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**Communications and Information**

**GROUNDING TECHNIQUES**

**COMPLIANCE WITH THIS PUBLICATION IS MANDATORY**

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This publication provides guidance for grounding and lightning protection for deployable communications-electronics (C-E) equipment associated with the theater air control system units, combat communications units, and communications squadrons supporting wing deployable communications packages. It implements policy found in AFPD 33-1, *Command, Control, Communications, and Computer (C4) Systems*. This publication applies to US Air Force Reserve Command (USARC) units and members. It will apply to ACC gained Air National Guard Units when included in ANGIND2. Send comments and suggested improvements on AF Form 847, **Recommendation for Change to Publication**, through channels to HQ ACC/SCC, 227 Hunting Ave, Ste 203, Langley AFB VA, 23665-2777.

**SUMMARY OF REVISIONS**

This publication is revised to include all deployable communications-electronics units in ACC and to convert it from an ACCR to an ACCI. It clarifies issues and provides units flexibility in engineering grounding systems. Corrections have been made to all attachments.

**1. General.** Use this publication in conjunction with TO 31-10-24 as a guide in constructing grounding systems. It establishes procedures for grounding of fault protection, signal reference, and lightning protection subsystems for mobile C-E equipment at remote sites, and provides guidance for the construction and installation of remote site central and/or facility (stand-alone) earth electrode subsystems. It also assigns responsibilities for the installation, testing, inspection and maintenance of the remote site earth electrode subsystems. References used to create this instruction include the National Electric Code, National Fire Protection Association 780, MIL-HDBK-419A and MIL-STD-124-188 and TO 31-10-24. It is not necessary to modify equipment for the sole purpose of complying with this instruction or TO 31-10-24.

**2. Responsibilities:**

2.1. The deployed site commander, engineer or designated representative will appoint a grounding team consisting of one supervisor and at least two members to ensure compliance with technical order 31-10-24 and this instruction for all deployed situations. When there are fewer than four people at a site, the site personnel will be the grounding team with the ranking individual being the supervisor.

2.2. Deployed grounding team chief or site engineer or commander will consider factors in determining the type of ground system required for the situation and a realistic resistance value for the site central or facility ground(s).

2.2.1. Work hours, materials, location, mission requirements, etc., will be the determining factors.

2.2.2. Grounding for a sustaining site should be designed with the anticipation of connecting the site to a central ground grid developed by the site Civil Engineer.

2.3. The Grounding Team Supervisor will:

2.3.1. Ensure the grounding plan is included with the site layout.

2.3.2. Ensure site central ground subsystem or facility ground subsystems are installed at deployed location prior to the installation of communications electronics equipment. The central or facility ground grids will be identified with a danger sign reading:

"CENTRAL/FACILITY GROUND - DO NOT DISCONNECT WITHOUT THE APPROVAL OF THE COMMANDER"

2.3.3. Establish a site grounding log. This log will show the site ground layout, ohm value(s), equipment checked, date of readings and equipment added to or deleted from the site central/facility ground system.

2.3.4. Ensure signal cables, power cables and ground wires in parallel runs are separated by at least 18 inches. When signal cables must cross power cables or ground wires, they should do so at a 90 degree angle.

2.4. The Grounding Team will:

2.4.1. Install and test the deployed site central or facility grounds (earth electrode subsystem) as shown in site examples attachments 3 through 6. The central/facility ground(s) will be tested using a vibra-ground or equipment specifically designed to test ground resistance. The design objective is 10 ohms or less of resistance. If this objective cannot be achieved, the grounding team chief will notify the site commander, engineer or designated representative. They will consider facts to determine a solution for the situation and a realistic resistance value for the site central/facility ground(s). Work hours, location, materials, mission requirements, etc., will be the determining factors.

2.4.2. Ensure all equipment, as applicable, is properly connected to the site central or facility ground system.

### **3. General Procedures for Ground Installation While Deployed:**

3.1. The Earth Electrode Subsystem.

3.1.1. The earth electrode subsystem may consist of a single ground rod or interconnected ground rods in a multi-rod configuration. The type of subsystem selected will depend on site design and/

or soil type/resistance. The multi-rod configurations recommended are the delta for normal soils, or the star arrangement for rocky or other problem soils (See attachment 1).

