SECTION H -- GROUNDING AND BONDING

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TABLE H-1 – SUMMARY OF CHANGES IN SECTION H

<table>
<thead>
<tr>
<th>Revision Date</th>
<th>Item</th>
<th>Action</th>
<th>Requirements Change Notification</th>
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<tr>
<td>05/02/2016</td>
<td>H-2</td>
<td>Modification</td>
<td>ATT-TP-76300-332</td>
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<td>05/02/2016</td>
<td>1.2</td>
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1. **GENERAL**

1.1. **Introduction**

1.1.1 The Installation Supplier shall ensure, as part of the evaluation of the installation, that all equipment added, rearranged or modified is properly installed and in conformance with AT&T installation specifications.

1.1.2 The Installation Supplier shall ensure, as part of the evaluation of the installation, that all work has been done in accordance with the detail specifications or approved changes to the detail specifications.

1.1.3 This section covers the Grounding and Bonding requirements for Installation Suppliers performing services for AT&T.

1.1.4 Changes in this issue of Section H are summarized in Table H-1.

1.1.5 This section contains workmanship requirements. It is based on the engineering, installation and material requirements for grounding and bonding contained in the following documents:

   a) ATT-TP-76416, Grounding and Bonding Requirements - for Network Facilities

   b) ATT-C-98022-71, SNET Building Ground System; ATT-W-98023-31, Building Ground & Equipment Ground System.

1.1.6 Additional information on Grounding and Bonding (e.g. cabling, connectors, labeling, etc.) can be found in other sections of this document.

1.2. **Definitions**

1.2.1 The following terms are used throughout this section. Note: Where different terms are used for the same object, the AT&T alternative names to which these terms apply are listed in brackets after the term.

   **Alternating Current Equipment Grounding Conductor – (ACEG)** The conductor used to connect the non-current-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system.

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

   **American Wire Gauge (AWG)** – Is a standardized wire gauge system used predominantly in North America for the diameters of electrically conducting wire. Also known as the Browne & Sharp wire gauge.

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

H-2
Carrier Communications Space Ground Bar (CO GRD bar) - A Carrier Communications Space ground bus bar that references the primary grounding system bus bar through the Vertical Riser. At least one of these bus bars is provided on each floor to permit the grounding of frames and power supplies, as required. Was previously called Floor Ground Bar (FGB)

DC Equipment Grounding Conductor (DCEG) - The conductor that bonds an equipment frame, cabinet or other enclosure to the CO GRD system, engineered to provide an electrical path of sufficient capacity to permit protective devices (e.g. fuses, circuit breakers) to operate effectively and to equalize the potential between equipment. The DCEG conductor may also bond an equipment unit within a frame, cabinet or other enclosure to the CO GRD system.

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

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

Foreign Object - Any electrically conductive surface that is part of the Common Bonding Network and is within 7 feet of a conductive surface that is part of the Isolated Bonding Network.

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

Ground Window - An imaginary, spherical area having a radius of 3 feet. This transition area contains, or is a portion of a bus bar that is the physical interface between the building’s common and isolated bonding network equipment.

Horizontal Equalizers – 1) Conductors of relatively low impedance that interconnect vertical risers in a building that is of a size that requires more than one vertical riser; 2) The grounding wire that extends from the ground reference (COG/OPGP) to equipment areas on the same floor.

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

Isolated Ground Plane - (See Isolated Bonding Network)

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

**Main Ground Bus (MGB)** - A bus bar located within the ground window that provides a physical means of connection between the CO GRD system and the isolated bonding network served by the ground window. Was previously called Ground Window Bar (GWB)

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

a) the connection point for all main grounding conductors and earth electrodes  
b) the point of origin for the Vertical Riser  
c) When convenient, the COG for the floor where it is located.

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

**Single Point Ground** - A method used to ground a circuit at only one physical point.

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

**Vertical Riser (VR)** - This conductor, also called the vertical equalizer, extends ground reference from the office’s primary ground bus to one or more other bus bars in the office. Note: The portion of this conductor that is routed horizontally between the office’s primary ground bus and the first connection to other bus bars in the office is also called the vertical riser.

