MEA 2017 NEC Grounding and Bonding Part 2

2-hour class presented by

Minnesota Electrical Association

This seminar will satisfy the 2-hour electrical code training for electricians required by the State of Minnesota.

Acknowledgements

Some material and illustrations presented are with permission of Cengage Learning from:
Electrical Grounding and Bonding 2014
by Phil Simmons

The National Electrical Code (NEC)® is:
Document 70 from the National Fire Protection Association (NFPA)

Objectives :

- Systems required to be grounded,
  - Permitted but not required to be grounded
  - Systems not permitted to be grounded
- Requirements for grounded systems
- Installing and sizing grounded service - and system conductors
- System conductors that are required to be grounded

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Objectives :

- Function of, and sizing, main and system bonding jumpers
- Grounding requirements for separately derived systems
- Grounding for two or more buildings supplied by a feeder or branch circuit
- Portable and vehicle-mounted generators
- High-impedance grounded neutral systems

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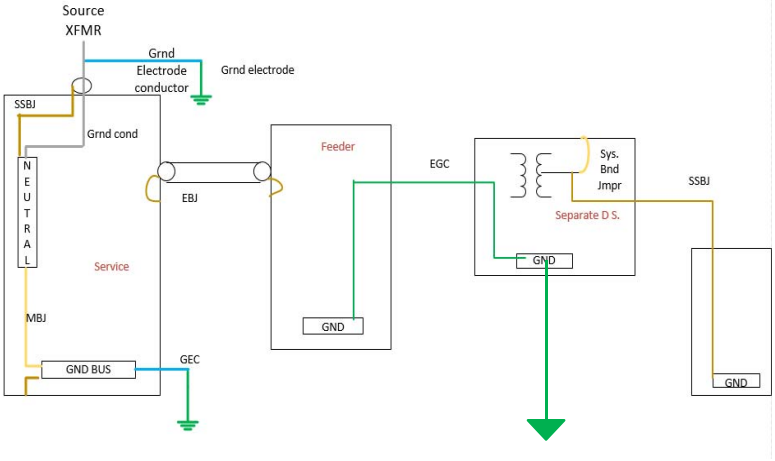
One line grounding



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250.20 AC Circuits and Systems to be Grounded

- Alternating-current circuits and systems are required to be grounded (connected to earth) if the system meets any of the conditions in 250.20(A), (B), (C), or (D)
- Voltage level supplied by the system is considered as a general rule
- Use of neutral for 3-phase systems also considered

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250.20 AC Circuits and Systems to Be Grounded

- Some circuits and systems are permitted to be grounded - 250.20(C) other than portable or mobile equipment. (see 250.188)
- If systems are grounded, the methods must comply with Article 250
- 250.21 - Some circuits are not required to be grounded. Parts (A)–(C)

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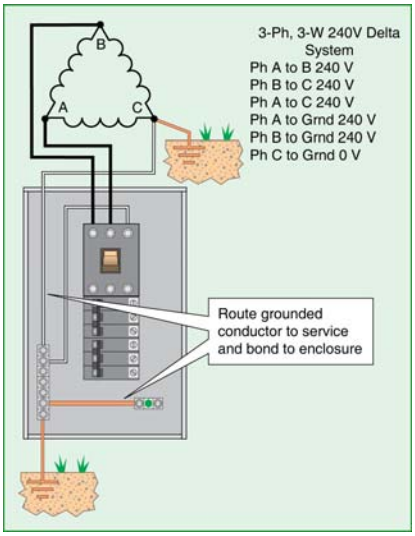
250.20 Informational Note; Example Corner Grounded Delta Systems

- Systems permitted but not required to be grounded
- Must meet 150-volt test of 250.20(A)(1) (if X-fmr exceeds 150V to grnd)
- If grounded, must comply with all other rules of Article 250



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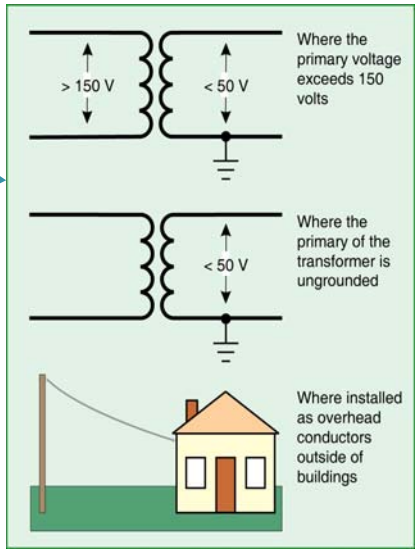
250.20(A) AC Systems of Less Than 50 Volts

AC systems of less than 50 volts are required to be grounded under any of the following conditions:



