

PROTECTIVE GROUNDING SYSTEMS
EQUIPMENT GROUND SYSTEM, CENTRAL OFFICES
GENERAL INTERFACE REQUIREMENTS FOR ELECTRONIC SWITCHING SYSTEMS
POWER SYSTEMS

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1. SCOPE

1.01 This section comprises:

- (a) A summary of the general characteristics of the isolated ground plane used with the No. 1 ESS electronic switching system.
- (b) General instructions for integrating an isolated ground plane with the various grounding systems that comprise the building integrated ground plane.

1.02 Reasons For Reissue

This section is reissued to make changes and additions as follows:

- (a) To add grounding requirements for the No.4 ESS Switching System.
- (b) To add information on establishing a ground window in locations other than above a PD frame.
- (c) To change the size of the bond that connects the ESS ground plane to the integrated ground plane from a No. 0 AWG to a 750,000 CM copper conductor and eliminate intermediate ground bus. Add supplementary ground bus.
- (d) To add reference that the MDF need not be part of the isolated ground plane.
- (e) To add reference concerning location of and routing of ac circuits for frame receptacles.
- (f) To delete reference to bus duct used to distribute power to lighting equipment.

- (g) To add grounding information concerning dc powered emergency lights.
- (h) To change information concerning grounding of protector frames.
- (j) To change reference to the size of the ground conductor between sheaths in the cable vault and the protector frame from No. 00 to No. 0.
- (k) To add reference to mechanical arrangements of sheath bonding.
- (l) To change information concerning provision of discharge ground leads between foreign ground systems and the main ground bus, in recognition of the change in size of the ESS ground bond per (c) above.
- (m) To delete information on provision of separate ESS ground bonds of lesser size than 750,000 CM to different ESS office having individual ground windows and power plants.
- (n) To delete reference to need for job analysis authorization for power sharing between different types of ESS offices.
- (p) To delete reference to need for job analysis authorization for provision of power to non-ESS equipment from an ESS dedicated plant.
- (q) To define that only the ground conductor of a circuit serving non-ESS equipment need be run to the ground window before connection to load equipment.
- (r) To add information that dc power feeders serving non-ESS electronic type equipment located within the ESS ground plane need not be routed through the ground window.
- (s) To add recommendations for spacing to be maintained between ESS and non-ESS electronic and electromechanical equipment.
- (t) To add information that discharge ground conductors routed to the ground window may be multiplied and tapped to the Main Ground bus with a single bond wire.
- (u) To add instructions to equalize voltage drop on power feeders serving non-ESS equipment.

- (v) Fig. 1, 2, 5—Intermediate ground bus removed. Lead B1 extended to Main Ground bus and changed to 750,000 CM. Supplementary ground bus added.
- (w) Fig. 5—Changed to agree with changes in requirements to ground the protector frame.
- (x) Fig. 5—No. 0 cable sheath ground was No. 00.
- (y) Fig. 6 added.
- (z) To make miscellaneous editorial changes.

1.03 The primary purpose of summarizing the No. 1 ESS system isolated grounding arrangement is to promote an understanding of the general principles involved in establishing an effective isolated ground system for electronic systems. The information is developed from requirements expressed in No. 1 ESS specifications. The requirements of other electronic systems are identical in principle and, generally, physically similar to the No. 1 ESS application.

1.04 General requirements for interfacing the isolated ground plane with other grounded objects in proximity to the isolated plane are referred to briefly in electronic system specifications. Methods of bonding or ensuring isolation that will result in least hazard to personnel and equipment are described herein and shall be employed as required to satisfy the requirements.

1.05 Requirement to provide an ac equipment ground conductor with branch circuits serving fluorescent lighting fixtures, specified herein, is a lighting system design requirement. Refer to Section 802-001-198 for information pertaining to ac equipment grounding of lighting distribution systems.

1.06 This section is supplementary to Section 802-001-192, Equipment Ground System, Central Offices. Other sections devoted to interface requirements for individual communication systems installed in central offices are listed in Section 802-001-192, SCOPE.

2. GENERAL

2.01 The No. 1 Electronic Switching System (No. 1 ESS) is one of a growing number of

communication systems that utilize solid state devices and printed wiring board circuitry to perform control and switching functions. These systems are categorized as "electronic" or "electronic switching" systems. Other systems, those that utilize magnetically operated relays and similar devices dependent on physical movement of metal contacts to effect control and switching, are generally defined as "electromechanical" systems. The No. 5 Crossbar System is typical. Generally, all systems introduced prior to No. 1 ESS (and the No. 101 ESS PBX) are electromechanical systems, and systems introduced since then are, to some extent, electronic systems. The No. 2 ESS, No. 3 ESS, TSPS, AIS and ETS systems are typical electronic systems.

2.02 Electromechanical devices are relatively immune to damage from voltage disturbances imposed on the circuitry or communication systems by switching transients, lightning strokes, and other surge producing conditions. Solid state devices may be destroyed by voltage spikes that exceed their relatively low breakdown voltage ratings. Printed wiring boards, normally manufactured with minimal space between conductive components, may be damaged by current spark-over when voltage disturbance creates an abnormal differential between closely coupled but insulated conductive paths therein. Memory devices can be falsely activated by inductive coupling between circuit paths. Ground reference, which may be used to recognize control voltage levels, may be forced to different levels in different areas of a ground plane when excessive current surges through it. These, and other idiosyncrasies of the electronic systems, normally not significant factors in electromechanical systems, require that a variety of unique conditions be employed to isolate the electronic system from voltage disturbances.

3. ELECTRONIC OFFICE GROUNDING FEATURES

3.01 An electronic system utilizes features as follows:

- (a) Isolated ground plane
- (b) Dedicated dc power plants
- (c) Single point ground reference.

3.02 In any building that houses communication equipment, a ground plane exists throughout

the structure. Continuity is extended by deliberate bonding, such as provided by conduit and ac equipment ground conductors of the ac distribution system, and the office CO GRD system conductors. Other paths occur through structural steel, water piping, air ducts, superstructure, cable racks, and other building metal. These various conductors are either deliberately or incidentally interbonded to form an integrated ground plane connected via a number of deliberate electrode connections or incidental current paths to earth. During fault occurrences in the ac or dc power networks, a large amount of current can be imposed on the ground plane. Lightning strokes on the building, or on ac conductors or telephone cable serving the building, can cause tremendous surges of current through the integrated ground plane. This current, if allowed to flow through the ground plane of an electronic system, could produce stresses that would cause malfunctions, damage, or destruction of components.

3.03 The method employed to eliminate stray currents generated outside the electronic system from coursing through members of the electronic system ground plane is to isolate that ground plane from any contact with the integrated ground plane except for a single point.

3.04 The ground system used with the 2-wire No. 1 ESS system is generally typical for that employed in all the electronic systems. The following information is based on the requirements and physical arrangement of the No. 1 ESS system. Physically, other electronic systems may be similar or drastically different. The same principles of isolation as those outlined below, however, are used in their ground planes.

4. THE NO. 1 ESS GROUND SYSTEM

4.01 The isolated ground plane is established by bonding equipment frames, power distribution frames, main distribution frames, and cable racks into an electrically interconductive unit which is insulated from contact with any other grounded metal work in the building, except for a single point of interconnection.

4.02 Dedicated 24- and 48-volt power plants are provided to supply dc power to the system circuits. These plants are dedicated to serve equipment associated with one isolated ground plane only. The plants differ from general purpose

plants in that they do not employ emergency cells or CEMF cells. This avoids possible damage caused by electrical disturbances resulting from switch operations. The discharge ground bus bars of these plants are insulated from plant framework to eliminate contact of the discharge system with any ground source except that of the isolated ground plane. The 111A and 326A code plants are typical.

4.03 The electronic office ground system requires ground reference. A single point system which eliminates the possibility of transient current flow through the electronic office ground plane from sources outside the electronic system is established by means of a "ground window".

A. Ground Window

4.04 "Ground Window" (Fig. 1) is defined as a spherical zone extending to a radius of approximately 3 feet from the midpoint of the "Main Ground" bus. The 3-foot radius is derived from a restriction on length of bonds to conduit entering the ESS area to 3 feet. The "Main Ground Bus" usually (see 4.09) is the ground bar of a group of bars (24V, 48V, ground) located above one power distribution (PD) frame selected as "ESS Point Ground". This PD is usually the one nearest the office miscellaneous power (MP) frame. Groups of bars are located on power cable rack above PD frames to function as a junction for 24V, 48V and ground conductors from the power plant and drop feeders into PD frames. The main ground bus bar is bonded to a CO GRD bus bar on the same floor, or when the building is not equipped with a CO GRD system, to the office principal ground point (ie, waterpipe) to establish a single point ground reference for the ESS ground plane. The discharge ground conductors connecting to the main ground bus bar extend ESS ground reference to batteries. Horizontal equalizer bonds are provided between the main ground bus bar and the ground bus bars of other bus bar groups serving other PD frames, to extend ESS ground throughout the ESS frame area and equalize ground potential between ground buses.

4.05 Fig. 2 illustrates the maximum number of floors over which one or more ESS type offices served by a common dc power plant may be located. It also shows the method of bonding used to form a common ground plane that is isolated from the integrated ground plane except for a

single bond connection to the CO GRD bus on the center floor.

4.06 The following restrictions are necessary to protect ESS solid state components and printed wiring boards from possible damage in case of a lightning stroke on the building or other voltage disturbances originating outside the equipment area served by the ESS ground plane:

- (a) Only one ground window may be utilized with a single isolated ground plane.
- (b) Under no circumstance shall any electronic system framework that comprises a portion of the ESS ground plane be more than one floor away from the ground window.

4.07 These restrictions limit the spread of ESS equipment to a maximum of three adjacent floors when the ground window is established on the middle floor. As shown in Fig. 2, ESS ground reference is extended between floors only by means of a 750,000 CM ESS vertical equalizer conductor. There is no continuity, except through the ground window between the ESS ground plane and the integrated ground plane on the upper or lower ESS floors. On the middle floor, only one bond, shown as a 750,000 CM wire connecting the CO GRD bus to the main ground bus, connects the ESS ground plane to the integrated ground plane.

