages.

1.1. GROUND THEORY

All communications facilities are related to ground or earth ground either by capacitive coupling, accidental contact or designed contact. If a conducting path for a lightning stroke is provided from the point of contact of the strike to a suitable ground apparatus or electrode, damage and shock hazards can be diminished.

In theory, a ground rod 1-inch in diameter driven into homogeneous 1000 ohm per meter (ohm/meter) soil one meter deep would present only 765 ohms of resistance to ground. Driving it another meter into the soil (two meters) would yield 437 ohms. Extending the depth to three meters would yield about 309 ohms.

Using three interconnected ground rods that are each one-meter long, driven into the same soil area one meter deep and one meter apart, ground resistance becomes 230 ohms. Burying the interconnecting wire below the soil surface further reduces the ground resistance to less than 200 ohms.

Lower ground resistance is, therefore, more rapidly achieved by installing multiple, interconnected ground rods.

All conductors and connections have some associated resistance, but the inductive reactance is normally much larger. All grounding and bonding conductors must have low inductance interconnections to minimize the inductive voltage transients. The “impedance” of a conductor is the mathematical correlation of the resistance and the inductive reactance associated with that conductor. This document refers to low resistance, low inductance connections as “low impedance” connections.

The M/A-COM site installation should have less than (below) five (5) ohms resistance between any connected point on the ground bus and earth ground. The exception to this requirement is noted in Section 2.1.4. *Antenna Structures On Tall Buildings*.

1.2. SCOPE

This standard has been prepared to address both safety and equipment damage prevention issues. The grounding, bonding, and shielding procedures described are intended provide low impedance “designed contact” between the communications facility and earth ground

This document is to be used as a guide for the design and installation of protective bonding and grounding of all M/A-COM private radio systems and dispatch sites.

1.3. GENERAL

The purpose of an effective ground system is to:

- Protect personnel by reducing the possibility of electrical shock.
- Provide a non-destructive, low impedance path to ground for lightning strikes and currents.
- Provide a low impedance path to ground for cable shields and other metal encased RF handling devices (antennae etc.).
- Protect wiring and other electrical components from damage.
- Reduce radio frequency noise and suppress damaging AC power service spikes.
- Maintain proper performance of the antenna system.
- Control fast-rising electrical surges, which produce high voltage differences between the ends of single conductors such as heavy copper wires and bars.
- Equalize surge potentials by controlled bonding of M/A-COM Communications site ground elements.

  These elements include the following:
  a) Non **I**solated **G**round **Z**one (**IGZ**) equipment grounds.
  b) Surge Producers
  c) Surge Absorbers
  d) IGZ Grounds

- Reduce voltage differences and control surge currents.

The prime source of danger and damage to equipment is lightning currents that are often conducted to the equipment through coaxial transmission lines.

One of the best ways to reduce the chance of damage from lightning is to provide a low impedance path to ground for lightning currents to prevent them from flowing through the equipment.

The isokeraunic map shown in Figure 16 on page 28 shows the mean annual number of days with thunderstorms in different regions of the United States.

NOTE

The region with the highest frequency is centered around south and central Florida.

Another source of surge ingress is through the building's electrical utility service. Utility service surges may be controlled by installing an AC MOV and Avalanche Surge Arrestor on the incoming power lines. Surge protection downstream of the breaker panel may be added if additional protection is required. ***All M/A-COM transmitting equipment is equipped with internal avalanche and MOV protection.***

1.4. RESPONSIBILITY

There are references to ground rods and ground connections throughout this document. In all cases there must be only one ground system at each site, building, room, or communications shelter. **ALL GROUNDS MUST BE TIED TOGETHER** (see Figure 8 on page 23, & Figure 30 on page 42).

There should be *no* separately maintained ground rods or ground systems associated with the communications shelter, site, building, or equipment room. Adherence to these requirements is the standard for M/A-COM Private Radio Systems communications facilities.

1.4.1. Minimum Requirements

The purpose of this specification is to establish minimum requirements for a grounding system that will provide protection for personnel and equipment. Any National Electrical Code or local building grounding-related codes which conflict with items specified within this document may take precedence.

Protective measures intended to prevent equipment damage and personnel hazards caused by lightning will incorporate system grounding and bonding using good RF practices. All conductors and connections have some associated resistance, but the inductive reactance is normally much larger. All grounding and bonding conductors must have low inductance interconnections to minimize the inductive voltage transients. The minimum bonding conductor size shall be a No. 6 AWG.

Grounding and cabinet bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place bonding conductors in ferrous metallic conduit that exceeds 1 meter (3 ft) in length, the conductors must be bonded to each end of the conduit with a No. 6 AWG (minimum) conductor.

1.4.2. Labels, Color-Coding, and Marking:

Each telecommunications grounding conductor must be labeled. Labels must be located on conductors as close as possible to their point of termination to allow ease of access to read the label. Labels must be non-metallic and include the information depicted in Figure 1 below.

WARNING
IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED PLEASE FIRST CALL OR CONTACT THE TELECOMMUNICATIONS MANAGER

Figure 1 – Grounding Conductor Label

Each telecommunications grounding conductor must be marked appropriately by a distinctive ***green color***. This includes all grounding conductors for telecommunications equipment as well as grounding to the AC service equipment (AC power).

The bonding conductor for telecommunications must bond the Telecommunications Main Grounding Busbar (TMGB) to the service equipment (power) ground.

1.5. PROCESS & DEFINITION

All elements of the ground system, and conducting elements in near proximity to the system must be connected and bonded together. This maintains any and all parts of the radio site at the same ground integrity, as related to true earth ground (see Figure 9 on page 23 & Figure 11 on page 25).

1.5.1. General grounding

Ground currents can circulate and produce voltage drops within a cabinet, rack, or sub-system producing a source of RF interference. Although they may be of small magnitude, they can still cause the signal-to- noise ratio to become objectionable. The recommended grounding system is called "The Single Point Ground" system. In this document, all system equipment grounds are referred to a single point. This point is also connected to the site or building ground.

Solid-state equipment, such as that found at any communications site, is sensitive to transient voltages and noise that may enter the ground system. A single point ground is required to isolate the communications equipment from the building, steel framework, superstructure, etc., except at the ***Master Ground Bar*** (MGB). The MGB is the only point where any other equipment grounds can come in contact with the communications site equipment grounds. In addition to the site ground connection, the MGB will include:

- Central site ground.
- AC equipment ground (green wire).
- Frame grounds.
- DC Power Plant grounds.

It is important to establish and maintain the single point ground concept. All equipment racks, cabinets, power frames, and power distribution units must be isolated from the building steel, ducts, pipes, etc., to insure that no extraneous currents will flow in the M/A-COM equipment cabinets, racks, or related hardware. Their grounds must be connected only to the single ground reference point at the MGB. All grounds must be tight (bonded) and all MGB leads must be as short as possible

1.5.2. DC power plant ground

The main DC power plant ground must be run from the discharge ground bar to the MGB for single floor buildings, or the ***Floor Ground Window*** (FGW) on each floor of multi-floor buildings. In small offices with no horizontal or vertical grounding arrangement this lead is generally 2/0 (00), or larger, wire.

1.5.3. Entrance cable grounding & bonding

The sheath of each telephone cable entering the building through underground or aerial ducts must be bonded to the ground system. If the MGB is close to the cable entrance, the cable sheaths should be bonded to this ground bar by means of a #2 insulated, stranded, copper wire. If the MGB is not nearby, or is in another part of the building, and a cable vault is provided, a Cable Vault Ground Bar (CVGB) must be located in the cable vault. The cable sheaths are then bonded to this bar by means of a #2 (or larger) insulated, stranded copper wire. The CVGB is then bonded to the MGB with a 2/0 AWG insulated cable.

All grounding and bonding conductors must have low inductance interconnections to minimize inductive voltage transients. The minimum bonding conductor size is No. 6 AWG.

Grounding and cabinet bonding conductors should not be placed in ferrous metallic conduit. If it is necessary to place bonding conductors in ferrous metallic conduit that exceeds 1 meter (3 ft) in length, the conductors must be bonded to each end of the conduit with a No. 6 AWG (minimum) conductor.

Any lightning arrestor not attached directly to the cable entry port is to be connected to a ground bar (preferably the MGB) by short lengths of insulated No. 6 AWG (or larger) wire or flexible copper straps. If this ground bar is a secondary ground bar, it must be connected to the MGB using a No. 2 AWG, (minimum) insulated cable.

1.5.4. Equipment frame grounds

The framework of all equipment racks must be grounded! Grounding is as important in small M/A-COM Private Radio Systems as it is in complex, multi-site, and multi-channel systems. The practices may vary from system to system, however the basic concept within this document must be followed.

1.5.5. Coax and Transmission Line Grounding

Each coaxial line used At M/A-COM communications sites and antenna tower locations must have a minimum of three lightning protection grounding kits attached. A grounding kit should be installed at 100-foot intervals wherever vertical cable runs on towers exceed 200 feet, (see Figure 23, page 34). This process is illustrated in more detail in Figure 7 (page 22), specifically points 1, 2, & 3.

Each coaxial cable must have an Andrew Gas Discharge Tube (GDT) or equivalent lightning arrestor near the cable entrance to the communications shelter or room. Quarter wave stubs or Gas Discharge Tubes (QWS or GDT) are the preferred types and are believed to be the best lightning arrestors presently available (see photo and illustrations in Figure 28 on page 39).

Grounding kits must be terminated at the master ground bar. All connections to the master ground bar must be clean and free of any oxidation to insure a low impedance connection. The lightning arrestors are effective in limiting the amount of lightning energy that can be transferred to the equipment through the inner conductor of the coax or transmission line.

1.5.2. Equipment Grounding

Each equipment rack, equipment cabinet, or equipment shelf must be grounded to a site ground through the in-building "Halo" (see glossary) ground. Equipment enclosures used inside of communications shelters must be attached to this system "Halo" ground in the same manner.

1.6. GROUND SYSTEM COMPONENTS

A complete grounding system for the antenna, towers, and buildings must be provided. This includes internal and external grounding systems for equipment in the communications buildings, the antenna towers and guys, transmission lines, telephone lines, DC power plants, AC power lines, and the communications facility.

No grounds may be run inside metal conduits because metal conduits increase the surge impedance of the grounding cables. The grounds that make up the inside Halo ground must be number 2 AWG or larger copper wire covered with an approved non-conductive **green** plastic covering.

If non-insulated wire is used for the inside halo (faraday) ground ring, a non-conductive insulating sleeve must cover the wire where it passes any metallic conduits or metal objects. Halo ground wires attached to exit ground wires must be solid, tinned, **bare** copper (number 2 AWG or larger).

1.6.1. Ground Rods

M/A-COM ground system ground rods must be bare ***copper-clad steel***, *5/8 inch in diameter, and a minimum of 8 feet in length.* Multiple, interconnected, copper-clad steel ground rods are normally provided (see Figure 30, page 42).

The minimum distance between ground rods must be 16 feet (where space permits) to maintain the integrity of the ground system. Exothermic bond/weld (Cadweld™) connections (Figure 14, page 27) must be made at all ground rod connections. For detailed information, contact ERICO/CadWeld™ at (800) 677-9089.

1.6.2 Chemical Ground Rods

A Chemical Ground Rod is an electrolytic ground rod (usually a 2 inch copper tube, see Figure 24 on page 35) designed to provide a low-impedance and low-resistance ground. Moisture is drawn into the rod by changes in atmospheric pressure. Through a process of continuos leaching, small amounts of an environmentally safe compound are released into the soil. This compound enhances the earth ground. The solution slowly leaches into the surrounding earth, creating an ion "root" that has a metallic base (see Figure 24 on page 33 and Figure 25 on page 36). This process continually conditions the soil, reducing soil resistance, enhancing the ground system effectiveness over time. The chemical rods provide lower resistance grounds than conventional solid, copper clad rods in virtually any soil.

The Lyncole XIT chemical ground rod is constructed of hard-drawn copper tubing. The rod is built to last up to 30 years in certain soils and climates. A heavy 2/0 or 4/0 "pigtail" should be attached to the chemical ground rod using the Cadweld™ process (see Figure 14, and Figure 15 on page 27) to provide for easy connection to other parts of the ground system. The pigtail is Cadwelded directly to the copper tube to provide the best possible physical and electrical bond.

Chemical ground rods can often provide a more reliable ground than using multiple copper clad ground rods. This is especially good where soil is shallow and the rock base prevents deep driving of copper clad ground rods

1.6.3 Ground Enhancing Backfill

A clay-salts compound called "Bentonite" may be used as backfill to provide additional ground enhancement.

Chemical ground rods used with a galvanic backfill, such as "bentonite," provide the best solution to a difficult grounding problem. Bentonite helps the soil to retain more moisture, which tends to increase soil conductivity. Adding the bentonite as backfill enhances the electrical contact with the earth.

1.7. CONDUCTORS

Conductors that are used below ground for connecting ground rods must be:

a) Stranded bare copper wire, number 2 AWG ***or larger.***

OR

b) Solid 18 AWG (minimum) bare copper **strap**, a minimum of two inches wide.

Conductors used above ground for interconnecting ground rings, Halo's, equipment racks and cabinets, and other metal items must be:

a) Solid or stranded copper wire number 6 AWG ***or larger.***

OR

b) Solid 16 AWG (minimum) copper **strap**, a minimum of two inches wide.

1.8. CONNECTIONS

All ground connections must be made using minimum length conductors with straight vertical (or horizontal) runs, if possible. Conductor bends, when required, must be greater than 12-inch radius. Connecting conductors must always transition in the direction of current flow or toward earth ground, and approach the main ground at an angle of roughly 45 degrees.

Connections of dissimilar metals can cause deterioration of grounding surfaces. Table 1 contains a list of metals divided into groups. Using only similar metals (from the same group) prevents ground contact surface deterioration.

Table 1 – Compatible Metals

Group A	Group B	Group C	Group D
Magnesium	Tin	Stainless Steel	Copper
Aluminum	Lead	Nickel	Silver
Zinc	Steel	Iron	

Surface contact of dissimilar metals may be used with the following stipulations:

Table 2 – Dissimilar Metals

CONTACT SURFACES	INSIDE	OUTSIDE (Weather Exposed)
Within same group	OK	OK
Adjacent groups	OK*	Weatherproof coating must be applied after direct metal-to- metal contact.*

* No liquid should be allowed to come into contact with surface gaps or metal contacts from adjacent groups.

1.8.1. Exothermic or Permanent Grounding Connections

Exothermic power and grounding connections must be made with a pre-engineered system using a controlled exothermic chemical reaction. Cadweld™ (see *Exothermic Weld* in the Glossary) is a bonding process that provides a metallic bridge connection that exhibits virtually no resistance and its conductivity approximates that of the associated conductors. Exothermic connections offer the following advantages over other types of connections:

- The connection permanently welds every strand of the conductor.
- The connection is made with portable equipment that requires no outside source of heat or power.
- Loosening or corrosion of the current path cannot occur.
- The connection is able to withstand repeated high current surges [faults] without damage to the connection or the conductor.
- No special skill and minimum training is required.
- Installation time is the same as with other kinds of connections.

1.8.2. Permanent Grounding Connection Specifications

All grounding connections (conductor-to-conductor, conductor-to-ground rod and conductor-to-structure or fence post) of #6 AWG and larger copper conductors must be permanently exothermically welded. Contact ERICO/ CadWeld™ (800-677-9089) for more detailed information.

Copper grounding conductors spliced with exothermic connections are considered a continuous conductor, as stated in NEC 250-81 Exception No. 1 and 250-91 Exception No. 3.

All connections must meet the applicable requirements of IEEE Std 80-1986. For this reason, Cadweld® exothermic connections are suggested as they are approved in NEC 250-81, -91, -113, and -115.

Welding material for copper-to-copper and copper-to-steel connections must contain copper oxide, aluminum and not less than 3 percent tin as a wetting agent. Starting material [if used] must consist of aluminum and copper oxides. It must not contain phosphorous or any caustic, toxic or explosive substance.

All exothermic connections made to the ground system, including test leads, must be made with an exothermic welding process specifically designed to restrict heat energy transfer to surrounding objects

Weld metal must be controlled at the point of manufacture and subjected to rigid quality control inspection procedures.

1.8.3. Below Ground

Connections made to ground rods, or to conductors below ground must be made using an exothermic process such as Cadweld or equivalent. This attachment procedure insures firm, electrically conductive, mechanically rigid, and maintenance free connections. Connecting and interconnecting conductors must be placed at the same depth as the tops of the ground rods.

Contact ERICO/CadWeld™ at **(800) 677-9089** for detailed information.

1.8.4. Doping Of Ground Systems

When unable to achieve grounds below 10 ohms, some doping of the earth may be necessary. One of the best methods used today to increase the conductivity (reduce resistance) of the ground is another Cadweld product called "GEM®". (ERICO® ***Ground Enhancement Material***) If GEM is unavailable bentonite may be used.

ERICO GEM is a superior, conductive material that improves grounding effectiveness regardless of soil condition. It is an ideal material to use in areas of poor conductivity soil, such as rocky ground, mountain tops and sandy soil. **GEM is added around a ground rod in an augured hole or around a conductor in a trench.** The GEM material increases the effective diameter of the rod or conductor.

ERICO GEM has a constant cured resistivity of 12 ohm/cm or less. It must set up to a hard, permanent material and does not decompose or dissolve over time. It does not require any maintenance after installation. It does not rely on the continuous presence of water, nor does it add salts to the earth that could contaminate the ground water. The material is packaged in 25 pound bags and may be added dry or pre-mixed in a slurry, like cement.

1.8.5. Above Ground

Connections made above ground, in areas exposed to weather, must use Cadweld (or a similar exothermic process), where possible. If environmental conditions prevent the use of the Cadweld process, an appropriate pressure-type connection may be used.

Where above ground pressure type connections are employed, stranded wire must be used. Connections made above ground must be made with appropriate passivation of the mating surfaces, or using special transition clamps such as a PolyPhaser™ Model J-1, J-2, or equivalent.

Stranded conductors must be connected to equipment racks using lugs or pressure clamps consistent with the wire size and grounding surface of the equipment being grounded.

Connections to tower guy wires must be pressure connections.

1.9. SURGE SUPPRESSION DEVICES

Substitutions for the specific recommended manufacturer surge suppression device types referred to in this document may be made as long at the substitute is of the same quality and performs the same function. Consideration must be given to the voltage clamping level, response time, and energy rating for the intended application. Power line surge suppressors similar to the Joslyn 1265-85 (see Figure 19, page 31) should be included at the service entrance breaker panel

1.9.1. The Following Practices Are to be *Avoided!*

a) Never run ground wires through metal conduit. When the ground must be carried through a **metal** conduit, **the ground wire must be bonded at each end of the conduit**.

NOTE: **PVC conduit is preferred as a single run ground conduit** where the ground wire exits the communications room or shelter (see note inFigure 7, page 22).

b) Never rely on the third wire (green wire) on AC power services for lightning ground.

A neutral conductor must never be grounded again after it has been grounded at the service entrance. This is to avoid 60 Hz return current passing through conduit, framework, etc., thereby causing noise in susceptible electronic circuits.

2. GROUND MEASURING TECHNIQUES

2.1 WHY MEASURE SOIL RESISTIVITY?

Soil resistivity measurements have a threefold purpose. First, such data are used to make sub-surface geophysical surveys as an aid in identifying ore locations, depth to bedrock and other geological phenomena. Second, resistivity has a direct impact on the degree of corrosion in underground pipelines. A decrease in resistivity corresponds to an increase in corrosion activity and, therefore, dictates the protective treatment required. Third, soil resistivity directly affects the design of a grounding system, and it is to that task that this discussion is directed. When designing an extensive grounding system, it is advisable to locate the area of lowest soil resistivity in order to achieve the most economical grounding installation.

Ground measurements made on a new site prior to ground-breaking or during site survey and site prep, may be made using the **AEMC model 4600 or 4610** to determine the soil resistance. This measurement will enable the M/A-COM engineer to determine the type of ground system that will be employed at the site; e.g. chemical, XIT, or conventional ground(s). *The Vendor for AEMC Measurement devices is Lyncole XIT Grounding; 3547 Voyager St., Torrance, CA 90503. Phone (800) 962.2610.*

Ground system measurements at an existing communications site with an existing ground system may be made using an instrument similar to the **AEMC Model 3710.** Use the instructions provided with the **AEMC model 3710 or 3730 Ground Test Instrument.**

2.2. FACTORS AFFECTING SOIL RESISTIVITY ON GROUND ELECTRODES.

Soil resistivity is the key factor that determines the resistance of a grounding electrode, and to what depth it must be driven to obtain low ground resistance. The resistivity of the soil varies widely throughout the world and changes seasonally. Soil resistivity is determined largely by its content of electrolytes, which consist of moisture, minerals and dissolved salts. A dry soil has high resistivity if it contains no soluble salts (Table 1). Two samples of soil, when thoroughly dried, may in fact become very good insulators having a resistivity in excess of 10^9ohm-centimeters. The resistivity of the soil sample changes quite rapidly until approximately 20% or greater moisture content is reached (Table 4).