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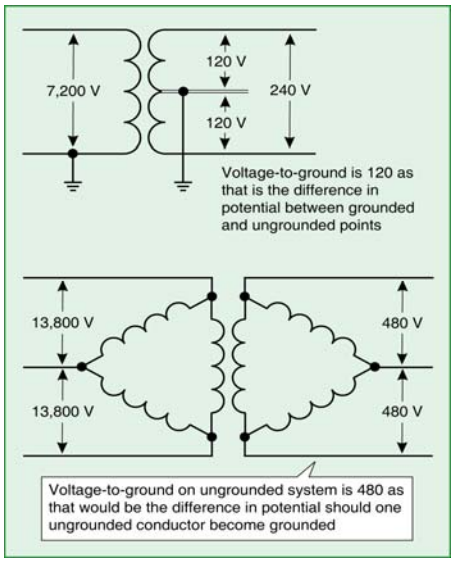
Article 100 Def: Voltage to Ground



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250.20(B) AC Systems of 50 to 1000 Volts

AC systems of 50 to 1000 volts that supply premises wiring and premises wiring systems are required to be grounded under specific conditions:

(1) Where the system can be grounded so the maximum voltage to ground on the ungrounded conductors does not exceed 150 volts

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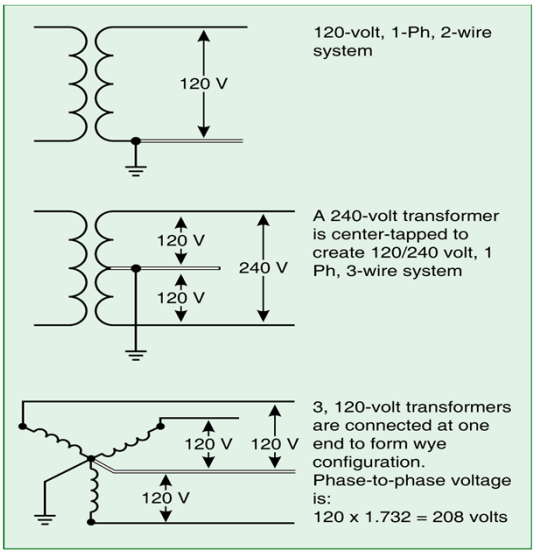
Systems 50 to 1000 Volts Required to be Grounded



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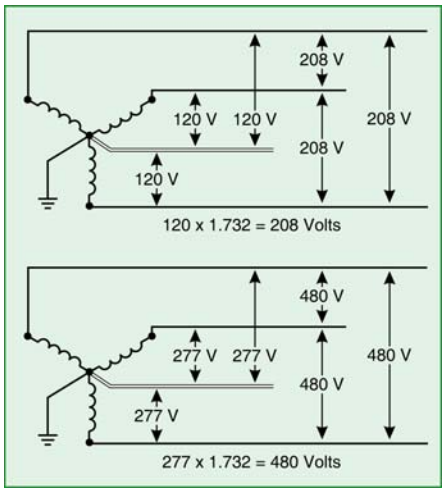
Systems 50 to 1000 Volts Required to be Grounded

(2) Where the system is 3-phase, 4-wire, wye connected in which the neutral is used as a circuit conductor

Typical voltages: 208Y/120; 480Y/277; 575Y/332; 600Y/346



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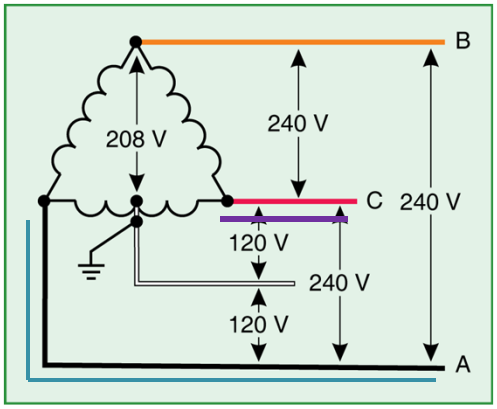
Systems 50 to 1000 Volts Required to be Grounded

(3) Where the system is 3-phase, 4-wire, delta connected in which the midpoint of one phase winding is used as a circuit conductor