4.08 The single point connection integrates the ESS ground plane with the integrated plane for the purpose of equalizing voltage between the otherwise isolated planes. The single point restricts current generated by a lightning stroke on the building from flowing through ESS frame members to earth. Additionally, current spikes generated by equipment operation or malfunction in systems that are not connected to the ESS ground plane cannot course through that plane since at least two connections are required to complete a circuit.

4.09 The ground window may be located in a position other than that described in 4.04. In a single floor ESS layout it may be expedient to establish the window in a position that would facilitate routing of conduits or power ground feeders that must pass through the window. In multifloor installations the ground window must be established on the middle floor. Often the middle floor is not equipped with a PD frame, therefore, a separate main ground bus is required. The main

ground bus should be located in the ESS area, which in a 3-floor installation may be presumed to include any point on the middle floor that intervenes between upper and lower floor ESS installations. The bus should be of a design similar to that used in the Fig. 1 application. It may be mounted on cable rack, framing channels, a column or a wall or other position accessible for cabling. It need not be insulated from other metal objects (cable rack, etc) but may be, if expedient. The ground window should **not** be located in a position remote from the ESS area.

4.10 In a single floor ESS installation it may be expedient to supply dc power to PD frames from below through nonmetallic sleeves in the floor. Battery and ground bus bars are assembled similar to that shown in Fig. 1 at the ceiling of the floor below the ESS system, under the PD frames. A ground bar at one of these assemblies may be utilized as a main ground bus or a separate bus in the area under the ESS system may be provided to establish a ground window. It should be noted that conduits serving the ESS equipment must be grounded in the ground window before extension through the floor to the ESS equipment.

4.11 When a separate main ground bus is used it shall be connected to a ground bus at the nearest PD frame with a 750,000 CM conductor. This bus need not be included in the horizontal equalizer network described in 6.02.

4.12 If space for termination of ground leads on the main ground bus has been exhausted, a supplementary ground bus may be installed. This bus shall be located within 3 feet of the main ground bus and shall be connected to it with a 750,000 CM conductor. Any ground leads that normally would be connected to the main ground bus may be terminated on the supplementary ground bus. A supplementary ground bus should not be used unless necessary.

B. Insulation

4.13 Isolation of No. 1 ESS equipment is accomplished by the use of insulators between points where metal work common to the integrated plane must be fastened to metal work common to the ESS plane. Such points include:

- (a) **Anchor bolts.** ESS frame anchor bolts may touch grounded structural metal in a

floor. An insulator separates bolt heads from frame metal.

(b) **Bottom of frames.** A sheet of insulating material is placed between frames and floor.

(c) **Superstructure supports.** Brackets extended above frames support unistrut channels that, in turn, support fluorescent lighting fixtures, conduits, and power cable racks that are part of the integrated ground plane. Insulators placed on top of the support brackets isolate the ESS plane.

(d) **Conduits.** Conduits connected to ESS ground plane equipment and supported from unistrut lighting support channels are insulated by means of fiber sheeting wrapped around the conduit at points of support.

4.14 This method of isolation is effective only for levels of voltage differential that do not exceed the spark-over withstanding ability of the insulating material. During a lightning stroke on a building, a high difference of potential will be developed between the top of the building and ground. The integrated ground plane, through bonding between building metal and the CO GRD system, nonisolated equipment frames and other metal objects, will maintain an effectively equal potential throughout any one floor but a difference of potential will exist between floors. A minimal difference will occur between adjacent floors.

4.15 Since the ESS ground plane is connected to the integrated ground plane at a single point, the instantaneous voltage impressed on the integrated plane of the floor level at which the connection is made is the voltage impressed on the entire isolated plane. If part of the isolated plane is located on another floor, the integrated plane of that floor will receive its reference through horizontal bonding at that level and a difference of potential will exist between the integrated and isolated planes. If the difference is great enough, spark-over can occur across insulated points, allowing current to surge through the isolated plane.

4.16 Optimum protection would be achieved if the entire ESS installation were confined to one floor. In large installations this is physically impractical; therefore, a practical limit that restricts location of any part of an isolated plane (except for power plant and certain units designed for

remote locations) to no more than one floor from the single point connection to integrated ground (ground window) is imposed. This limit should never be exceeded.

C. Power Plant Location

4.17 For maximum protection of personnel and power equipment from lightning surges, the ideal location of the power plant equipment is as close as practical to the ground window, preferably on the same floor. In existing buildings, space restrictions or floor loading limits may require location of the power plant several floors away from the ground window. Power plant batteries and discharge ground components obtain voltage reference from the floor containing the ground window. Plant framework, battery stands, and other metalwork are part of the integrated plane. This can result in momentary high voltage differential between discharge ground components and frame metal, relative to the distance between floors. While this constitutes a greater hazard to personnel than if the power plant were restricted to no more than one floor away from the ground window, personnel are not normally in contact with discharge ground components. Insulators used to isolate the discharge ground bus bar from frame metal are superior to insulators used in the ESS frame area, which minimizes possibility of spark-over even though differentials are greater. For these reasons, location of ESS dedicated power plants on floors other than those within one floor level of the ground window is acceptable.

D. Typical Bonds From The Main Ground Bus

4.18 The main ground bus in the ground window serves as the interface point between the ESS isolated ground plane and the building integrated plane. In addition to a connection to the floor CO GRD bus, direct bonds of minimal practical length are required from the main ground bus to points on different objects comprising a part of the integrated ground plane ("foreign" ground objects). Use of such bonds ensure that voltage difference between members of the two planes will be equalized to the greatest possible extent. Such equalization tends to reduce the incident of spark-over between the two planes and possibility of shock hazard to personnel interposed between the planes. Normally, direct bonds also are required between the foreign ground objects and the CO GRD bus, to provide a direct path for discharge of current to earth.

4.19 In a typical No. 1 ESS installation the main ground bus is bonded directly to:

- (a) The floor CO GRD bus (see Fig. 1, 2).
- (b) Discharge ground bus bars at PD frames (see Fig. 1, 2).
- (c) Protector frame (when on same floor as ground window. Otherwise protector frame is bonded to CO GRD bus. See Fig. 2).
- (d) Lighting system (not shown in Fig. 2. See Fig. 1).
- (e) AC service conduit and equipment ground conductors (See Fig. 1, 2).
- (f) Foreign ground objects in vicinity of ESS equipment (See Fig. 1).
- (g) Ground conductors of power supplies to non-ESS system equipment.

5. CONNECTION TO THE CO GRD BUS

5.01 Connection between the Main Ground bus and the CO GRD bus is made with a 750,000 CM type RHW stranded copper conductor.

5.02 It is advantageous to keep the interbonding conductor at a minimum length. Where practical, the CO GRD bus and the main ground bus should be located close together. It is recognized that this cannot always be achieved; therefore, no restriction is specified for the length of the conductor.

5.03 In offices not equipped with a CO GRD system, a CO GRD system shall be installed where expedient. Otherwise, the 750,000 CM conductor must be run directly to the office principal ground point. When run directly and the principal ground point is more than one floor away from the ground window location, in buildings that have reliable ground continuity between the top and bottom of the building (steel frame construction or wire-wrapped reinforced concrete construction), the main ground bus shall also be bonded to building steel. In buildings not known to have continuity to ground through building structural steel, a bond should be provided on the floor to a cold water pipe that is known to be a low impedance path to the principal ground point. The conductor shall

be No. 0 AWG. The bond point on building steel or water pipe shall be on the same floor as the main ground bus and the run length shall be as short as practical. The function of this conductor is to equalize potential between integrated and isolated ground plane components on the same floor. See Section 802-001-192, Part 4 for information on CO GRD vertical risers.

6. NO. 1 ESS INTERNAL GROUND BONDING

6.01 The bonding arrangement within the isolated ground plane consists of three principal components:

- (a) A horizontal equalizer network
- (b) A framework ground network
- (c) Continuity through discharge ground conductors.

6.02 The horizontal equalizer network consists of 750,000 CM conductors extended between the ground bus bars (including the main ground bus) located above PD frames. Discharge ground conductors extended from the power plant terminate at these bars. The discharge ground circuit is dropped to ground buses on individual PD frames by means of 350,000 CM conductors. PD frames are usually positioned throughout the ESS equipment area to form a rectangular position pattern. The 750,000 cm equalizer conductors extend between ground buses to form an equivalent rectangular path (ring) that allows battery return current to flow between the various discharge ground conductors and equalize voltage differential on the different ground bus bars. In effect, the horizontal equalizers bond all of the discharge ground conductors into one massive battery current return path.

6.03 When the installation is located on two or three adjacent floors, the equalizer networks on the several floors are bonded together with a 750,000 CM vertical equalizer conductor extended from the main ground bus to a ground bus above one PD frame on each adjacent floor as shown in Fig. 2. This bond serves to extend the potential reference imposed at the ground window to the ESS equipment on the adjacent floors and it assures equalization of potential within the ESS ground plane. More than one vertical equalizer per floor is normally not required.

6.04 Reliable framework grounding is accomplished by routing of No. 6 AWG bare stranded copper wire along each frame line. The wire is connected to the ground bar in a PD frame to provide continuity to the ground window via horizontal equalizer conductors. Crimp type connectors are positioned along the No. 6 wire and connected to frame metal of each equipment frame in the vicinity of the individual PD frames. One wire is extended to the MDF to provide framework grounding. The MDF is normally part of the isolated plane when located adjacent to the ESS equipment. In some installations an existing or remotely located MDF grounded to the integrated ground plane insulated from the ESS ground plane may be used.

6.05 Discharge ground conductors, provided to carry battery return current from PD frames, are connected to a common discharge ground bus on the power plant battery control board (BCB). The battery receives ESS ground plane reference via the discharge ground conductors. This reference may vary by as much as one-half volt from that at the ground window, dependent on the voltage drop produced by dc current flowing in the conductor. The difference between ground window and battery has insignificant unbalancing effect on the ESS ground plane. The 750,000 CM horizontal equalizer network allows ground current to flow proportionately through all of the discharge ground conductors, thereby maintaining voltage equalization throughout the ESS ground plane.