Table 3 – Resistivity By Soil Type

SOIL	RESISTIVITY (Ohm-cm) [Range]
Surface soils, loam, etc.	**100 - 5,000**
Clay	**200 - 10,000**
Sand and gravel	**5,000 - 100,000**
Surface limestone	**10,000 - 1,000,000**
Limestones	**500 - 400,000**
Shales	**500 - 10,000**
Sandstone	**2,000 - 200,000**
Granites, basalts, etc	**100,000**
Decomposed gneisses	**5,000 - 50,000**
Slates, etc	**1,000 - 10,000**

Table 4 - Resistivity by Moisture Content

Moisture content, % by weight	Resistivity, Ω-cm Top soil	Resistivity, Ω-cm Sandy loam
0	$>10^9$	$>10^9$
2.5	250,000	150,000
5	165,000	43,000
10	53,000	18,500
15	19,000	10,500
20	12,000	6,300
30	6,400	4,200

Table 5 - Resistivity by Soil Temperature

Temperature C	Temperature F	Resistivity, Ohm-cm
20	68	7,200
10	50	9,900
0	32 (water)	13,800
0	32 (ice)	30,000
-5	23	79,000
-15	14	330,000

The resistivity of the soil is also influenced by temperature. Table 5 shows the variation of the resistivity of sandy loam, containing 15.2% moisture, as the temperature changes from +20º to -15ºC. In this temperature range the resistivity varies from 7200 to 330,000 ohm-centimeters

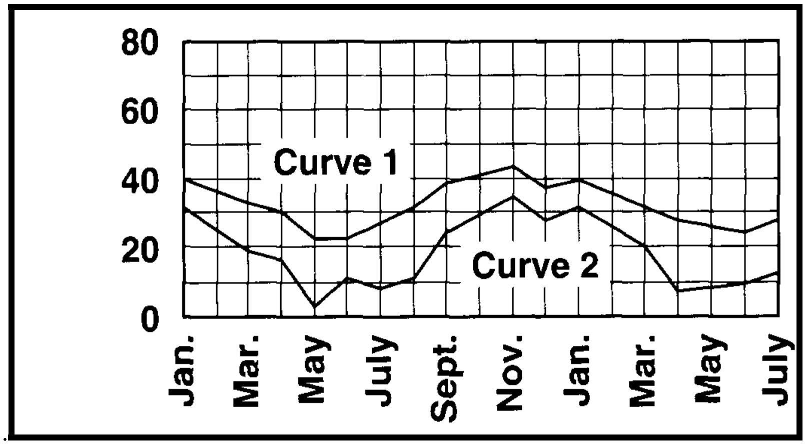


Figure 2 – Soil Resistivity by Seasonal Variation
(With an electrode of ¾ inch pipe in rocky clay soil. Depth of the electrode in earth is 3 ft for curve 1, and 10 ft for curve 2.)

Soil resistivity is directly related to moisture content and temperature. Therefore it is reasonable to assume that the resistance of any grounding system will vary throughout the different seasons of the year. Such variations are shown in Figure 2.

Both temperature and moisture content become more stable at greater distances below the surface of the earth. The ground rod should be driven a considerable distance below the surface of the earth for the grounding system to be most effective at all times. Best results are obtained if the ground rod reaches the water table.

Table 6 – The Affect of Salt Content on Soil Resistivity

(Sandy loam, Moisture content, 15% by weight, Temperature, 17°C)

Added Salt (% by weight of moisture)	Resistivity (Ohm-centimeters)
0	10,700
0.1	1,800
1.0	460
5	190
10	130
20	100

Table 7 - The Affect of Temperature on Soil Resistivity

(Sandy loam, 20% moisture. Salt 5% of weight of moisture)

Temperature (Degrees C)	Resistivity (Ohm-centimeters)
20	110
10	142
0	190
-5	312
-13	1,440

Table 6 and Table 7 illustrate the effects of salt content and temperature on similar types of soil.

2.3 SOIL RESISTIVITY MEASUREMENTS

The optimum soil resistivity of a sizable tract of land may be determined using the information given in through Table 7. Assuming that the objective is low resistivity, preference should be given to areas containing moist loam as opposed to dry, sandy areas. Consideration must also be given to the depth at which resistivity is required.

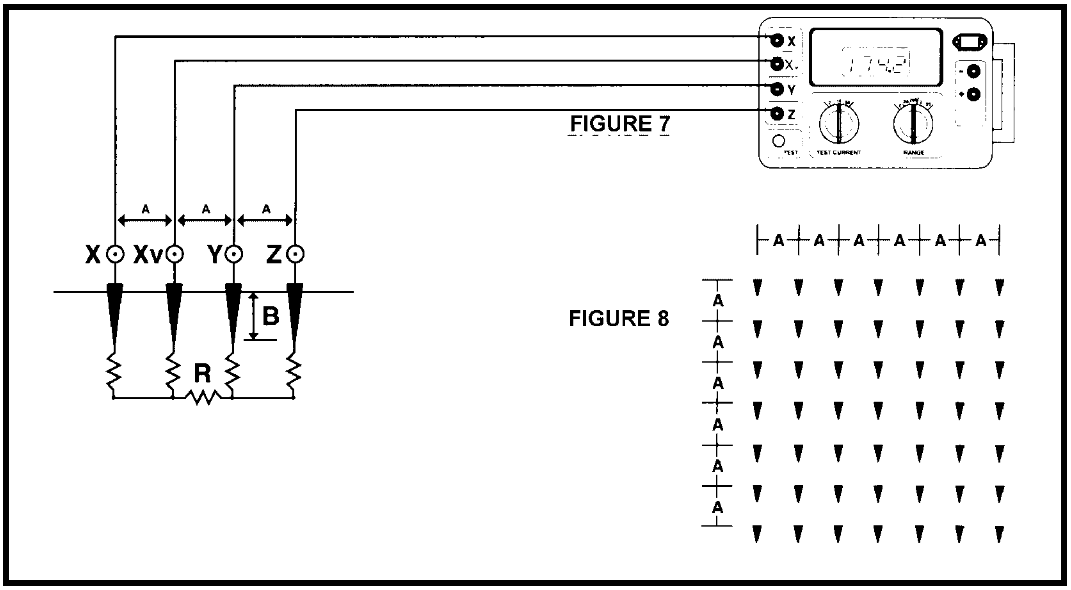


Figure 3 - Soil Resistivity Measurements Using the Model 4500

Referring to Figure 3, A= the distance between the measurement electrodes (in centimeters), and B= measurement electrode depth (in centimeters).

Practical soil resistivity measurements can be made using the AEMC Model 4500, as shown in Figure 3, using the following formula. Choose the target depth of the ground rod.

For the purpose of this measurement:

Set A= the target depth of the ground rod

B= A ÷ 20

$$\rho = 2\pi \bullet AR$$

Where ρ = Soil Resistivity (ohm-cm) Ω/cm

A= Model 4500 Measurement Electrode Spacing (cm)

R= Model 4500 reading (Ω)

(B= Model 4500 Measurement Electrode Depth (cm))

This formula represents the average resistivity of the ground at a depth equivalent to the distance "A" between two electrodes.

Example:

The area investigated has been narrowed down to a plot of ground approximately 75 square feet (7 m^2). Assume that you need to determine the resistivity at a depth of 15 feet (450 cm). The distance "A" between the electrodes must then be equivalent to the depth at which average resistivity is to be determined (**15 ft, or 450 cm**). Using the Wenner formula given above, the measurement electrode depth must be 1/20th of the electrode spacing or **8-7/8"** (22.5 cm). The AEMC Model 4500 reads 15Ω resistance between electrodes.

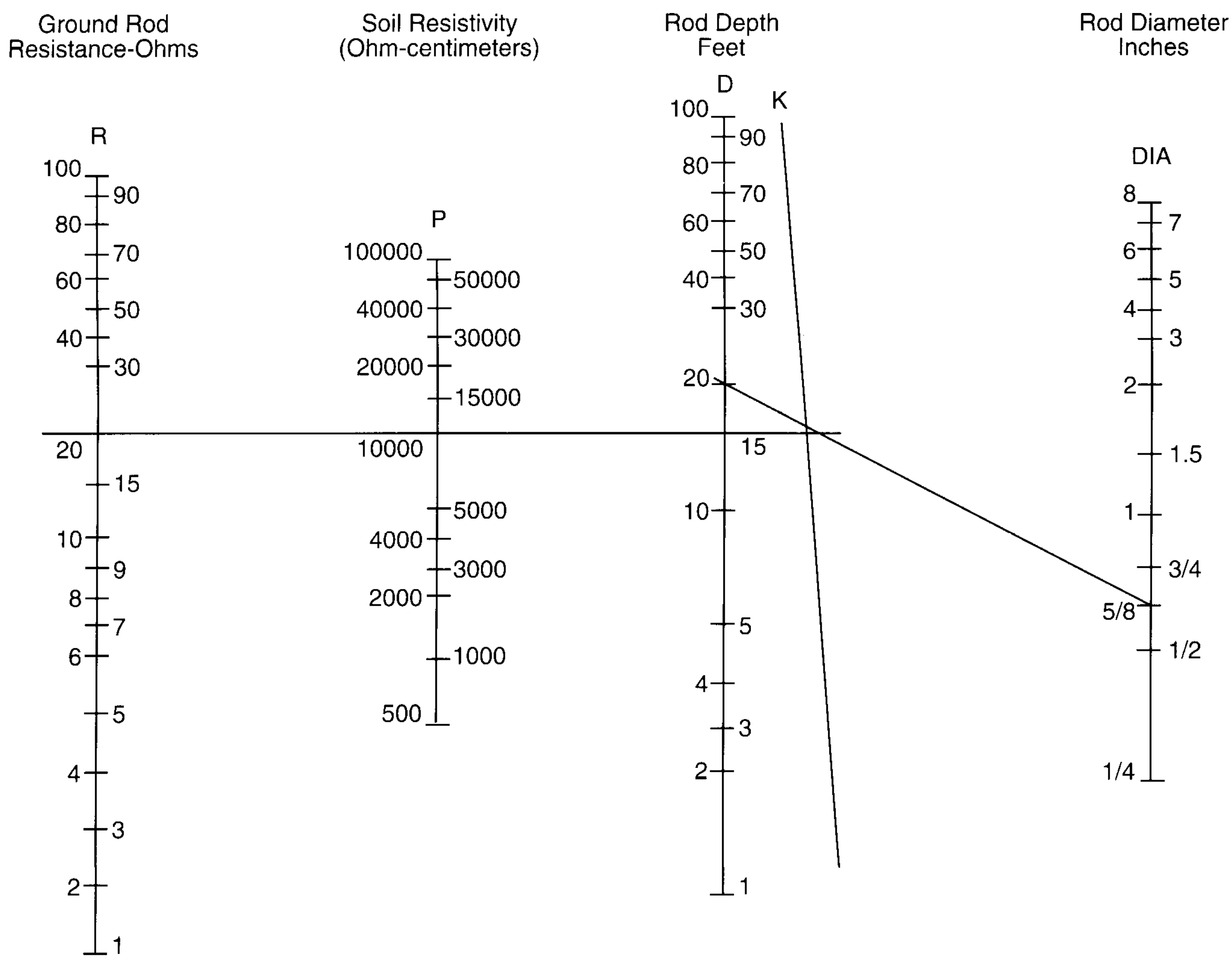
R (model 4500 reading) = 15Ω

A (distance between measurement electrodes) = 450 cm

ρ (resistivity) = $2\pi \bullet AR$

$$\rho = 6.28 \bullet 450 \bullet 15 = \underline{42,390\ \Omega/cm}$$

The soil resistivity at a depth of 15 feet is, therefore, 42,390 Ω/cm for the chosen plot of ground.



Represents an example of a 20 ohm, 20 foot ground rod.

1. Select required resistance on R scale.
2. Select apparent resistivity on P scale.
3. Lay straightedge on R and P scale, and allow to intersect with K scale.
4. Mark K scale point.
5. Lay straightedge on K scale point and DIA scale, and allow to intersect with D scale.
6. Point on D scale will be the rod depth required for resistance on R scale.

Figure 4 -Grounding Nomograph

The Grounding Nomograph in Figure 4 is used to further improve the grounding system by relating practical constraints such as the ground rod diameter and length to the calculated soil resistivity to optimize the total ground rod resistance.

2.4 GROUNDING SYSTEM MEASUREMENTS

Figure 5 - Ground Measurement Using the AEMC Model 3730

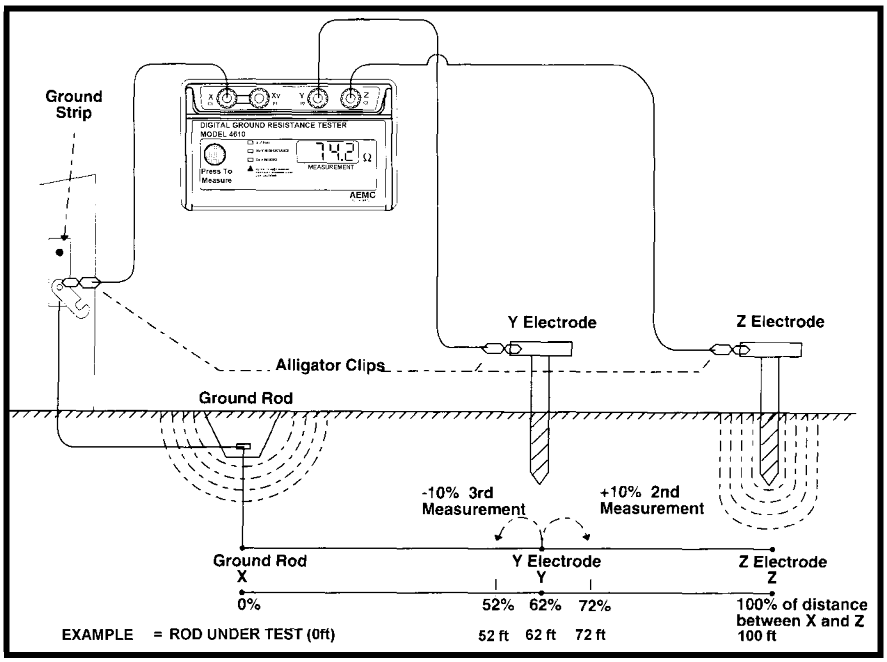


Figure 6 - "*62 Percent Method*" Ground Measurements

Figure 6 shows ground measurements made using the AEMC 4610, and AEMC 4500
(*Commonly referred to as the "**62 percent method**."*)

The ground rod or grounding system measured must be disconnected from all equipment and structures for accurate results.

NOTE: If the ground rod to be tested is attached to an active (live) power distribution panel, USE EXTREME CAUTION WHEN REMOVING THE LINK TO ISOLATE THE GROUND ROD(s) UNDER TEST. A voltage potential difference between the ground lead and the AC power "neutral" line could present hazardous currents on the system ground (i.e. EMF and currents between the local ground and the utility grid ground). Injury could result when the ground system is isolated.

Suggestion: **SWITCH POWER OFF: Open main power disconnect before removing (opening) ground lead connection.**

3. EXTERNAL GROUNDING SYSTEM

External grounding rings installed by M/A-COM or approved contractors must individually encircle the antenna tower, the building, or equipment shelter.

Ground rods for the tower and building must be installed so that the tops of the rods are a minimum of 24 inches below the soil surface. The ground rods for tower ground must be installed so that the bottom ends of the rods are deeper than the lowest part of the tower footing.

Each ground ring, including the tower, building, fence, or other ground ring must be interconnected with a minimum of two number 2 AWG (or larger) stranded copper wires. Where Andrew (or similar) cable entry panels are employed, copper straps or parallel 2/0 copper wire must be connected to the main ground to form a very low impedance path to earth ground. Connections to the ground, or ground ring must be made using an exothermic process (Cadweld, or equivalent), wherever possible. Contact ERICO/CadWeld™ at (800) 677-9089 for detailed information. (See *Exothermic Weld* in the)

3.1. ANTENNA TOWER GROUNDS

3.1.1. Monopole Towers

The ground system for monopole masts must consist of a minimum of three ground rods, connected together per paragraph 1.7, *Conductors Below Ground*.

The mast connection to the ground system must be made with stranded, number 2 AWG (or larger) wire. Connections to the mast must be in accordance with the manufacturer's instructions or use the exothermic Cadweld method. The connections must be short and direct, with no sharp bends (see Figure 9, page 23).

3.1.2. Wooden Antenna Poles

The proper grounding system for wooden antenna poles consists of a minimum of two ground rods connected together and installed per paragraph 1.7, *Conductors Below Ground*.

Connections to the antenna or antenna mast at the top of the pole, must be made according to the manufacturer's recommendations. A number 2 AWG (or larger) stranded copper ground wire must be extended down along the pole, away from any other conductors (to avoid possible flashover).

3.1.3. Self Supporting Lattice Towers

The self-supporting lattice tower grounding system consists of a ground rod at each tower leg. If necessary, additional ground rods may be used to decrease ground resistance, or to reduce the distance between rods. Ground rods must be connected together per paragraph 1.7, *Conductors Below Ground*. Each tower leg must be connected to the grounding system with number 2 AWG (or larger) stranded wire. Connections to the tower leg must be short and direct, with no sharp bends.

3.1.4. Guyed Lattice Towers

The guyed lattice tower grounding system consists of three ground rods at the tower base. These ground rods must be connected together per paragraph 1.7, *Conductors: Below Ground*. The ground conductors used to connect the grounding system must be number 2 AWG (or larger) stranded wire. Connections to the tower must be short and direct, with no sharp bends.

A ground rod must also be installed at each guy anchor point, approximately one foot from the anchor footing (see Figure 12 on page 25, Figure 23 on page 34 and Figure A-2 on page 50). The top of the ground rod must be a minimum of 24 inches below the soil surface, where possible. The bottom of the ground rod must extend below the lowest point of the anchor footing.

Number 2 AWG stranded copper wire must be used to connect each of the guy wires to the ground rod at the guy anchor. Each ground rod must be connected to the tower "ground ring" below ground, using number 2 stranded copper wire.

3.1.5. Antenna Support Structures On Buildings

Radio antenna installations on the tops of buildings must have the tower, down conductors, transmission line shields, and other conducting objects within 6 feet of the tower or antenna base securely bonded together per paragraph 1.7, *Conductors Above Ground* and 1.8-1.8.5, *Connections: Above Ground*.

The common bond point at the top of steel-frame structures may, where possible, be bonded to building steel with number 2 AWG (or larger) copper wire. The tower may also be bonded at the roof level to a large, metal, earth grounded, cold water pipe (if available).

The common bond point at the top of reinforced concrete buildings must be connected to ground using number 2 AWG (or larger) stranded copper conductors. These may be bonded to the earth grounded cold water main in the basement of the building or bonded to the building ground system. The tower should also be bonded at roof level to a large, metal, earth grounded, cold water pipe (If available).

Guy wires associated with building-top towers must be grounded at their anchor points to a common bond point in the same manner as for grounding terrestrial towers (see Figure A-2, page 50). A dissimilar metal interconnect device must be used between the guy wire and the ground wire. There must be a three inch (minimum) "play" loop between guy-to-guy ground connections whenever the ground wires from multiple guys are daisy-chained together.

The ground resistance of tall building installations should be less than ten (10) ohms between any equipment-connected ground bus and earth ground.

An instrument similar to the **AEMC Model 3700 HD** may be used to make ground resistance measurements. The measurements must be made according to the instructions provided with the **AEMC 3700 HD Ground Test Instrument.** *For vendor information on AEMC measurement devices contact Lyncole XIT Grounding; 3547 Voyager St., Torrance, CA 90503. Phone (800) 962.2610.*

3.2. EQUIPMENT BUILDINGS

The external grounding system used around the exterior of the communications shelter or building is called a “Halo Ground”. This ground system consists of a ground rod at each corner of the building. Additional ground rods must be added, if necessary, to restrict the distance between rods to less than 10 feet.

A ground rod must be installed directly below the coax transmission line entrance to the building. Ground rods are spaced approximately 2 feet out from the perimeter of the building.

