FIGURE 9-2
Limiting of Voltage Potential on Equipment

to come in contact with the motor frame, there would be no appreciable voltage difference present between the frame and ground. Thus, a person in contact with the motor frame and a grounded surface will not experience any appreciable voltage difference. In effect, the connection of the equipment grounding conductor to the motor frame has ensured that the voltage on the motor frame will be kept to a minimum in the event of a phase-to-ground short circuit in the motor windings.

Provide a Low-Impedance Path for Fault Current

Grounding as a means of providing a low-impedance path for the flow of fault current is illustrated in Figure 9-3. As in Figure 9-2, conditions are shown for both an ungrounded motor frame and a grounded motor frame. As before, for the ungrounded situation, the motor will operate satisfactorily in the event of a fault between the ungrounded conductor and the motor frame with no obvious indication that the motor frame is not grounded.

FIGURE 9-3
Providing Path for Flow of Short Circuit Current
There is no path for the flow of current to return to the system, since the motor frame is not grounded. The result is that there is no appreciable increase in current through the motor feeder overcurrent devices. The overcurrent device contacts remain closed, and the system remains energized.

Connecting the motor frame to ground by use of an equipment grounding conductor provides a low-impedance path between the motor frame and ground. An ungrounded energized conductor coming in contact with the motor frame will result in an appreciable amount of short circuit current flowing through the overcurrent devices. The overcurrent devices will operate to clear the short circuit, thereby removing the dangerous condition and causing the motor to shut down. In this case, the equipment ground serves as a means to allow a sufficient magnitude of short circuit current to flow, permitting operation of the protective devices.

9-2

SYSTEM GROUNDING

The NEC requires grounding of certain systems for safety purposes. Specifically, Section 250.20(B)(1) of the NEC requires grounding of a system that can be grounded such that the maximum voltage between the ungrounded (phase) conductors and the grounded conductor does not exceed 150 V. This requirement would apply to the 120 V, single-phase, two-wire system shown in Figure 9-4(A) and the 120/240 V, single-phase, three-wire system shown in Figure 9-4(B). Section 250.20(B)(2) of the NEC also states that any three-phase, four-wire, wye-connected system that uses the neutral conductor as a return for unbalanced load current must be grounded. Examples of three-phase, four-wire, wye-connected systems that must be grounded are the 208Y/120 V and 480Y/277 V systems shown in Figure 9-4(C). Three-phase, four-wire systems supplied from a delta connection with one of the transformers tapped midphase are required to be grounded in accordance with Section 250-20(B)(3) of the NEC. The 240/120 V, three-phase, four-wire delta system shown in Figure 9-4(E) is an example of this requirement. Three-phase, three-wire systems supplied from a delta connection, as shown in Figure 9-4(D), are not required to be grounded by the NEC. While it is not required, the three-phase, three-wire delta system is permitted to be grounded. Certain industrial applications require an ungrounded three-phase, three-wire system. Typical system voltages for three-phase, three-wire delta systems are 240 V, 480 V, and 600 V.

The secondary supply of each system in Figure 9-4 is shown as being derived from the secondary of a utility transformer. The primary winding configuration will vary depending on the practices of the local service utility. The service entrance conductors are shown between the utility transformer and the service entrance. These conductors may be installed by either the utility company or the electrical contractor, depending on the local requirements and regulations. The service entrance is shown to the far right in each schematic.

Note that in each system shown in Figure 9-4, an earth ground is provided on the secondary of each transformer. To provide this earth ground, a driven ground rod or other made electrode is placed either near the pole, for overhead service, or near the pad-mount transformer, for underground services. For reasons previously discussed, the earth ground at the transformer provides a means of grounding the secondary winding of the transformer.
The grounded service conductor is connected to the grounded transformer secondary terminal as shown. This grounded conductor is routed with the ungrounded conductors to the service entrance. At the service entrance, an additional earth ground is provided by the grounding electrode system. The actual components comprising the grounding electrode system are discussed in the next section. On the load side of the service entrance, separate grounded conductor and equipment grounding conductors are required.
9-3 GROUNDING ELECTRODE SYSTEM

The grounded conductor of the supply system is connected to the grounding electrode system at the service entrance. The grounding electrode system effectively ties the system to earth ground at this point. The purpose of connecting the system to earth ground is to provide a means for overvoltages and induced surges to dissipate to ground. The grounding electrode system also forms a zero-voltage-potential plane in the vicinity of the electrical service. Thus, the bonding of all metal components of the raceway system and equipment enclosures to the grounding electrode system will ensure that there is no appreciable voltage difference between these components and earth ground.