7. GROUND PLANE ISOLATION FOR OTHER THAN NO. 1 ESS SYSTEM

7.01 The previous description is based on the physical configuration of the No. 1 ESS system. Other systems that require an isolated ground plane for protection of components include No. 2 ESS, No. 3 ESS, No. 4 ESS, AIS, TSPS, and ETS. These systems, and new systems that will be introduced in the future, may not conform physically with the No. 1 system; however, the requirement for isolation except for a single point applies to all systems requiring isolated grounding. In addition to the isolation methods employed in the No. 1 system: air gap and insulator separations, other methods of isolation may be employed. One such method is by transformer isolation in converters. DC power is supplied to the primary side of a converter from a dc plant grounded to an integrated ground plane. The converter transformer secondary

winding and associated rectifier and filter equipment are isolated from the integrated plane and obtain ground from the isolated system ground plane. The 620A converter plant is typical of this arrangement.

7.02 Specific grounding requirements are provided in individual system specifications prepared for each ESS type system. A comparison of that system's requirements to those of the No. 1 ESS system, as shown in Fig. 2 and described herein, will reveal similarities and differences. Keeping in mind that all isolated ground systems must employ a single point ground window interface with the integrated ground plane, a comparison will facilitate an understanding of physical limitations of equipment arrangement in any system utilizing an isolated ground plane.

7.03 The ground window need not be of the type shown in Fig. 2, which is normally used with the No. 1 ESS system. However, where power distribution (PD) frames similar to the No. 1 system frames are used, a cable rack supported complex of 24V, 48V and ground bars as shown in Fig. 2 has proved to be a practical point for establishing a ground window. In other installations, such as a small installation fed by converters employing transformer isolation to maintain a separation between the isolated and integrated ground planes, a bus bar mounted on a wall, a column, or on the frame of the bay that mounts the converters would be suitable locations. It should be noted that it is not significant whether or not the bus bar mounts on a frame that is part of either the integrated or isolated ground planes. It must, however, be located as close as practical to the isolated plane so that interbonding paths are kept short. (See 4.09—4.11.)

7.04 Electronic switching systems are connected to peripheral communication circuits, generally through a multitude of circuit conductors. A certain amount of current generated by the dedicated battery of the electronic system is discharged into the foreign ground system that serves these peripheral units. In the 2-wire No. 1 ESS system, the amount of current is relatively small and generally no consideration in the design of the ground system is necessary. In other electronic systems such as 4-wire No. 1 ESS and TSPS, a significant amount of current may be transmitted through signaling trunk circuits that are part of

the isolated ground plane equipment group. Refer to Part 8.F for bonding requirements.

7.05 The requirement for a dedicated power plant: one that serves electronic systems associated with one ground window exclusively, is excepted for the remote office TSPS system. The 48-volt power supply may be obtained from an office power plant whose discharge ground bus bar is not insulated from the integrated ground plane, that has been provided primarily to serve electromechanical systems equipment. Discharge ground conductors extended to Remote Power Distribution (RPD) frames must be routed through the ground window and bonded to the main ground bus (see ED-1B006-()).

7.06 The requirement expressed in 4.06(b) that framework comprising a portion of the ESS ground plane be no more than one floor away from the ground window does not restrict location of electronic circuitry. Such circuitry may be located on any floor. It must be isolated from mounting framework. Framework must be bonded to the integrated ground plane via the CO GRD system. The circuit components must be insulated or otherwise separated from members of the integrated plane so that voltage differential developed between the isolated and integrated plane will not allow current sparkover or represent a hazard to personnel.

7.07 The Automatic Intercept System (AIS) utilizes Central Intercept Bureau (CIB) positions which may be located several floors from the principal equipment installation. The frames of the consoles are bonded to CO GRD on the floor on which they are located. Special protection measures are taken in the design of the console to ensure adequate insulation of the circuit components from the frame.

8. FOREIGN GROUND SYSTEMS BONDING REQUIREMENTS

8.01 Conductive material in proximity to but not part of the isolated ground plane (lighting fixtures, ac conduit, ironwork, protector frame) must be isolated from the ground plane but must maintain an equal potential for protection purposes. Ground potential is established by connecting these items to the ground window and the floor CO GRD bus bar. Electromechanical systems equipment and other conductive materials on the same floor but not in close proximity to the electronic system

installation are grounded at the floor CO GRD bus bar in the conventional manner.

A. Conduits

8.02 Metallic conduits extending ac service into the ESS area must be routed through the ground window and bonded therein to the main ground bus. Typical (No. 1 ESS) conduits are as follows:

- (a) Protected ac service from emergency ac plant (EM-PLT) to ac distribution equipment in the miscellaneous power (MP) frame.
- (b) Essential ac service from power service cabinet (PSC) to ac distribution equipment in the MP frame.
- (c) 115V commercial ac service from lighting ac distribution panel boards to frame receptacles.

8.03 AC service conduit must provide a continuous equipment ground path between the enclosure containing the circuit overcurrent protection device and the enclosure of the load equipment, as specified in NEC Article 250. Additionally, if overcurrent devices rated above 20 amperes are used to protect a circuit an equipment grounding conductor must be run in the conduit, as specified in Section 802-001-198. Since the ac equipment ground system is part of the building integrated ground plane, such conduit must be routed through the ground window and bonded to the main ground bus before it contacts ESS ground plane metal. If an equipment ground conductor is included in the conduit it also must be bonded to the main ground bus. Conduit alone may be bonded by use of a conduit clamp (Section 802-001-190 Part 5.B) and a No. 6 AWG wire not longer than 3 feet. A combination bond for both conduit and equipment ground wire may be made as illustrated in Fig. 3. Such bonds are also shown in Fig. 1.

8.04 Protected and essential circuit conduits terminate within the MP frame. Frame receptacle circuit conduits are generally branched after passage through the ground window to growth ends of frame lines. The runs are terminated with conduit fittings approved for grounding in end guards of each frame line. That termination constitutes a ground connection to a load unit enclosure. The enclosure is comprised of the end guard and frame metal of the entire frame line

and ground continuity throughout is assumed. Circuit conductors are extended without conduit or a "green wire" to receptacles in the frame line. Conduit and/or armored cable are used to extend ground continuity between gaps in a frame line. After routing through the ground window into the ESS frame area, conduit may contact metal that is part of the ESS ground plane, but must be isolated from contact with components of the integrated ground plane. Generally, conduit is supported from the lighting support channels by means of U-clips. The support channels are part of the integrated ground plane. When so supported, the conduit must be insulated from contact with the support with two layers of fiber sheet as shown in Fig. 4. It should be noted that conduits containing receptacle circuits in a three-(or two-) floor installation must be grounded in the ground window and then routed to other floors without contacting the integrated ground plane. It is usually most expedient to run the circuits from the lighting ac distribution panelboard on the middle floor. The conduit may be routed between floors through a sleeve located near the one provided for the 750,000 CM vertical equalizer conductor.

8.05 Protected or essential circuits may be extended in metallic raceway from the MP frame to equipment such as teletypewriters located remotely from the isolated ground plane area. The run shall be routed through the ground window and the raceway enclosing metal shall be bonded to the main ground bus. When so connected, the raceway metal in the portion of the run from the MP frame to the ground window is considered as part of the ESS isolated ground plane. The remainder is considered part of the integrated plane. The remote equipment frame shall be bonded to the CO GRD system. The frame must be isolated from circuit components within the unit that receive ground reference via communication conductors from the isolated ground plane, if any.

B. Lighting System Components

8.06 Fluorescent lighting fixtures, "Unistrut" channel supports, and panelboard ac distribution equipment must be formed into a part of the integrated ground plane and bonded to the ground window in a manner that tends to minimize voltage difference between the components and members of the isolated ground plane while forming a path for lightning current flow to earth.

8.07 Lighting systems components are in close proximity to the ESS ground plane. Typically, fluorescent lighting fixtures are suspended from ESS cable racks by means of insulators or, in older installations, from unistrut channels, which are supported on brackets mounted in cable ducts that are in turn supported from ESS frames. Insulators atop the brackets isolate the fixture-channel complex from the bracket-cable duct-frame assembly to maintain a separation between the integrated and isolated planes. Raceway used for ac distribution to lighting equipment is supported from the unistrut channel network. Panelboards, if used for ac distribution, are normally mounted on walls near the ESS complex.

8.08 Minimum requirements for an adequate ground bond of lighting system components are as follows:

(a) **Panelboard:** A No. 6 AWG bond shall be provided from the interior or exterior of the panelboard enclosure to the floor CO GRD bus.

(b) **Unistrut channel support network:**
The support channels shall be joined to the integrated ground plane. A ground path may be assumed to exist through any metallic interconnection of channels except fluorescent lighting fixture runs. Where such metallic interconnection does not exist isolated channels or groups of channels shall be bonded with No. 6 AWG wire as required to form the channel network into an interconductive unit. The channel network shall be grounded as follows:

(1) On the floor containing the ground window, the channel network shall be bonded with No. 6 AWG wire from a point near the ground window to the Main Ground bus, and a No. 6 AWG bond shall be run to the floor CO GRD bus from a nearby point on the channel network.

(2) On floors containing electronic equipment associated with a ground window on another floor, the channel network shall be bonded with No. 6 AWG wire to the floor CO GRD bus from a nearby point on the network. Connection to the Main Ground bus is not required.

(c) **Fluorescent lighting fixtures:** Fixtures equipped with ballasts shall be grounded by means of an ac equipment ground conductor. An ac equipment ground (AC EG) conductor shall be provided in the ac distribution raceway as specified in Section 802-001-198. A summary of those requirements follows:

(1) **Feeder circuits:** An AC EG conductor shall be provided with feeder conductors serving a branch circuit ac distribution panelboard. The conductor shall terminate on the interior of the panelboard enclosure (or ac equipment ground bus, if provided).