3.3. BULKHEAD PANEL

A weatherproof metal bulkhead panel must be installed on the building equipment wall (see Figure 17 on page 29 & Figure 18 on page 30). The panel must be comparable to the **Andrew Type APORT-13-4** or the **PolyPhaser Earthed Entrance Panel** (PEEP) models. The size of the panel is determined by the number and size of the transmission lines interconnecting through it (see Figure 18, page 30 for dimensions). Use appropriate cable boots to weatherproof the connections.

The external panel must include a ground bar for transmission line shield to ground connections and connections to the external ground system (see Figure 7 on page 22 & Figure 9 on page 23). The ground bar must be made to avoid dissimilar metal connections as stated in Table 1, page 9 (also see Figure 27 on page 38, and paragraph 1.7, *Conductors Above Ground.).* The ground bar shown in Figure 27 must be connected to the building external ground system by number 2 AWG wire. Two conductors or two copper straps may be used to form a low impedance path to the system ground).

An internal sub panel similar to the Andrew Arrestor-Port™ (see Figure 18, page 30), bolted directly to the bulkhead panel with multiple bolts may be used to mount the transmission line surge suppresser specified in paragraph 3.6, *Coaxial Suppressor*. The sub-panel must be securely fastened with a low resistance, low inductance path to the bulkhead panel (stranded No. 2 AWG ***or larger***).

The Andrew Arrestor Port II™ grounding system has 13 openings for Type “N” or 7/16 DIN bulkhead mount surge arrestors and four 4" holes for standard waveguide boots. Integrated universal grounding bars provide eight two-hole grounding leads on each side of the bulkhead grounding plate.

3.4. FENCES

Metal fences within 6 feet of any ground ring or any grounded object must be grounded at twenty-foot intervals, or at a minimum of each corner post and at each gate metal support post (wherever possible). This is to provide additional shock hazard protection from lightning. Any metal fence greater than 8 feet from the ground ring should be grounded at fifty (50) foot intervals along its length (see Figure 30, page 42).

A copper-clad steel ground rod, 8 feet long (minimum), and 5/8 inch diameter must be driven into the ground within one foot of the fence, near a fixed gate hinge post where appropriate. The top of the ground rod must be a minimum of 24 inches below the ground surface (see Figure 11 & Figure 12 on page 25 for similar connections), or at the same level as the external ground ring to which it will be connected. Additional ground rods may be installed for each 50 feet of fence, at equal spacing outside 6 feet of the ground system but surrounding the facility.

Each ground rod must be connected underground by the most direct path to the nearest tower or building ground ring using a stranded copper wire, number 2 AWG or larger (see Figure 11 on page 25 & Figure 30 on page 42).

Above ground connections must be made using an exothermic weld or a pressure clamp near the bottom of the metal post. Connections made below ground must use exothermic welds (Cadweld). Tinned copper ground strap (braid) must be used to connect metal fence gate(s) to the main post. Use pressure clamps with these connections.

3.4.1. Nearby Metal Objects

The following components must be connected to the external grounding system using a number 2 AWG (or larger) stranded copper wire.

a) The transmission line entry window into the building. This is the entry point into the equipment area. All transmission lines are grounded to this window, and extra care must be used to insure a very low inductance path to ground.
b) Ice shielding and exterior cable trays between the tower and the building.
c) The emergency generator and any platform or base used by the generator.
d) Fuel tanks, above or below ground.
e) Any other large metal or conductive objects within 6 feet of the communications shelter, tower, or the system ground.
f) Any other ground systems provided by telephone, or electric utility providers. Local electric codes should be observed when making this attachment.

3.5. TRANSMISSION LINES

This section applies to the antenna and transmission lines outside the communications shelter or building, where entry is made into the equipment shelter (See Appendix A, Figure A-5, page 52). These requirements do not apply to antenna and transmission lines that are contained entirely within the equipment room or communications shelter.

3.5.1. Shield Grounds

The outer conductors of coaxial transmission cables must be grounded with an appropriate coaxial cable grounding kit (see Figure 23, page 34). A grounding kit must be installed at each of three points on the cable:

1) Immediately outside the cable entrance to the equipment room, shelter, or building. This ground must be located before the lightning suppressor.
2) At the bottom of the vertical run of the cable, at a point near and above the bend onto the ice-bridge or support trestle. This grounding point must be as near to the ground as possible.
3) At the top of the vertical run of cable, at the termination or antenna. This point is grounded or bonded to the tower using the clamp supplied with the grounding kit.

All three points should be grounded in accordance with the recommendations provided in the grounding kit instructions. These instructions are included in grounding kits similar to the **Andrew type 204989** or the **PolyPhaser "Uni-Kit 2"**.

3.6. COAXIAL SUPPRESSOR

A **Poly-Phaser type IS-B50** (or equivalent) lightning suppressor must be installed at each building or communications shelter cable entrance. This suppressor must be bonded to the nearby ground bus plate to remove surge currents from the center inductor of the cable.

3.7. TOWER-TOP PREAMPLIFIERS

M/A-COM will install an impulse suppressor similar to the **PolyPhaser IS-DC50LN DC "injection"** type wherever coaxial-transmission-line-DC-voltage-supplied tower-top amplifiers are used. Certain tower-top amplifiers are already equipped with this type protection (see Figure 10, page 24).

PolyPhaser type IS-GC50LN "pick-off" surge suppressors may be installed (according the manufacturer's instructions) as an additional protective measure at the input ports of the tower-top amplifiers or preamplifiers. This protection is in addition to the M/A-COM internal amplifier protective devices. All tower-top preamplifier chassis must be grounded to the tower.

An added protection device may be required where cable entry bulkheads are a part of the coaxial cables between the tower top amplifier and the M/A-COM communications equipment. The **PolyPhaser IS-DC50LNZ** pick-off and re-injector (PICKOR) may be used. Figure 10 on page 24 provides illustrated details for the installation of these devices.

DC ground, shunt-fed antennas should be used as additional protection for the tower-top preamplifiers, where possible. Cable attachments to the antennas should be kept as short as possible.

3.8. TOWER-MOUNTED MICROWAVE AND REPEATER EQUIPMENT

The input and output points of tower top repeaters are the most important points to protect. Tower, telephone or control lines are often overlooked. Coaxial line protectors are used at the M/A-COM repeater inputs and outputs, and at the pre-amp front end. Power line protectors must be local and single-point grounded at the top of the tower, along with the repeater equipment. The need for power protection is doubled for tower top repeater and pre-amp installations where 120 or 240 VAC is supplied to the top of the tower.

Microwave equipment operating at frequencies above 18 GHz usually have **Gunn** (microwave diode) down converters located on the back of the dish, powered by one or two coaxial lines. These lines also handle the uplink and downlink frequencies, as well as AFC (Automatic Frequency Control) error information. The **PolyPhaser IS-MD50LNZ** (or equivalent) should be used at the top and bottom of the tower to properly protect this type of equipment. The **PolyPhaser IS-DC50LNZ** is another type of protection device used in these applications and is fully transparent to control voltages and signals from microwave equipment.

3.9. COMMUNICATIONS EQUIPMENT ROOM INTERNAL GROUNDING

A Halo ground should be used inside the communications shelter to provide ground connection to the equipment inside the shelter. The Halo should form a "ring" around equipment racks, cabinets, cable trays, and equipment shelves in such a manner as to enable the use of short length conductors attached from the equipment to the ground ring (Halo).

The exception to this requirement is when the equipment room is located below the soil surface (below ground) level!

The Halo must be made of number 2 AWG stranded copper wire attached to standoffs (see Figure 9, page 23) at approximately eight (8) feet above the equipment room floor.

Four (4) ground risers (minimum) are used whenever the perimeter of the room or communications shelter is less than 100 linear feet. A ground riser should be used at each corner of the perimeter of any room or building (see Figure 7, page 22), wherever possible. A ground riser must be attached every twenty (20) feet for installations where the perimeter of the equipment room exceeds 100 feet. These ground risers are made of number 2 AWG *SOLID* copper, which exit the room or building thruogh **polyvinyl conduits** (see "PVC exit" Figure 7, page 22).

The main function or purpose of the inside ground ring (Halo) is to form a faraday cage/shield. Actual tests prove that this system captures stray or ingress EMF that is generated by nearby electrical disturbances (lightning etc.). Many dropped calls have been proven to be caused by EMF lines-of-force crossing the fields of cables carrying RS232 or TTL (logic) signals.

3.9.1. Grounding Equipment Cabinets, Racks, And Shelves

Each equipment cabinet or rack must be equipped with a ground-bus that is attached to the external system ground through the in-building halo ground. Each equipment chassis secured in a cabinet or rack must be connected to the cabinet or rack ground-bus. The preferred ground connection points are on the equipment mounting rails within the cabinets or racks. Paint-cutting lock-washers must be used where metallic chassis-to-rail connections are made.

Equipment cabinets and enclosures are attached to the system ground using number 6 AWG (or larger) stranded copper wire (see Figure 9 on page 23 & Figure 20 on page 32). The length of these connections should be kept as short as possible to decrease inductance.

The main ground window near the cable entry panel is connected to overhead cable ladders/trays using a number 2 stranded copper wire. The number six ground wires from each cabinet are attached to the overhead ground bus using Burndy™ "HyPressure" HyTap, HyTail, or HyLug (or equivalent) crimps (see Figure 26, page 37), and doped with Penetrox® E Oxide Inhibitor (or equivalent). Burndy™ HyTap is the recommended link, distributed by XIT/Lyncole.

3.9.2. CABLE TRAYS

Cable trays must be attached to the internal ground halo using number 2 AWG (or larger) stranded copper wire. Additional connection must be made between cable tray sections when mechanical connections (lugs, bolts) are made between cable tray sections (see text in Figure 9 on page 23). Number 6 AWG (or larger), stranded copper wire must be used to ensure a good electrical ground connection between tray sections (see Figure 20, page 32).

Grounds between cable trays, equipment cabinets, equipment racks, and AC utility power enclosures must be made using number 2 AWG or larger stranded copper wire.

The Burndy compression system should be used when compression type connectors are used at an M/A-COM installed site or system. This system includes connectors for taps, splices, and structural steel terminations. These connectors may only be used in certain M/A-COM site ground applications ***inside*** of communications rooms or shelters. ***These compression connectors are not to be used underground or beneath soil.*** The Burndy system connectors are listed with **Underwriters Laboratories under Standard UL467**. Most of these connectors have been successfully tested according to the requirements of **IEEE Standard 837**.

4. PLANS AND DOCUMENTATION

Drawings and Ground reference documentation must include the following items:

a) A grounding and bonding plan.

b) Ground rod specifications.

c) Surge suppression device specifications.

d) Bulkhead panel type specifications.

e) Coaxial cable grounding kit specifications.

All lightning and surge protection measures included in an M/A-COM Private Radio System are submitted as a part of the overall system specification. This specification takes into account the radio installation, equipment to be protected and local conditions. All requirements covered in this specification must be met, unless a specific, written waiver is provided by the customer and agreed to by M/A-COM.

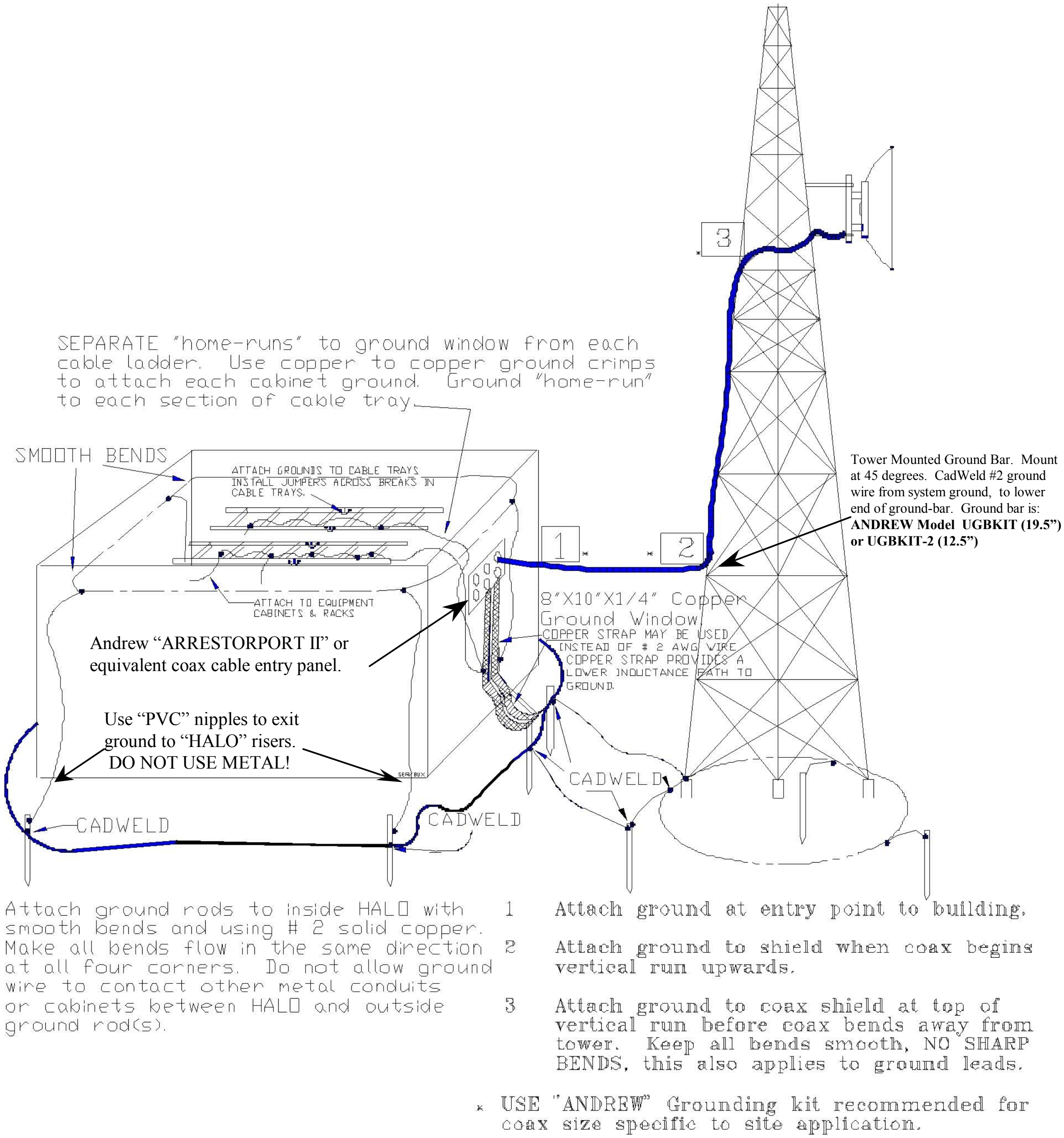


Figure 7 - Basics of Site Grounding

Figure 7 illustrates some of the grounding techniques described in this document. In addition it depicts how the inside and outside Halo grounds are interconnected. The installer should insure that all wire bends and turns in the "Halo" ground "ring" are smooth with no sharp points or bends. This same rule applies to the #2 copper wires (shown in the corners of the communications room) connecting the internal Halo to the outside ground ring. Use PVC nipples where ground leads exit to outside (*halo)* ground ring.

The exit ground wire to/from the MGB must be number 2/0 (00) (or larger) copper wire.

A copper strap (2, 4, or 6-inch widths), may be used with the **copper** cable entry bulkhead (Andrew Arrestor-Port II). For the inside copper "Master Ground Bar" (MGB), use the Andrew UGBKIT or equivalent.

Ground rods for the tower and building must be installed so that the tops of the rods are a minimum of 24 inches below the soil surface.