### 2. GROUNDING SYSTEM CONDUCTORS AND CONNECTIONS

#### 2.1. General Requirements

2.1.1 All equipment shall be bonded to the appropriate grounding network before any other conductors are connected.

2.1.2 The Main Ground Bus (MGB) shall be within 1 floor of the isolated ground bonding network frames it serves.

2.1.3 All Common Bonding Network (CBN) grounding conductors shall be connected to the CBN side of the MGB. All Isolated Bonding Network (IBN) grounding conductors shall be connected to the IBN side of the MGB. See Figure H-5

2.1.4 Grounding conductor connections shall be made so that conductors are dressed in the direction of the main ground reference whenever possible. Increased conductor length and bending radius are more important considerations than the direction of connection. The direction of the bend shall be made for ease of installation and to maintain an acceptable bending radius.

2.1.5 Grounding conductors larger than #1/0 AWG shall be spliced or joined with compression-type H-tap.
2.1.6 Compression-type butt splice (i.e., 180 degree) connectors shall not be used.

2.1.7 The free ends of insulated conductors shall be covered with heat shrink end caps.

2.1.8 H-tap compression connectors on grounding conductors shall be protected using fire-retardant hard-shell or soft-shell covers.

2.1.9 All newly installed grounding conductors covered by this TP and that require insulation shall conform to the insulation colors shown in Table H-2 below. These color standards were first described in AT&T-NOTICE-000-000-415, dated March 20, 2002. Conversion of existing insulation colors purely for the sake of uniformity is not warranted.

<table>
<thead>
<tr>
<th>REGION</th>
<th>NON-RAISED FLOORS</th>
<th>RAISED FLOORS</th>
</tr>
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</tr>
<tr>
<td>AT&amp;T Southeast</td>
<td>Green</td>
<td>Green</td>
</tr>
</tbody>
</table>

2.2. Horizontal and Vertical Equalizers

2.2.1 All vertical and horizontal equalizer conductors shall be routed so that U shaped configurations are avoided.

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

2.2.3 Cable supports and sleeves provided for routing of horizontal and vertical equalizer conductors shall not be used for routing of any type of cable or conductor other than grounding conductors. Note: Horizontal equalizer conductors may be placed on the same cable brackets used to support other cables if secured to the opposite surface of the brackets.

2.2.4 Horizontal runs shall be supported along the exterior of cable rack stringers or from framing bars by means of clips or similar devices that do not form a closed metallic ring around the conductor. Short runs through walls shall be supported within 2" PVC plastic or other approved non-metallic conduit.

2.2.5 Vertical risers shall be run through floors in core-drilled holes or in 2" PVC plastic or other non-metallic conduit. If a cable hole is adjacent to the column supporting the vertical riser, the cable hole may be used in place of non-metallic conduit as long as a separation is maintained between the vertical riser and other conductors routed through the cable hole.
2.2.6 Vertical risers shall be secured to columns and walls using supports located within 2 feet of the floor, the ceiling, each side of any intervening bus bar, and at an interval of 2 feet (or less) between these points.

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

2.2.8 All cable connections to the vertical riser and horizontal equalizer shall be made with bends towards the COG/OPGP.

3. **AC EQUIPMENT GROUNDING**

3.1. **Feeder and Branch Circuit Equipment Grounding System**

3.1.1 For enclosures that require terminations of an Alternating Current Equipment Grounding (ACEG) conductor, the conductor shall be connected to the enclosure by one of the means listed below:

a) a ground bus bar  
b) a terminal strip  
c) a grounding bushing  
d) a grounding clip  
e) a screw fastener  
f) the enclosure is surface mounted and direct metal-to-metal contact exists between it and the receptacle's mounting yoke  
g) the receptacle is cover-mounted and the enclosure and cover combination are listed as providing satisfactory ground continuity between the enclosure and the receptacle

Note 1: Grounding clips are normally used only at junction boxes and receptacle enclosures.  
Note 2: A screw fastener (machine screw, nut, bolt, stud, etc.) shall be used for no other purpose than to terminate ACEG conductors.