(2) **Panelboard and wireway applications:** A single No. 12 AWG green insulated AC EG conductor shall be extended from the panelboard enclosure (or AC EG bus, if provided) through each wireway provided for branch circuit distribution to fluorescent lighting fixtures. At each point on the wireway where a branch circuit is extended from the wireway in conduit to a fixture line, the AC EG conductor shall be tapped and a branch conductor shall be extended to the fixture line. At each point of branching the AC EG conductor shall be bonded to the wireway (ground connector as shown in Fig. 4 of Section 802-001-190 is recommended). The AC EG conductor shall be extended through each fixture in the line, tapped, and connected to each fixture enclosure.

(3) **Ballasts:** The primary purpose of providing an AC EG conductor is to ensure that the ballast is effectively grounded. The recommended point of termination of the AC EG conductor within the fixture is on one of the screws or studs normally furnished to mount the ballast to the enclosure, using a crimp type one-hole connector. The AC EG conductor may be alternatively connected to the enclosure by other means if it is determined that a reliable ground path, free of insulation by paint or other coatings, exists between the ballast and enclosure metal.

(4) **Equipment grounding of fixtures via continuity through raceways:** Grounding by this method only is not considered to be reliable since grounding of any one fixture in a line would depend on a ground path dependent on a series of raceway to enclosure metal connections between preceding fixtures in the

line. Continuity would depend on penetration of paint on enclosures and tight raceway connections of every joint in the series. Use of an AC EG conductor in parallel with the raceway is considered to be essential. When the ballast is grounded by an AC EG conductor the fixture enclosure is considered to be adequately grounded.

(5) **Equipment grounding of fixtures via channel supports:** Support of fixtures from grounded channel supports is not considered as a method of grounding fixtures. The standard method of supporting fixtures uses a metal clamp that grasps an indentation formed in the top of the lighting fixture. The exterior surface of the fixture to which the clamp is affixed is painted, forming insulation between the grounded clamp and the fixture metal.

(d) **Emergency lighting:** DC powered incandescent emergency lights are provided in equipment rooms, stairways, and other locations as specified in Section 802-015-158. A relay switch and distribution fuse equipment are normally mounted in flush or surface mounted equipment boxes. The boxes are located in a convenient position on a wall, usually in the power room. Branch circuits are run in conduit to lights. The boxes and conduit shall be considered as part of the integrated ground plane and shall be kept separate from the components of the ESS ground plane. The dc branch conductors of the emergency lighting distribution system are isolated from the boxes and conduit and other grounded objects except for the ground path that serves as ground reference to the dc power plant. When the emergency lighting power supply is obtained from an ESS dedicated plant, the ac distribution system, but not the enclosing conduit system, may be considered as a part of the ESS ground plane. Otherwise, the circuitry may be considered as part of the integrated ground plane.

8.09 In addition to conduit, lighting, and superstructure metal, other metallic components of the integrated ground plane are located in close proximity to the isolated ground plane. Such components include protector frames, electromechanical systems frames, ventilation ducts, electrical conduit, utility piping, and various other conductive objects. The CO GRD system (Section 802-001-192) is used

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to bond these objects into a single integrated plane. Voltage equalization between the integrated and isolated planes is accomplished through the bond between the CO GRD bus and the main ground bus. When the physical arrangement is such that the CO GRD bus is not located in close proximity to the main ground bus, the length of the interconnective path between closely located members of the two planes may be significantly reduced by a direct bond between the main bus and the integrated plane object. Direct bonds are required as described in the following paragraphs.

C. Protector Frame (Fig. 5)

8.10 A protector ground point is established by mounting two-hole bolted tongue crimp connectors at a point on the rear frame base of the protector frame line (see ED-1A200-10). A No. 0 ground lead is extended from this point to the cable vault for bonding of trunk and subscriber cable sheaths. The protector ground point shall be a point on the frame base nearest the cable vault grounding point. The number, size, and terminating points of additional ground bonds extended from the protector ground point depend on the location of the protector frame in relation to the ground window and presence of a CO GRD system. The protector frame may be located either:

- (a) On the same floor with the ground window, or
- (b) On another floor.

A CO GRD system for the building may either:

- (c) Exist, or
- (d) Not exist.

8.11 When conditions (1) and (3) apply (Fig. 5A), No. 0 AWG conductors are extended from the protector ground point to:

- (a) The floor CO GRD bus, and
- (b) The main ground bus in the ground window.

8.12 When conditions (1) and (4) apply, a CO GRD system as shown in Fig. 5A must be provided and No. 0 AWG conductors shall be extended as described in 8.11, otherwise a 750,000

CM conductor must be installed between the office principal ground point (ie, water pipe) and the main ground bus (see 5.03). When the direct 750,000 CM run is employed, as depicted in Fig. 5C, a No.0 AWG conductor must be run from the protector ground point to the main ground bus. This bond, at some point in the run, shall be bonded to building steel or water pipe as described in 5.03. If a direct path between the protector and the principal ground point is significantly shorter than the route via the ground window a No. 0 bond shall also be provided between these two points.

8.13 When conditions (2) and (3) apply (Fig. 5B), a No. 0 AWG conductor is required from the protector ground point to the CO GRD bus on the floor on which the protector frame is located. No connection is required between the protector ground point and the ground window main ground bus. The No. 0 AWG conductor serves as a discharge ground path for lightning currents, as a voltage equalizer, and as a frame ground.

8.14 When conditions (2) and (4) apply, a CO GRD system as shown in Fig. 5B must be provided and No. 0 AWG conductors shall be extended as described in 8.13, otherwise a 750,000 CM conductor must be installed between the office principal ground point (ie, water pipe) and the main ground bus (see 5.03). When the direct 750,000 CM run is employed, as depicted in Fig. 5D, the main ground bus is bonded to nearby building steel or water pipe as covered in 5.03. The protector ground point shall also be connected on its floor to a similar building ground so that continuity is established between the main ground bus and the protector ground point via the bonds and building steel. If a direct path between the protector ground point and the office principal ground point is significantly shorter than the path afforded through the 750,000 CM conductor a No. 0 AWG bond shall also be provided between these points.

D. Cable Sheathing

8.15 Trunk and subscribers cable sheaths entering the building via the cable vault must be grounded. The sheath may be terminated in the vault or extended to the vicinity of the protector frame before termination. Grounding is achieved by bonding the sheaths to the protector frame ground point, where continuity to the office ground electrode is provided via protector frame grounding bonds. The cable sheath shall be bonded to the

protector frame ground point with a No. 0 AWG conductor. Additionally, a direct run shall be provided to the office principal ground point if sheathing is terminated away from the vicinity of the protector frame and such a run will provide a significantly shorter path from sheath to the principal ground point than that afforded via the bond to the protector frame. Mechanical arrangements of sheath bonding are not covered herein. One common method consists of extending individual small bonds from sheath ends to a common ground bus. A No. 0 is extended from the bus to the panel frame.

E. Electromechanical and Miscellaneous Frames

8.16 Floor and wall mounted communication frames, cabinets, and other units connected to ground by the CO GRD system (or assumed to be grounded by incidental ground paths when the CO GRD system does not exist), thereby forming a portion of the building integrated ground plane, are often located in close proximity to members of the isolated ground plane. Close proximity of members of the two ground planes can result in hazard to personnel and electronic equipment. Close proximity is defined as a separation of less than 3 feet when integrated ground members are interbonded with a CO GRD system or 6 feet when interconnections depend on incidental ground paths.

8.17 Lightning strokes on a building, or other massive discharge of current into the integrated ground plane, can create severe instantaneous differences of voltage between different parts of the ground plane. When current flows in the integrated plane between the points that serve as voltage reference points for the isolated ground plane and the integrated members in close proximity to the isolated plane, a voltage difference (a charge) appears between the members of the two ground planes. The extent of difference that may occur between members of the two ground planes is, in part, dependent on the impedance of the interbonding ground path between the charged members. If the impedance is great enough the charge may overcome insulation resistance resulting in destructive current sparkover to the isolated plane. Personnel interposed between charged surfaces are exposed to shock hazard. Minimal difference is assured between members in close proximity when they are integrated into a common ground plane by use of a direct bond between points of closest proximity. Since this would destroy the single integration point concept between the isolated and integrated ground

systems, interbonding is restricted to the main ground bus and members of the integrated ground plane.

8.18 Members of one isolated ground plane may be located on one, two, or three adjacent floors. A multiplicity of integrated plane objects may be in close proximity to isolated plane members on each floor. It is impractical and unnecessary to run a separate bond wire from the main ground bus to each object. They may be grouped and assumed to be one object, requiring only one (No. 6 AWG) bond wire between the Main Ground bus and a point on the group, under certain restrictions outlined below:

- (a) **Group:** Individual objects in proximity may be assumed to be grouped if reasonably direct continuity paths exist between points of proximity. Continuity may consist of any metallic path that is bolted or similarly fastened together; including frames, cable racks, conduit, discharge ground conductors, CO GRD conductors, frame bond wires or combinations thereof. One group shall be restricted to a length of continuity run of 100 feet between outermost objects in proximity.
- (b) **Bond Wires:** Separate No. 6 AWG bond wires shall be provided to a point on each group that results in the shortest run length. A single bond wire may be extended to a common location on floors other than the one containing the ground window and spliced and extended to different groups requiring a bond. The bond shall also serve to ground lighting system components (see 6.05). Bond wires shall be kept isolated from any contact with members of the isolated plane.
- (c) **Omission of Bond Wires:** Bond wires between the main ground bus and integrated ground objects in close proximity to members of the isolated ground plane may be omitted when the interbonding path afforded by the CO GRD system is less than twice the length of the conductive path afforded by the bond wire.
- (d) **Job Requirements:** Bond wires may also be omitted where examination of job grounding arrangements indicate that a significant improvement in interbonding would not be accomplished. There are many complex relationships that cannot be predefined. The job engineer, therefore, must assume responsibility for

determining the grouping and bonding requirements that will result in provision of conductive paths of lowest practical impedance.