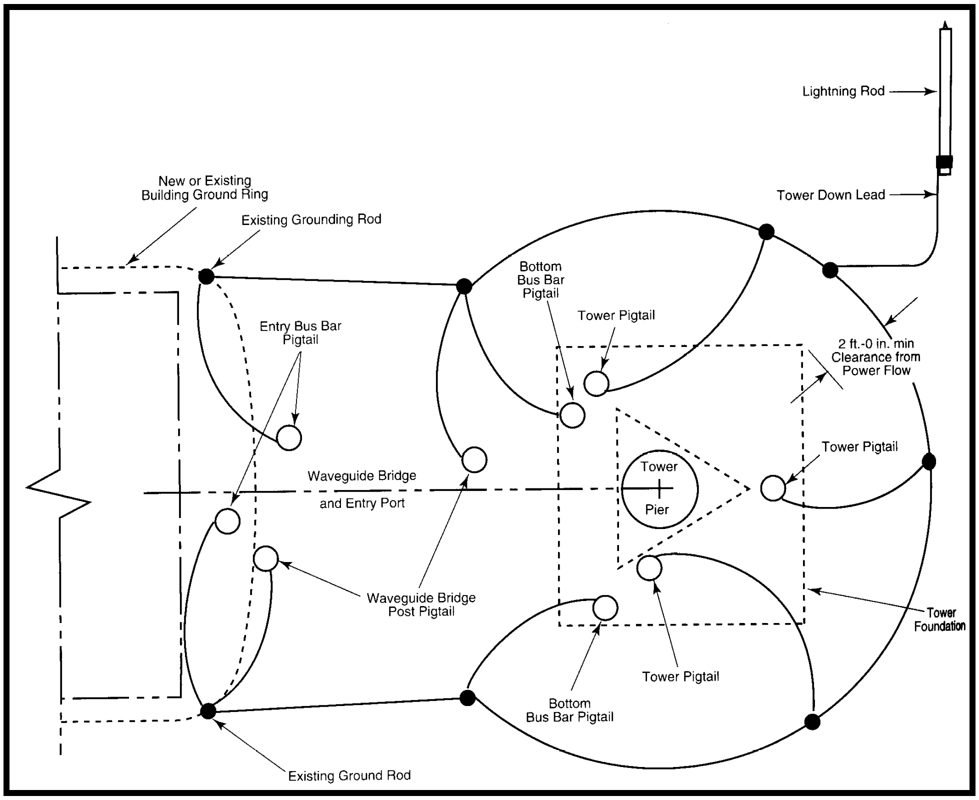


Figure 8 - Tower Halo Ground Ring

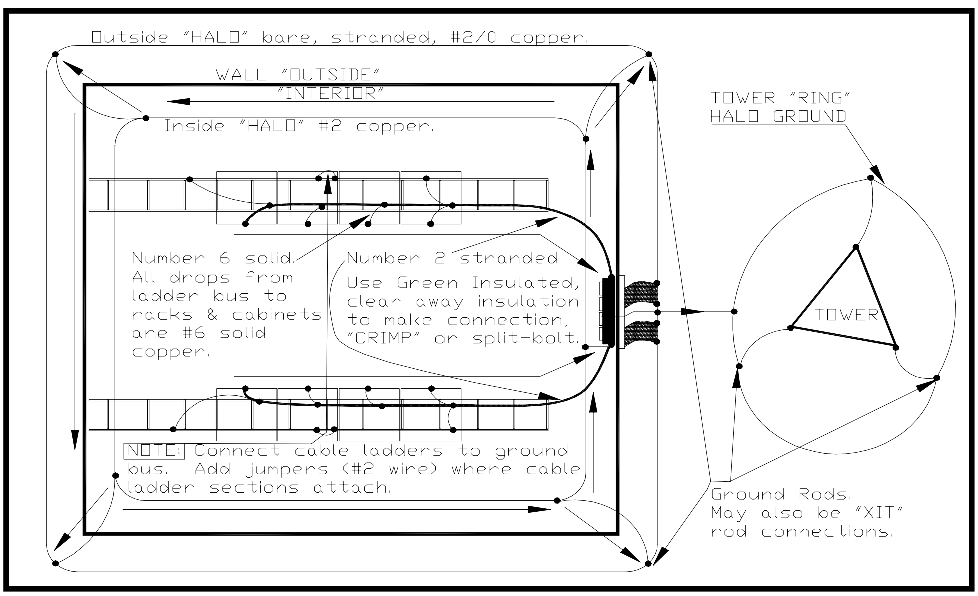


Figure 9 – In-Building Halo Ground Ring

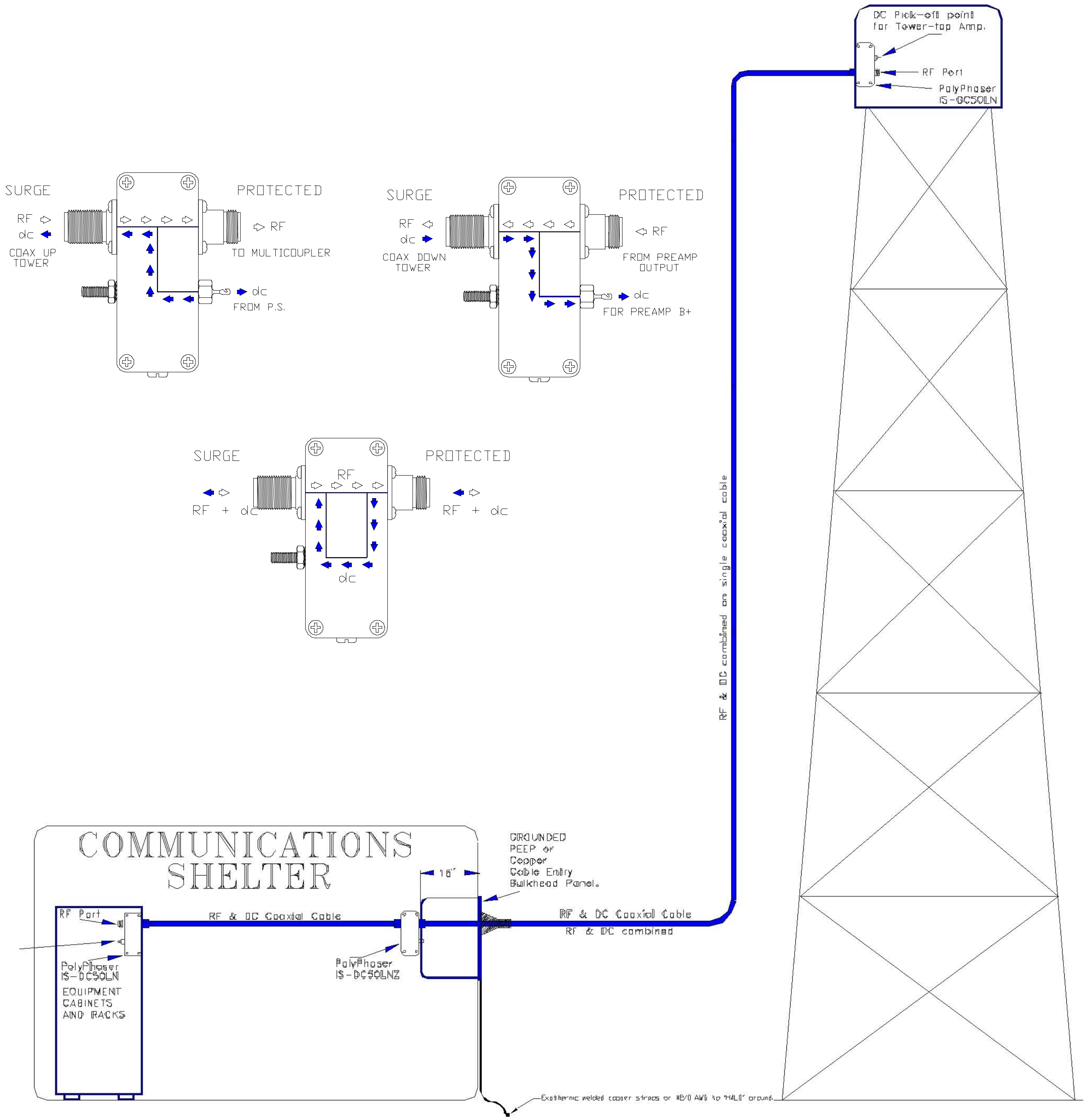


Figure 10 - Tower -Top Amplifier & DC Power Insert/Pick-Off Connections

This figure illustrates the method used when supplying DC voltage to tower-top amplifier(s) using the PolyPhaser injection and pick-off devices.

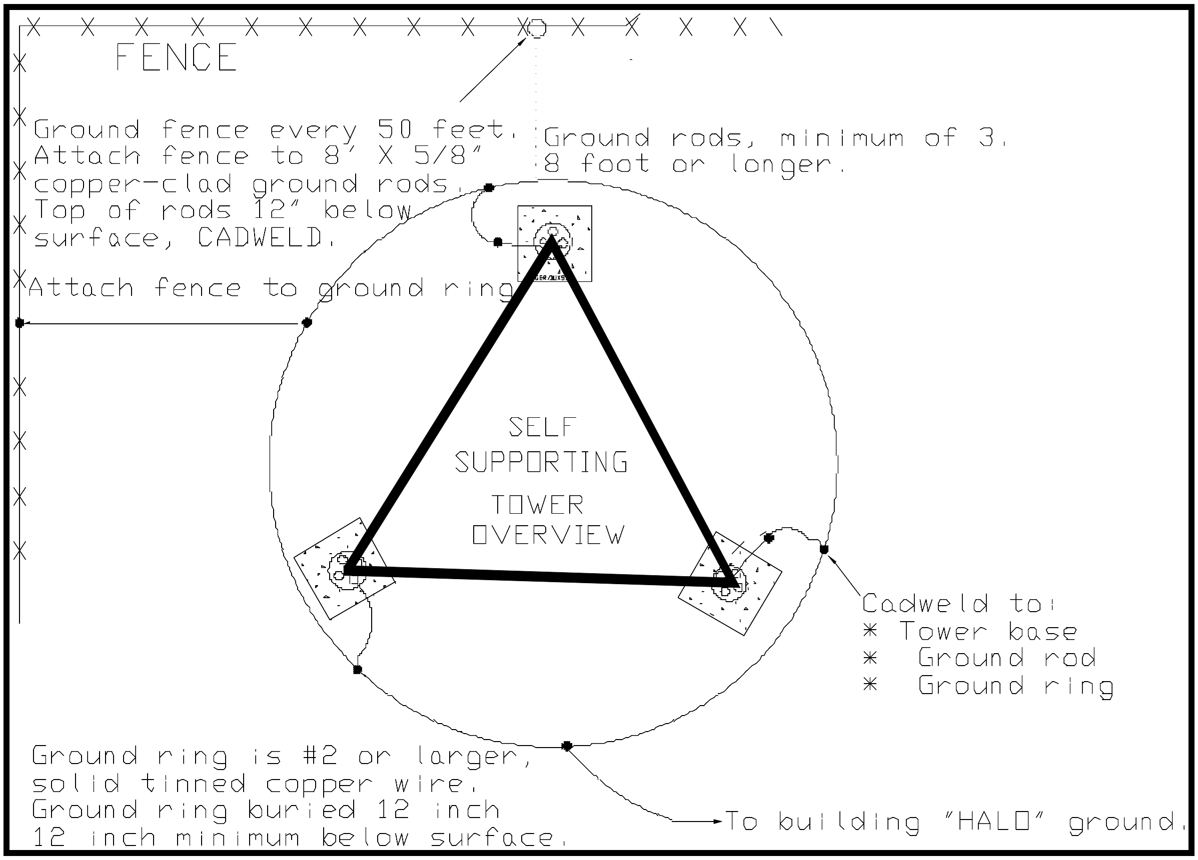


Figure 11 - Typical Transmit/Receive Site

Figure 11 illustrates a typical transmit/receive site. Note the areas of the fence that come in close proximity to the tower and building grounds. All grounds are connected together. There are no separate ground systems at the same location.

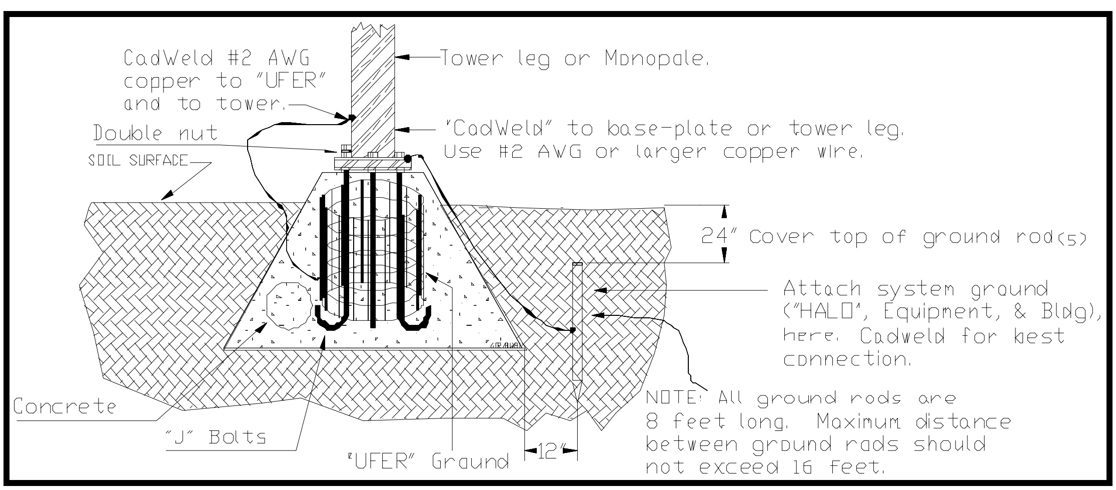
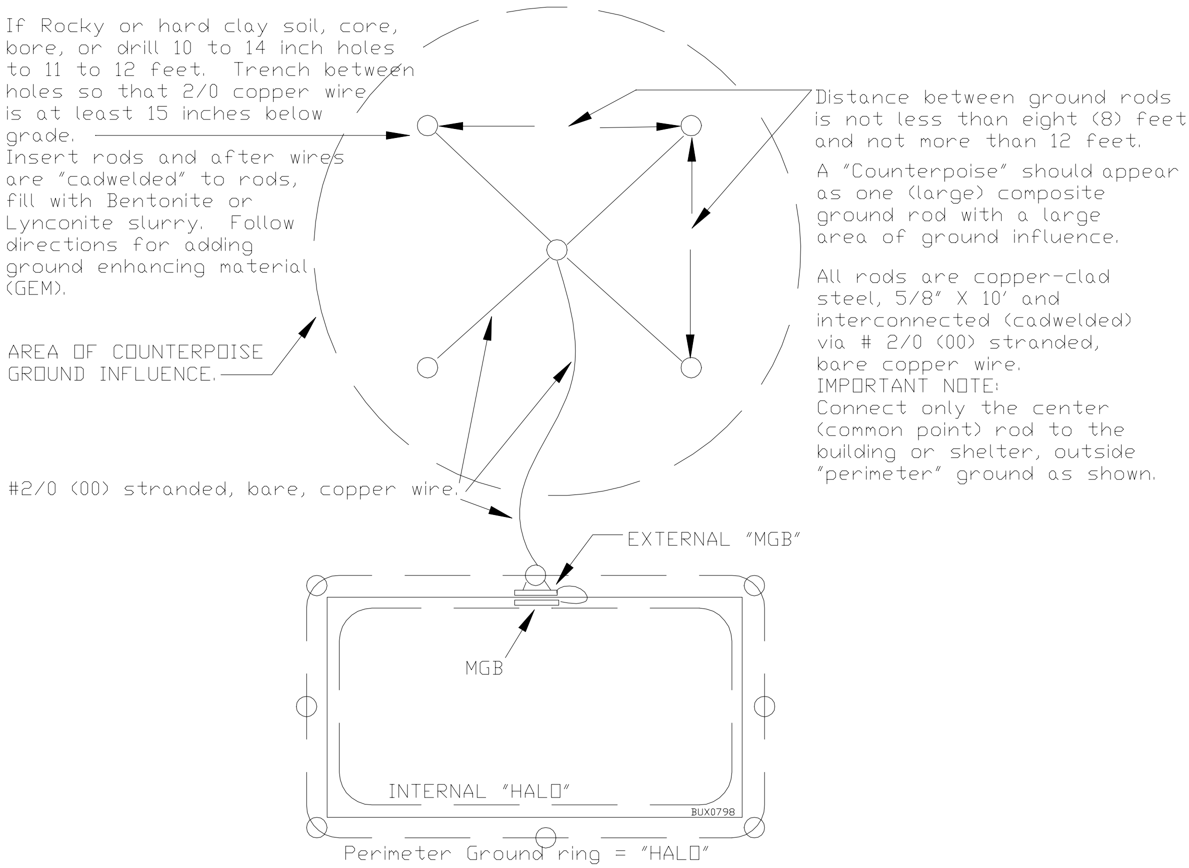


Figure 12 - "UFER" Ground

"UFER" ground refers to steel and metal bars imbedded into concrete floors or tower foundations. The "UFER" ground should never be relied on as the exclusive or stand-alone site ground system



GROUNDING SCHEME EMPLOYED WHERE REAL-ESTATE IS LIMITED AND LOCAL PERIMETER GROUND IS NOT SUFFICIENT TO ACHIEVE LOW GROUND RESISTANCE.
NOTE: Do not connect fences and towers to the counterpoise. Make these connections to one of the shelter ground rods or the external shelter Master Ground Bar (MGB).

Figure 13 Counterpoise Ground Diagram

NOTE: **To enhance the affect of the counterpoise ground, use XIT chemical rods in place of the 5/8" X 10' copper-clad rods.**

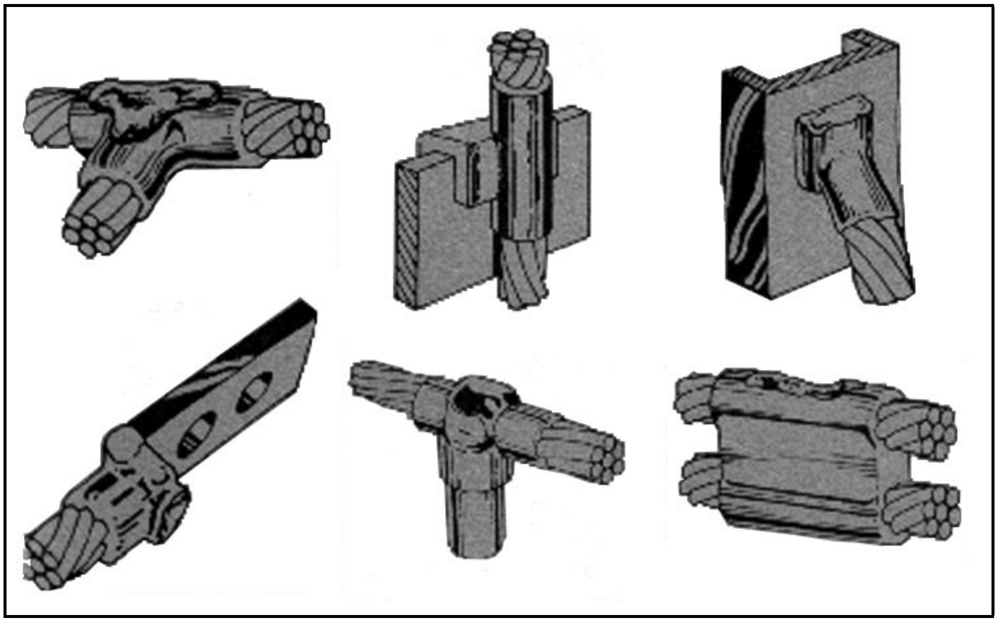


Figure 14 - Typical "Exothermic" Welds Made Using the Cadweld Method.

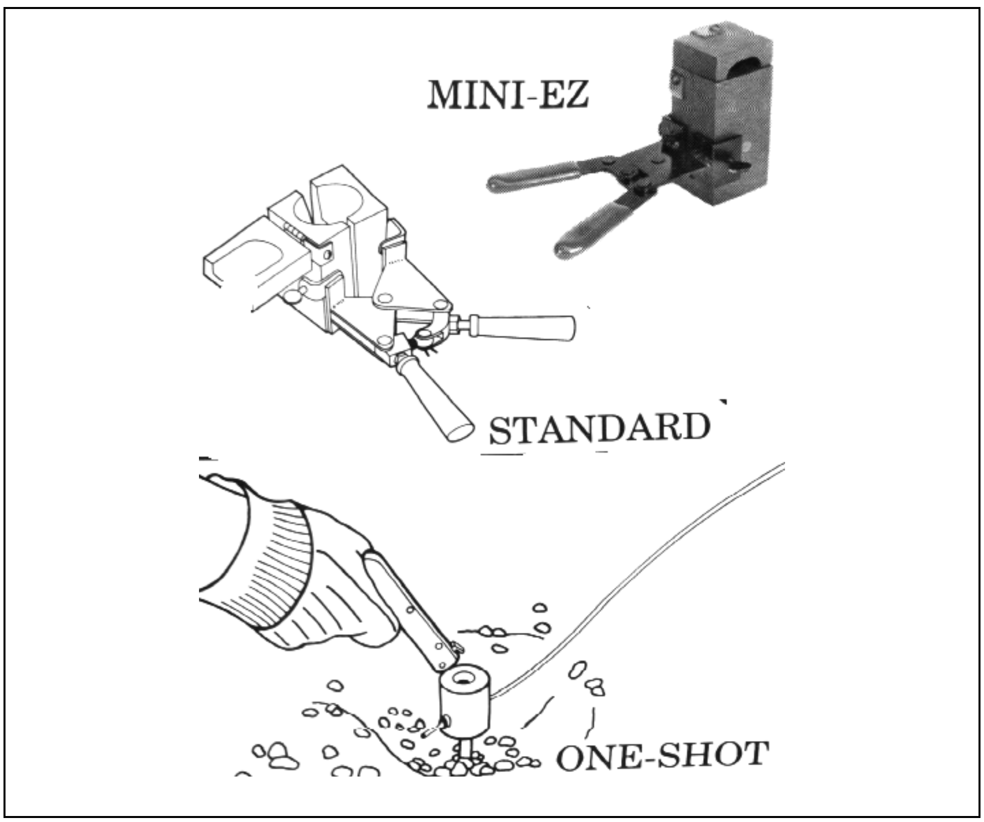


Figure 15 - Examples of the Tools Used to Make Exothermic Welds

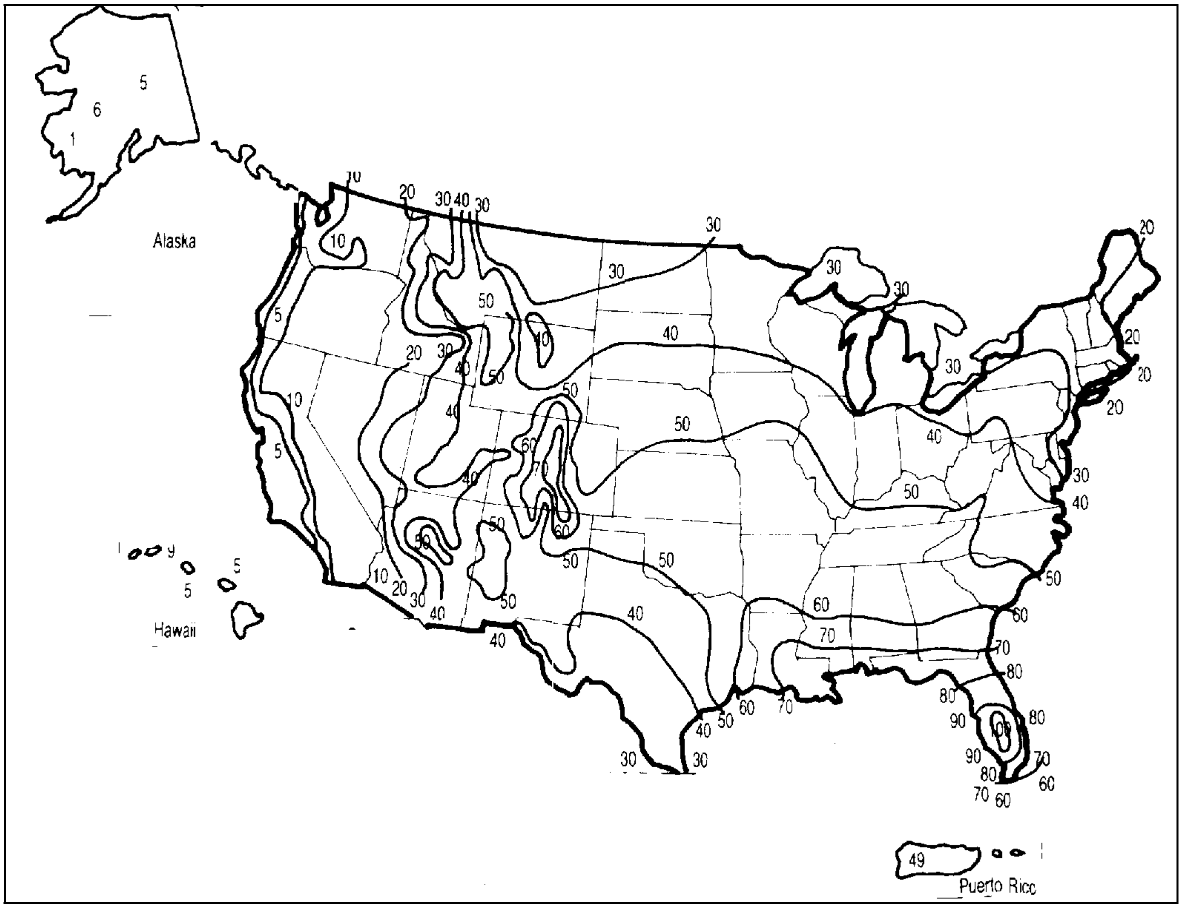


Figure 16 - Isokeraunic Map

The isokeraunic map shown here shows mean annual number of days with thunderstorms in the United States.