3.1.2 For enclosures that do not require terminations (pull boxes, T's, etc.) and when ground continuity is maintained via the conduit and bonding type bushings and lock nuts, termination of the ACEG conductor shall not be required.

3.2. **Extending ACEG Conductors**

3.2.1 Since AC distribution systems are of different ages, it is likely that a system not originally equipped with a separate ACEG conductor will be encountered. It is often not feasible to place an ACEG conductor in the existing upstream feeder conduit or raceway. However, the conduit or raceway may be able to serve as the ACEG conductor. The point from which an ACEG conductor is extended will usually be an enclosure such as a:
a) Distribution panel
b) Pull box
c) Junction box
d) Receptacle box
e) Lighting fixture.

3.2.2 Before any AC distribution system is extended or rearranged from a point in a distribution system not equipped with a separate ACEG conductor, the integrity of the ACEG system upstream from the enclosure shall be verified. This is done by determining whether an acceptable type of conduit or raceway has been used and by verifying the tightness of the fitting(s) used to fasten the conduit or raceway to the enclosure.

3.2.3 For existing distribution systems not equipped with a separate ACEG conductor, only the following types of conduit or raceway shall serve as an ACEG conductor:
   a) Electrical metallic tubing (EMT)
   b) Intermediate metal conduit (IMC)
   c) Rigid metal conduit
   d) Metal raceways listed for grounding.

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

3.2.4 The ACEG conductors being added shall be terminated to the enclosure by one of the means described above.

3.2.5 If more than two ACEG conductors are being added (typically at a distribution panel), it is preferable to add a ground bus to the panel. This bus may be bonded to the panel using its mounting screws provided the paint is removed from the mounting surface of the panel and NO-OX-ID “A” anti-corrosive compound is applied to the bare metal.

4. COMMUNICATION SYSTEMS & MISCELLANEOUS EQUIPMENT

4.1. Frames, Bays, Cabinets and Units

4.1.1 All frames, bays, cabinets and units shall be properly grounded. Cabinets and relay racks shall be grounded to the aisle grounding conductor per Section K of this practice.

4.1.2 Cabinets with plated rails shall be assembled with one set (left/right) of vertical rails bonded to the cabinet using bonding conductors consisting of #6 AWG green wire and 2 hole connectors and the masked cabinet holes provided by the manufacturer for this purpose. The front and rear uprights are effectively bonded through bolted, plated shelf angles or strain relief bars provided by the manufacturer or OTV when required for equipment mounting requirements (see associated equipment standard drawings). If shelf angles are not used, all vertical rails should be bonded to the cabinet using bonding conductors consisting of #6 AWG green wire and 2 hole connectors. (Note: the equipment chassis mounted to both the front and rear rails IS NOT to be considered as the bonding conductor).
4.1.3 Cabinets with painted vertical rails shall be assembled with each set (left/right) of rails bonded to the cabinet using bonding conductors consisting of #6 AWG green wire and 2 hole connectors and the masked cabinet holes provided by the manufacturer for this purpose.

4.1.4 When a unit in a frame, cabinet or other enclosure requires a separate grounding conductor from the unit, the grounding conductor shall be extended from the unit to one or more of the following:
   a) A crimp type parallel tap to a grounding conductor of equivalent or larger size within the enclosure
   b) The same point of connection on the enclosure metalwork as the framework grounding conductor if of equivalent or larger size
   c) A grounding terminal (wire-wrap, solder, etc.) within the frame or cabinet
   d) A crimp type parallel tap to a grounding conductor of equivalent or larger size outside the enclosure.

4.1.5 The 1” galvanized pipe often used as a means of support between the framework and the auxiliary framing may be used as the lineup grounding conductor for the extension of existing applications only. This method is not allowed for new lineups.