8.19 In estimating impedance of a ground conductor to the flow of current, it should be kept in mind that lightning current generates the greatest voltage differentials. Lightning current characteristically rises to peak value extremely fast (ie, a steep wave front). Impedance in a conductor to this type of current is primarily inductive reactance. The resistance of the conductor is not significant, therefore the size of the conductor, and to some extent the material (copper, steel) and method of joining the conductor (incidental or deliberate bonding) is not significant. The length of the conductor is very significant in controlling the voltage differential, since the value of inductance is a product of inductance per conductor-foot \times length. Sharp turns in the bond wire introduce an increase in potential due to impedance to current with a steep wave front. In summary, therefore, ground bonds provided to minimize lightning generated voltage differences shall be No. 6 AWG wire (difficult to damage) run as short and straight between bonding points as is physically practical.

F. E and M Signaling and Similar Equipment

8.20 In order to perform its function as an intermediate switching point between a large number of remote equipment units that are not a part of the isolated ground plane, the internal circuitry of electronic switching systems is necessarily connected to these units with many conductor paths. Direct connection between ground planes is unacceptable; however, the conductor paths, even though each is isolated from foreign ground by a considerable impedance, when considered as impedance circuits in parallel may present in effect a very low impedance. Certain of these circuits carry battery current. Signaling circuits, in particular, are of this type.

8.21 E and M lead signaling circuits, which are generally used in great quantities in interoffice trunking applications, consist basically of a trunk unit and a signal unit, interconnected by conductors referred to (by their letter identification designations) as E and M leads. The signal unit is equipped with a biased relay that senses changes in potential on communication lines. The relay closes a circuit to ground that is extended via E and M leads to a relay winding in the trunk unit. The relay

winding receives power from the office battery supply. Certain E and M lead signaling circuits of recent design provide a ground lead paired with E and M leads for return of current. The following remarks pertain to those that do not.

8.22 In electronic systems applications, the trunk unit is included in the isolated ground plane. The signal unit is in the building integrated ground plane. Therefore, the dedicated power plant of the electronic system provides current that goes to ground outside the isolated ground plane, and, since the only paths between the outside ground plane and the isolated plane are through the ground window, the ground current must return to the battery via the window.

8.23 E and M lead (and other) signaling systems are often used in quantity in TSPS and 4-wire No. 1 ESS (military application) systems. This can result in a substantial current load on the bond wire between the main ground bus in the ground window and the CO GRD bus. Refer to Section 802-001-193 Part 4D, Signaling System Ground Requirements, for further information on accumulated ground current and its unbalancing effect on ground plane potential.

8.24 Most ESS offices before 1976 used a No.0 AWG bond between the CO GRD bus and the main ground bus. Later offices use 750,000 CM. When the CO GRD-main ground bond (see 5.01) connecting a TSPS or other isolated ground plane is loaded with a heavy ground current and/or the length of conductor is long enough to cause a significant voltage drop (1/2 volt or more - equivalent to 65 amperes on a No. 0 AWG wire 75 feet long or 200 amperes on a 750,000 CM lead 170 feet long) the condition must be relieved. Where the specifications of an electronic system specify a procedure for calculating a method of relieving the voltage drop, that procedure shall be followed. Where specifications do not provide such information, the following shall be applied:

- (a) Identify and determine location of units that connect dc power originated by the dedicated power plant to foreign ground systems (example: E and M signaling units not employing a ground return conductor with E and M leads).
- (b) Calculate the approximate ground current that such units expel into the foreign ground system. The calculations shall be made on a

basis of separate sums for each group of units served by a common floor CO GRD horizontal equalizer conductor (see Section 802-001-192 Part 3). Generally, four or fewer horizontal equalizer conductors, serving areas extending in different directions from the floor CO GRD bus, are provided on a floor.

(c) Calculate the size of conductor required to connect a point on the discharge ground system serving the equipment area: A BDFB ground bus bar or a point on the main aisle ground equalizer of a crossbar distribution system or equivalent; to the main ground bus in the ground window of the electronic system installation. Calculation shall be made on the basis of 1/2 volt drop. Power Lead Calculator GS-5420 Model 4-66 or formula: $22.2 \times \text{AMPS} \times \text{FEET} = \text{CIRC MIL}$, may be used to determine wire size.

(d) Provide a ground conductor from each group of units per (b). The conductors may be continuous to the main ground bus; or they may be combined with other such conductors into a single (or group of interbonded) conductor having a voltage drop effect equivalent to that of the various individual conductors, if expeditious.

(e) The effectiveness of the addition of such conductors may be checked by monitoring the voltage drop across the CO GRD-main ground bond (see 5.01). Voltage drop during busy hour should not exceed 1/2 volt, otherwise the conductors per (d) must be supplemented until such a level is maintained.

8.25 The need for bonds described above is not dependent on the type of electronic system. Generally, it may be presumed to be unnecessary when E and M signaling trunks do not appear in the electronic system equipment frames. Where such equipment is assigned, the bonds shall be furnished in accordance with engineering calculations of probable ground current and installed prior to placing the office into operation. Whether or not bonds are provided, it is recommended that a check per 8.24 (e) be performed as soon as practicable after activation of the office. If the check indicates an excessive voltage drop, temporary relief may be provided by provision of multiple No. 0 AWG or larger size conductors in parallel with the CO GRD-main ground bond. The temporary bonds should be removed when bonds per 8.24 (d) are provided. The temporary arrangement may cause

a significant load to be imposed on the CO GRD vertical equalizer conductors. That could cause a significant voltage drop in the vertical equalizer and/or other conductors that comprise a series path with the CO GRD-main ground bond between the ground current producing units and the Main Ground bus. A voltage drop would create an undesirable ground plane unbalance.

8.26 In building not equipped with a CO GRD system, existing ESS offices may be equipped with a No. 0 conductor between the main ground bus and the office principal ground point. Newer offices will be equipped with a 750,000 CM MGB-PGP bond. A bond is also provided from building steel to the main ground bus (see 5.03). Normally, ground current returning to the ESS power plant battery from foreign ground planes will divide between the MGB-PGP bond and such incidental paths as may exist between the foreign ground plan and the main ground bus via building steel. The MGB-PGP bond path is usually long and circuitous. When incidental paths exist voltage drop is minimized. However, there is no guarantee that an incidental path of significant conductance will exist in any one office, therefore in some offices, the entire current must return to battery through the MGB-PGP bond. Because the bond is longer than in offices having a CO GRD system, it is probable that more severe voltage drop problems will occur in this type of office when significant ground current must be returned from foreign ground planes. If the ESS system is bonded directly to the principal ground point, it is recommended that special effort be made to provide additional conductors [8.24(d)] before placing equipment into service since it is not practical to provide a temporary substitute as described in 8.25.

G. Building Metalwork

8.27 Air ducts, electrical conduit, metal piping, and other components of the building complex are assumed to be a part of the integrated ground plane without deliberate bonding. When such members are in close proximity with members of an isolated ground plane, they shall be bonded to the main ground bus in the ground window. Generally, it is expected that bonding of such objects shall be by extending a bond wire to other bond wires having access to the ground window, such as those described in Part 8.E.

9. MULTIPLE NO. 1 ESS OFFICES

9.01 More than one No. 1 ESS office may be installed in a central office building. When each ESS office has a dedicated power plant, there is no restriction on the location of the individual office equipments in relation to each other. Each office shall have its own ground window connected to the CO GRD system bus.

9.02 More than one No. 1 ESS office may be served from a single power plant. The primary restrictions for such an application are:

- (a) The offices that share a common dc power plant shall share a single ground window.
- (b) PD frames shall be dedicated to serve equipment associated with one office only.

9.03 The requirement for sharing one ground window imposes the same restrictions on location of ESS frames of the combined offices to that of a single office, restricting location to a maximum of three adjacent floors. Other ground requirements may be applied as though the frames associated with the different offices were one office. In this respect the internal bonding arrangement of each office (see Part 6) shall be interconnected to form a common ground plane. Horizontal equalizer conductors shall be applied as though the PD frames were associated with one office. Vertical equalizers shall be extended as required to adjacent floors. The bare No. 6 AWG wire frame ground network shall be similarly extended to frames without regard to office assignment.

9.04 PD frames are usually provided in groups of two. The PD frames provide an intermediate point in the 24- and 48-volt dc distribution system for branching of supplies from the power plants to the load units in electronic type communication equipment frames. Generally, electronic systems use a form of circuit redundancy that allows service to continue without interruption in the event of a circuit component failure. The first pair of PD frames normally supply power to the critical control equipment and to switching equipment. Additional pairs of PD frames are provided when the capacity of previous pairs are exceeded. Power is alternately provided to one of each pair of mate circuits from one of a pair of PD frames to ensure that loss of a discharge circuit feeding one PD or a branch circuit serving communication circuits will not

disable both of the redundant circuits simultaneously. A PD frame provided to serve one of the ESS systems shall not be used to supply power to equipment associated with any other ESS system.

10. DIFFERENT ELECTRONIC SYSTEMS SHARING A COMMON POWER PLANT

10.01 The +24V and -48V power plants provided to furnish power to a No. 1, 2, 3 ESS; TSPS; ETS; AIS or similar type of ESS system may also provide power to other ESS systems that normally obtain power from such power plants. A single ground window must be employed. The lineups of different electronic systems must be kept physically apart (see 11.03), but the frames of the different electronic systems must be combined into a single isolated ground plane as described for multiple No. 1 ESS offices in Part 9. PD frames must be dedicated to serve only the equipment in that particular system for which the PD frame is furnished.

10.02 The No. 4 ESS Toll System is powered by converters fed from a 140V dc power plant (Section 802-001-193). This plant may feed other than the No. 4 ESS equipment as outlined in Part 12.

11. POWER FOR NONELECTRONIC SYSTEMS EQUIPMENT FROM AN ELECTRONIC SYSTEMS POWER PLANT

11.01 ESS systems served by 140V power plants are covered in Part 12. Part 11 applies to systems served by +24V and -48V power plants.