NOTE

The region with the highest frequency is centered around south and central Florida.

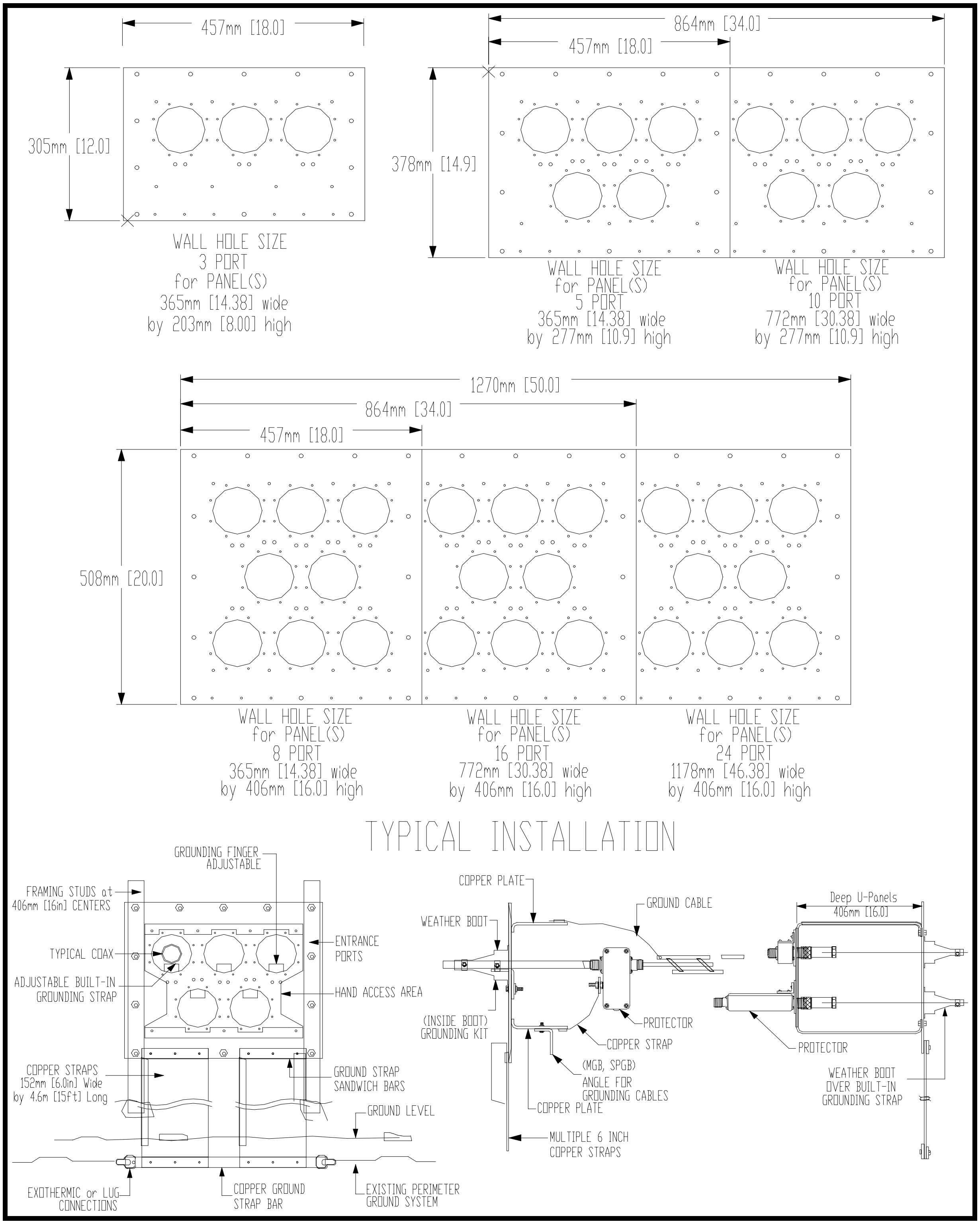


Figure 17 - Typical Installation Cable Entry Panel(s).

An inside and an outside panel may be installed where walls exceed a usable depth. Use number 2 or 2/0 stranded wire to preserve the integrity of the ground to the Master Ground Bar (MGB).

Arrestor Port II Integrated Cable Entry/Grounding System:

Part Number	APORT-13-4
Description	Surge arrestor grounding system with 13 openings for Type N or 7-16 DIN bulkhead mount surge arrestors and four 4" holes for standard waveguide boots. Integrated universal grounding bars have provisions for eight two-hole grounding leads on each side of the bulkhead grounding plate.

Dimensions Entry	A	B	C	D
Plate	25.5"	25.5"	20.5"	15"

Cable Penetrations	4", includes plastic cover
Surge Arrestor Knockouts	Round; Type N, 7-16 DIN Female, 7-16 DIN Male
Weight	17.68 1bs

CONSTRUCTION

Entry Plate	Aluminum, painted gray
Grounding Bulkhead	1/8" copper, tin plated
Bulkhead Fastening Hardware	Stainless steel
Bulkhead/Entry Panel Seal	Rubber gasket
Knock-out Removal	Hammer out from inside only

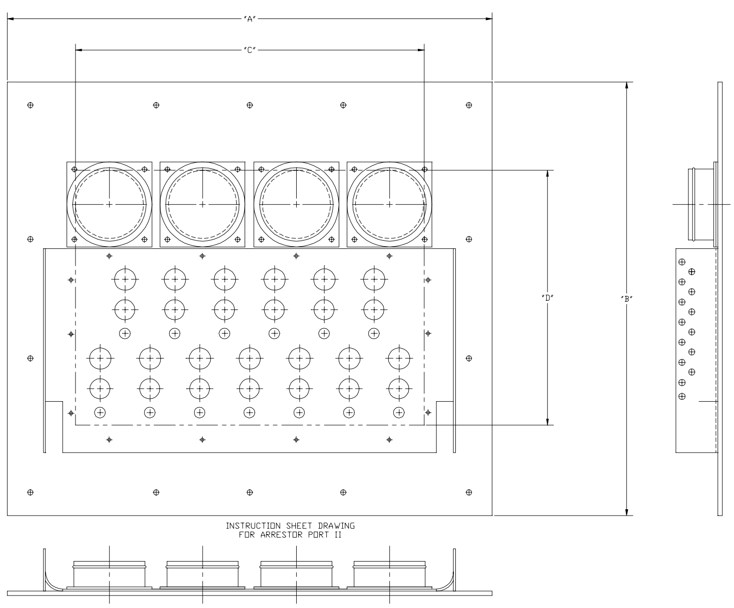


Figure 18 - The ANDREW Integrated Cable Entry/Grounding System

SURGITRON™ Series

1265-85: 120/240VAC,	1 Wire Center Tap Ground
* 1452-85: 240/120VAC,	4 Wire Delta, Center Tap Ground
* 1455-85: 208/120VAC,	4 Wire Grounded Wye

* 1456-95: 480/277 VAC, 4 Wire grounded Wye

* Indicates Joslyn 3 phase devices. The "PM" indicates remote "power monitoring" capability. Not normally a part of an M/A-COM installation as the associated power panels and auto-change-over switches have the remote monitoring integral. This would be redundant power monitoring.

General:

Joslyn's Surgitron™ PM series of AC power arrestors combines a surge protector with a built in Power Monitor. All mode (L-N, L-G, N-G) protection with redundant high energy MOV's in each mode ensure long life in the most severe of environments. All MOV's are individual and the monitoring diagnostics provide a predictive maintenance warning, allowing arrestor module replacement before failure occurs. Critical voltage aberrations are constantly monitored and stored in on board counters. *An integral modem is provided and all information can be remotely accessed using the supplied Windows95 software and a modem equipped PC.

Surge Protection:

Surge current capability, 8/20 (s, per		160k*A*
Surge energy capability, 8/20 (s, per		
	120 VAC units	>2,000 Joules
	277 VAC units	>3,400 Joules
Surge life capability, 8/20 (s, per		
	3kA	>20,000 operations
	10 kA	>2,000 operations
Time equivalent, severe environment		>50 years
Response time		<1ns
Maximum operation altitude		4000 meters
Power consumption		5 watts

INSTALLATION: ***1265-85***

DIMENSIONS:

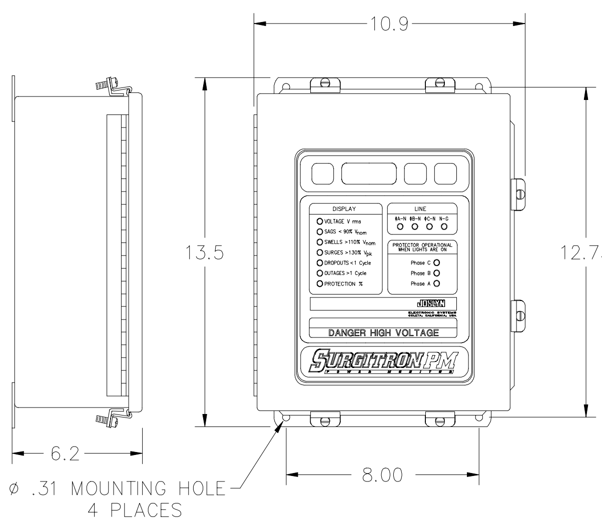


Figure 19 - Joslyn Model 1265-85

The device shown here is an example of the MOV type used to clip or suppress power surges that could otherwise damage equipment (*see Sections 1.2 & 1.9*).

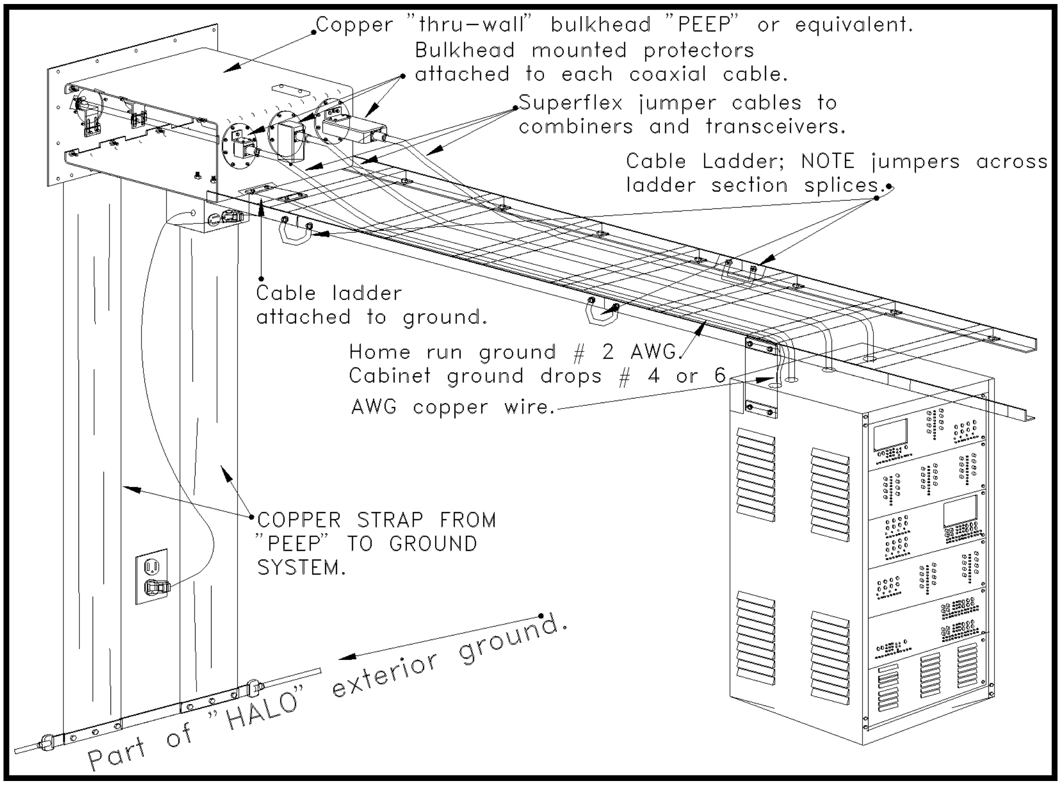


Figure 20 - Ground Attachments in Installation

Figure 20 illustrates methods employed when attaching grounds and cable protection devices in an M/A-COM installation. Note that some installations will have copper strap between the bulkhead entry panel and the Halo ground ring. By using multiple conductors of # 2 AWG copper wire or copper strap, inductance in the ground conductor is greatly reduced.

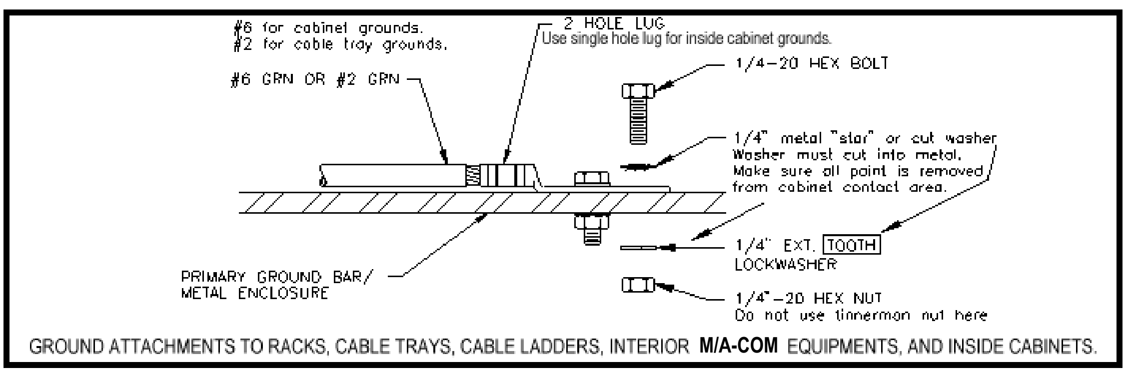


Figure 21 - Ground Attachment Methodology

66 Punchdown Block, Clip-Mounted Protector, Performance Specifications

Voltage Protection Level

PBM6605 240-380 Vpeak
PBM6607 45 Vpeak

Peak Repetitive Pulse Current
1.0 x 2.0 usee - 225Amp
8 x 20 ~sec - 150 Amp
10 x 1000 ~sec -100Amp
Temperature -20 Degrees C to +50 Degrees C
Dimensions 1.75"x.90"x.40"
4.45 cm x 2.29 cm x 1.02 cm

These protectors are designed to clip on the 66 punch-down block replacing the standard bridge-clip.

Features of the ***TransTector*** PB66 proTect series:

- · Bi-polar, bi-directional suppressors
- · Silicon Avalanche diode design provides reliability and long term life
- · Lower (safer) voltage protection level than MOVs or gas tubes for better protection
- · Designed to provide non-degrading protection for a life-span of 10 years or more
- · Protects most commonly used signal lines (telephone, RS-422, RS-232, lease line, etc)
- · Simple installation
- · Compatible with most all communication systems
- · Automatic protection, does not fault or interrupt the signal line
- · Protection for both normal and common mode

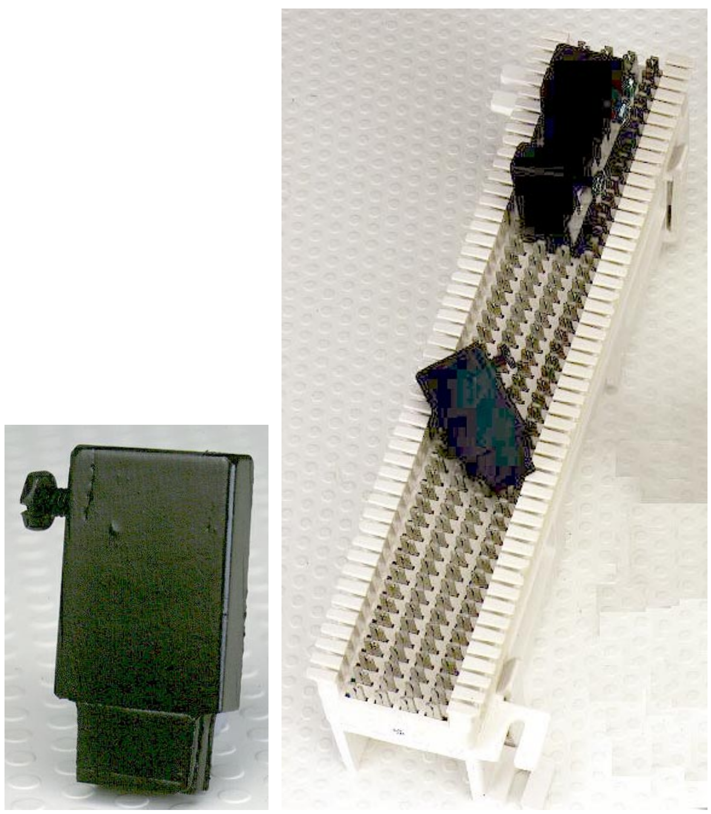
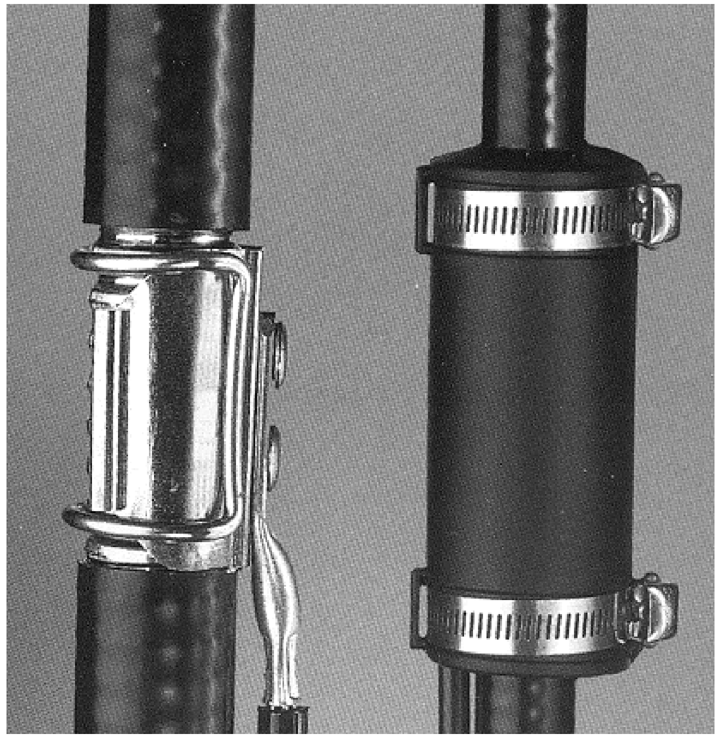


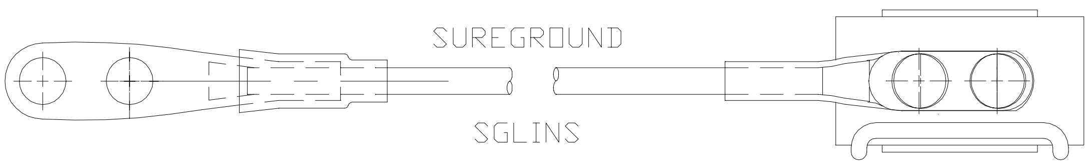
Figure 22 - 66 Punchdown Block

Figure 22 shows the specs and some illustrations for the Transtector clip-on SAD's. Note in the *Feature Description* that these devices are employed in the signal level (telephone, RS-422, RS-232, and lease line applications). Also note the ***Peak Repetitive Pulse Current*** beats most devices for this class of operation and application. *For more information on Transtector devices, contact PolyPhaser Corp. at (800) 325-7170.*

"SureGround™



"SureGround "plus"™



Andrew cable "**SureGround**™ grounding kits" handle lightning strikes up to 125,000 amperes.

Item Description	**LDF5-50A**	**LDF6-50**	**LDF7-50A**
SureGround Kits			
Ground Kit – 0.6 m (2 ft) lead, 1 hole factory attached lug	SGL5-06B1	SGL6-06B1	SGL7-06B1
Ground Kit – 0.6 m (2 ft) lead, 2 hole factory attached lug	SGL5-06B2	SGL6-06B2	SGL7-06B2
Ground Kit – 1 m (3 ft) lead, 1 hole field-attached lug	SGL5-1083	SGL6-10B3	SGL7-1003
Ground Kit – 1 m (3 ft) lead, 2 hole field-attached lug	SGL5-10B4	SGL6-10B4	SGL7-10B4
Ground Kit – 1.5 m (4 ft) lead, 2 hole field-attached lug	SGL5-15B4	SGL6-15B4	SGL7-15B4

Figure 23 - Andrew SureGround Kits

Andrew "SureGround™" kits are used when making 3 point ground connections at cable entry, tower base and tower top. *For cables that exceed 200 feet vertical run, include additional ground attachments at 100 foot intervals.* For three-point tower ground illustration see Figure 7 on page 22.