3.1.2. The distance the rods are to be spaced in multi-rod configurations will be 1½ to 3 times the length of the longest ground rod in the system. For example, if the longest rod in a system is 9 ft, then the spacing for the rods will be 13.5 to 27 ft. (See attachment 1)

3.1.3. The interconnecting wires in a ground grid will be bare solid or stranded and may be 1/0 AWG. If smaller wire is used, the size selected will not be smaller than #6 AWG and will be based on the combined rating of the main input overload protection devices of equipment powered by a common source. Refer to table 1 to determine the minimum size required.

3.1.4. For small communications equipment (e.g., personal computers, ground radios, TSSRs, etc.) that is powered by small, single phase generator sets, the third wire contained within the power cord provides a sufficient connection to ground, provided the generator set is properly grounded--unless the equipment technical order requires an additional ground.

3.2. Ground Rods and Ground Runs:

3.2.1. For the purposes of this instruction the term "single ground rod" is defined as a single or multi-sectioned ground rod with a minimum diameter of ½ inch and a minimum length of eight feet of rod surface in contact with the ground. If this eight foot length can not be met, a multi-rod grid will have to be constructed. The ½ inch diameter, 8 foot continuous length ground rod is also sufficient to meet this requirement.

**Table 1. Ground Wire Size and Rating.**

COMBINED AMP RATING OF MAIN OVERLOAD PROTECTION	WIRE SIZE
200A or less	#6 AWG
201 - 400A	#4 AWG
401 - 500A	#2 AWG
501 - 600A	#1 AWG
601 - 800A	1/0 AWG
<i>NOTES</i>	
1. The wire sizes listed in table 1 are " <u>MINIMUM</u> " and are not required for every contingency; most large sites will require #6AWG and 1/0.	
2. If lightning protection devices are connected to the grid, the minimum size wire used will be 1/0 AWG.	

3.2.2. Ground clamps must be the proper size for the ground rod in use.

3.2.3. Ensure all ground rods and clamps are free of paint, dirt, grease and oxidation.

3.2.4. Locate ground rods approximately 2-6 ft from the equipment to be grounded and as close to the ground connection as possible.

3.2.5. Avoid positioning ground rods and stringing ground wire in front of entranceways or across high traffic areas.

3.2.6. Do not allow the ground wire to form coils as it is laid between ground connections.

3.2.7. Multiple systems and generators may be connected to a single ground rod provided you use a separate clamp per connection. There is no specific limit to the number of connections to a single ground rod.

3.2.8. Unless otherwise specified in this instruction, TO 31-10-24, or the equipment TO, ground wire may be solid or stranded and bare or insulated.

3.2.9. Any external fault protection wire physically attached to the power cable is considered part of the cable and will be green insulated.

3.2.9.1. To attach the external wire to the power cable use green or black duct tape at least 1/4" wide, or tie straps, and space 24-36" between securing points.

### 3.3. Equipment and Generator Connections:

3.3.1. Before attaching or removing a ground lead to a ground system where power is applied, connect a temporary safety bonding strap between the new lead and the ground rod. The temporary ground strap must be equipped with insulated connectors. If temporary ground straps are not available, all equipment attached to the ground grid must be depowered prior to removal or addition of a ground lead. (see figure 2-2 of TO 31-10-24).

3.3.2. Measure equipment-to-ground rod resistance with an ohmmeter to ensure that ground terminal connection between the equipment chassis and ground rod is not loose or corroded. The reading should be one ohm or less.

3.3.2.1. Ensure that power is off, measure between the equipment ground stud and the ground rod. The object is to check the resistance through the ground connections. This check should be accomplished whenever equipment is disconnected and then replaced or reconnected.