11.02 Installations of toll and other types of non-ESS equipment, excluding electro-mechanical switching systems (Crossbar, SXS, etc) may be supplied from the ESS system power plant. The following information comprises a general summary of conditions governing such applications.

11.03 Two general categories of non-ESS equipment compatibilities are discussed.

- (a) Non-ESS electronic systems such as "T" or "N" Carrier mounted on ESS type bays insulated from building ground can be interbonded into the isolated ground plane as described in Part 10. Installations of this type have usually resulted in the toll and ESS equipment frames being juxtaposed. What effect the close proximity might have on the operational integrity of each

system is not always predictable. It is therefore recommended that, in the future, toll equipment be installed as a separate entity. A 2-foot gap (1-aisle width) shall be provided between toll equipment frame lineups and ESS equipment frame lineups. Furthermore, mounting space on individual bays shall not be filled with equipment accessed by both systems. Interframe cabling within each system shall also be kept isolated in order to reduce the possibility of noise coupling.

(b) Non-ESS electromechanical circuits regardless of the type of framework on which they are mounted or whether they have been rated as operationally compatible with ESS, shall be located outside the isolated ground plane. The only exceptions should be those circuits which have been specifically designed as an integral part of the ESS. It is recommended that a 4-foot gap (the width of two aisles) be provided between ESS equipment frames bonded to the isolated ground plane and non-ESS equipment frames bonded to the integrated ground plane. This separateness shall carry over, where practical, to cables and cross-connection fields. Cable racking and other metallic structures shall be separate so that the only point of ground continuity between the ESS and electromechanical systems is through the ground window.

11.04 Certain rules have been outlined for No. 1 ESS power plant sharing applications, which are similar to requirements expected to be enforced for other electronic systems power plant applications:

(a) ESS battery or ground conductors shall not be directly linked with other battery or ground systems. Interconnection of ESS battery through a load impedance to non-ESS ground is allowed as covered in Part 8.F.

(b) Non-ESS electromechanical circuits, and non-ESS electronic circuits located outside the ESS ground plane, shall be supplied by separate feeders from the power plant. The ground feeder of the circuit must be routed to the ground window and bonded or connected therein to the main ground bus before extension to the noncompatible load. ESS restrictions do not require that the battery feeder shall be paired with the ground feeder for the portion of the run to the ground window if a significant additional length of battery conductor is required to maintain pairing. Where significant battery

feeder length is not a factor or if the equipment served requires pairing for attenuation of electrical noise, the conductors shall be paired together.

(c) Non-ESS electronic circuits that are located within the ESS ground plane shall be supplied by separate feeders from the power plant. The ground feeder of the power distribution circuit need not be routed through the ground window.

(d) The capacity of the power plant shall be at least equal to the sum of all tenants total power requirements.

(e) The surge current demand on the plant (maximum sudden change due to switching of dc loads of non-ESS equipment) shall not exceed 25 percent of that portion of the plant capacity allotted to the non-ESS tenant.

(f) Mutual sharing between tenants of any portion of their assigned plant capacity is not allowed.

(g) The non-ESS circuit voltage range must be compatible with the ESS system voltage range, -42.75 to -52.5 volts and +20.75 to +26.25 volts.

11.05 When the ground conductor of a power circuit serving non-ESS equipment is longer than the battery lead [see 11.04(b)], the ground conductor shall be increased in size as required to maintain an equal voltage drop in the battery and ground legs.

11.06 The ground conductor of the power circuit serving non-ESS equipment [see 11.04(b)] may be connected directly to the main ground bus, or it may be bonded with a conductor not exceeding 3 feet in length, if expedient. One bond conductor may be serially connected to several ground conductors, within the 3-foot limitation. The bond conductor shall be of the same size as the largest ground conductor, but need not exceed No. 0 AWG. Alternately a supplementary bus may be provided as described in 4.12 if sufficient space for terminating ground conductors is not available on the main ground bus.

11.07 Noncompatible equipment units shall be grounded in accordance with CO GRD system requirements specified in Section 802-001-192.

12. NO. 4 ESS TOLL SWITCHING SYSTEM GROUND REQUIREMENTS

A. Introduction

12.01 The No. 4 ESS Toll Switching System is comprised of two groups of frames located in two distinctly different equipment areas: The network area and the transmission area. Each has its own distinctive ground requirements.

12.02 The frames associated with the No. 4 ESS system are identified in SD-4A008-01 and SD-82194-01. Grounding requirements are covered therein and on ED-4A081-(). These notes comprise a summary of those requirements. Practices to be followed in establishing an interface of grounding systems employed in the No. 4 ESS areas with the CO GRD system are outlined hereunder.

B. Network Area (Fig. 6)

12.03 The network area of the No. 4 ESS system is similar to the No. 1 ESS system in that it utilizes an isolated ground plane and single point ground reference. It differs in that it does not use a dedicated dc battery plant for power. Instead, it uses converter plants for 24V and 48V power and bay mounted converters to produce other voltages. The converters are driven by 140V power from a 415A dc battery plant.

12.04 The ESS ground plane in the network area is isolated from the 140V distribution system. The 140V distribution system is limited to a spread over 11 adjacent floors. Refer to Section 802-001-193 for a detailed description of the 140V distribution system and methods of isolation employed.

12.05 Converter plants that serve network area equipment are located in the network area. The frames are isolated from contact with other than members of the ESS ground plane. The methods used to maintain the ESS ground plane are identical to insulating and bonding procedures used with the No. 1 ESS system. Ground reference is provided via a ground window with a No. 0 single point connection to the CO GRD system. It should be noted that the No. 1 ESS system uses a 750,000 CM conductor for this purpose.

Ground Window

12.06 The ground window used in the No. 4 ESS network area is similar to the ground window described in Part 4A, except the main ground bus is normally located above the miscellaneous frame and the 24V and 48V busbars are not required.

12.07 The main ground bus is supported above the MISC frame on cable rack and bonded with a No. 0 wire to the CO GRD bus on that floor. Other ground busbars are located above 620 and 625 type converter plants in the network area. The main ground bus and the other ground busbars are joined together with 750,000 CM horizontal equalizer bonds, same as in the No. 1 ESS system (see Fig. 6).

12.08 Although it is expected that network area frames will normally be located on a single floor, other arrangements may be necessary. The network area is restricted to three adjacent floors. Only one ground window may be utilized with a single isolated ground plane and the maximum number of floors that may be served by one ground window is three, same as for the No. 1 ESS system (see Fig. 2). None of the frames that comprise the network area may be located more than one floor away from the ground window. Continuity between network area equipment on different floors shall be maintained with a 750,000 CM vertical ground equalizer conductor extended from the main ground bus to one of the ground busbars above converter plants on the upper and lower floors.

Insulation

12.09 Isolation of network area frames is accomplished by use of insulators, similar to those employed in the No. 1 ESS system, described in Part 4B.

Typical Bonds From The Main Ground Bus

12.10 A variety of bonds are extended from the main ground bus, similar to those described for the No. 1 ESS system in Part 4D. Other requirements outlined in Parts 5, 6, (except 6.05), 7 (except 7.05), and 8 (except 8C and 8D) also apply to a No. 4 ESS network area installation.

12.11 It is not expected that a protector frame will be closely associated with a network

area. If it is, Parts 8C and 8D describe grounding requirements.

C. Transmission Area (Fig. 6)

12.12 Equipment located in the transmission area is principally that associated with toll trunking facilities. These bays are not made part of the ESS ground plane of the network area. They are not required to be isolated from foreign grounds.

12.13 Transmission area frames are bonded together using No. 6 AWG wire to form a framework ground system, same as employed in the network area and similar to that described in 6.04. In the No. 4 ESS application the No. 6 AWG wire is connected to a ground bus above the 620 or 625 converter plants to provide continuity to the ground window. Miscellaneous equipment in the vicinity may be grounded by extension of the transmission area frame ground. When network and transmission areas are contiguous or if it is otherwise expedient, the transmission frame ground system may be connected to the main ground bus instead of the CO GRD bus.

12.14 Ground reference is provided to the transmission area by direct connection to the CO GRD system same as practiced for electromechanical switching systems. The CO GRD system is described in Section 802-001-192.

12.15 The CO GRD system extends 750,000 CM horizontal equalizer conductors into the various sectors of an equipment floor. In these sectors a conductor is branched and tapped to principal points in the power distribution systems of switching equipments other than ESS: To ground buses on battery distribution fuse boards (BDFB) and to ground equalizer conductors of battery distribution equalizing centers. When a No. 4 ESS transmission area is installed the CO GRD horizontal equalizers shall similarly be extended into the transmission area and connected to the ground buses provided above 620 and 625 type converter

plants that serve equipment in the transmission area. In addition to provision of ground reference to the power supply, the branched CO GRD conductor serves as a ground current path between the different 620 and 625 type plants.

D. Power Equipment (Fig. 6)

12.16 Parts 10 and 11 of this section do not apply to the power system employed in No. 4 ESS installations. The No. 4 ESS system obtains power from 620 and 625 type converter plants and from equipment frame-mounted converters. The 140V power is supplied to converters as described in Section 802-001-193.

12.17 A ground bus capable of terminating 750,000 CM horizontal equalizer and two 350,000 CM drop feeders shall be installed on cable rack above each 620 or 625 type plant in the network and transmission areas to serve as a splice point for ground conductors. The buses shall be used to connect horizontal equalizers as described previously. Two 350,000 CM drop feeders shall also be dropped from an overhead bus to two ground buses A and B furnished in the distribution bay of a 620 or 625 type converter plant.

12.18 It is important to note that several converter plants will be used in both the network and transmission areas. These plants will be constantly producing varying amounts of current. A significant portion of this current will be transmitted via switching and control system circuitry to random ground points throughout the area. This current must be afforded a low impedance path back to the originating converters. In the network area, horizontal equalizers form a ring that provides at least two paths from any one ground bus to other ground buses. In the transmission area, the CO GRD horizontal equalizer system links the ground buses together. It is recommended that the branches of the equalizer be arranged to provide interconnecting paths that are as short as is reasonably practical.