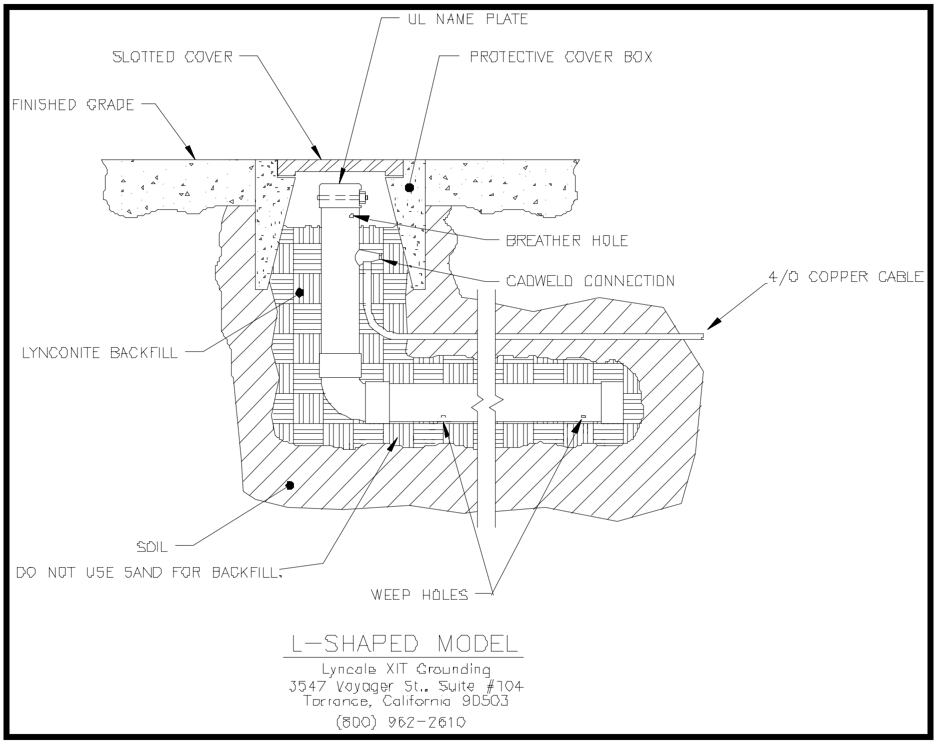


Figure 24 - Installation Instructions for XIT Lyncole L-Shaped (Calsolyte™) Ground System

Site Selection Considerations

-The XIT Grounding System may be installed indoors or outdoors.

-The XIT rod must be situated to allow breather holes at top of unit to remain clear and open to air at all times.

-It is not recommended to install grounding system where watershed or down spout carry-off will flood unit.

Site Preparation

-Prepare a minimum 6" wide trench for placement of electrode.

-Depth of trench must be 6" deeper than the vertical length of the system. (Normally 42 inches)

-Top breather holes must be left open to the atmosphere for continuous air circulation by using the protective cover box provided.

System Preparation

-Remove sealing tapes from the horizontal section only of the XIT rod. Tapes must be saved and made available to the electrical inspector to verify proper installation.

Installation

-Position the XIT rod in the trench. Support rod so that it is approximately 2 inches from bottom of 6" - 8" wide trench. (Extra Lynconite will be required if the trench is wider than 8")

-Elbow of the rod should be located slightly above the end of the rod.

-Mix 1 part Lynconite to 4.5 parts water (14 gallons per 50lb. bag). Stir constantly until mixture reaches a slurry consistency, similar to pancake batter. Adding the Lynconite to water facilitates mixing.

-Use only 100% Lynconite slurry for backfill.

-Pour Lynconite around the XIT rod in trench. Finish filling trench with soil.

-Place protective box with cover over the top of the rod so that the cover is at grade level. Use backfill or grout to stabilize box around the rod. This keeps breather holes free of obstruction and debris. Box should not contact the top of the rod.

-Remove top sealing tape ONLY after backfill is complete. This prevents soil from blocking the breather holes.

-Save red sealing tape from horizontal section and top sealing tape for inspection purposes.

NEVER USE SAND AS A BACKFILL!

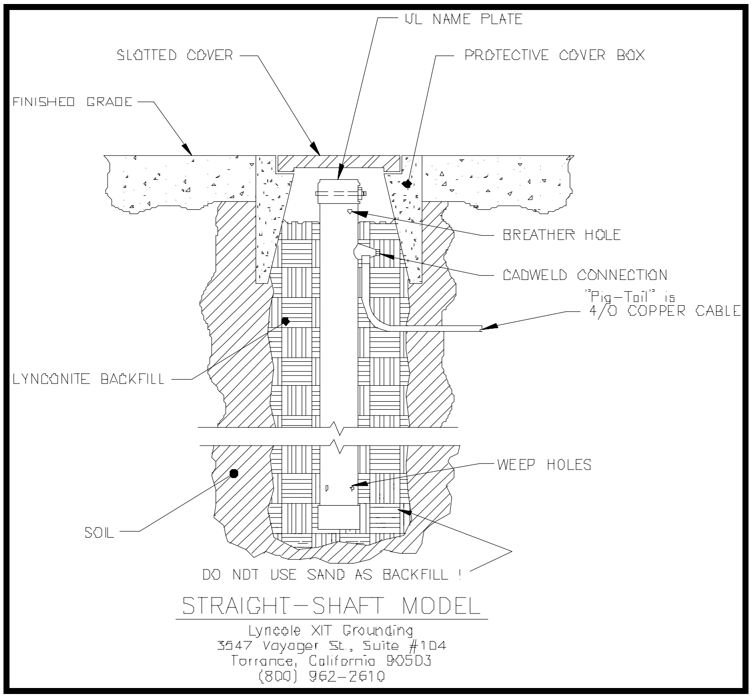


Figure 25 - Installation Instructions for Straight Shaft (Calsolyte™) Ground System

Site Selection Considerations

-Unit may be installed indoors or outdoors.

-Unit must be situated to allow breather holes at top of unit to remain clear and open to air at all times.

-It is not recommended to install grounding system where watershed or down spout carry-off will flood unit.

Site Preparation

-Auger a hole into the earth (minimum diameter 6"). Minimum diameter of 8" recommended for 20ft. or greater length rod. Hole should be bored to allow installed unit to be as close to vertical as possible. A 14" hole must be provided for the cover box.

-Depth of hole must be 6" deeper than the vertical length of the system.

-Top breather holes must be left open to the atmosphere for continuous air circulation by using an XIT protective box.

System Preparation

-Remove sealing tapes from the bottom of unit only.Tapes must be saved and made available to the electrical inspector to verify removal and proper installation.

-Do NOT remove the red "Bury to Here" marker from the top of the unit.

Installation

-Position the XIT unit in the hole. Use red "Bury to Here" marker as a guide to depth in which unit shall be buried in Lynconite.

-One bag of Lynconite is included with each 10' XIT Rod.

-Mix 4.5 parts water to 1 part Lynconite (14 U.S. Gallons of water to 50lb. bag), constantly stirring until mixture reaches a slurry consistency, similar to pancake batter. Add the Lynconite to the water for ease in mixing.

-Use only 100% Lynconite slurry for backfill.

-Pour backfill around rod in augered hole. Do not mound backfill past red marker.

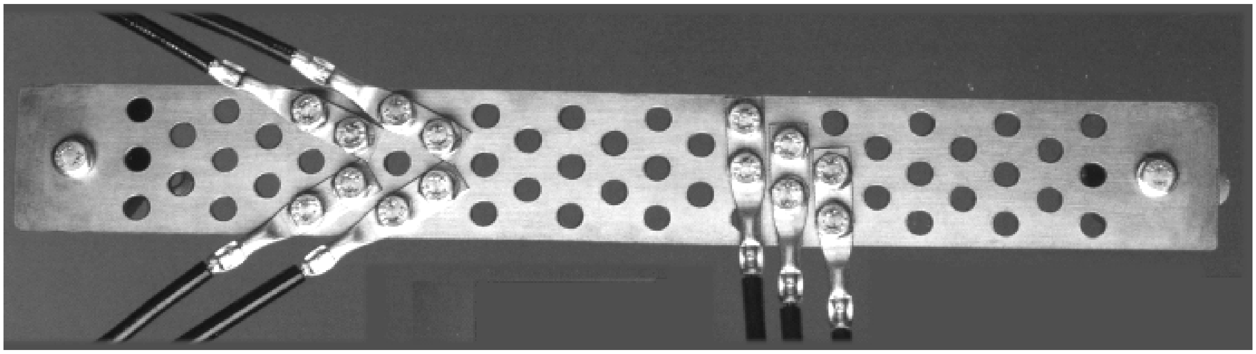
-Place XIT box with cover over the top of the rod so that the cover is at grade level. Use backfill or grout to stabilize box around the rod. This keeps breather holes free of obstruction and debris. Top of box should not contact the top of the rod.

-Remove top sealing tape ONLY after backfill is complete. This prevents soil from blocking the breather holes.

NEVER USE SAND AS A BACKFILL!

Figure 26 - BURNDY Crimp Connectors

Figure 26 displays many of the BURNDY crimp connections. These "crimp" type connectors are primarily used ***inside*** communications rooms/shelters where CadWeld and open flame soldering and bonding is not allowed. "BURNDY" products are available from Lyncole/XIT Grounding products, (800) 962-2610.



The ***Master Ground Bar*** (MGB) comes in two sizes (models) for use inside or outside the M/A-COM Private Radio System communications room:

Andrew Part Number	Size
UGBKIT-2	¼” X 12-½ ” X 2-½“
UGBKIT	¼” X 19-½ ” X 2-½“

This ground bar may also be used on the tower for grounding point of the wave-guide and Helix™ cable ground kits.

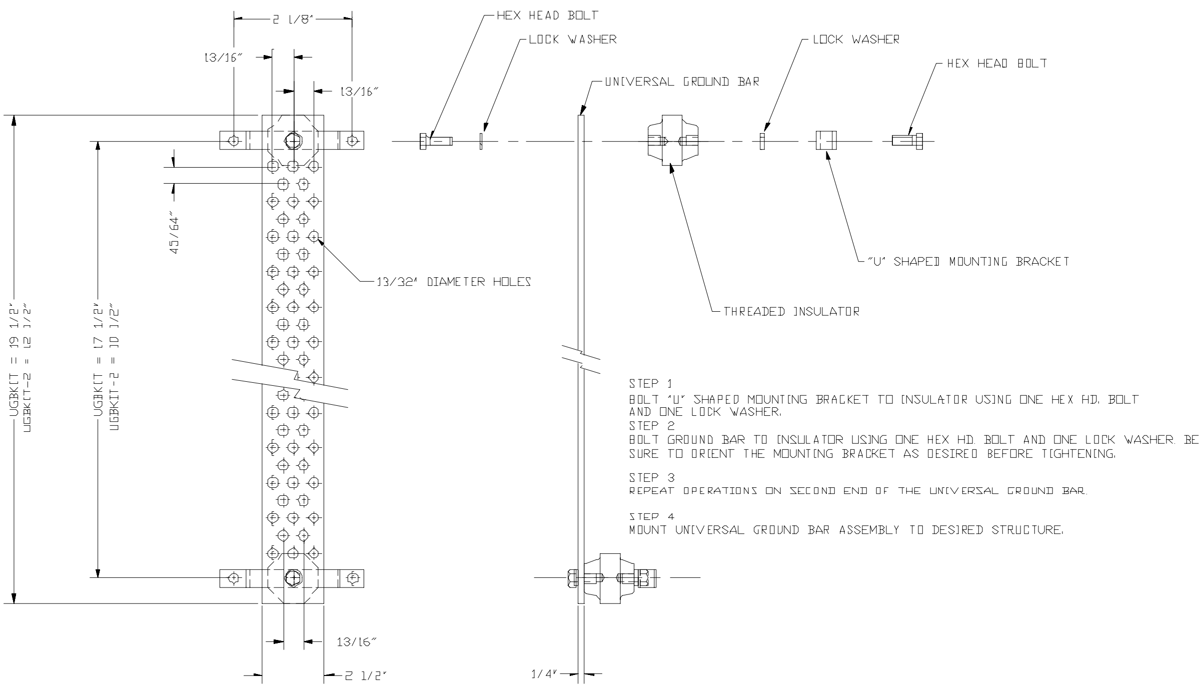
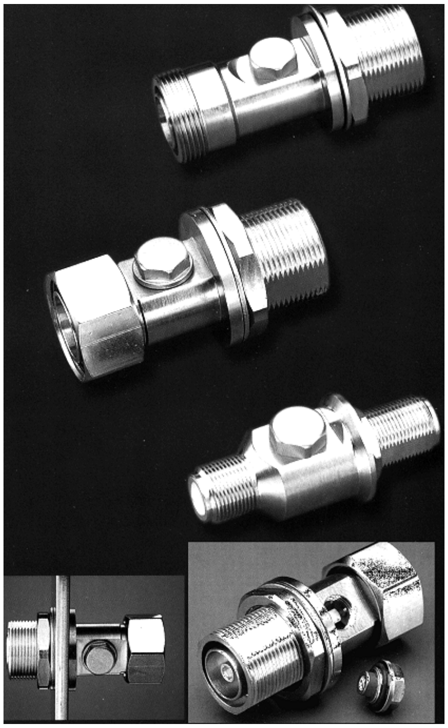
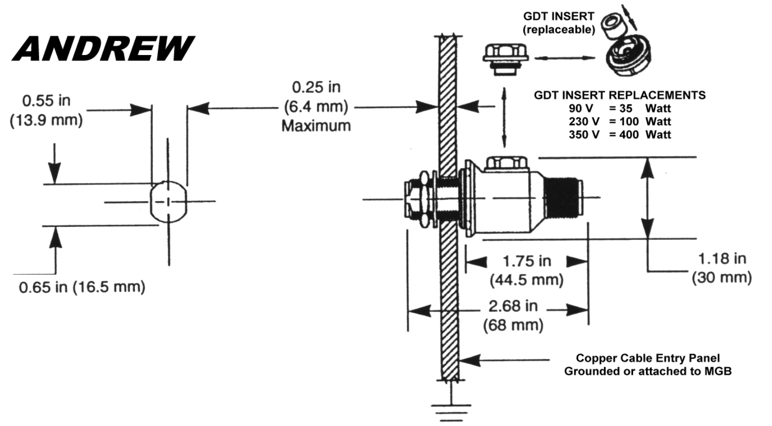


Figure 27 – Andrew Master Ground Bar (MGB)



Gas Tube Surge Arrestor APG-BNFNF-

N-Female Bulkhead to N-Female, 0 - 2500 MHz



The Andrew Gas Discharge Tubes Surge Arrestors shown here have replaceable GDT inserts. This has the advantage of being able to replace the GDT insert without removing the arrestor from the coax cable or the ground bus panel.

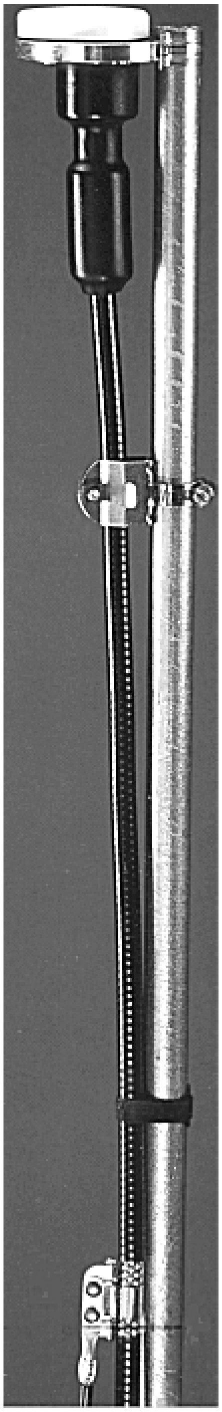
The new miniature version of the popular Arrestor Plus™ bulkhead mount T-Series surge arrestor provide more flexibility when configuring lightning protection systems. Ideal for close spaces such as OEM cabinets and tower top amplifiers, the T-shaped Miniature Quarterwave Arrestor provides multistrike lightning protection.

The Miniature Quarterwave Arrestors bulkhead mounting capability is ideal for confined installations, either indoors or out. Bulkhead mounting interfaces simplify installation by mounting directly to a grounding bar, entry plate, or radio cabinet. The arrestor is then inserted in a through hole and secured with provided hardware. An 0-ring seals out moisture. Grounding is also done through this interface, saving time and effort by eliminating the need to attach separate hardware.

Using quarterwave stub technology, this surge arrestor offers true multistrike protection. Silver plated components and high pressure contacts throughout the Miniature Quarterwave Arrestor also ensure low levels of intermodulation and excellent VSWR performance. The mini-arrestor easily fits inside equipment enclosures and is fully weatherproof, making it suitable for a variety of outdoor applications.

The QWS is one of the fastest known lightning protectors in todays PRS industry.

Figure 28 - *ANDREW* Gas Tube Surge and Quarter Wave Shorted Stub Surge Arrestors



GPS-KIT12 ANTENNA KIT

PARAMETER	VALUE
Connector, Impedance	N-Female, 50 Ohm
Frequency	1575 +10 MHz
Preamplifier Gain	26 dB
Preamplifier Noise Figure	2.5 dB
Preamplifier dc-Voltage	+5Vdc
Preamplifier dc-current	25 mA
Antenna VSWR	2.0:1
Antenna Polarization	RHCP
Antenna Gain Coverage at Zenith	3.5 dBiC
Antenna Gain Coverage at 10°	-3.0 dBiC

GPS-KIT12 Antenna Kit Specifications

Parameter	Description
GPS Antenna, N-Female	3" dia. w/white radome
Antenna Mount	Aluminum, 6061-T6
Antenna Gasket	Black Neoprene
8-32 Screws x 0.63" (4 each)	18-8 stainless steel
#8 Lockwashers (4 each)	18-8 stainless steel
Connector Shroud	Aluminum, 6061-T6
Galvanized Steel Pipe Mast	3/4" nom. OD., 33" length
Pipe Clamp (3 each)	18-8 stainless steel
10-32 Screws x 0.50" (2 each)	18-8 stainless steel
1/2" Cable Hanger (2 each)	18-8 stainless steel
Cable Hanger Support (2 each)	18-8 stainless steel
1/4-20 Bolts x 0.75" (2 each)	18-8 stainless steel
1/4-20 Nuts (2 each)	18-8 stainless steel
Round Member Adapter (2 each)	18-8 stainless steel
3M™ Cold Shrink'	Weatherproofing kit
LDF4 Grounding Kits (2 each)	Andrew Type 204989-1
L4PNM (2 each)	N-Male LDF4 connectors

The GPS antenna kit is weatherproof and designed for outdoor use. It has been tested to meet the following specifications:

Thermal Shock	MIL-STD-202, Method 107, Condition A-1, -55°C to +85°C
Moisture Resistance	IEC 529 Class IPX4S

Figure 29 - *Andrew* GPS-KIT12 Antenna Kit

The Andrew GPS-KIT12 Antenna Kit is supplied with all items required for proper installation. NOTE: the LDF4 Grounding kits (2 each) should be installed as shown in the accompanying installation instructions. *Where the GPS-KIT12 is installed beneath an ice-bridge/grid, the antenna should be spaced at least 24" below the ice protection grid to allow for satellite "look-angle" signal ingress.*

5. SUMMARY OF EXTERIOR SITE GROUNDING

This section provides an overview of the guidelines for grounding an M/A-COM EDACS site. Although the areas of focus are towers, buildings, fences and related bonding methods, the thrust of this document is to emphasize that *proper* ***grounding is the first priority in the installation of an M/A-COM EDACS site.***

General Notes:

- See the site specific grounding plan drawing for ground rod locations. Ground rods must be 5/8" or 3/4" copper-clad steel, 8 to10 feet in length.
- Ground rod spacing must be on 16' to 20' centers.
- Tops of ground rods must be a minimum of 24 inches below the soil surface.
- If solid rock is encountered, contact the M/A-COM project or program manager.
- The ground rods must **never** be cut off because of rock.
  When rock is encountered, it is acceptable to bore 4" x 10' into the rock, set ground rods and fill holes with bentonite slurry, or GEM. GEM is a "ground enhancement material from ERICO/CadWeld™. Contact ERICO/CadWeld™ at ***(800) 677.9089*** for detailed information.
- Grounding must be "megger" tested to assure 10 ohms or less resistance (under typical. conditions). 5 ohms is preferred.
- 2/0 copper stranded wire is specified. However, in some cases, number 2 may be used if approved by the M/A-COM project manager.