The components of the grounding electrode system are shown in Figure 9-5. To form a true zero-potential grounding plane for all components of the system, Section 250.50 of the NEC requires that where present in the building, the metal framework of the building, metal underground water pipe, concrete-encased electrode, ground ring, and any other made or supplemental electrodes must be bonded together. Bonding refers to the intentional electrical connection between two or more metallic components. This bonding will ensure that all components so connected will assume the same electrical potential, with no potential difference between them.

The grounding electrode conductor is typically bare copper and must be protected where subject to physical damage. Protection is usually afforded by installing the grounding electrode conductor in rigid metal conduit, intermediate metal conduit, electrical metallic tubing, or rigid nonmetallic conduit (SCH 80). If protected by metallic conduit, both ends of the conduit must be bonded to the grounding electrode conductor to prevent the chocking effect of inductance, which will increase the effective impedance of the grounding electrode conductor during fault conditions. Section 250.64(C) of the NEC prohibits splicing of grounding electrode conductors unless connectors listed for such an application are used. Splicing may be done with irreversible compression-type connectors or exothermic weld.

Metal Underground Water Pipe

The metal underground water pipe is a required part of the grounding electrode system, subject to several NEC rules, which are covered in Section 250.52(A)(1). Essentially, any metal underground water pipe in contact with the earth for at least 10 feet of its length must be part of the grounding electrode system. This 10 foot section of underground pipe must be continuous and cannot be made discontinuous by removal of any joints or by the installation of nonmetallic sections. Continuity must be maintained by installing suitable bonding jumpers around devices likely to be disconnected and around nonmetallic sections.

It is common practice in many installations to use the interior metal water pipe as a bus for the connection of other grounding electrode conductors. In other words, a single grounding electrode conductor may be run from the service entrance equipment to the interior metal water pipe. Other grounding electrodes are then connected to the interior metal water pipe and run to their respective grounding electrodes. Section 250.52(A)(1) of the NEC restricts this practice to interior metal water pipe within 5 feet of the service entrance equipment. The interior metal water piping that is more than 5 feet from the service entrance cannot be used as a bus for the connection of other grounding electrode conductors.
FIGURE 9-5
Grounding Electrode System Requirements

The exception to this rule is commercial and industrial occupancies where qualified maintenance personnel are permitted to maintain the system. Also, the entire length of the interior metal water piping used for the purpose of connecting other grounding electrode conductors must be exposed.

Sizing of the grounding electrode conductor connecting the metal underground water pipe to the ground bus of the service entrance equipment is based on the size of the ungrounded service entrance conductors. Table 250.66 of the NEC, shown in Table 9-1,
### TABLE 9-1
Table 250.66 Grounding Electrode Conductor for Alternating-Current Systems

<table>
<thead>
<tr>
<th>Size of Largest Ungrounded Service-Entrance Conductor or Equivalent Area for Parallel Conductors&lt;sup&gt;a&lt;/sup&gt; (AWG/kcmil)</th>
<th>Size of Grounding Electrode Conductor (AWG/kcmil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Aluminum or Copper-Clad Aluminum</td>
</tr>
<tr>
<td>2 or smaller</td>
<td>1/0 or smaller</td>
</tr>
<tr>
<td>1 or 1/0</td>
<td>2/0 or 3/0</td>
</tr>
<tr>
<td>2/0 or 3/0</td>
<td>4/0 or 250</td>
</tr>
<tr>
<td>Over 3/0 through 350</td>
<td>Over 250 through 500</td>
</tr>
<tr>
<td>Over 350 through 600</td>
<td>Over 500 through 900</td>
</tr>
<tr>
<td>Over 600 through 1100</td>
<td>Over 900 through 1750</td>
</tr>
<tr>
<td>Over 1100</td>
<td>Over 1750</td>
</tr>
</tbody>
</table>

Notes:
1. Where multiple sets of service-entrance conductors are used as permitted in 230.40, Exception No. 2, the equivalent size of the largest service-entrance conductor shall be determined by the largest sum of the areas of the corresponding conductors of each set.
2. Where there are no service-entrance conductors, the grounding electrode conductor size shall be determined by the equivalent size of the largest service-entrance conductor required for the load to be served.

<sup>a</sup>This table also applies to the derived conductors of separately derived ac systems.