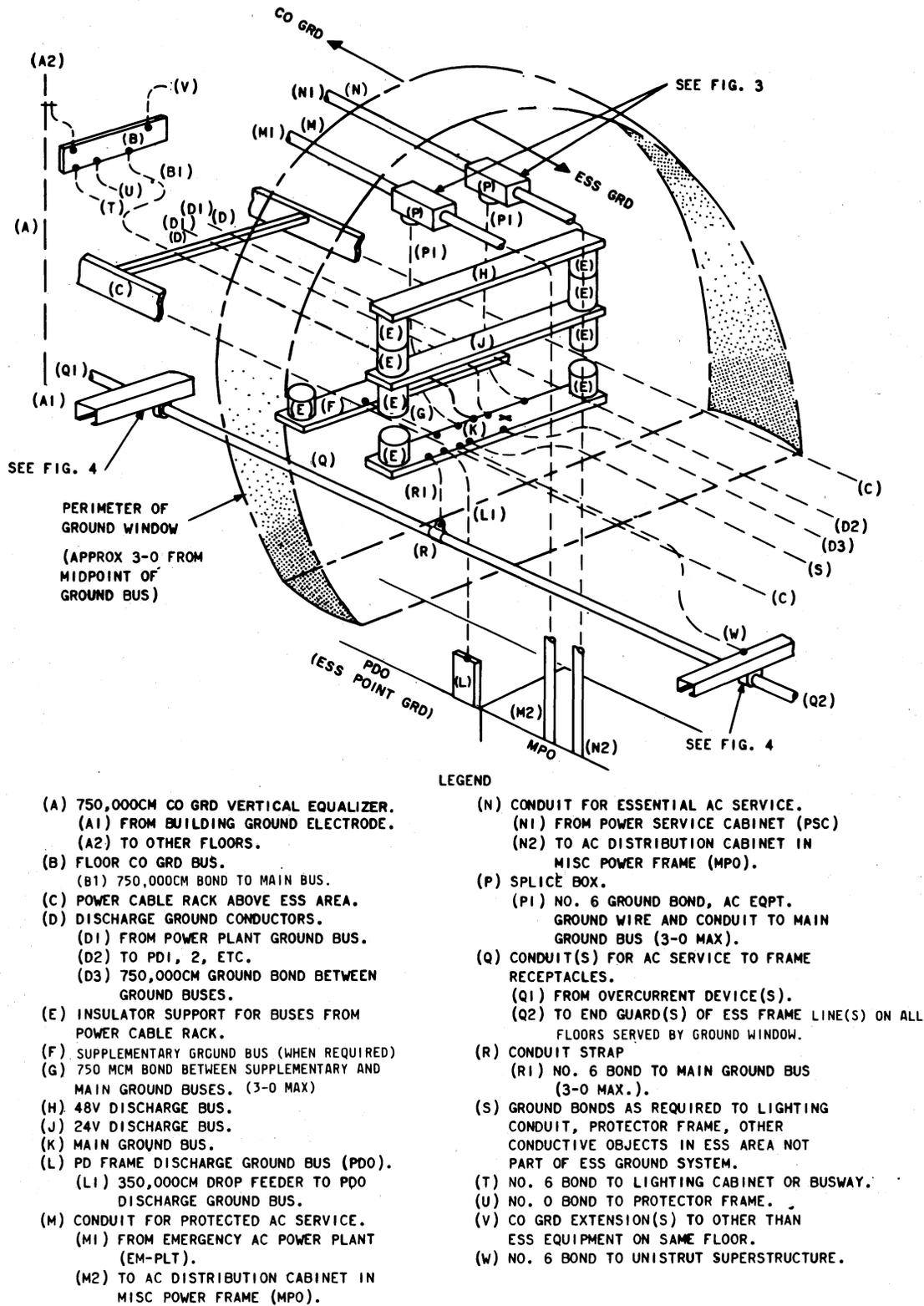


Fig. 1—Typical Interface at Ground Window Between Electronic Office (Single Point) and Central Office Ground Systems

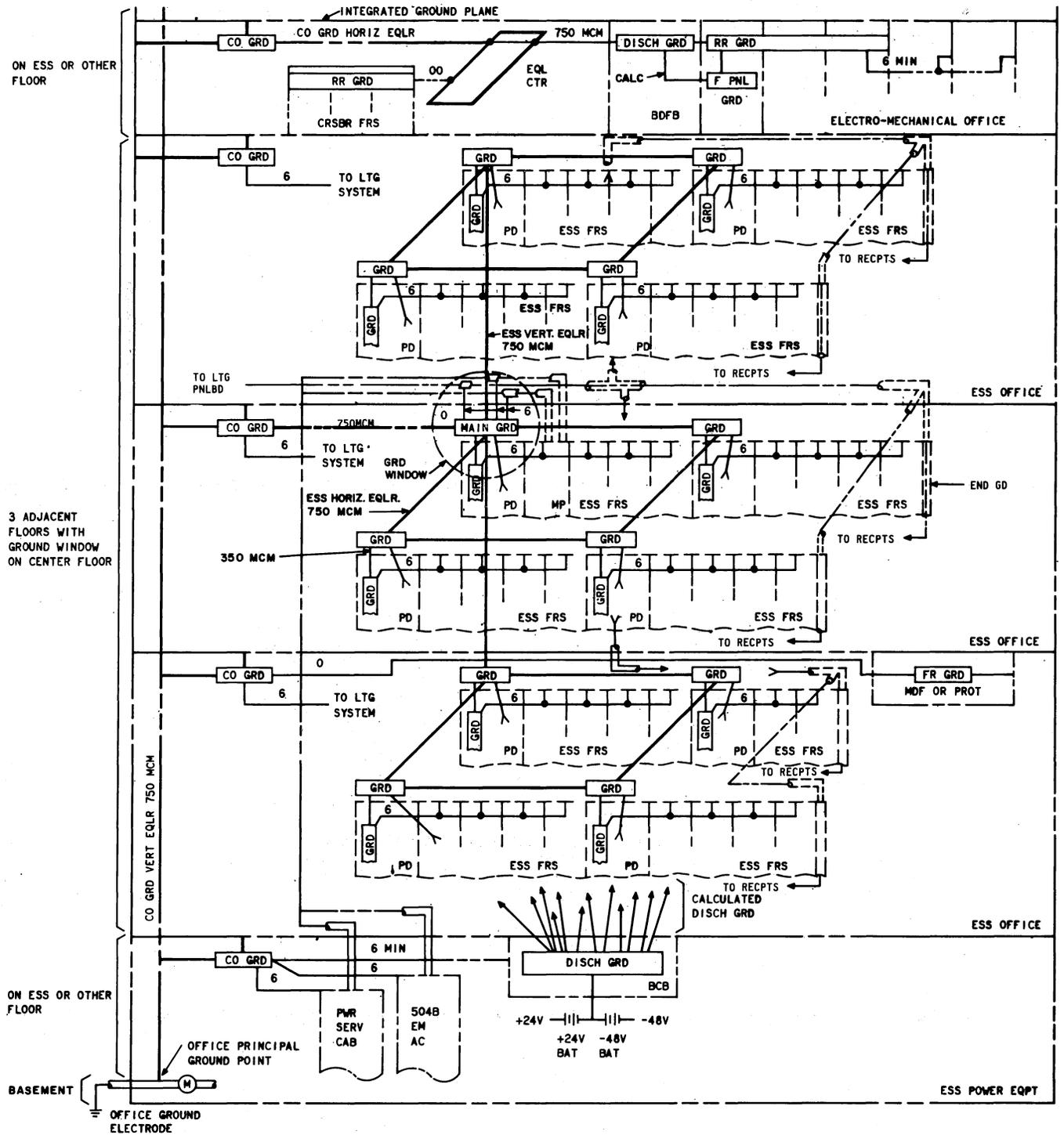


Fig. 2—Maximum Multifloor ESS Ground Plane Spread When a Single ESS Dedicated 24V/48V Power Plant Supplies Power to One or More ESS Offices

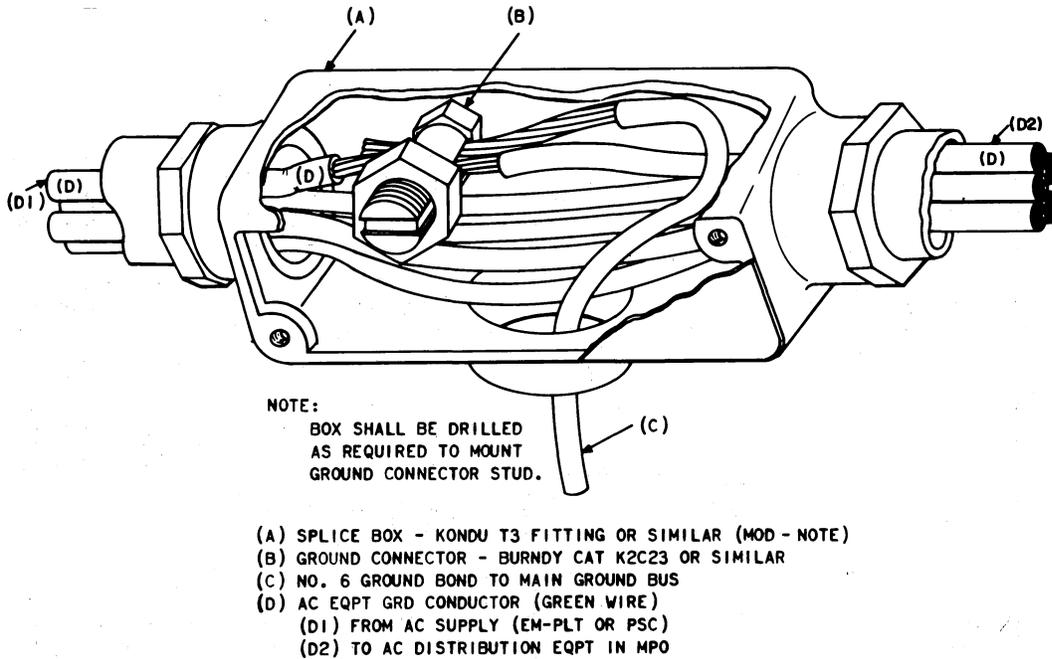


Fig. 3—Method of Connecting Essential and Protected AC Circuits Equipment Ground Conductor and Conduit to Main Ground Bus at Ground Window