NOTES for Bonding & Attachments

- All connections other than CADWELDS must be crimped copper (BRUNDY) lugs. Dissimilar metal, Pressure type connections must have Penetrox® E Oxide Inhibitor (or equivalent) applied.
- All **underground** connections must be CADWELDed™. **No aluminum** connectors are to be used. Right angle CADWELD™ (other than the ground rods to ring connection) may be used. All wire-to-wire connections should utilize "Y" or "T" connections. Right angle wire-to-wire connections are discouraged.
- M/A-COM "Field Service" or Field Service designated personnel shall inspect all underground welds prior to the covering and compaction of the soil.
- No vertical jumpers should be welded (CADWELDed) within 2' of the ground rod.

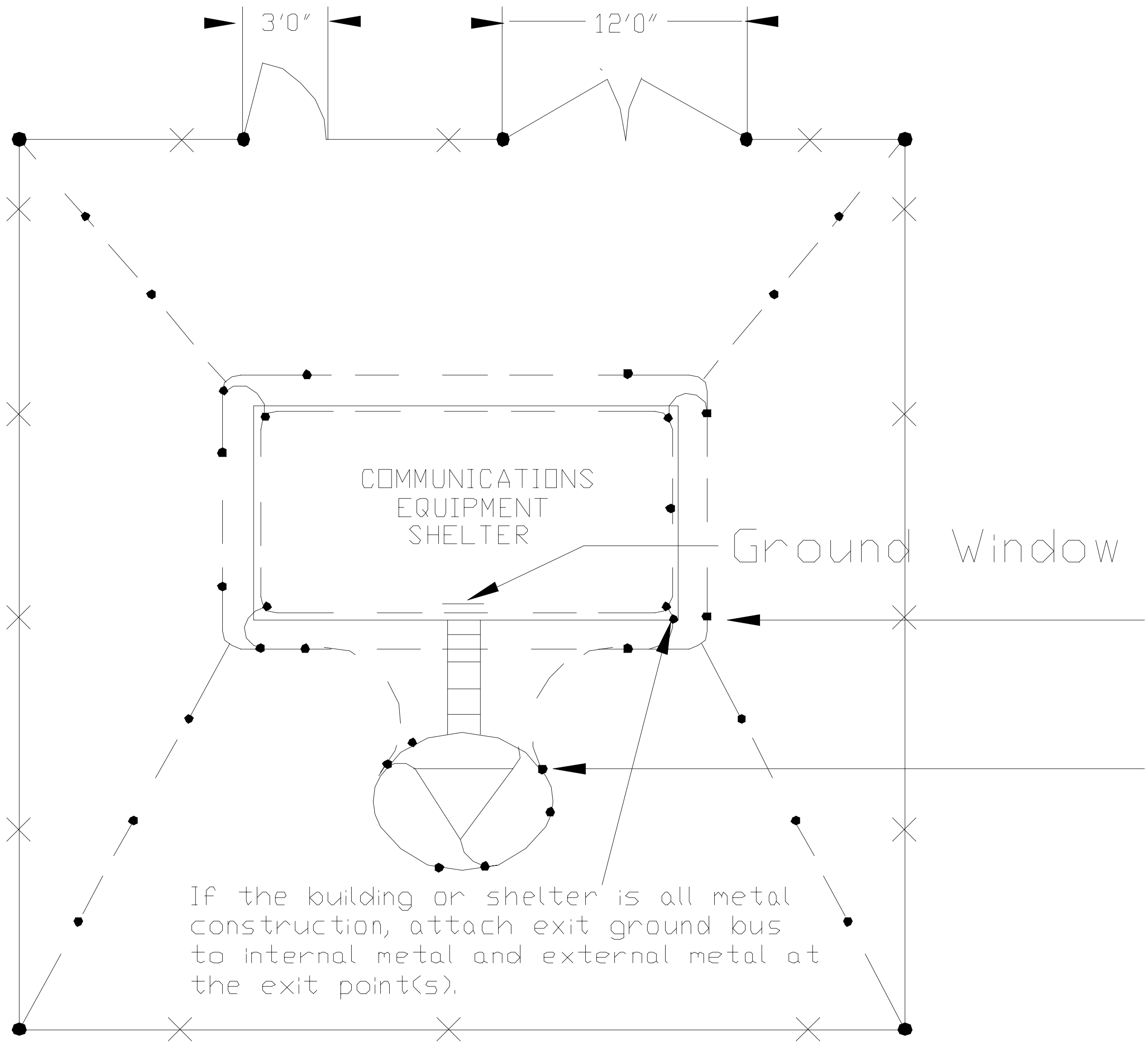


Figure 30 – Site Grounding Overview

SITE GROUNDING

1) A 2/0 stranded bare copper wire must circle the building 2' from the foundation and 3' underground. The corners of this ring must make all bends and turns to right angles using a radius of at least two (2) feet.
2) A 2/0 stranded bare copper wire must circle the tower foundation 2' from the foundation and 5' underground. This must be tied to the building ground loop in 4 places by CADWELD. This connection MUST NOT be at right angles, but should use a "Y" connection.
3) See site grounding plan for ground rod locations.
4) A 2/0 stranded bare copper wire must run from the fence gate and corner posts to the building ground ring or the tower ring (whichever is closer) at a depth of 3'. These runs must have 5/8" X 10' ground rods spaced every 16'-20'. These runs must be brought to ground level and suspended above ground with inexpensive posts until the fencing is installed. Cables must be CadWelded™ to the posts.
5) A #2/0 stranded bare copper wire must be run from the building ring, end connected to the copper buss bar that is located on the side of the building under the cable entry bulkhead/port. The connection of this jumper must be made with a minimum bend radius of 9" to the building ring

and use a “Y” connection going to the other direction of the ring. All external connections to the exterior ground ring “halo” must be made with parallel CadWelds™. Any lead that enters the building must be run through a PVC pipe and attached to the building ground.

6) A 2/0 stranded bare copper wire must be run from the tower ring between the tower and the building and must be connected to a 1" X 24" X ¼" copper bus-bar (12, 3/8" holes) that will be attached to the tower with “J” bolts. This bar will be attached to the first diagonal cross member of the tower above 8'-6" or a short distance above the ice bridge. The 2/0 ground lead must be attached to the lowest end of the bar.

7) Three (or four) similar 2/0 ground leads must be run from the ***tower ring*** to the legs of-the tower. These must be CadWelded™ to the tower. If tabs or tails are provided by the tower manufacturer for this purpose, use downward angled CadWeld™. This will provide an easy path for lightning to reach the ground field. *THE GROUND LEADS SHALL HAVE* ***NO*** *SHARP BENDS.*

8) Four additional 2/0 ground leads come out of the corners of the building (supplied as part of the building) and must be connected to the 2/0 building ground ring via “Y” CadWelds™.

9) One additional jumper must be placed directly below the electrical service entrance port. This must be tied to the building ground ring.

10) Guy wires must be grounded using number 2 stranded copper wire, attached to a 5/8" or 3/4" diameter X 10' long round rod. This ground lead must be run in a straight line and must connect all guys at a single guy point. Use clamp connections only, **no** CadWelds to guys. Cadweld only where connections are made to the ground rod. Use Penetrox® E Oxide Inhibitor or Andrew No-Oxy compound where dissimilar metals contact, or where pressure connections are made.

11) A 2/0 stranded/insulated lead from the tower lightning rod must be CadWelded™ to the tower ring ground using “Y” connections.

12) The leads must be connected to the anchor with a compression clamp (copper or brass), or a copper strap.

GLOSSARY

AMPERE
An ampere (current) is a (coulomb/second)

ANTENNA ENTRANCE
A pathway facility from the antenna to the associated equipment.

BACKBONE
A facility (eg. pathway, cable or conductors) between telecommunications closets, the entrance facilities, and the equipment rooms within or between buildings.

BANDWIDTH

The range within the limits of a band. The difference in frequency between the upper and lower 3dB power degredation response frequencies.

BI-PHASE
Found as a power feed to most U.S. homes. Derived from a center tapped transformer, it contains two hot phases (180§) with a center tap neutral return. Normally supplied as two 120 volt single phases with 240 volts available across both phases. The neutral return is usually earth grounded.

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

BONDING CONDUCTOR FOR TELECOMMUNICATIONS
The conductor that interconnects the telecommunications bonding infrastructure to the building's service equipment (power) ground.

CAPACITANCE
For purposes of this application - measured at 1.0kHz unless otherwise stated.

CLAMP
To clip. To hold turn-on voltage as current is increased. Turn-on voltage is the same, or nearly the same, as "on" voltage drop.

CLAMPING RATIO
The ratio of voltage drop at a given current to the turn-on voltage.

CLAMPING SPEED
Measured with full lead length using a 1kV/ns waveform in a 500 system, with >300MHz or larger bandwidth.

CLOSET, TELECOMMUNICATIONS
An enclosed space for housing telecommunications equipment, cable terminations, and cross-connect cabling. The closet is the recognized location of the cross connect between the backbone and horizontal facilities.

COMBINER
The summation (combining) of multiple transmitters into one transmission line. The peak voltage from each signal will be additive and will be higher than the sum of the indicated power.

COMMON-MODE
Pertaining to signals or signal components referenced to ground.

COMMERCIAL BUILDING
A building or portion thereof that is intended for office use.

COULOMB
A measurement of charge. Often used to indicate the amount of transferred charge through a gas tube to determine gas tube life. "G" abbreviation. A coulomb is (current x time).

CROWBAR
To turn-on and clamp close to ground level. Having a high turn-on trigger voltage and a low "on" voltage.

DIFFERENTIAL MODE
Referenced only between conductors (not referenced to ground).

DIPLEXER/MULTIPLEXER/COMBINER
The combining of two (or more) transmitter outputs onto one transmission line.

DUPLEXER
Receive and transmit simultaneously on one transmission line. Where a T-connector splits/combines the signals to two groups of filters. The receiver filter passes the receive frequency while rejecting (band stop) the transmitter's frequency. The transmitter filter passes its frequency while attenuating the receive frequency.

EFFECTIVELY GROUNDED
Intentionally connected to earth through a ground connection or connections of sufficiently low impedance and having sufficient current-carrying capacity to prevent the buildup of voltages that may result in undue hazard to connected equipment or to persons.

ELECTRICAL CLOSET
A floor-serving facility for housing electrical equipment, panel boards, and controls. The closet is the recognized interface between the electrical backbone riser and associated pathway.

EMI/RFI
Electro Magnetic Interference/Radio Frequency Interference. Broad spectrum noise or interfering signals.

EMP
Electro Magnetic Pulse, usually referred to as the manmade generation by detonation of a nuclear bomb at a high altitude, which generates a very fast pulse (RF) which can be captured by antennas and long unshielded lines. Sometimes referred to as NEMP, HEMP, etc. Lightning can also generate an EMP near the event. Referred to as LEMP.

ENTRANCE FACILITY, TELECOMMUNICATIONS
An entrance to a building for both public and private network service cables (including antennae) including the entrance point at the building wall and continuing to and including the entrance room or space.

ENTRANCE POINT. TELECOMMUNICATIONS
The point of emergence of telecommunications conductors through an exterior wall, a concrete floor slab, or from a rigid metal conduit or intermediate metal conduit.

ENTRANCE ROOM OR APACE, TELECOMMUNICATIONS
A space in which the joining of inter- or intra-building telecommunications backbone facilities takes place. An entrance room may also serve as an equipment room.

EQUIPMENT ROOM, TELECOMMUNICATIONS
A centralized space for telecommunications equipment that serves the occupants of the building. An equipment room is considered distinct from a telecommunications closet because of the nature or complexity of the equipment.

EXOTHERMIC WELD
A method of permanently bonding two metals together by a controlled heat reaction resulting in a molecular bond.

FARADAY SHIELD
An electrostatic (E field) shield made up of a conductive or partially conductive material or grid. A Faraday cage or screen room is effective for protecting inside equipment from outside radiated RF energies.

FILTERING (EMI/RFI)
Measured in a 500 system – loaded, per MIL-STD-220.

FREQUENCY RANGE
The bandwidth over which both the listed maximum VSWR and Insertion Loss specifications are valid.

GROUND
A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth.

GROUNDING ELECTRODE
The earth buried metallic copper or copper clad rods which are used as an direct path to ground

GROUNDING ELECTRODE CONDUCTOR
The conductor used to connect the grounding electrode to the equipment grounding conductor, or to the grounded conductor of the circuit at the service equipment, or at the source of a separately derived system.

GROUND IMPEDANCE
The ground resistance and the inductance/capacitance value of the grounding system. Also called dynamic surge ground impedance.

GROUND LOOP

An undesired potential EMI condition formed when two or more pieces of equipment are interconnected and earthed for shock safety hazard prevention purposes.

GROUND RESISTANCE
The resistance value of a given ground rod or grounding system as measured, usually defined by a fall of potential of a 100Hz signal (2% method, **see *APPENDIX "B"* Ground Measuring Techniques).**

IMPEDANCE
The total opposition (resistance and reactance) a circuit offers to the flow of alternating current at a given frequency.

INFRASTRUCTURE. TELECOMMUNICATIONS
A collection of those telecommunications components, excluding equipment, that together provide the basic support for the distribution of all information within a building or campus.

INSERTION LOSS
Loss of a device across the stated frequency range. This type of loss is due to the insertion of the unit in series with a signal path.

JOULES
A unit of energy. One joule for one second is equal to one watt of power. A Joules is (current x time x voltage).

LEAKAGE CURRENT

Undesirable flow of current through or over a surface of an insulating material or insulator. Usually measured at 50 or 60Hz with 120, 240, or 440 volts AC. However, it can be AC or DC at a specific voltage and/or frequency.

LOOP RESISTANCE
Total resistance as measured across the input with the output shorted.

MAXIMUM POWER
Maximum Continuous Wave (CW) transmit power, without unit degradation.

MAXIMUM SURGE
The maximum single surge current and specified waveform that can be handled by a device without failure during the conduction of that waveform and which ends the life of the .

MULTI-STRIKE CAPABILITY
In most applications current sharing will occur, and in a direct strike event the unit will survive to work again.

PATHWAY
A facility for the placement of telecommunications cable.

POWER
Power - measured in watts, is expressed as (voltage X current).

RECEIVER MULTICOUPLER
Sometimes with an amplifier, this device has one antenna line input, and multiple receiver outputs.

RF
Radio Frequencies - any and all frequencies that can be radiated as an electromagnetic wave (plane wave).

SAFETY GROUND
The local earth ground, or the earth ground that grounds the neutral return. (Neutral must only be grounded once at the entry location).

SHF
Super High Frequency - from 3000MHz to 30GHz.

SHUNT PROTECTOR
Line-to-ground. No power or signal passage through unit.

SINGLE PHASE
A true single phase supply, usually a two-wire system with one hot phase and a neutral return. A safety earth ground is also present.

SKIN EFFECT
The tendency of rf currents to flow near the surface of a conductor. Thus they are restricted to a small part of the cross-sectional area, which has the effect of increasing the resistance.

TELECOMMUNICATIONS
Any transmission, emission, and reception of signs, signals, writings. images, and sounds, that is, information of any nature by cable, radio, optical, or other electromagnetic systems.

TELECOMMUNICATIONS BONDING BACKBONE
A copper conductor extending from the telecommunications main grounding busbar to the farthest floor telecommunications grounding busbar.

TELECOMMUNICATIONS BONDING BACKBONE INTERCONNECTING BONDING CONDUCTOR
A conductor that interconnects the telecommunications bonding backbones.

TELECOMMUNICATIONE CLOSET
see closet telecommunications

TELECOMMUNICATIONS EQUIPMENT ROOM - see equipment room, telecommunications

TELECOMMUNICATIONS INFRASTRUCTURE - see infrastructure, telecommunications

TELECOMMUNICATIONS MAIN GROUNDING BUSBAR
A busbar placed in a convenient and accessible location and bonded by means of the bonding conductor for telecommunications to the service equipment (power) ground.

TERMINATION HARDWARE
A device used to connect cable or wires for the ease of cross connecting or for the extension to another cable or equipment.

THREE PHASE
It consists of sinusoids 120 degrees apart on at least three wires (Delta) and often four wires (Wye). The fourth wire is a grounded neutral return. ID a Delta system there is no reference to ground and thus it is more susceptible to lightning problems.

THROUGHPUT ENERGY
A measure of the efficiency of a system; the rate at which the system can handle energy.

TOTAL SURGE ENERGY
Total sum of surge energy for all lines of a protector unit. Measured in joules. The minimum total energy that results in the failure of the unit.

TRANSFER IMPEDANCE
Referring to coax, is the impedance to transfer into or outside the coax at various frequencies usually below 1MHz. Due to loss of skin effect attenuation or shielding at these low frequencies, coax can be susceptible to interference and noise as well as the radiation of such signals.

TURN-ON TIME - GAS TUBE "FIRING"
The amount of time that exists in the period that occurs when the ramp voltage barely exceeds the turn-on voltage of the device, and the point at which 50% of the peak voltage is achieved during the turn-on (crowbar) process.

UHF
Ultra-High Frequency - normally from 300 to 3000MHz, however in this catalog we breakout 800 to 1000MHz separately even though it is within this category.

VHF
Very High Frequency - from 30 to 300MHz.

VLF

Very Low Frequency - from 300Hz to 3kHz.

VOLT
The unit of measure of electomotive force. The difference of potential required to make a current of 1 ampere flow through a resistance of 1 ohm.

VSWR
Voltage Standing Wave Ratio (VSWR). In a stationary wave system (such as a coaxial cable) the ratio of the amplitude or voltage at a voltage maximum to that of an adjacent voltage minimum.

GROUND RELATED ABBREVIATIONS AND ACRONYMS

AC	alternating current
ACEG	Alternating Current Equipment Ground
AWG	American Wire Gage
BICSI	Building Industry Consulting Service International
CBC	Coupled Bonding Conductor
CISPR	International Special Committee on Radio Interference
DC	direct current
CSA	Canadian Standards Association
CVGB	Cable Vault Ground Busbar
EF	Entrance Facility
EIA	Electronic Industries Association
EMT	Electrical Metallic Tubing
FGW	Floor Ground Window
IGZ	Independent Ground Zones
GDT	Gas Discharge tube
MGB	Master /ground Bar
MOV	Main Oxidizer Value
MUX	Multiplexer
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NEC	National Electrical Code
QWS	Quarter Wave Stub
TBB	Telecommunications Bonding Backbone
TBBIBC	Telecommunications Bonding Backbone Interconnecting Bonding Conductor
TC	Telecommunications Closet
TEF	Telecommunications Entrance Facility
TER	Telecommunications Entrance Room
TGB	Telecommunications Grounding Busbar
TIA	Telecommunications Industry Association
TMGB	Telecommunications Main Grounding Busbar

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APPENDIX A
MICROFLECT™ DEVICES
& PART NUMBERS ASSOCIATED WITH GROUNDING OF TOWERS, ICE-BRIDGES, GUY ANCHORS, AND CABLE ENTRY PORTS.