4.1.6 The external chassis ground, if provided on a unit, shall be utilized to ground the unit, except where AT&T standard drawing indicates that the chassis ground connection is not required. If the AT&T standard drawing indicates that a chassis ground is not required, a copy of the drawing shall be left in the job folder.

4.1.7 Frame extensions shall be bonded to the existing frame via the threaded nut and bolt assemblies connecting the two sections. When frame extensions are provisioned with a #6AWG bond, this bond shall also be used.

4.1.8 BDFBs with an insulated or external battery return bus bar shall be grounded with a #1/0 AWG conductor from the framework to the horizontal equalizer or CO ground bar, whichever is closest.

4.1.9 BDFBs with non-insulated battery return bus bar shall be grounded with a 750kcmil conductor from the return bus bar to the horizontal equalizer or CO ground bar, whichever is closest.

4.1.10 A minimum #2/0 AWG main aisle conductor shall be used between the CO GRD bus bar and an area containing a group of bays or miscellaneous units, or an area with more than one lineup of equipment. The #2/0 AWG conductor shall originate at an OPGP or CO GRD bus bar, or from another horizontal equalizer of equal or larger size. Separate #2 AWG conductors serving only one side of an aisle, shall then be branched from this conductor to serve an equipment lineup or individual equipment units. In existing installations, #6 AWG aisle ground conductors shall have a maximum length of 50 feet.

4.2. Conduits, Raceways, and Other Bonds to the MGB/GWB

4.2.1 The Main Ground Bus (MGB) shall be within 1 floor of the isolated ground plane frames it serves.

4.2.2 All Common Bonding Network (CBN) grounding conductors shall be connected to the CBN side of the MGB. All Isolated Bonding Network (IBN) grounding conductors shall be connected to the IBN side of the MGB.

4.2.3 Metallic conduits and raceways containing AC circuits serving isolated bonding network equipment shall be routed near the MGB and bonded to the CBN side of the MGB/GWB. The ACEG conductor in the conduit shall also be bonded to the CBN side of the MGB/GWB.
4.2.4 The bond to the MGB/GWB shall be made using a minimum #6 AWG conductor no more than three feet in length. Figure H-3 shows one possible method to bond the conduit and ACEG conductors to the MGB/GWB. A mechanical connector may be used to create a collection point to provide a means to bond ACEG conductors, conduit, raceway and junction box (if used) and the #6 AWG bond to the MGB/GWB.

4.2.5 After bonding to the MGB, conduit within the IBN network may contact isolated bonding network metalwork, but it shall remain insulated from contact with members of the common bonding network.

4.2.6 All metallic conduits and raceways containing AC circuit conductors shall be intentionally bonded together to form an electrically continuous enclosure. Insulating bushings, non-conductive unions, or any similar material or methods shall not be used in metallic conduits or raceways to interrupt their continuity.

4.2.7 Every conductor with continuity to both the common bonding network and the isolated bonding network, such as the shield of a coaxial cable, shall pass through the ground window and be bonded to the MGB/GWB with a conductor no longer than 3 feet.

4.2.8 The MGB may be mounted on cable rack, a column, a wall or any other location that provides adequate cable access.
   a) The hardware securing the MGB shall provide electrical insulation from any metallic object to which it is mounted.
   b) A #6 AWG bonding lead shall be installed between the MGB and any metallic object to which it is mounted.

4.2.9 All components of an isolated bonding network equipment system shall be referenced (connected) to ground only via the MGB.

4.2.10 When the battery return bus bar of the power plant consists of one or more straight sections of bus bar longer than six feet, the MGB may be established at any point along the bus bar.
   a) Battery return conductors serving common bonding network loads shall be terminated on the battery return bus bar within the boundaries of the MGB.
   b) Battery return conductors for isolated bonding network loads shall be terminated on the remaining portion(s) of the battery return bus bar.

4.3. **Isolated Bonding Network Tests**

4.3.1 Each frame or group of frames in the isolated bonding network shall have isolation tests performed in accordance with manufacturer’s instructions.