Typical voltage is 120/240-volt, 3-phase, 4-wire



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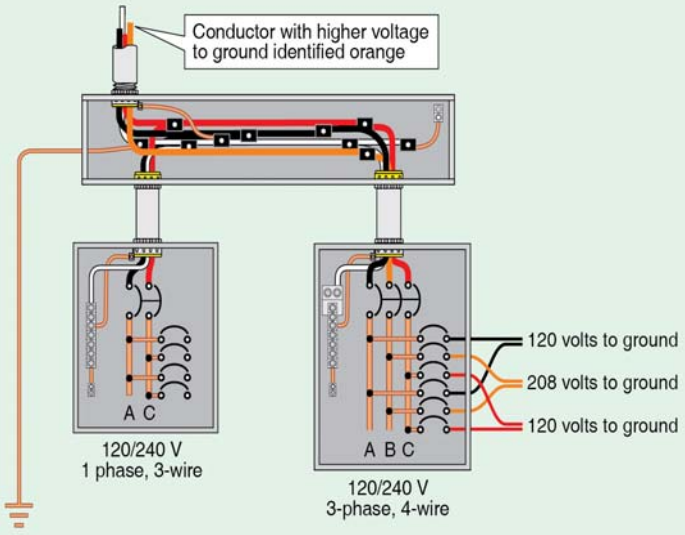
Conductor With Higher Voltage to Ground

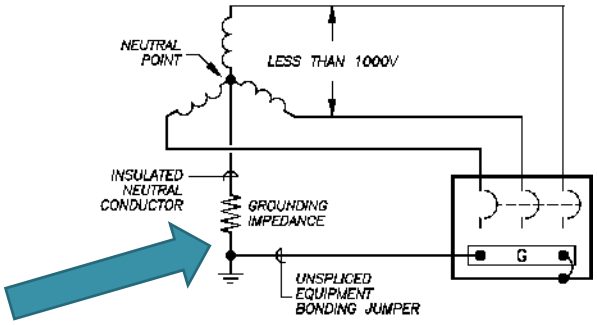


250.20 (C) AC systems over 1000 V

- Ac systems that supply mobile or portable equipment shall be grounded as specified in 250.188. Grounding of systems that supply mobile or portable equipment
- If supplying other than mobile of portable equipment, the systems are permitted to be grounded

250.20 (D) Impedance grounded neutral systems

Impedance grounded neutral systems shall be grounded as per 250.36 or 250.187



250.21 AC Systems of 50 to 1000 Volts Not Required to be Grounded (but may be)

1. Electric systems used exclusively to supply industrial furnaces for melting, refining, tempering, and the like.
2. Separately derived systems used exclusively for rectifiers that supply only adjustable-speed industrial drives.

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250.21 AC Systems of 50 to 1000 Volts Not Required to be Grounded

3. Separately derived systems supplied by transformers that have a primary voltage rating 1000 volts or less, provided all the following conditions are met:

   a) The system is used exclusively for control circuits
   b) Qualified persons service the installation
   c) Continuity of control power is required

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250.21 AC Systems of 50 to 1000 Volts Not Required to be Grounded

4. Other systems that are not required to be grounded in accordance with the requirements of 250.20(B)

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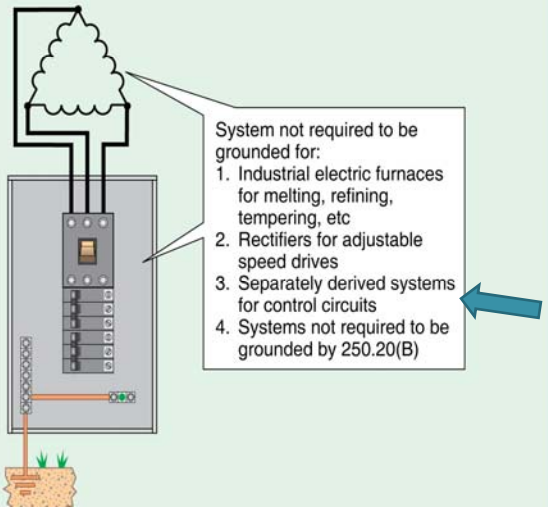
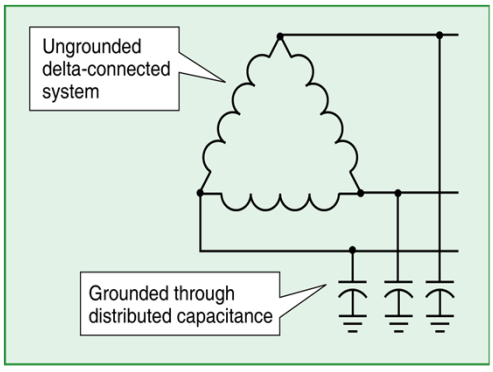
250.21 AC Systems of 50 to 1000 Volts Not Required to be Grounded



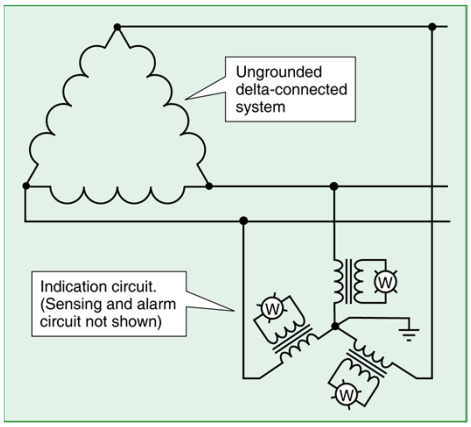
Actual Ungrounded System

- Ungrounded systems are grounded through distributed capacitance when insulated conductors are installed in metal enclosures.
- Sputtering faults can cause transient over voltages.



