ungrounded conductor located at the point where the conductor receives its supply or at an alternative location in the circuit when designed under engineering supervision that includes but is not limited to considering the appropriate fault studies and time–current coordination analysis of the protective devices and the conductor damage curves. The overcurrent protection shall be permitted to be provided by either 240.100(A)(1) or (A)(2).

(1) Overcurrent Relays and Current Transformers. Circuit breakers used for overcurrent protection of 3-phase circuits shall have a minimum of three overcurrent relay elements operated from three current transformers. The separate overcurrent relay elements (or protective functions) shall be permitted to be part of a single electronic protective relay unit.

On 3-phase, 3-wire circuits, an overcurrent relay element in the residual circuit of the current transformers shall be permitted to replace one of the phase relay elements.

An overcurrent relay element, operated from a current transformer that links all phases of a 3-phase, 3-wire circuit, shall be permitted to replace the residual relay element and one of the phase-conductor current transformers. Where the neutral conductor is not regrounded on the load side of the circuit as permitted in 250.184(B), the current transformer shall be permitted to link all 3-phase conductors and the grounded circuit conductor (neutral).

(2) Fuses. A fuse shall be connected in series with each ungrounded conductor.

(B) Protective Devices. The protective device(s) shall be capable of detecting and interrupting all values of current that can occur at their location in excess of their trip-setting or melting point.

(C) Conductor Protection. The operating time of the protective device, the available short-circuit current, and the conductor used shall be coordinated to prevent damaging or dangerous temperatures in conductors or conductor insulation under short-circuit conditions.

240.101 Additional Requirements for Feeders

(A) Rating or Setting of Overcurrent Protective Devices. The continuous ampere rating of a fuse shall not exceed three times the ampacity of the conductors. The long-time trip element setting of a breaker or the minimum trip setting of an electronically actuated fuse shall not exceed six times the ampacity of the conductor. For fire pumps, conductors shall be permitted to be protected for overcurrent in accordance with 695.4(B)(2).

(B) Feeder Taps. Conductors tapped to a feeder shall be permitted to be protected by the feeder overcurrent device where that overcurrent device also protects the tap conductor.

ARTICLE 250
Grounding and Bonding

I. General

250.1 Scope

This article covers general requirements for grounding and bonding of electrical installations, and the specific requirements in (1) through (6).

(1) Systems, circuits, and equipment required, permitted, or not permitted to be grounded
(2) Circuit conductor to be grounded on grounded systems
(3) Location of grounding connections
(4) Types and sizes of grounding and bonding conductors and electrodes
(5) Methods of grounding and bonding
(6) Conditions under which guards, isolation, or insulation may be substituted for grounding

Informational Note: See Figure 250.1 for information on the organization of Article 250 covering grounding and bonding requirements.

The title of Article 250, *Grounding and Bonding,* conveys that grounding and bonding are two separate concepts. The two concepts are not mutually exclusive, and in many cases they are directly interrelated through the requirements of Article 250.

250.2 Definition

Bonding Jumper, Supply-Side. A conductor installed on the supply side of a service or within a service equipment enclosure(s), or for a separately derived system, that ensures the required electrical conductivity between metal parts required to be electrically connected.

Metal equipment enclosures, metal raceways, and metal cable trays are examples of equipment containing supply-side conductors that are required to be bonded. Where bonding jumpers are used, they are required to be installed and sized as specified in 250.102(A), (B), (C), and (E). Bonding jumpers installed on the load side of a service, feeder, or branch-circuit OCPD are *equipment bonding jumpers.*

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250.3 Application of Other Articles

For other articles applying to particular cases of installation of conductors and equipment, grounding and bonding requirements are identified in Table 250.3 that are in addition to, or modifications of, those of this article.