3.3.3. If a long ground wire run needs splicing, drive a single ground rod and connect the ends with a separate clamp for each end of the splice. For this connection, a single 3-foot section of rod may be used since it is for support of the connection and not the primary ground source.

3.3.4. Equipment and generators connected by 5-wire power cable are connected to the earth electrode subsystem through the internal conductors in the power cable.

3.3.5. On 5-wire equipment interfaced with 4-wire generator sets, connect an external ground wire from the power panel ground terminal of a 5-to-4-wire adapter to the ground connection of the generator set.

3.3.5.1. External fault protection wire must be #6 AWG or larger. If the external fault wire is physically attached to the power cable, it must be green insulated. Otherwise it may be bare.

3.3.6. On 4-wire equipment powered by 5-wire generator sets connect an external ground wire from the power panel ground terminal of the equipment to the ground terminal of a 4-to-5-wire adapter. From the adapter to the generator set, the connection is made within the power cable.

3.3.7. On 4-wire equipment powered by 4-wire generator sets connect an external ground wire from the power panel ground rods to the ground rod of the generator set. If this wire is strapped or taped to the power cable, it is considered part of the power cable and must be green insulated.

3.3.8. Stand-alone 4-wire air conditioners will be connected to their own ground rod. Co-located units may share a common ground rod as long as a separate clamp is used for each connection.

3.3.9. The size of the ground wire from the van, shelter or other equipment to the ground rod will be based on Table 1 of this instruction. If the site engineer directs the burying of ground conductors, the wire will be bare.

3.3.10. Ground signal reference panels IAW the equipment technical order. Minimum size #6 AWG wire will be used.

3.3.10.1. For system technical orders that require the signal reference panel to be connected to the fault protection subsystem, the connection will be made to the to the power panel ground rod.

3.3.10.2. Multiple signal reference panels on a van or shelter may be connected to the same ground rod using separate clamps.

3.3.11. Ground wires from equipment to ground rods will be as straight as possible with no bends sharper than 90 degree or smaller than 8 inches in diameter.

3.3.12. Power distribution boxes with 5 wire cable input do not require a separate ground since they receive ground from the generator through the 5th wire of the cable.

3.4. Bulk Storage Fuel Drums. Drums containing class I fuels will be grounded with a static ground during storage and refueling operations. When refueling ground support equipment and vehicles, a ground strap will be used between the equipment being fueled and the refueling system.

#### **4. Grounding Kits:**

4.1. Each unit should establish a kit for installing a grounding system when deployed. Suggested items are listed in Attachment 2 to assist units in assessing their kit requirements.

#### **5. Lightning Protection:**

5.1. Equipment providing lightning protection will be installed IAW equipment technical orders

5.2. Equipment with lightning protection will be connected to the site central ground system by a #1/0 AWG or equivalent cable to the air terminal ground rod. This cable will be as short as possible, with no coils or sharp turns.

**6. Procedures for Ground Installation while in Garrison:** An in-garrison facility ground should be coordinated with base civil engineers. If the facility ground has been installed by the unit, maintenance and certification of the facility ground should be reviewed by base civil engineering. In either situation, the unit will be responsible for an annual inspection and test of the facility ground. The central grounding

point will be identified with a danger sign which reads: "CENTRAL GROUND-DO NOT DISCONNECT"