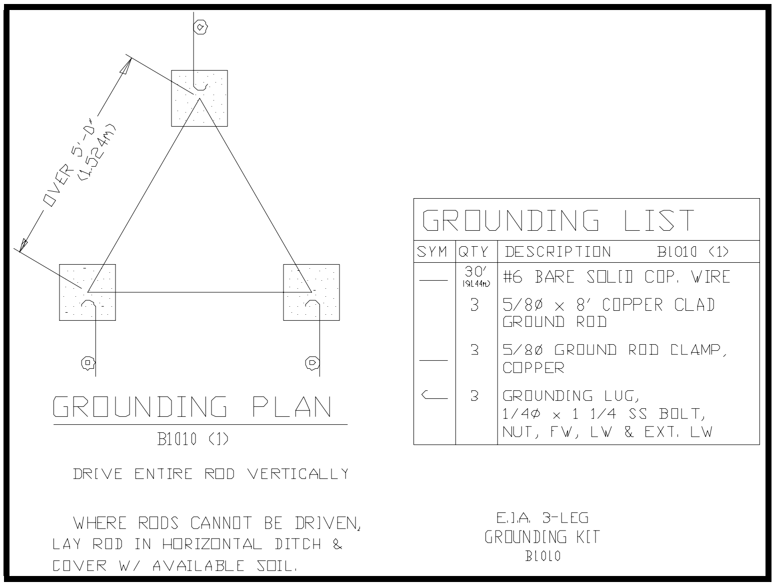

Figure A-1 3 Leg Tower Grounding Kit

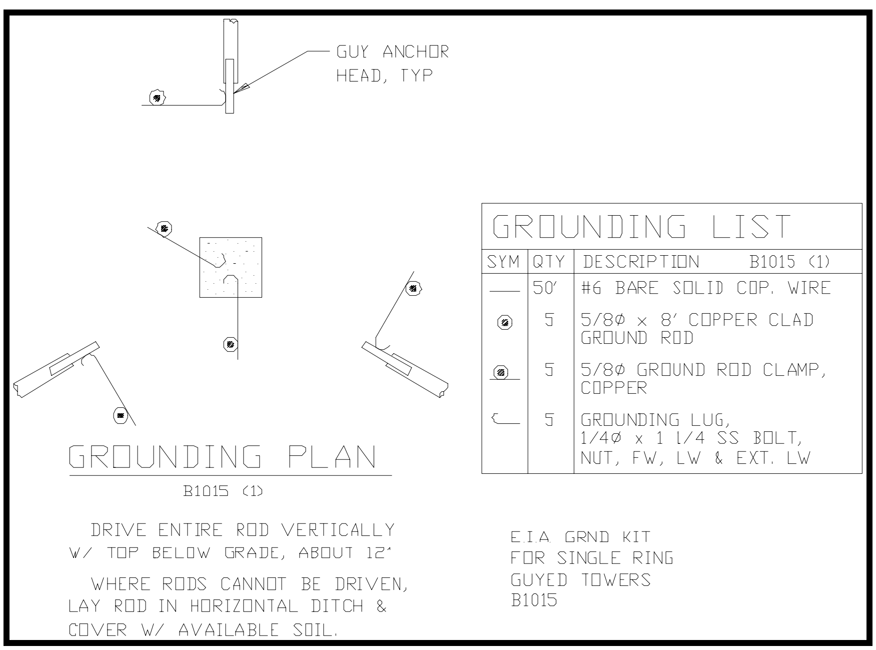

Figure A-2 Guyed Tower Grounding Kit

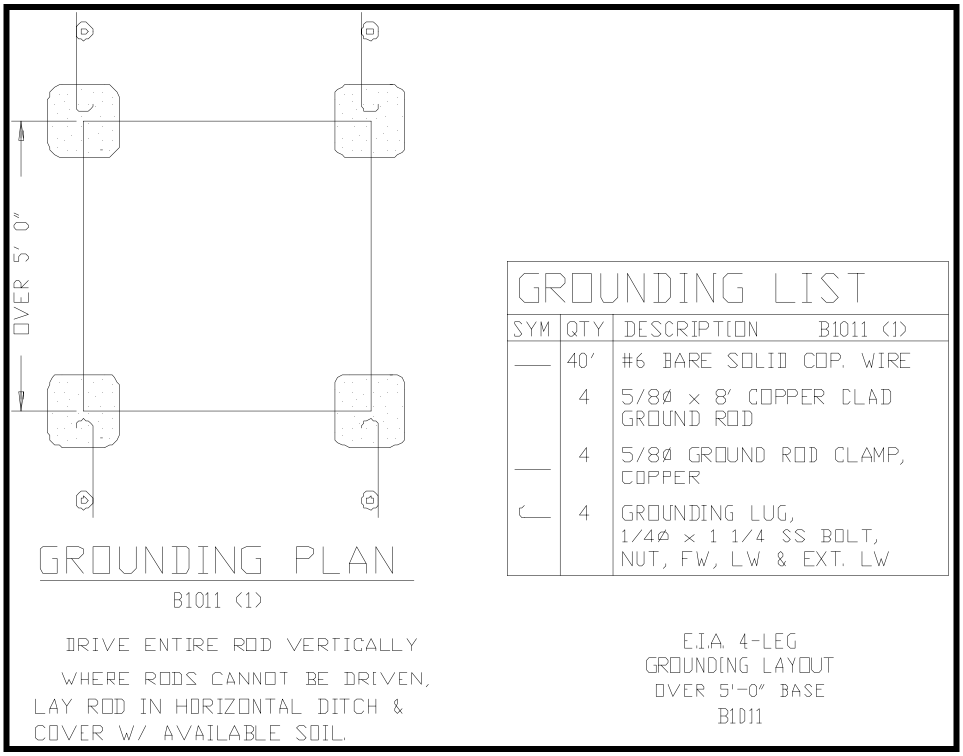

Figure A-3 Four Leg Tower Grounding Kit

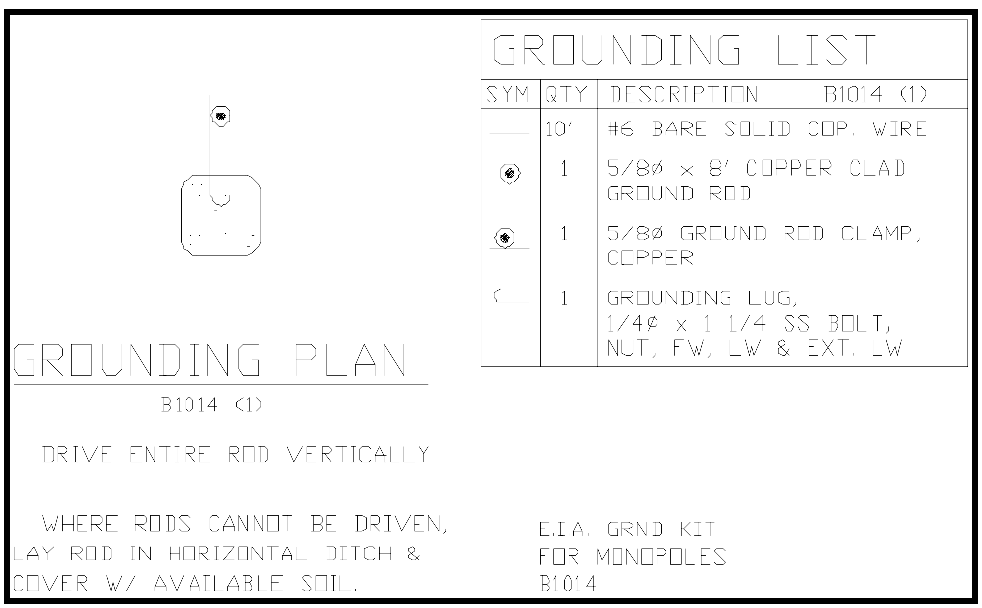

Figure A-4 Monopole Tower Grounding Kit

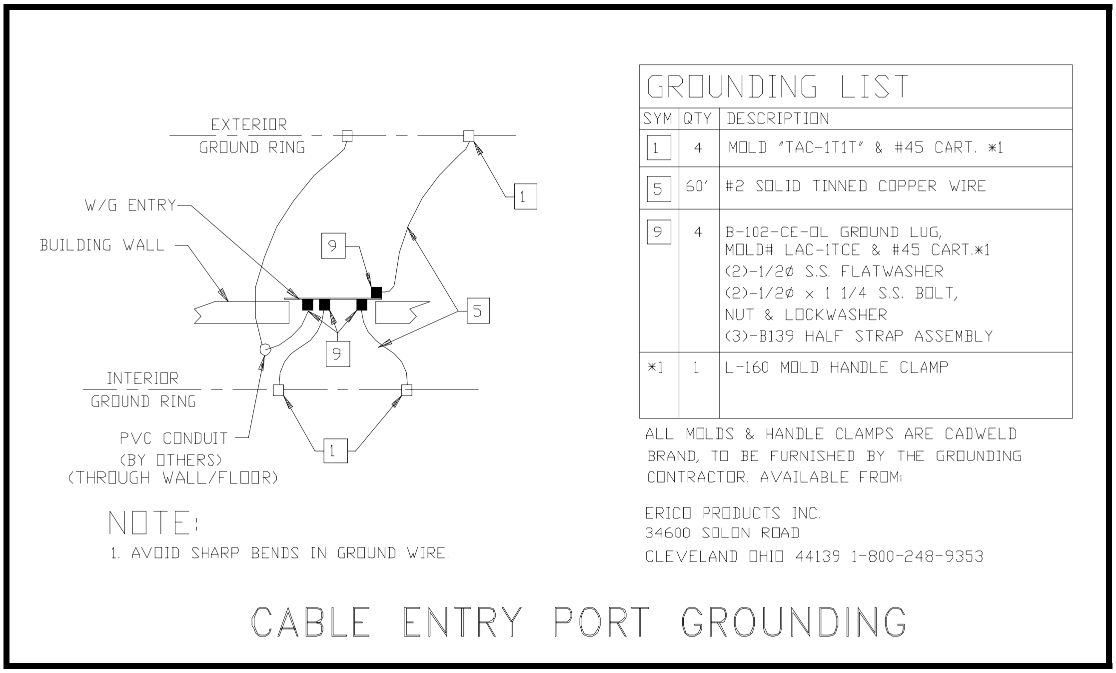

Figure A-5 Cable Entry Port Grounding Kit

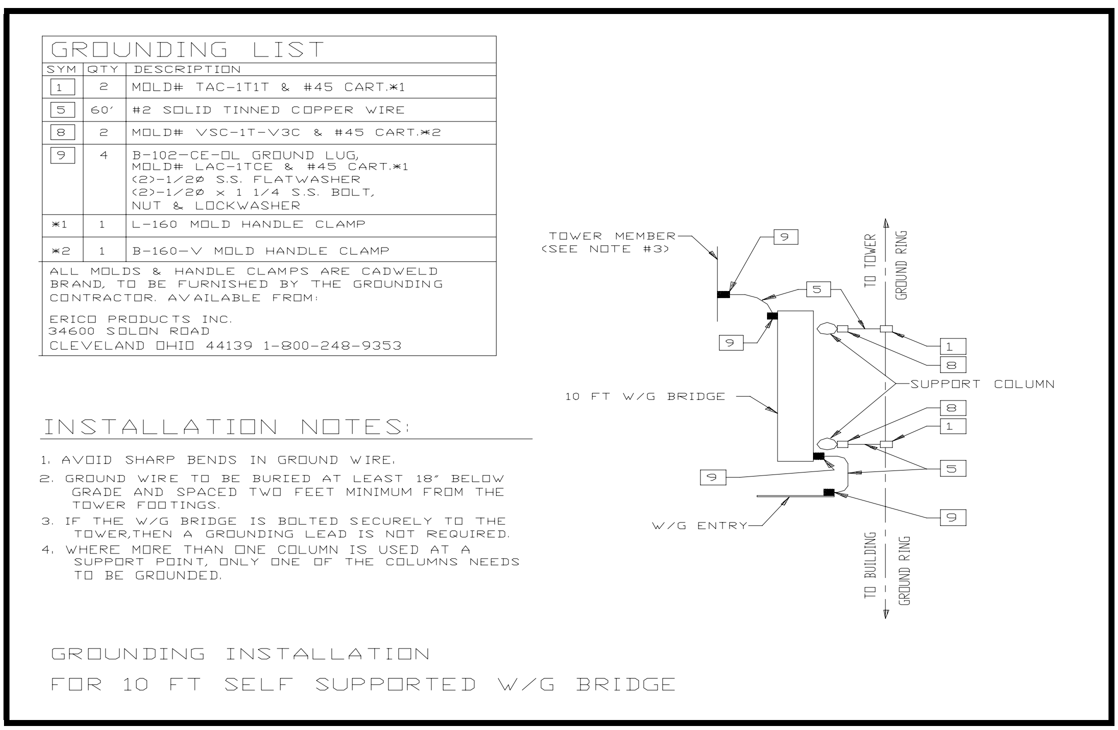

Figure A-6 10' Self-Supported W/G Bridge Grounding Kit

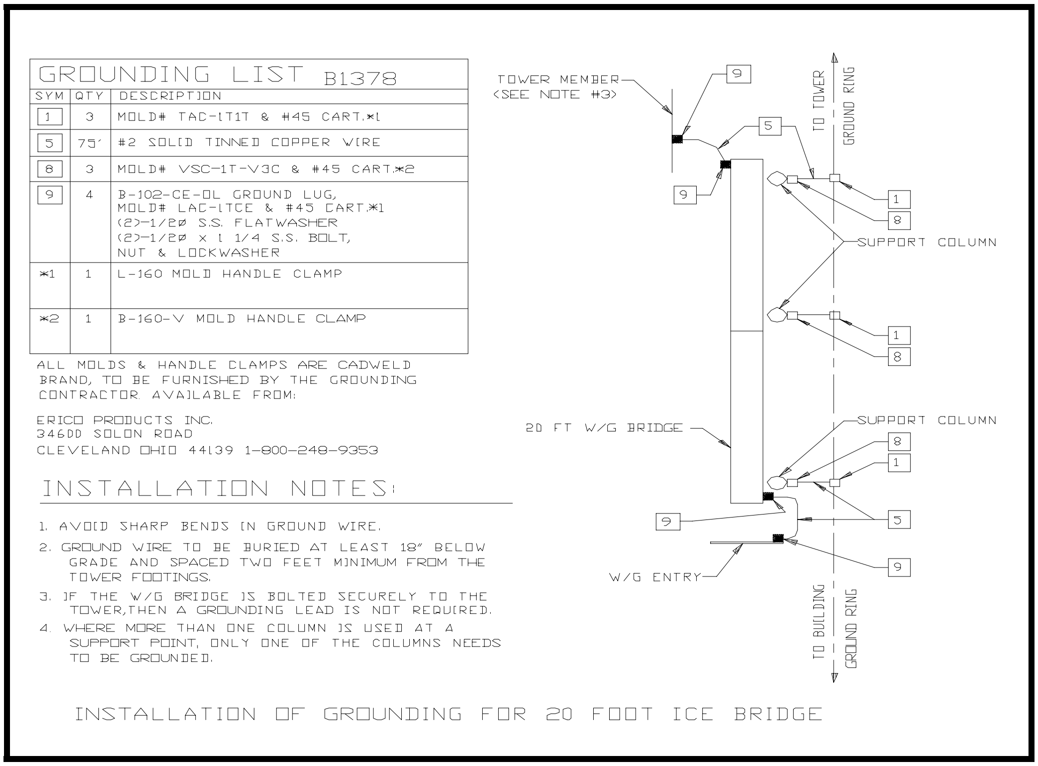

Figure A-7 20' Ice Bridge Grounding Kit

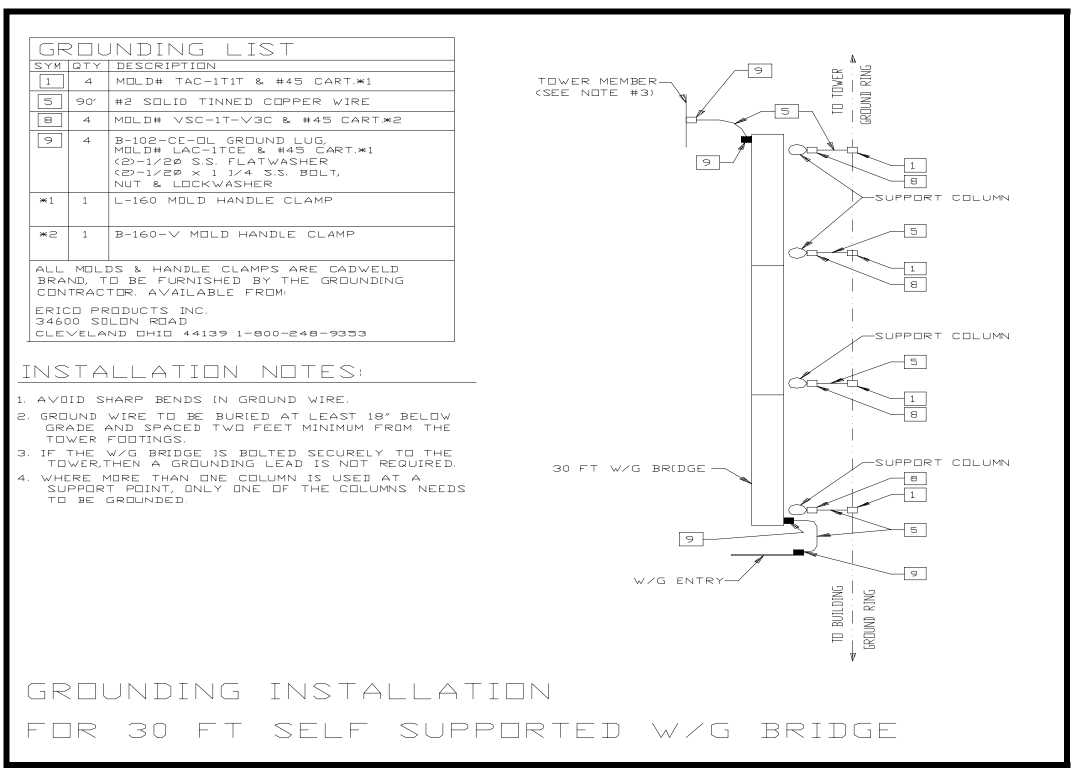

Figure A-8 30' Self-Supported W/G Bridge Grounding Kit

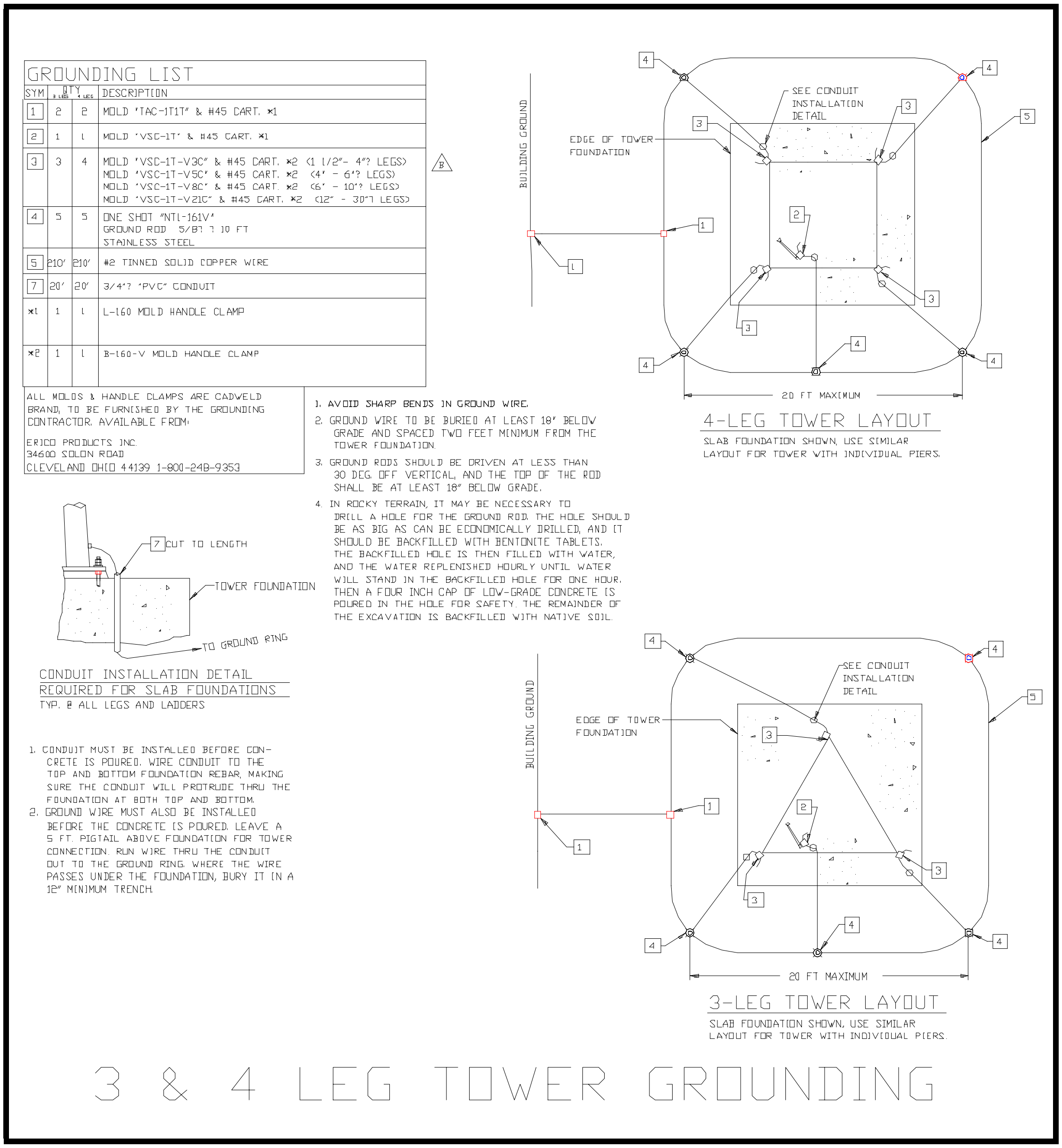

Figure A-9 3 and 4 Leg Tower Grounding Kit

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