250.21(B) Ground Detection Required

- Ground detection required for any ungrounded system from A(1) through A(4) from 120V to 1000V
- Various types and levels of sophistication are available.
- The detection system is to be as close as practicable to the system supply
- NEC is silent on the type installed



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Marking Requirement

- **250.21(C) Marking.** Ungrounded systems shall be legibly marked "Caution Ungrounded System Operating __X___ Volts Between Conductors" at the source or first disconnecting means of the system. The marking shall be of sufficient durability to withstand the environment involved.
- Additionally -408.3(F)(2) Panelboards -Ungrounded Systems.
- "Caution Ungrounded System Operating _____ Volts Between Conductors"

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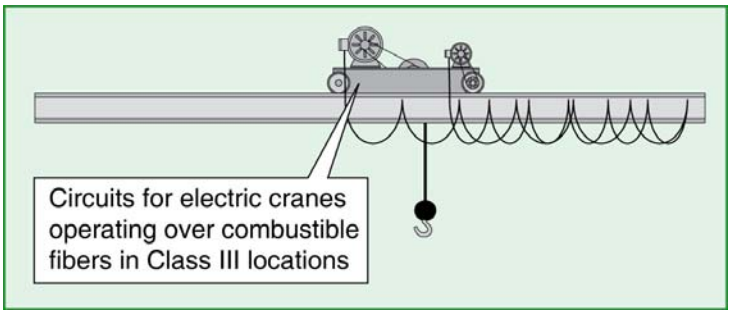
250.22 Circuits Not to Be Grounded

1. Circuits for electric cranes operating over combustible fibers in Class III locations as provided in 503.155



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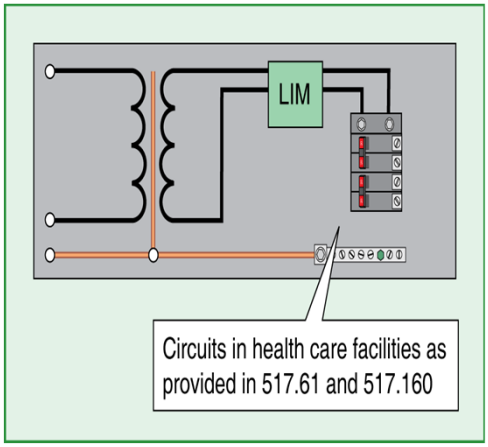
250.22 Circuits Not to Be Grounded

2. Circuits in health care facilities as provided in 517.61- Classified Anesthetizing locations and 517.160- Isolated power systems

Uses Line Isolation Monitor (LIM)



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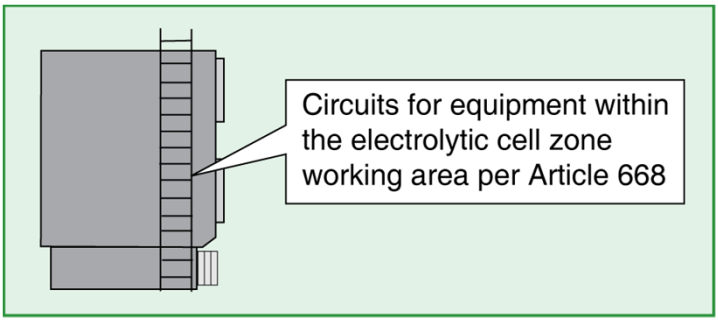
250.22 Circuits Not to Be Grounded

3. Circuits for equipment within the electrolytic cell line working zone as provided in Article 668



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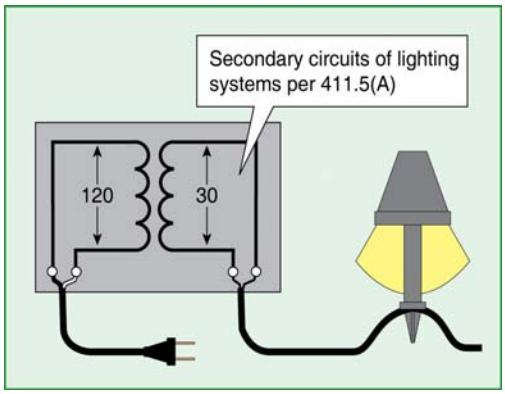
250.22 Circuits Not to Be Grounded