4.3.2 It is an objective that at the completion of new switch (or other IBN equipment) installations, no more than 1 ampere of AC or DC current shall flow on any grounding conductor from IBN equipment as measured at the MGB termination.
   a) The installer shall use a clamp-on ammeter to measure the DC and AC amperage on the lead(s) from the equipment Isolated Bonding Network (IBN) to the isolated connection at the MGB. The installer shall record this reading on a Test Record Form and place a copy in the job folder.
b) The vendor shall take corrective action to reduce readings greater than 1 ampere before the equipment is turned over to AT&T unless AT&T approves the higher value.

c) For existing IBN installations, it is recognized that ongoing equipment installation and removal activity by others may cause undetected grounding violations. These grounding violations could cause current flow on conductors between the IBN equipment frames and the MGB to exceed the 1 ampere requirement established for new installations. Accordingly, at the start and completion of all growth additions or modifications involving IBN equipment (i.e. frame, bay, shelf, and circuit pack) the vendor shall measure the AC and DC current on all grounding conductors connected from IBN equipment frames to the MGB. Depending on the manufacturer and size of the IBN installation, there may be multiple conductors.

d) These measurement(s), along with date and time, shall be recorded on a test record at both the beginning and end of the job with the recorded values also given to AT&T. A copy of this test record shall be filed in the job folder. It is recommended that this requirement be made part of the local Method of Procedure (MOP) that describes how this work will be completed.

e) There shall be no change between the current measurements before and after the job completion. This will verify the IBN equipment supplier did not create grounding violations as part of the installation activity. It is recognized that there may be subtle variations in the current measurements due to Carrier Communications Space traffic conditions that exist at the time the job-beginning and job-ending measurements are taken. Therefore, the beginning and ending current measurements may be different but the ending reading shall not increase by more than 5% from the beginning reading.

f) Depending on the beginning and ending current measurements, a variety of actions may be appropriate. A summary of conditions and suggested actions appear in Table H-3 below.

<table>
<thead>
<tr>
<th>CONDITION</th>
<th>SUGGESTED ACTION</th>
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<tr>
<td>Beginning reading &lt; 1 ampere</td>
<td>Proceed with job installation</td>
</tr>
<tr>
<td>Ending reading &lt; 1 ampere</td>
<td>Proceed with job close out</td>
</tr>
<tr>
<td>Beginning reading &gt;1 &amp; &lt; 10 amperes</td>
<td>Proceed with job installation.</td>
</tr>
<tr>
<td>Ending reading &gt;1 &amp; &lt; 10 amperes and within 5% of beginning reading</td>
<td>Proceed with job close out</td>
</tr>
<tr>
<td>Ending reading &gt;1 &amp; &lt; 10 amperes and greater than 5% of beginning reading</td>
<td>Vendor shall take corrective action¹</td>
</tr>
<tr>
<td>Beginning reading &gt; 10 amperes</td>
<td>AT&amp;T to take corrective action¹²</td>
</tr>
<tr>
<td>Ending reading &gt; 10 amperes</td>
<td>Vendor shall take corrective action¹</td>
</tr>
</tbody>
</table>

¹ Corrective action includes investigation and modification of facilities as necessary to reduce the beginning current readings to 10 amperes or below or to reduce the ending current readings to within 5% of the beginning reading.
2. It is an AT&T objective that the timing of growth additions occurs such that the jobs are completed and ready for service at the same time the additional capacity and/or capabilities are needed. If AT&T were to take action to correct bonding and grounding problems and this action caused a delay in the start and completion of the growth addition, this corrective action could prove counter productive. It is therefore advisable that AT&T personnel take preliminary current measurements approximately 3-6 months in advance of the job start in order to correct known problems in advance of the scheduled job start.

4.4. **Insulation for Isolated Bonding Network Equipment**

4.4.1 Insulating material shall be installed between a metallic object that is part of the isolated bonding network and material securing or fastening it to a metallic object that is part of the common bonding network.

4.4.2 Any metal detail extended above isolated bonding network equipment to support an object that is part of the common bonding network shall use insulation material to maintain separation between the two bonding networks.