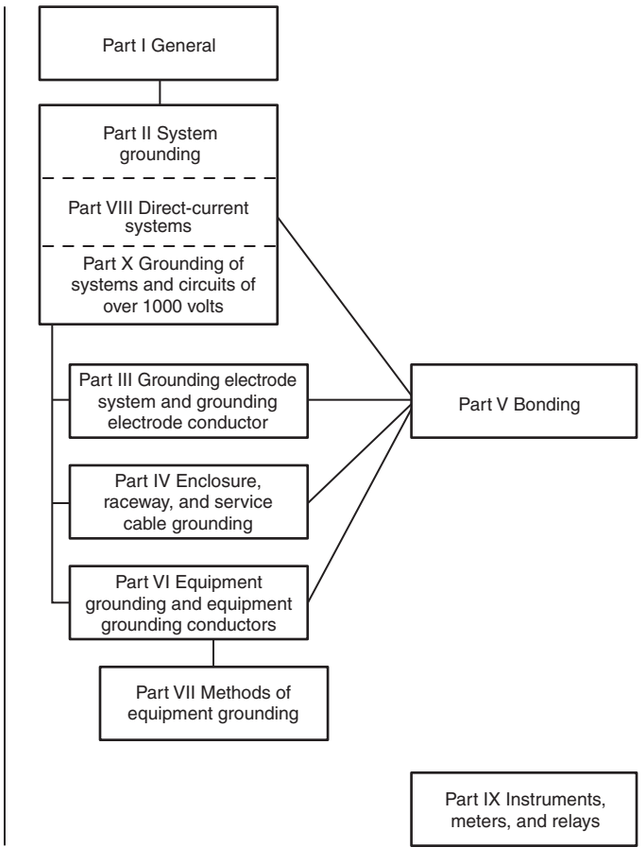

FIGURE 250.1 *Grounding and Bonding.*

250.4 General Requirements for Grounding and Bonding

The following general requirements identify what grounding and bonding of electrical systems are required to accomplish. The prescriptive methods contained in Article 250 shall be followed to comply with the performance requirements of this section.

Performance-based requirements provide an overall objective without mandating specifics for accomplishing that objective. The first paragraph of 250.4 indicates that the performance objectives stated in 250.4(A) for grounded systems and in 250.4(B) for ungrounded systems are accomplished by complying with the prescriptive requirements found in the rest of Article 250.

The requirements of 250.4 do not provide a specific rule for the sizing or connection of grounding conductors. Rather, the section outlines overall performance objectives for grounding conductors as applied to both grounded and ungrounded systems.

(A) Grounded Systems.

(1) Electrical System Grounding. Electrical systems that are grounded shall be connected to earth in a manner that will limit the voltage imposed by lightning, line surges, or unintentional contact with higher-voltage lines and that will stabilize the voltage to earth during normal operation.

Informational Note: An important consideration for limiting the imposed voltage is the routing of bonding and grounding electrode conductors so that they are not any longer than necessary to complete the connection without disturbing the permanent parts of the installation and so that unnecessary bends and loops are avoided.

(2) Grounding of Electrical Equipment. Normally non–current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth so as to limit the voltage to ground on these materials.

(3) Bonding of Electrical Equipment. Normally non–current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path.

(4) Bonding of Electrically Conductive Materials and Other Equipment. Normally non–current-carrying electrically conductive materials that are likely to become energized shall be connected together and to the electrical supply source in a manner that establishes an effective ground-fault current path.

(5) Effective Ground-Fault Current Path. Electrical equipment and wiring and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit facilitating the operation of the overcurrent device or ground detector for high-impedance grounded systems. It shall be capable of safely carrying the maximum ground-fault current likely to be imposed on it from any point on the wiring system where a ground fault may occur to the electrical supply source. The earth shall not be considered as an effective ground-fault current path.

The performance objective for the effective ground-fault current path is not always to facilitate operation of an OCPD. For high-impedance grounded systems, for example, the performance objective is to ensure operation of the required ground detector in order to activate some type of an alarm or other signal indicating the existence of a ground-fault condition.

(B) Ungrounded Systems.

(1) Grounding Electrical Equipment. Non–current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected to earth in a manner that will limit the voltage imposed by lightning or unintentional contact with higher-voltage lines and limit the voltage to ground on these materials.

TABLE 250.3 *Additional Grounding and Bonding Requirements*

Conductor/Equipment	Article	Section
Agricultural buildings		547.9 and 547.10
Audio signal processing, amplification, and reproduction equipment		640.7
Branch circuits		210.5, 210.6, 406.3
Cablebus		370.9
Cable trays	392	392.60
Capacitors		460.10, 460.27
Circuits and equipment operating at less than 50 volts	720	
Communications circuits	800	
Community antenna television and radio distribution systems		820.93, 820.100, 820.103
Conductors for general wiring	310	
Cranes and hoists	610	
Electrically driven or controlled irrigation machines		675.11(C), 675.12, 675.13, 675.14, 675.15
Electric signs and outline lighting	600	
Electrolytic cells	668	
Elevators, dumbwaiters, escalators, moving walks, wheelchair lifts, and stairway chairlifts	620	
Fixed electric heating equipment for pipelines and vessels		427.29, 427.48
Fixed outdoor electric deicing and snow-melting equipment		426.27
Flexible cords and cables		400.22, 400.23
Floating buildings		553.8, 553.10, 553.11
Grounding-type receptacles, adapters, cord connectors, and attachment plugs		406.9
Hazardous (classified) locations	500–517	
Health care facilities	517	
Induction and dielectric heating equipment	665	
Industrial machinery	670	
Information technology equipment		645.15
Intrinsically safe systems		504.50
Luminaires and lighting equipment		410.40, 410.42, 410.46, 410.155(B)
Luminaires, lampholders, and lamps	410	
Marinas and boatyards		555.15
Mobile homes and mobile home park	550	
Motion picture and television studios and similar locations		530.20, 530.64(B)
Motors, motor circuits, and controllers	430	
Natural and artificially made bodies of water	682	682.30, 682.31, 682.32, 682.33
Outlet, device, pull, and junction boxes; conduit bodies; and fittings		314.4, 314.25
Over 600 volts, nominal, underground wiring methods		300.50(C)
Panelboards		408.40
Pipe organs	650	
Radio and television equipment	810	
Receptacles and cord connectors		406.3
Recreational vehicles and recreational vehicle parks	551	
Services	230	
Solar photovoltaic systems		690.41, 690.42, 690.43, 690.45, 690.47
Swimming pools, fountains, and similar installations	680	
Switchboards and panelboards		408.3(D)
Switches		404.12
Theaters, audience areas of motion picture and television studios, and similar locations		520.81
Transformers and transformer vaults		450.10
Use and identification of grounded conductors	200	
X-ray equipment	660	517.78