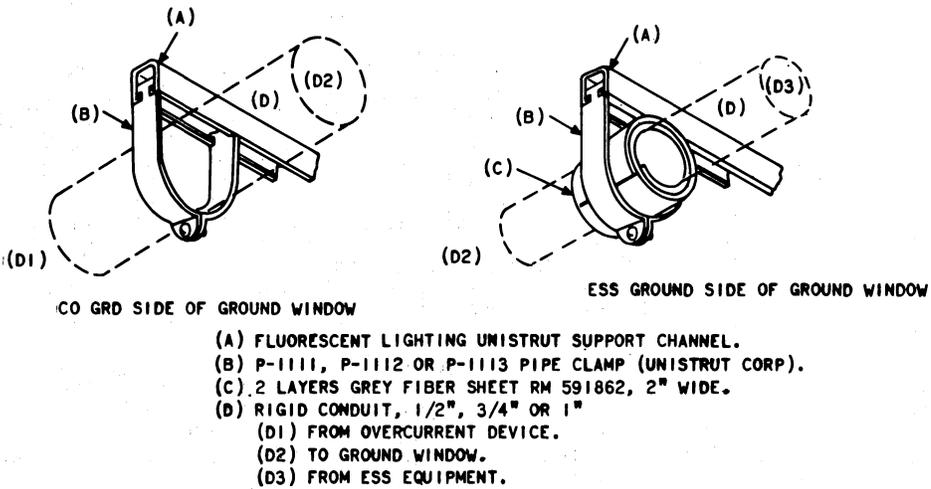


Fig. 4—Method of Supporting Conduits Entering ESS Area Through Ground Window From Fluorescent Lighting

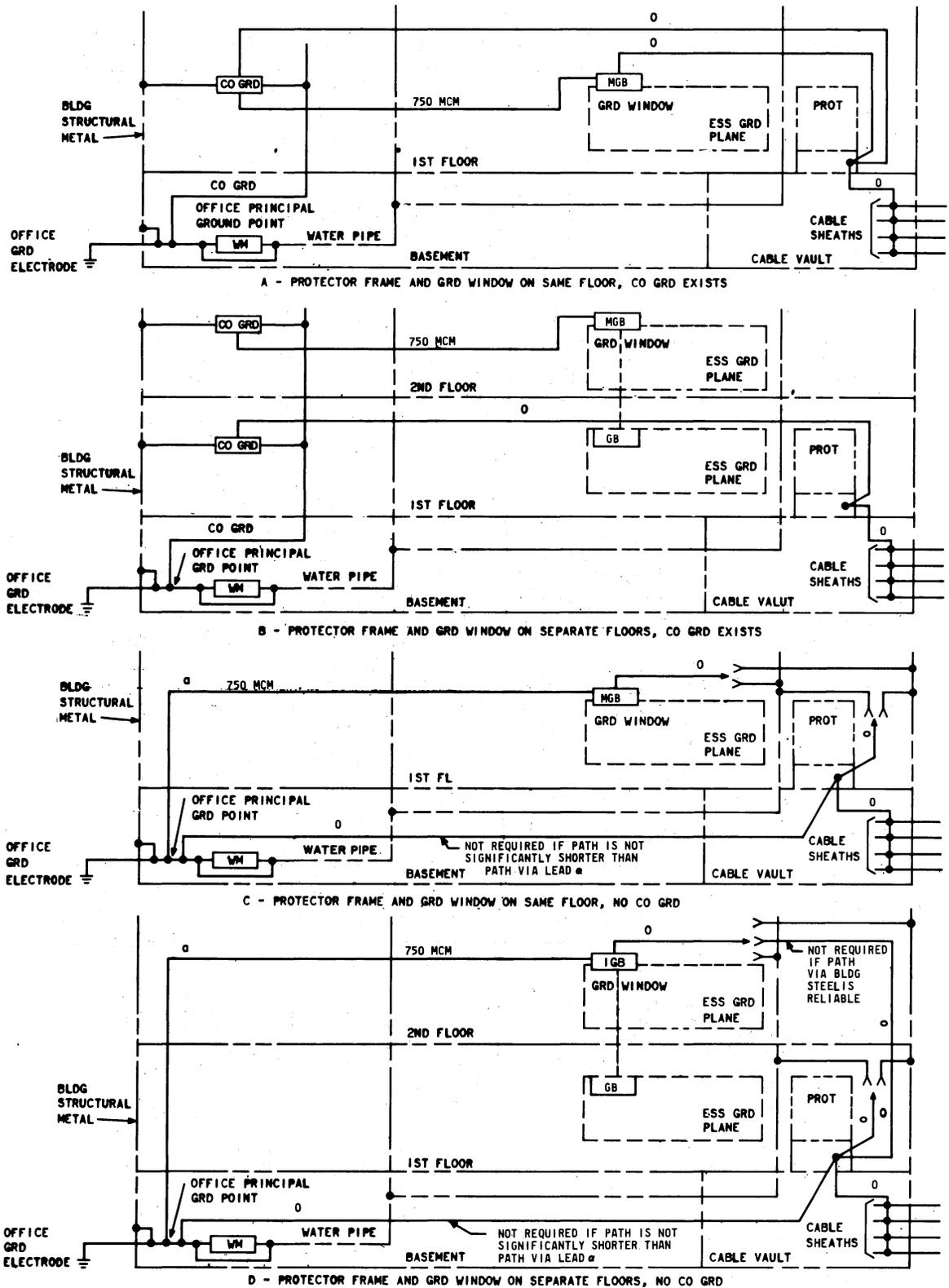


Fig. 5—Protector Frame Grounding Requirements in No. 1 ESS Offices

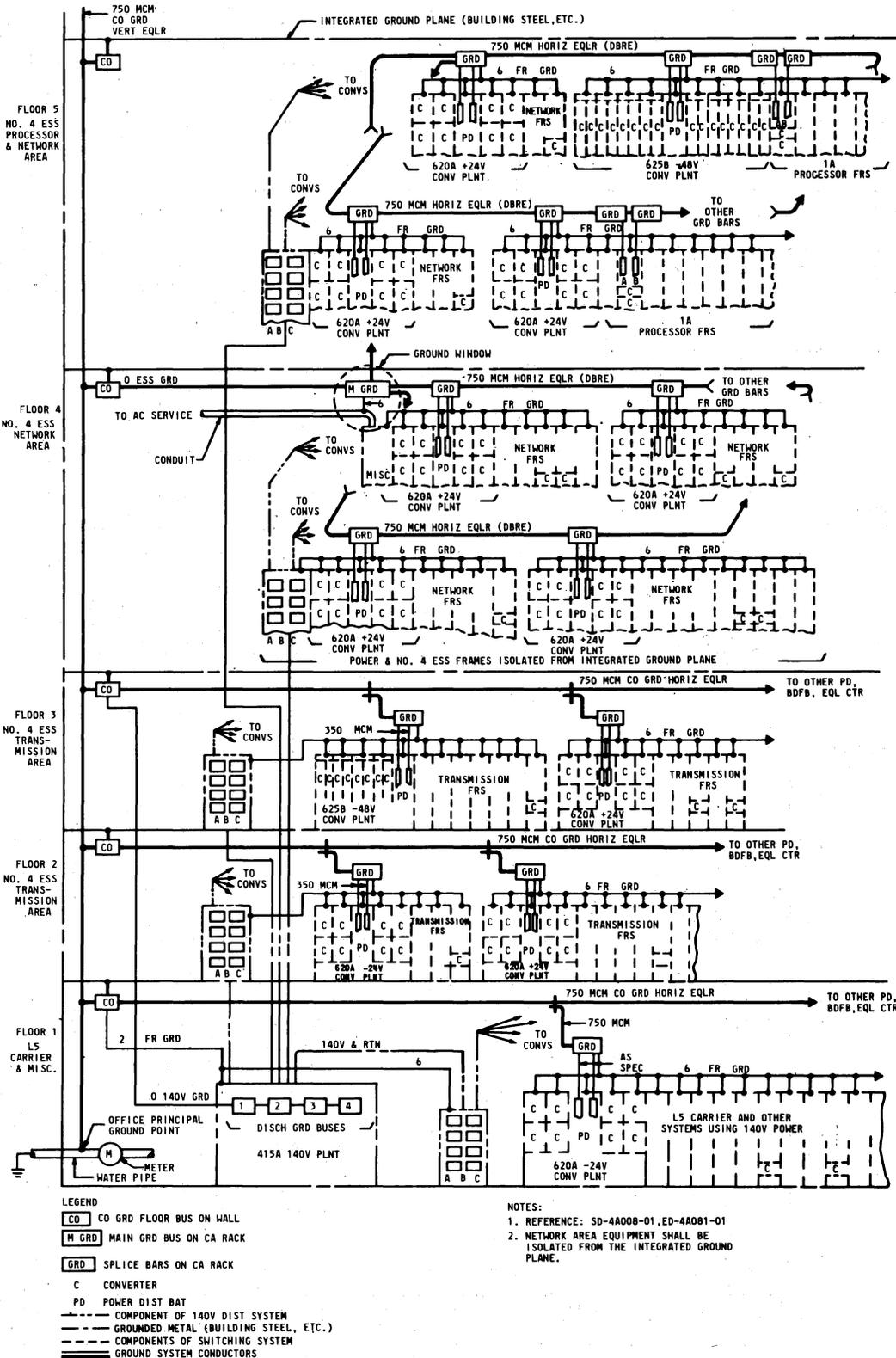


Fig. 6—Typical Grounding Arrangement for an Office Equipped With a No. 4 ESS Toll Switching System