4.4.3 Conduits that are part of an isolated bonding network shall be insulated from contact with common bonding network objects using two wraps of sheet fiber or bus bar insulators placed at all contact points.

4.5. **Foreign Object Bonds**

4.5.1 Common Bonding Network conductive apparatus located within 7 feet of the Isolated Bonding Network shall be bonded to the MGB/GWB with a No. 6 AWG conductor. Other large conductive objects (not associated with any network) that personnel may contact during their normal work activities while still in contact with an IBN device shall be bonded to the MGB/GWB. The CBN conductive apparatus and objects that shall be bonded include:

a) **Equipment Frames** – One No. 6 AWG is C-tapped or H-tapped to the lineup ground cable over each lineup of frames that are within 7 feet.

b) **Metallic stands, cabinets and desks** - Freestanding items placed in fixed locations such as metallic stands, desks and cabinets shall require bonding. Cabinets that are anchored to the walls or floor shall be bonded as well as all metallic spare circuit pack cabinets.

c) **Ironwork** - Auxiliary framing, cable rack, threaded rods, stanchions, cable hole hardware, and other metallic supports and details shall be considered one unit; therefore, only one bond to the ironwork is required. This bond shall be in a central location over the switch. In the event that different levels of auxiliary framing or cable rack are not interconnected by threaded rod or other metallic details over the isolated ground plane area, each level will be considered a separate unit and will require individual ironwork bonds.

d) **Lighting fixtures** - Lighting fixtures and the associated conduit are considered one unit and, therefore, only one bond to a lighting fixture is required.

e) **Air ducts** - When air ducts are separated by nonmetallic fittings, each section of duct shall be bonded; otherwise, the entire duct system will be considered one unit and only one bond is required.
f) **Metallic raceway or conduit** - This includes conduit providing AC to building equipment and/or IBN equipment areas, and conduit used to run alarm wiring. Each conduit run shall be bonded only once. Two-hole grounding lugs shall be used by installing the Burndy-type GAR-TC Ground Connector, or installing two conduit clamps (refer to Figure K5). If several conduit runs are mechanically connected together, such as at the power distribution cabinet, a conduit box, or via conduit clamps secured to a unistrut support, only the cabinet, box or support requires the bonding connection, not the individual conduit runs.

g) **Building fixtures** - Large volume conductive objects such as air-conditioning units, AC power distribution cabinets, water coolers, water pipes, radiators, door frames and window frames shall be bonded. Doors and doorframes are considered one unit and do not require individual bonds. Pipes shall be grounded per figure K-5. Small items that are not normally touched by personnel or that are generally considered portable do not require bonding. This includes fire extinguishers and holders, light switch and outlet receptacle cover plates, wastepaper baskets, desk lamps, Venetian blinds, signs, dropped ceiling supports, etc.

4.5.2 Based on the specific building configuration and the number of foreign objects that require bonding, one or a combination of the following methods shall be used to accomplish the bonding of foreign objects. For all applications, "daisy chain" connections shall **not** be used:

a) **Collection Bus Bar** - When there are a number of foreign objects to be bonded, a collection bus bar can be used to gather the # 6AWG conductors from the foreign objects. A # 6AWG conductor shall also be used to connect the collection bar to the ground window. This method helps to minimize the number of terminations on the MGB/GWB. See Figure H-1.

b) **Collection Conductor** - This method is similar to the collection bus bar above except a # 6AWG collection conductor will be used to gather the # 6AWG conductors from multiple foreign objects. Each conductor from the foreign objects shall be connected to the collection conductor using compression C-tap or H-tap connectors. The collection conductor can then be terminated on a collection bus bar or directly on the MGB/GWB. See Figure H-2.

c) **Direct Connection** - When there are a limited number of foreign objects to be bonded, a direct connection can be made between the foreign object and the MGB/GWB using a # 6AWG conductor.