<sup>b</sup>See installation restrictions in 250.64(A).

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This lists the minimum required size of the grounding electrode conductor for connection to the metal water pipe. Note that although the required grounding electrode conductor may be copper, aluminum, or copper-clad aluminum, copper is usually used. Also note that for service entrance conductors larger than 1100 kcmil copper, or 1750 kcmil aluminum, the minimum-size grounding electrode conductor required for connection to the metal water pipe is #3/0 copper or 250 kcmil aluminum.

### EXAMPLE 9-1
Determine the minimum-size copper grounding electrode conductor for connection of the system to the metal underground water pipe for services consisting of the following ungrounded service entrance conductors:

- a) #4/0 XHHW aluminum
- b) 500 kcmil XHHW copper
- c) four 500 kcmil XHHW copper parallel per phase


Solution:

a) From Table 250.66, the required minimum size is #4 copper.
b) From Table 250.66, the required minimum size is #1/0 copper.
c) The total equivalent cross-sectional area is $4 \times 500 \text{ kcmil} = 2000 \text{ kcmil}$. Thus, from Table 250.66, the required minimum size is #3/0 copper.

The metal underground water pipe must be supplemented with an additional electrode as required by Section 250.53(D)(2) of the NEC. This additional electrode can be the metal framework of the building, a concrete-encased electrode, a grounding ring, or a made electrode, as appropriate.

**Metal Framework of Building**

The connection of the metal framework of the building to the grounding electrode system ensures that any accidental contact between an ungrounded conductor of the supply to the building structural steel will result in no excessive voltage on the structural steel members. This connection will also ensure that sufficient fault current will flow to operate any overcurrent protective devices on the source side of the fault. The minimum size for the grounding electrode conductor connected to the building structural steel is also based on Table 250.66 of the NEC.

**Concrete-Encased Electrode**

An electrode embedded in the concrete foundation or footer in direct contact with the earth can serve as part of the grounding electrode system according to Section 250.52(A)(3) of the NEC. To serve this purpose, the NEC requires the embedded conductor to be bare or galvanized steel reinforcing bar not less than $\frac{1}{2}$ inch in diameter or a minimum of 20 feet of #4 AWG or larger bare copper conductor. The NEC also requires these electrodes to be encased in at least 2 inches of concrete and to be placed near the bottom of the footing. The grounding electrode conductor that serves as the connection to this concrete-encased electrode is not required to be larger than #4 AWG copper. Consultation with the local electrical inspector to determine if bonding of the reinforcing steel is required is strongly advised if reinforcing bar is to be used as part of the foundation or footing in any building.

**Ground Ring**

A ground ring is defined by Section 250.52(A)(4) of the NEC as consisting of at least 20 feet of #2 AWG or larger bare copper conductor directly buried at least 30 inches below the top of finished grade. This ground ring typically encircles the entire building. The grounding electrode conductor that serves as the connection to the ground ring is not required to be larger than the conductor used for the ground ring.
Made Electrode

As previously mentioned, a grounding electrode system consisting solely of a metal underground water pipe must be supplemented with an additional grounding electrode. The supplemental electrode may be the building structural steel, a ground ring, or a concrete-encased electrode. Section 250.52(B) of the NEC prohibits metal underground gas pipe or aluminum electrodes to be used as a grounding electrode. The most common practice is to use a rod and pipe electrode or plate electrodes as the supplemental made electrode. The grounding electrode conductor that serves as the connection to the made electrode is not required to be larger than the #6 AWG copper or #4 AWG aluminum.

Section 250.52(A)(5) of the NEC allows a pipe electrode to consist of pipe or conduit no smaller than ¾ inch trade size and at least 8 feet in length. In addition, the NEC requires a rod electrode to be at least ¾ inch in diameter and 8 feet in length. Where not inherently corrosion resistant, the outer surface of any rod or pipe electrode must be galvanized or coated to prevent corrosion. Aluminum ground rods are not permitted by the NEC. The most common rod electrode is the ¾ inch diameter, 8 foot long, copper-clad steel ground rod. In accordance with Section 250.53(G) of the NEC, rod and pipe electrodes are typically driven vertically to a depth of 8 feet below finished grade. If rock prevents the rod from being driven vertically to a depth of 8 feet, the rod may be driven at an angle not to exceed 45 degrees from the vertical. The rod may also be buried horizontally in the trench at least 30 inches below finished grade. In all cases, the rod must be in direct contact with the earth for at least 8 feet of its length. Requirements for plate-type electrodes are covered in Section 250.52(A)(6) of the NEC.