4. Secondary circuits of lighting systems as provided in 411.6(A): Lighting circuits at 30V or less – Class 2



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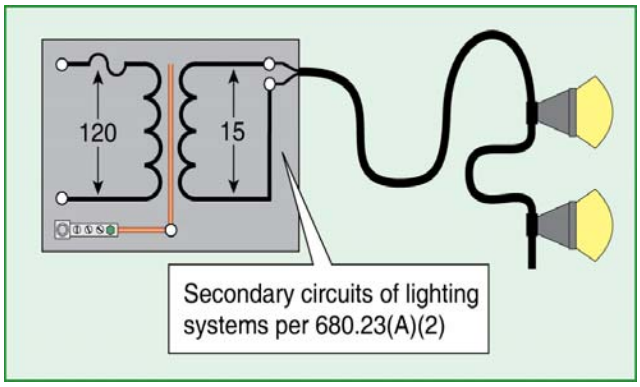
250.22 Circuits Not to Be Grounded

5. Secondary circuits of lighting systems as provided in 680.23(A)(2): Underwater luminaires



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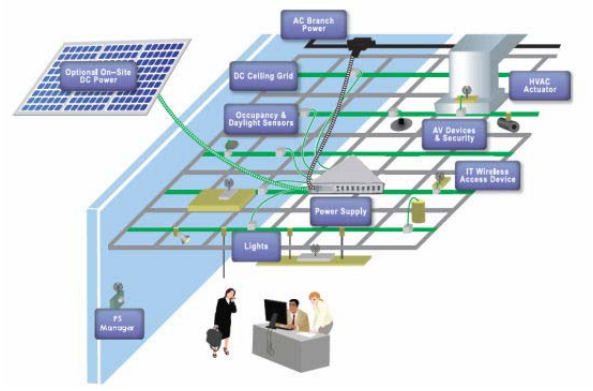
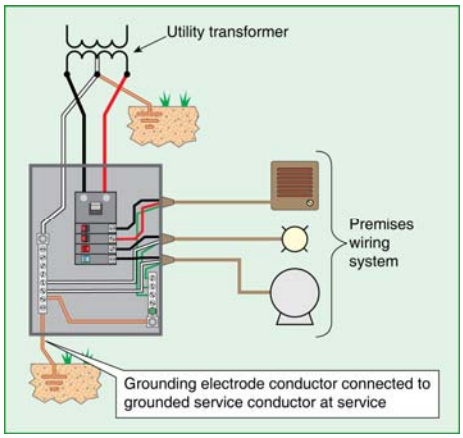
250.22 Circuits Not to Be Grounded

6. NEW Class 2 load side circuits for suspended ceiling low voltage power grid distribution systems as provided in 393.60(B)



250.24(A) System Grounding Connections for service supplied AC systems

A premises wiring system supplied by a grounded ac service must have a grounding electrode conductor connected to the grounded service conductor **at each service** per 250.24(A)(1) - (A)(5)



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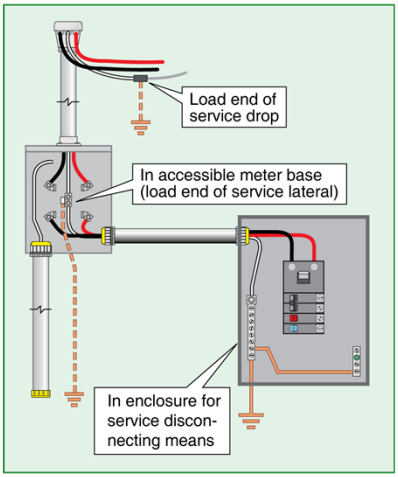
250.24(A)(1) General

GEC connection shall be made at any accessible point from the load end of the overhead service conductors, service drop, underground service conductors, or service lateral to, including the terminal or bus to which the grounded service conductor is connected at the service disconnecting means.



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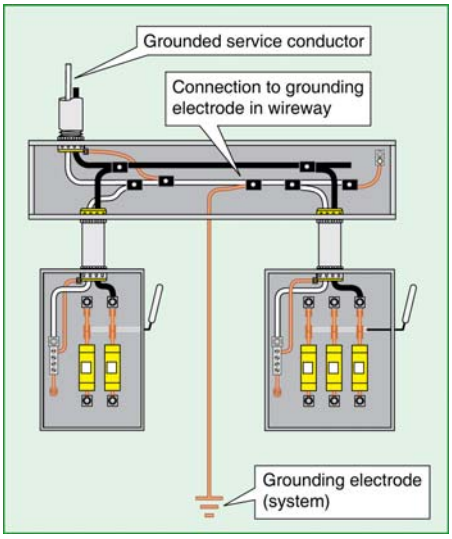
Generally Accepted Locations