5. **RADIO SITES AND EQUIPMENT**

5.1. **Interior Ring Ground System**

5.1.1 The peripheral conductor (also referred to as the "interior ring" or "halo ground") need not be installed as a single continuous conductor. Unnecessary splices shall be avoided, but when installation is simplified by installing the peripheral conductor in segments, and segments are joined by an exothermic weld (preferred) or crimp type parallel connector, such segmentation is permitted.

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

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

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

5.1.5 The peripheral conductor shall be located at a height from the floor that allows for convenient bonding of supplementary conductors. For 9'-0" frames, the recommended height is 9'-8".

5.1.6 Supports shall be provided at an interval of between 12 and 18 inches. Extra supports may be provided where the peripheral conductor may be distorted, such as at bonding points. When the peripheral conductor is not located on a wall, it shall be supported from cable racks or auxiliary framing channels.

5.1.7 Supplementary conductors may be supported from cable rack stringers or framing channels using 9-ply waxed polyester twine, cable ties, clamps or clips. If clamp or clip supports are used, a type that does not require drilling of channels and stringers is preferred. All supports shall be placed at an interval of 12 to 18 inches. Removal of paint from the channel or stringer is not required when clamps or clips are used. Scratches in the finish shall not be painted, and clamps or clips shall not be painted. A job-fashioned detail may be used to route the conductor around obstructions at cable rack junctions or other points interfering with the conductor.

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

5.1.9 When there is no significant difference in the length of the bond paths to a hatch plate from either end of a supplementary conductor, both ends shall turn in the direction of the hatch plate. When the building is equipped with more than one equipped hatch plate, the end of the supplementary conductor shall turn in the direction of the nearest hatch plate.

5.1.10 If one or more hatch plates are not equipped with waveguides, the supplementary conductor shall turn in the direction of the nearest equipped hatch plate. When coax or waveguide is added to the unequipped hatch plate, a second bond shall be made at the turn, in the opposite direction, to create a bi-directional turn. Note: Where doubt exists as to the correct direction for a turn, a bi-directional arrangement may be used. Universal application of bi-directional bonds is not recommended.

5.2. Unit Bonds

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

5.2.2 Bends shall be made with the greatest practical radius. The bend radius shall not be less than 1 foot.

5.2.3 Where unit bond conductors join peripheral or supplementary conductors, they shall turn in the direction of the nearest hatch plate. A single conductor connecting two units to a peripheral or supplementary conductor may be used without regard to the direction of turns.

6. POWER PLANT GROUNDING

6.1. Frames, Cabinets and other Components

6.1.1 All frames, cabinets and other components of a power plant shall be equipped with a minimum #6 AWG to the CO GRD System. This includes frames in a power board line up, rectifier bays, metal battery stands, etc.

6.2. Grounding Conductor

6.2.1 The power plant line up conductor shall be sized to accommodate the maximum expected primary distribution. For 600A distribution, the power plant line up conductor shall be a #1/0 AWG minimum and shall be connected to the nearest:
   a) DC System Grounding Conductor (when MGB is part of the power plant battery return)
   b) MGB (when MGB is part of the power plant battery return)
   c) Horizontal Equalizer of equal or greater size
   d) CO GRD or OPGP bus bar DCEG conductors for power plant frames, cabinets and other equipment shall be branched from a power plant lineup conductor. A typical power area grounding arrangement is shown in Figure H-4.

6.2.2 The DC system Grounding Conductor extends from the battery return bus bar to the CO GRD (or OPGP) for all power plants except shared power plants with a remote MGB. The default size for plants over 1200 amps shall be a 750 kcmil conductor. Its minimum size shall be based on the maximum plant capacity specified by the manufacturer.