The resistance to ground of any made electrode must not exceed 25 ohms, as required by Section 250.56 of the NEC. If the resistance exceeds 25 ohms, the made electrode must be supplemented by at least one additional electrode. This additional electrode may be the metal underground water pipe, a concrete-encased electrode, a ground ring, the metal frame of the building, or other made electrode. Typically, an additional made rod or plate electrode is installed to meet this requirement. Additional made electrodes must be spaced at least 6 feet apart to obtain maximum benefit.

9-4

SERVICE GROUNDING REQUIREMENTS

Single Service Disconnect

The requirements for grounding services differ somewhat depending on the arrangement of the service entrance equipment. The requirements for grounding at the service entrance comprised of a single panelboard containing the main service disconnect are shown in Figure 9-6(A). Note that in Figure 9-6(A), the grounded service conductor is connected to the neutral bus in the service entrance equipment. A separate ground bus for connection of the equipment grounding conductors and grounding electrode conductors is also shown. The neutral bus is bonded to the ground bus by means of a main bonding jumper. The main bonding jumper also connects the ground bus to the service entrance equipment enclosure.
Most panelboards marked as suitable for use as service entrance equipment have a combined neutral bus and ground bus. This combined bus consists of a terminal strip with terminals for connection of the grounded conductor and the grounding conductors of the system. The combined bus is typically insulated from the equipment enclosure itself. In these types of panelboards, the main bonding jumper consists of a screw terminal in the neutral bus. Bonding of the enclosure is accomplished by turning the screw, thereby connecting the combined neutral and ground bus to the equipment enclosure. The grounding
electrode conductors connect each of the components of the grounding electrode system to the ground bus, as shown.

In many installations, the main service disconnect is separated from the main service panel, as shown in Figure 9-6(B). An installation where the main service disconnect is located near the service drop and meter, with the panel located inside the building, is an example of such a separation. To meet the requirements of Section 250.6(A) of the *NEC*, bonding of the grounded service conductor and the grounding electrode system can occur only at the service entrance equipment. No other connection between the grounded conductor and grounding conductors is permitted. In the system shown in Figure 9-6(B), a separate, insulated grounded conductor is required to run from the service disconnect to the panel. An equipment grounding conductor is also run from the service disconnect to the panel. In the panel, there is no connection between the neutral bus and the ground bus. If a panelboard having a single neutral/ground bus is installed, the main bonding jumper screw must not be installed. In addition, a separate equipment ground bus must be installed to allow for connection of the equipment grounding conductors.

The main bonding jumper connects the service equipment enclosure to the grounded service conductor of the system. In the event of a short circuit to ground on the supply side of the main service overcurrent device, ground fault current will flow through the service raceway to the service equipment enclosure, then through the main bonding jumper to the grounded conductor of the system. Thus, the main bonding jumper must be sized to carry the ground fault current until the upstream protective devices operate to clear the fault.

The main bonding jumper is sized according to Table 250.66, as shown in Table 9-1, for service entrance conductors having a cross-sectional area up to 1100 kcmil for copper or 1750 kcmil for aluminum. Above these maximum-size service entrance conductors, Section 250.102(C) of the *NEC* requires the cross-sectional area of the main bonding jumper to be at least equal to 12.5% of the cross-sectional area of the service entrance conductors. Where different conductor material is used for the service conductor and main bonding jumper, the size of the main bonding jumper is determined by assuming a phase conductor of the same material as the bonding jumper. The ampacity of the assumed phase conductor must be at least equal to the ampacity of the installed phase conductors.

**EXAMPLE 9-2**

Determine the required copper main bonding jumper for the following service entrance conductors:

a) #4/0 XHHW copper
b) 500 kcmil XHHW copper
c) four 500 kcmil XHHW copper per phase
d) 600 kcmil XHHW aluminum
e) four 500 kcmil XHHW aluminum per phase

**Solution:**

a) The required copper main bonding jumper is read directly from Table 250.66 as #2 AWG.
b) The required copper main bonding jumper is read directly from Table 250.66 as #1/0 AWG.
(12.5%)(2000 kcmil) = 250 kcmil

Therefore, a 250 kcmil copper conductor at minimum is required for the main bonding jumper.