1. At the weather-head for overhead services
2. At the meter socket or current transformer enclosure (verify with the utility and electrical inspector)
3. At a wireway or auxiliary gutter on the line side of the service equipment
4. Within the service equipment enclosure



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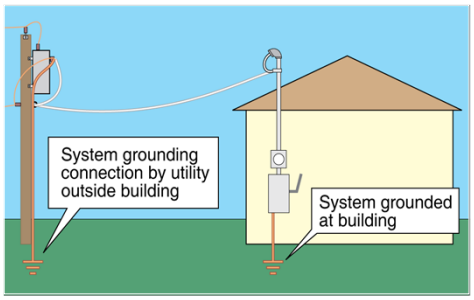
250.24(A)(2) Outdoor Transformer

If the transformer supplying the service is located outside, at least one additional grounding connection is required to be made from the grounded service conductor to a grounding electrode

* Exception for high impedance grounded systems



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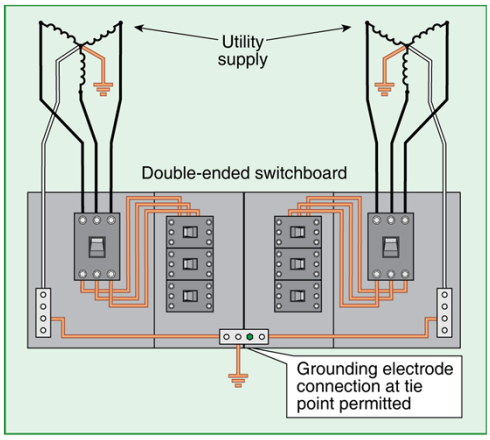
250.24(A)(3) Dual-Fed Services

A single grounding electrode connection to the tie point of dual-fed services is permitted



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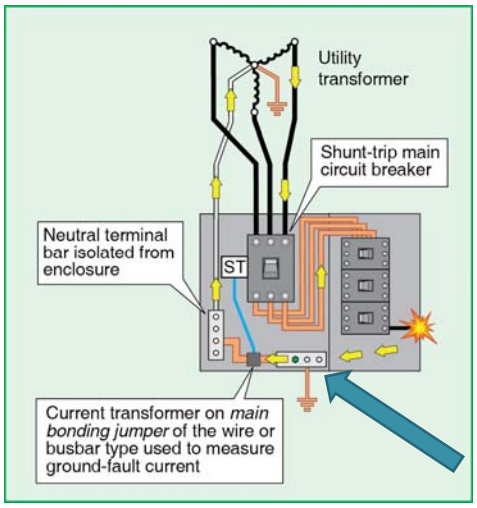
250.24(A)(4) Main Bonding Jumper as Wire or Busbar

If the main bonding jumper is a wire or busbar, the grounding electrode conductor is permitted to connect to the equipment grounding terminal bar or bus to which the main bonding jumper is connected .



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250.24(A)(5) Load-Side Grounding Connections

- A grounding connection is not permitted on the load side of the service disconnecting means unless permitted in Article 250. (connections other than service panel as in SDS)
- IN: See 250.30 for separately derived systems, 250.32 for buildings or structures supplied by a feeder or branch circuit and 250.142 for other permitted uses.

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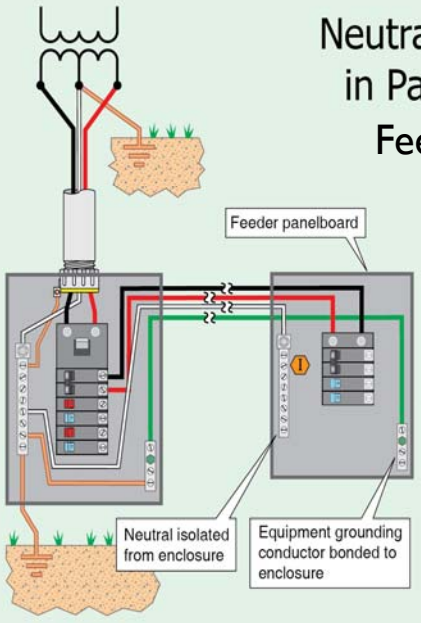
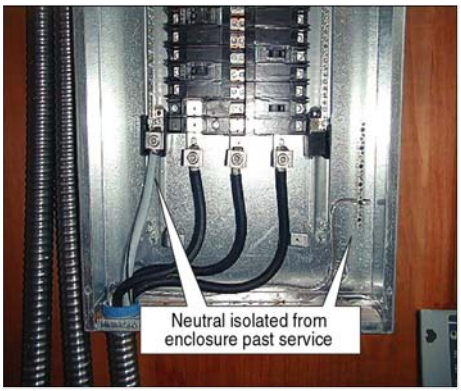
Neutral Isolated in Panelboard Feeders