<table>
<thead>
<tr>
<th>Power Plant Capacity (Amperes)</th>
<th>Minimum Size of System Grounding Conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 200</td>
<td>6 AWG</td>
</tr>
<tr>
<td>201 – 500</td>
<td>2 AWG</td>
</tr>
<tr>
<td>501 – 1199</td>
<td>4/0 AWG</td>
</tr>
<tr>
<td>1200 +</td>
<td>750 kcmil</td>
</tr>
</tbody>
</table>

6.2.3 For any equipment frame, cabinet or other enclosure containing rectifiers, the minimum size for a DCEG conductor shall be #6 AWG. Table H-4 below shall be used to determine the size of the framework ground conductor based on the size of the output rating of the largest rectifier in
the framework. The current limiting or over-current protection feature of rectifiers may not activate until 110% of the rated current output is reached. For example, a 400-ampere rectifier may not shut down until reaching 440 amperes. The conductor size in Table H-4 is based on Table 250-122 from the NEC.

<table>
<thead>
<tr>
<th>Rectifier Output / Inverter Input Rating (DC Amperes)</th>
<th>Rectifier Current Limit (DC Amperes)</th>
<th>DCEG Conductor Size:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 100</td>
<td>Up to 110</td>
<td>6 AWG</td>
</tr>
<tr>
<td>200</td>
<td>220</td>
<td>4 AWG</td>
</tr>
<tr>
<td>400</td>
<td>440</td>
<td>2 AWG</td>
</tr>
</tbody>
</table>

6.2.4 The DCEG conductor for any DC-to-AC inverter shall be a minimum #6 AWG.

   a) Table H-4 shall be used to determine the minimum size for the DCEG conductor based on the rating or setting of the DC input circuit's over current protective device. This requirement applies to all stand-alone inverters and to all bay-mounted inverters. This DCEG conductor is required in addition to the ACEG conductor for the AC input and/or output circuits.

   b) If the inverter is the source of a separately derived system, this conductor shall be required in addition to the Grounding Electrode Conductor.

6.2.5 Power Plants shall be grounded per Figure H-4.
Note: Figure H-1 applies only to Common Bonding Network equipment that is located within 7’ of Isolated Bonding Network equipment. The Foreign Object bond lands on the IBN MGB, is in addition to the equipment frame bond to the CBN.
FIGURE H-2 - Using a Collection Conductor to Bond Foreign Objects

Note: Figure H-2 applies only to Common Bonding Network equipment that is located within 7' of Isolated Bonding Network equipment. The Foreign Object bond lands on the IBN MGB, is in addition to the equipment frame bond to the CBN.
FIGURE H-3 - BONDING OF CONDUIT AND ACEG CONDUCTORS TO MGB/GWB

From AC distribution panel in the Common Bonding Network

#6 AWG

To loads in the Isolated Bonding Network

ACEG conductors

#6 AWG to MGB/GWB

Phase & Neutral Conductors
Figure H-4 Typical Power Plant Grounding Arrangement

- **A** - 750 kcmil
- **B** - #1/0 AWG
- **C** - #2 AWG
- **D** - #4 AWG
- **E** - #6 AWG

**Grounding Conductors**

- When MGB is part of the power plant battery return:
  - a) DC System Grounding Conductor
  - b) MGB
  - c) Horizontal Equalizer of equal or greater size
  - d) CO GRD or OPGP bus bar

**Additional Elements**

- Battery Stand A
- Battery Stand B
- Digital Switch / Transport
- Power Plant IBN / CBN Loads
- Vertical Equalizer
- Horizontal Equalizer
- Direct to COG
- 400 A Rectifiers
- 200 A Rectifiers
- DC System Grounding Conductor
- 600 A Distribution
- Insulated Bus Bar
- Control and Distribution
Sequencing of Conductors along an MGB that is Part of a Power Plant's Battery Return Bus

Figure H-5

- **Battery Return Busbar Above Power Plant**
- **Logic Ground Conductor from Isolated Bonding Network Loads**
- **Framework Ground Conductor from Isolated Bonding Network**
- **Framework Ground Conductor from Isolated Bonding Network Adjacent Floor**
- **CO GRD or OPGP Bus Bar**
- **Power Plant Framework Ground Conductor**
- **Protector Frame Ground Conductor**
- **Foreign Objects**
- **Return Conductors from Battery +**
- **Ground Window**
- **Return Conductors from Common Bonding Network Loads**