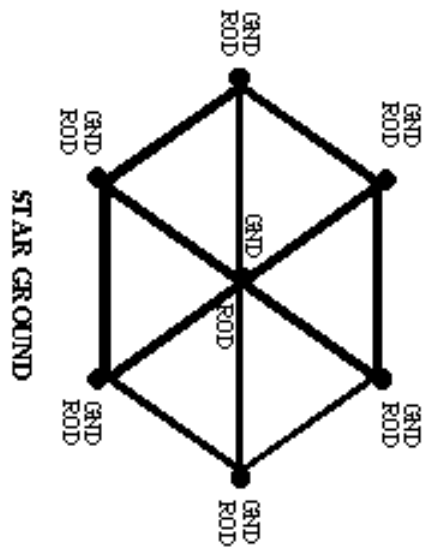
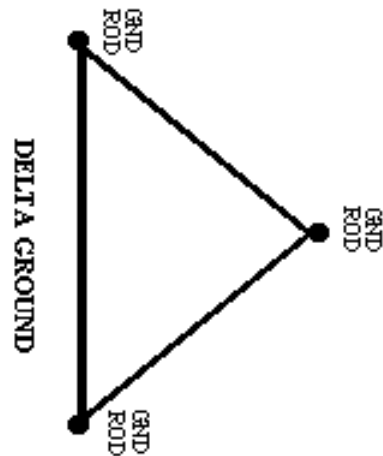
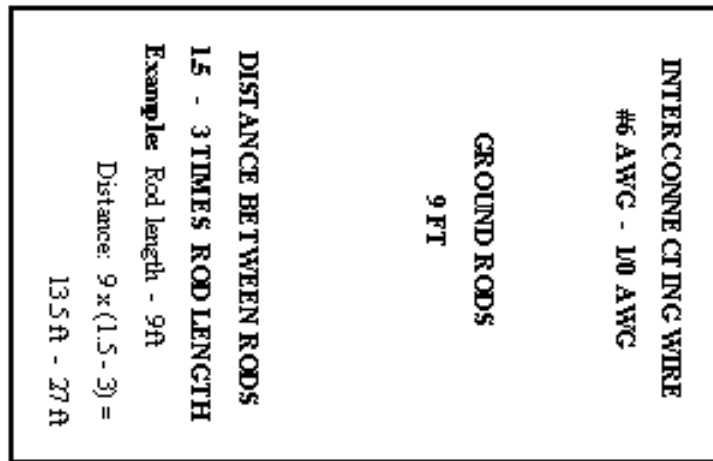
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Commander

Attachment 1

MULTIPLE GROUND ROD GRIDS

A1.1. Typical Multiple Ground Rod Grids. Typical multiple ground rod grid configurations are shown in the following chart:

Figure A1.1. Multiple Ground Rod Grid Configuration.



**Attachment 2****MOBILITY GROUNDING KIT**

**A2.1. Mobility Grounding Kits.** The figure below provides suggested contents for a mobility grounding kit. Units may tailor as necessary.



Figure A2.1. Grounding Kit.

ITEM	CBCS/ACS/ ACOMS	ASOC/RI S/WICP
1/0 AWG (bare or insulated; solid or stranded)	500 ft	200 ft
#6 AWG (bare or insulated; solid or stranded)	3000 ft	2000 ft
Rod, grounding (Each rod is composed of 2 or 3 sections, ¾ in. in diameter) Total: 6 - 9 ft	20	15
Slip hammer	2	2
Clamp, grounding:		
S53505	10	7
VTA-4	10	5
¾ in.	100	50
Safety goggles	One pair per ground team member	One pair per ground team member
Hammer, sledge	2	2
Box wrench set	2	2
File, with handle	2	2
Tape measure	2	2

Figure A2.2. Grounding Kit (Continued).

Wire brush	2	2
Emery paper	6 sheets	4 sheets
Leather work gloves	One pair per ground team member	One pair per ground team member
Magnesium sulfate (Epsom salts) *	20 lbs	20 lbs
Other items as determined by unit		