Load-Side Grounding Connections

- Neutral terminal bar isolated from enclosure
- Equipment grounding conductor connects to enclosure



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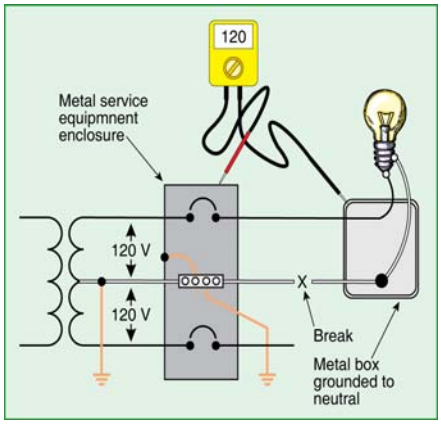
Hazard of Using a Neutral to Ground Equipment (Not allowed)

EG: If equipment is grounded to the neutral past the service, a loose neutral connection will result in a shock hazard if a ground fault occurs



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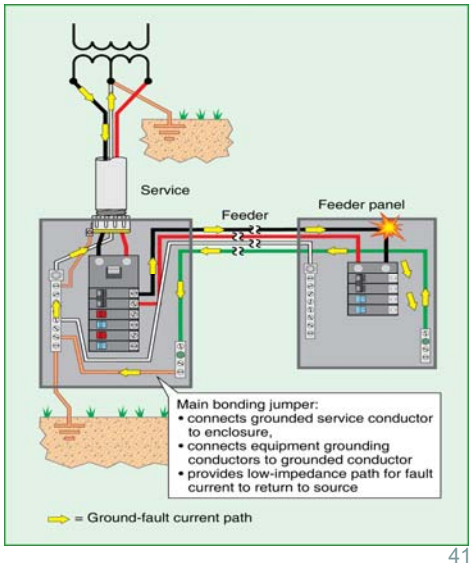
250.24(B) Main Bonding Jumper

For a grounded system, a main bonding jumper must connect the equipment grounding conductor(s) and the service disconnect enclosure to the grounded service conductor within each service disconnect enclosure as per 250.28



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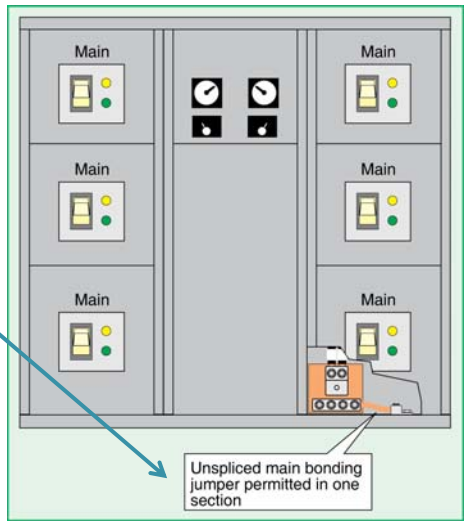
An Exception to 250.24 (B)

- An unspliced main bonding jumper is only required in one section of an assembly listed for use as service equipment
- Usually furnished by manufacturer



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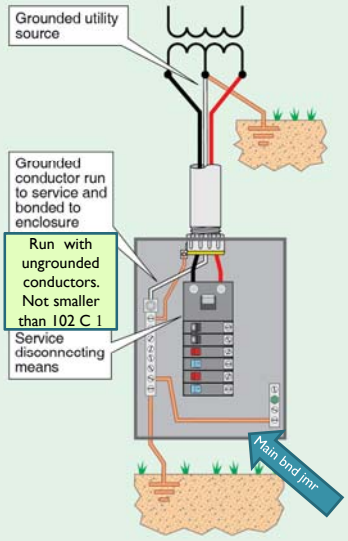
250.24(C) Grounded conductor to the service equipment

Grounded Conductor to Service Equipment

1000V or less

If an ac system operates at less than 1000 volts and is grounded at any point, the grounded conductor is required to be run to each service disconnecting means and be connected to it by a main bonding jumper



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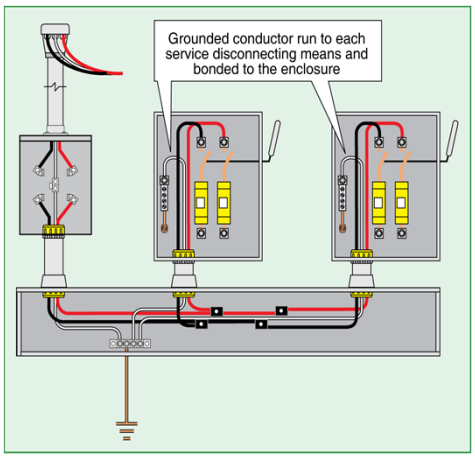
250.24(C) Grounded Conductor Brought to Service Equipment