d) The minimum required main bonding jumper size is based on the copper equivalent of the 600 kcmil aluminum service-phase conductors. From Table 310.16 of the NEC, the ampacity of the 600 kcmil XHHW aluminum conductors is 340 A @ 75°C. The equivalent copper conductor is 500 kcmil, having a table-listed ampacity of 380 A @ 75°C. The required copper main bonding jumper size is based on 500 kcmil copper. From Table 250.66, the required main bonding jumper is #1/0 copper.

e) The minimum required main bonding jumper size is based on the copper equivalent of the four 500 kcmil XHHW aluminum conductors per phase. These conductors have an ampacity of 310 A each @ 75°C, or 1240 A for all four in parallel. The equivalent copper conductor is 350 kcmil, having a table-listed ampacity of 310 A @ 75°C, or 1240 A for four conductors parallel per phase. The total cross-sectional area of four 350 kcmil conductors per phase is 1400 kcmil. The minimum required cross-sectional area for the main bonding jumper is

(12.5%)(1400 kcmil) = 175 kcmil

Therefore, a minimum #4/0 copper conductor having a cross-sectional area of 211.6 kcmil is required for the main bonding jumper.

The grounded service conductor originates from the utility supply and terminates in the service entrance equipment. Section 250.24(B) of the NEC requires the grounded conductor to be run to each service disconnect and to be routed with the ungrounded phase conductors. The minimum required size of the grounded service conductor is based on the size of the ungrounded phase conductors in accordance with Table 250.66. For ungrounded phase conductors larger than 1100 kcmil copper or 1750 kcmil aluminum, Section 250.24(B)(1) of the NEC requires the grounded conductor to be sized no smaller than 12.5% of the cross-sectional area of the phase conductors. The grounded service conductor is not required to be larger than the ungrounded phase conductors.

For cases where the service conductors are installed in parallel in two or more raceways, the grounded conductor shall also be routed in parallel in each raceway. Section 250.24(B)(2) of the NEC requires the size of the parallel grounded conductor in each raceway to be based on the cross-sectional area of the ungrounded phase conductor in each raceway. The grounded service conductor cannot be smaller than #1/0 for parallel installations.

Note that sizing of the grounded conductor for the purposes of this section does not take into account the requirements for sizing based on the unbalanced load current expected. Sizing of the grounded conductor to carry the maximum unbalanced load current is determined in Chapter 10, on services. The actual size of the grounded conductor is based on the larger of that required for grounding and that required to carry the maximum unbalanced load current.
EXAMPLE 9-3

Determine the size of copper grounded conductor required for the following based solely on grounding requirements:

a) 500 kcmil XHHW copper
b) four 500 kcmil XHHW copper parallel per phase run in four raceways.

Solution:

a) The minimum required grounded conductor is read directly from Table 250.66 as #1/0 AWG copper.

b) Since each raceway contains one 500 kcmil conductor per phase, the minimum required grounded service conductor in each raceway is also #1/0 AWG copper. Therefore, each conduit will contain three 500 kcmil XHHW copper ungrounded phase conductors and one #1/0 AWG grounded conductor.

Multiple Service Disconnect

In multiple occupancy units, or in other similar installations, the service may consist of several service disconnects, as shown in Figure 9-7. Under this condition, the grounded service conductor must be run to each service disconnect as required by Section 250.24(B) of the NEC. The exception to this rule is that a single grounded conductor may be run to a group of service disconnects located in the same equipment enclosure. The size of the grounded service conductor entering the wireway from the service would be based on the cross-sectional area of the service conductors. The size of the grounded service conductor taps from the wireway to the individual service disconnects would be based on the cross-sectional area of the ungrounded tap conductors.

EXAMPLE 9-4

A service consisting of three disconnects is supplied by one 500 kcmil XHHW copper conductor per phase. The service disconnects are rated 100 A, 100 A, and 200 A. The tap conductors to the 200 A disconnect are #3/0 AWG XHHW copper, and the tap conductors to the 100 A disconnect is #3 AWG XHHW copper. Determine the size of the copper conductor that will meet the requirements for grounding for (a) the grounded service conductor, (b) the grounded service conductor tap to the 100 A disconnect, and (c) the grounded service conductor tap to the 200 A disconnect.