(2) Bonding of Electrical Equipment. Non–current-carrying conductive materials enclosing electrical conductors or equipment, or forming part of such equipment, shall be connected together and to the supply system grounded equipment in a manner that creates a low-impedance path for ground-fault current that is capable of carrying the maximum fault current likely to be imposed on it.

(3) Bonding of Electrically Conductive Materials and Other Equipment. Electrically conductive materials that are likely to become energized shall be connected together and to the supply system grounded equipment in a manner that creates a low-impedance path for ground-fault current that is capable of carrying the maximum fault current likely to be imposed on it.

(4) Path for Fault Current. Electrical equipment, wiring, and other electrically conductive material likely to become energized shall be installed in a manner that creates a low-impedance circuit from any point on the wiring system to the electrical supply source to facilitate the operation of overcurrent devices should a second ground fault from a different phase occur on the wiring system. The earth shall not be considered as an effective fault-current path.

The performance requirements for grounding in both grounded and ungrounded systems can be categorized into two functions: system grounding and equipment grounding. These two functions are kept separate except at the point of supply, such as at the service equipment or at a separately derived system.

Grounding is the intentional connection of a current-carrying conductor to ground or to something that serves in place of ground. In most instances, this connection is made at the supply source, such as a transformer, and at the main service disconnecting means of the premises using the energy. Where a system operates "ungrounded," it does not have an intentionally grounded circuit conductor (i.e., grounded conductor), but equipment grounding through the use of an equipment grounding conductor (EGC) is required.

The two reasons for grounding are:

1. To limit the voltages caused by lightning or by accidental contact of the supply conductors with conductors of higher voltage
2. To stabilize the voltage under normal operating conditions (which maintains the voltage at one level relative to ground, so that any equipment connected to the system will be subject only to that potential difference)

Exhibit 250.1 shows a grounded single-phase, 3-wire service supplied from a utility transformer. Inside the service disconnecting means enclosure, the grounded conductor of the system is intentionally connected to a grounding electrode via the grounding electrode conductor. Bonding the equipment grounding bus to the grounded or neutral bus via the main bonding jumper within this enclosure provides a ground reference for exposed non–current-carrying parts of the electrical system. It also provides a circuit for ground-fault current through the grounded service conductor back to the utility transformer (source of supply). At the utility transformer, often an additional connection is made from the grounded conductor to a separate grounding electrode. This bonding of the EGC bus to the neutral bus facilitates the operation of OCPDs or relays under ground-fault conditions, not the connection to earth.

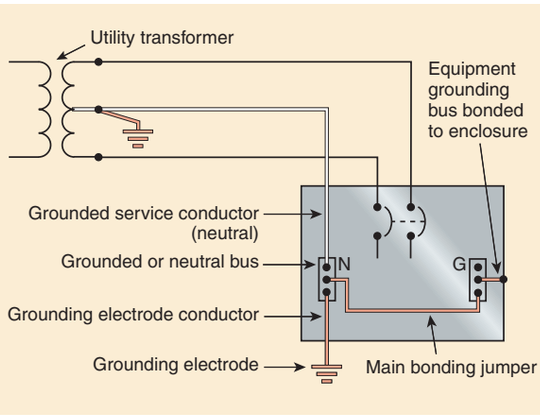

EXHIBIT 250.1 *Grounding and bonding arrangement for a single-phase, 3-wire service.*

250.6 Objectionable Current

(A) Arrangement to Prevent Objectionable Current. The grounding of electrical systems, circuit conductors, surge arresters, surge-protective devices, and conductive normally non–current-carrying metal parts of equipment shall be installed and arranged in a manner that will prevent objectionable current.

(B) Alterations to Stop Objectionable Current. If the use of multiple grounding connections results in objectionable current, one or more of the following alterations shall be permitted to be made, provided that the requirements of 250.4(A)(5) or (B)(4) are met:

(1) Discontinue one or more but not all of such grounding connections.
(2) Change the locations of the grounding connections.
(3) Interrupt the continuity of the conductor or conductive path causing the objectionable current.
(4) Take other suitable remedial and approved action.

Many electronic controls and computer equipment are sensitive to stray currents. Circulating currents on EGCs, metal raceways, and building steel develop potential differences between ground and the neutral of electronic equipment. Installation designers must look for ways to isolate electronic equipment from the effects of such stray circulating currents.