**NOTE:**

1. The above items are suggestions. Adjust quantities and composition as mission requirements dictate.

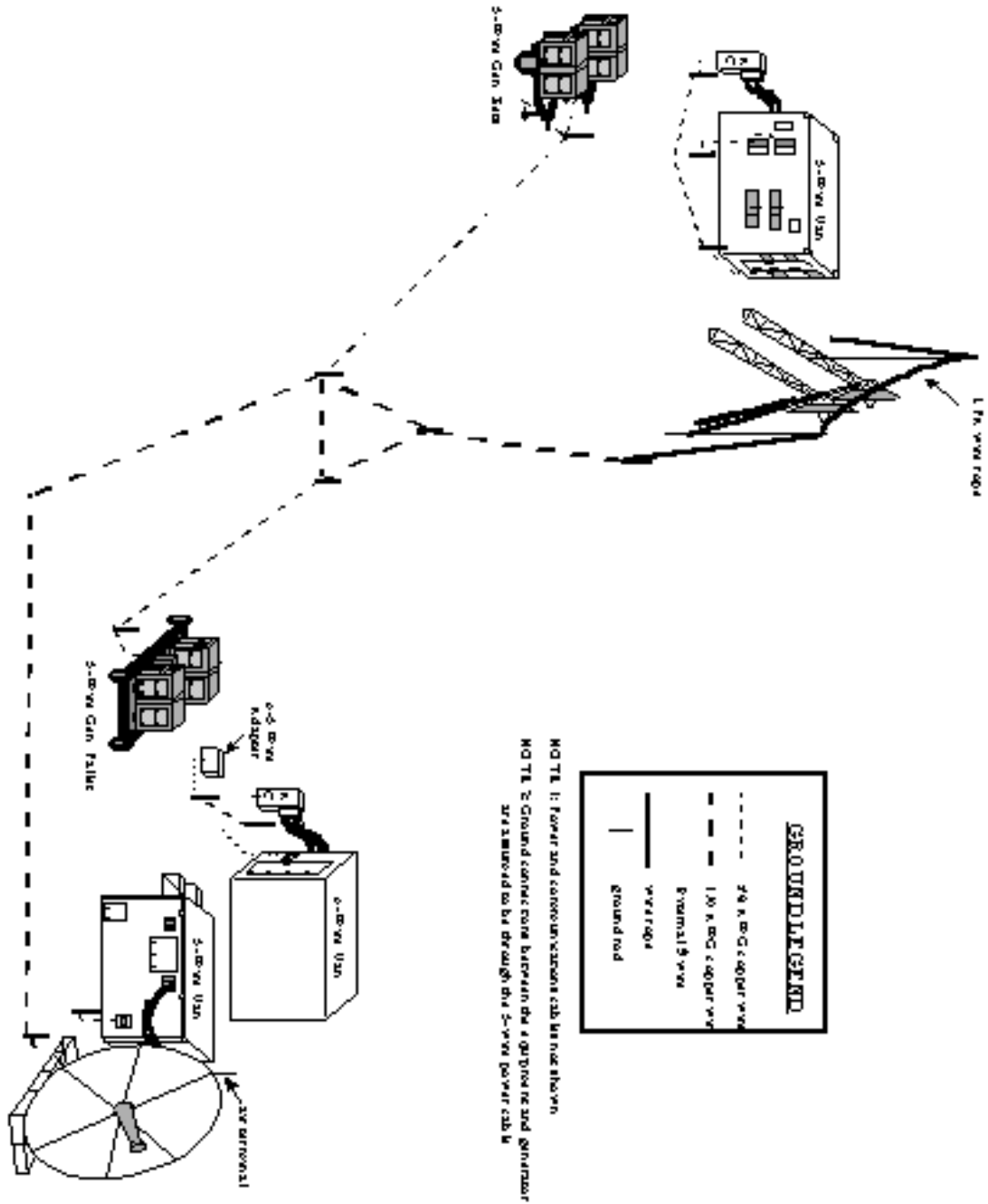
\* Magnesium sulfate will be used as necessary to decrease earth electrode subsystem resistance. Determination of use will be made by the site commander or engineer or designated representative.

**Attachment 3**

**COMMUNICATIONS SITE WITH CENTRAL GROUND GRID**

**A3.1. Communications Site with a Central Ground.** The figure below shows a typical central ground installation. Actual sites will vary.

Figure A3.1. Communications Site with Central Ground.