Solution:

a) The size of the grounded service conductor is based on the 500 kcmil service conductors and is read directly from Table 250.66. The required size is #1/0 AWG copper.

b) The size of the grounded service conductor is based on the #3 AWG copper tap conductors and is read directly from Table 250.66. The required size is #8 AWG copper.

c) The size of the grounded service conductor is based on the #3/0 AWG copper tap conductors and is read directly from Table 250.66. The required size is #4 AWG copper.
Figure 9-7
Service Grounding Requirements—Multiple Service Disconnect

Section 250.64(D) of the NEC permits the grounding electrode conductor to be tapped, as shown in Figure 9-7. The grounding electrode conductor must remain intact without any splices or joints that will compromise the continuity of the grounding electrode conductor. The size of the grounding electrode conductor is determined as previously discussed for the individual service disconnect and grounding electrode system. The grounding electrode taps to each service disconnect are sized based on the size of the ungrounded phase conductors supplied by the respective service disconnect enclosure.

Example 9-5
Determine the required grounding electrode conductor for the service configuration of Example 9-4.
Solution: The main grounding electrode conductor is based on the 500 kcmil copper service conductors. The grounding electrode conductor taps are sized based on the size of the conductor taps entering the individual service disconnects. Therefore, the required grounding electrode conductors are #1/0 AWG copper for the main grounding electrode conductor, #8 AWG copper for the grounding electrode conductor tap to the 100 A disconnect, and #4 AWG copper for the grounding electrode conductor tap to the 200 A disconnect.

Service Supplied from Another Building

The method of grounding a service supplied from another building is shown in Figure 9–8. Note that the grounded service conductor is connected to the grounding electrode system at the main service panel. Separate equipment-grounding conductors and grounded conductors are run from the main panel to the subpanel. This situation is similar to the grounding requirements of the system shown in Figure 9–6(B). A grounding electrode system satisfying the requirements as previously stated is required in the separate building.

EXAMPLE 9–6

A separate building is supplied with a 200 A service from the main service entrance. A 200 A overcurrent device located in the main service panel protects the #3/0 XHHW copper feeder conductors to the separate building service. Determine the size of the copper conductor required for (a) the grounded service conductor and (b) the equipment grounding conductor for this installation.

![Diagram of grounding system](image)

**FIGURE 9–8**

Grounding of Service Supplied from a Separate Building
Solution:

a) The minimum-size grounded service conductor required between the main panel and subpanel is based on the size of the feeder conductors and is read from Table 250.66. Therefore, the minimum required grounded service conductor is #4 AWG copper. This conductor must be insulated to ensure that there is no connection between the grounded conductor and the grounding system on the load side of the service disconnect. Keep in mind that this is the minimum required for grounding purposes only. The actual size will be determined only after unbalanced current is taken into account.

b) The minimum-size equipment grounding conductor required is based on the 200 A overcurrent device protecting the feeder conductors. The required equipment grounding conductor is read directly from Table 250.122, as shown in Table 9–2 on page 227. The required size is #6 AWG copper as read from the table.

9–5 GROUNDING OF SEPARATELY DERIVED SYSTEMS

A separately derived system is a system in which there is no direct electrical connection between the ungrounded phase conductors of the service and the ungrounded phase conductors of the separately derived system. In addition, there is no direct electrical connection between the grounded (neutral) conductor of the service and the grounded (neutral) conductor of the separately derived system. The need for a separately derived system occurs in many commercial and industrial power distribution systems where a supply voltage different from that of the service voltage is required for certain loads. A common example is a commercial establishment supplied at a service voltage of 480Y/277 V that requires 120 V for general-use receptacles and other 120 V loads. A single-phase or three-phase dry-type transformer is commonly used to step down the voltage to the appropriate level. In the example just described, a three-phase transformer having a 480 V, delta-connected high-side winding and a 208Y/120 V wye-connected secondary winding could be used. As an alternative, a single-phase transformer having a 480 V high-voltage winding and a 120/240 V low-voltage winding could also be used to provide the required low voltage.

Another example of a separately derived system is an emergency generator connected to the building electrical system by means of a transfer switch. If the transfer switch switches all ungrounded and grounded conductors, then the generator system is considered a separately derived system. If, however, the transfer switch does not switch the grounded conductor along with the ungrounded phase conductors, then the generator system is not considered a separately derived system.

Section 250.30(A)(1) of the NEC requires that the grounded conductor of a separately derived system must be connected to the equipment grounding conductors either at the source of the separately derived system or at the first disconnect. The grounding requirements for separately derived systems supplied from transformers are shown in Figure 9–9. With reference to Figure 9–9(A), the bonding jumper is shown connected between the secondary neutral terminal of the transformer and the transformer enclosure. The secondary neutral terminal is also connected to the grounding electrode system.