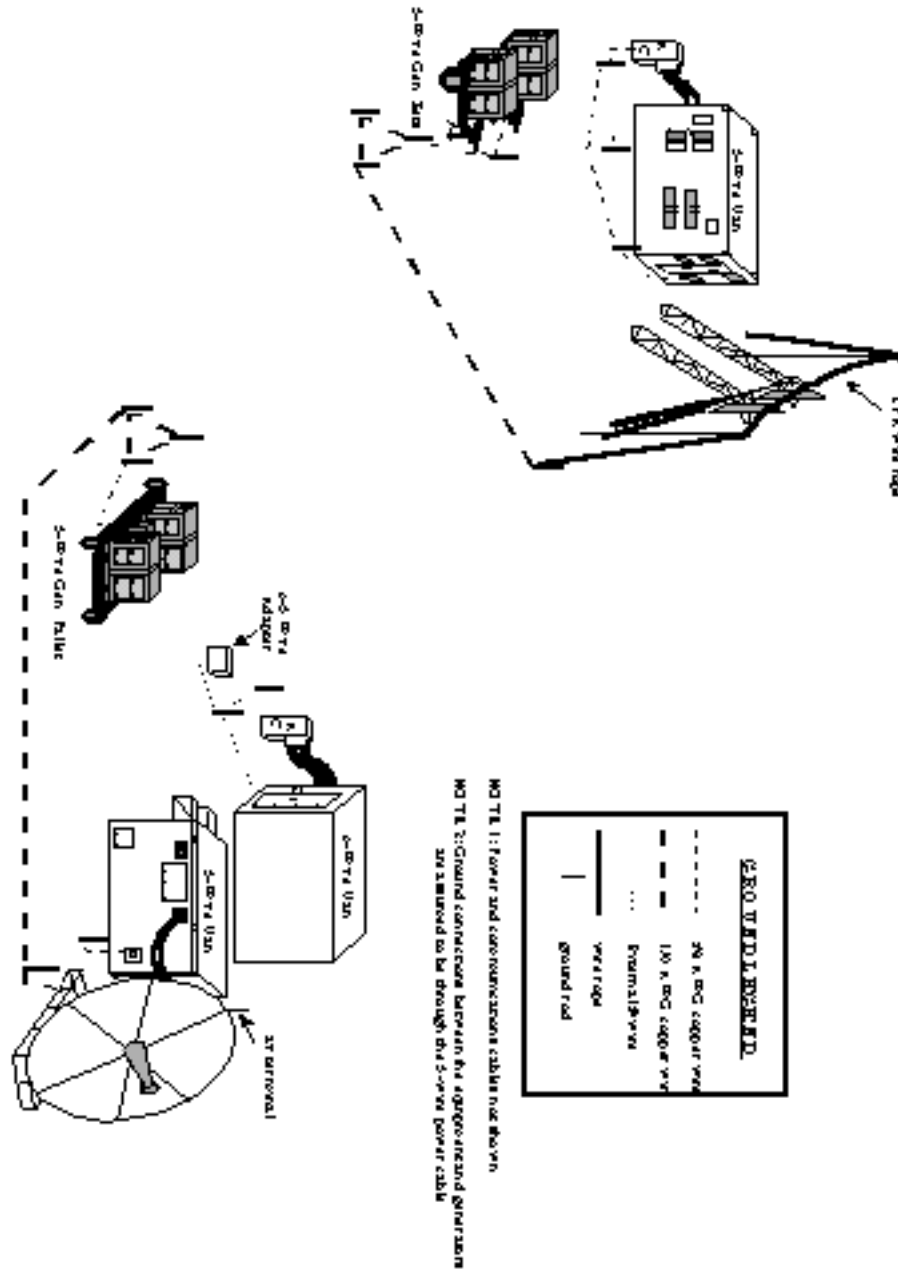


Attachment 4

COMMUNICATIONS SITE WITHOUT A CENTRAL GROUND GRID

A4.1. **Communications Site without a Central Ground.** The figure below shows a typical site without central ground installation. Actual sites will vary.

Figure A4.1. Communications Site without Central Ground.



Attachment 5

AIR CONTROL SQUADRON WITHOUT A CENTRAL GROUND GRID

A5.1. Air Control Squadron without a Central Ground. The figure below shows a typical ACS without a central ground installation. Actual sites will vary.

Figure A5.1. Air Control Squadron without Central Ground.