- Grounded conductor run to each service disconnecting means from wireway.
- Provides vital path for fault current to return to the source (utility transformer)



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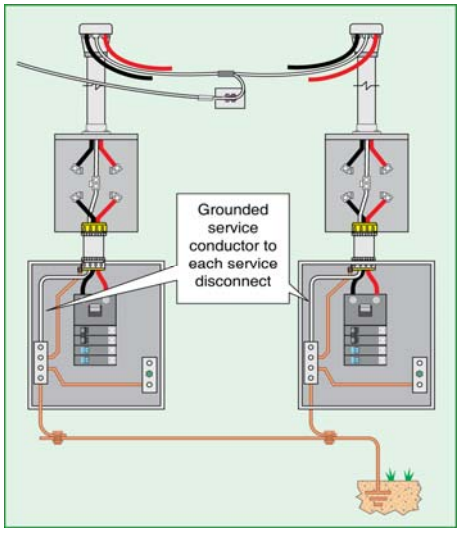
250.24(C) Grounded Conductor Brought to Service Equipment

Grounded conductor to each service disconnecting means supplied from service drop or overhead service conductors



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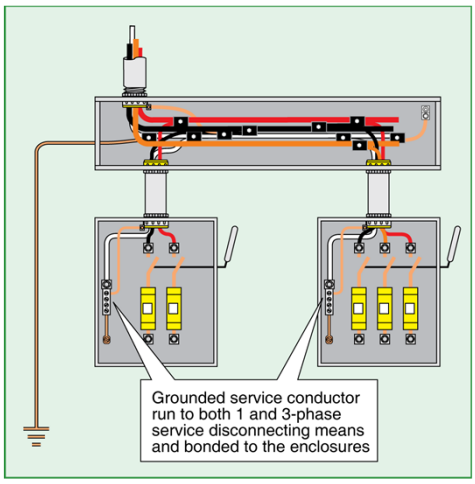
250.24(C) Grounded Conductor Brought to Service Equipment

Grounded service conductor required to be bonded to each service disconnecting means for 1-phase and 3-phase service disconnects



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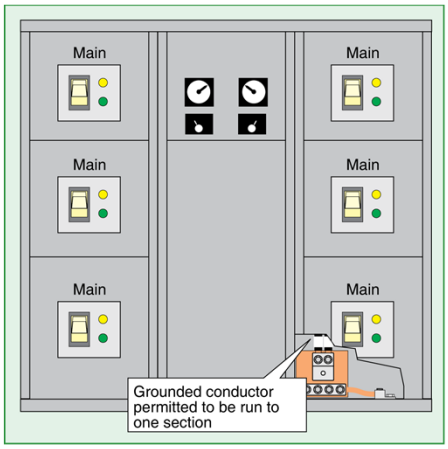
An Exception to 250.24(C)

Grounded service conductor only required to be bonded to one section of listed service equipment consisting of more than one service disconnecting means



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250.24(C)(1) Sizing for Single Raceway

- Grounded system conductor (often a neutral) is required to be not smaller than the required grounding electrode conductor specified in Table 250.102(C)(1)
- Not required to be larger than the largest ungrounded service-entrance conductor

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250.24(C)(1) Sizing for Single Raceway

- Obtain size of service-entrance conductors
- Use the size of these conductors in Table 250.102(C)(1) to determine the minimum size of the grounded system conductor
- Compare to the size of grounded conductor required from load calculation in 220.61
- Compare to instructions from design engineer
- Install the largest of these conductors

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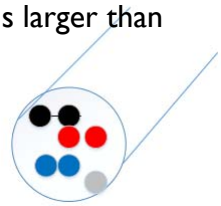
250.24(C)(1) Sizing for Single Raceway

For parallel sets of conductors installed in compliance with 310.10(H):

- If in one raceway such as a wireway, determine the area of the largest set of conductors in parallel and consider as one conductor
- Follow Table 250.102(C)(1) for size of neutral conductor
- If area of ungrounded set of conductors is larger than 1100 kcm copper then
- Table 250.102(C)(1), apply 12.5% rule



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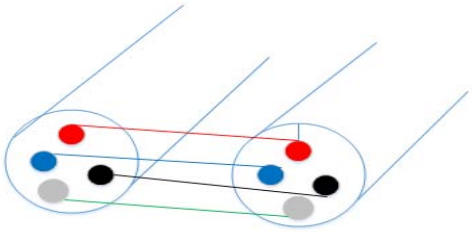
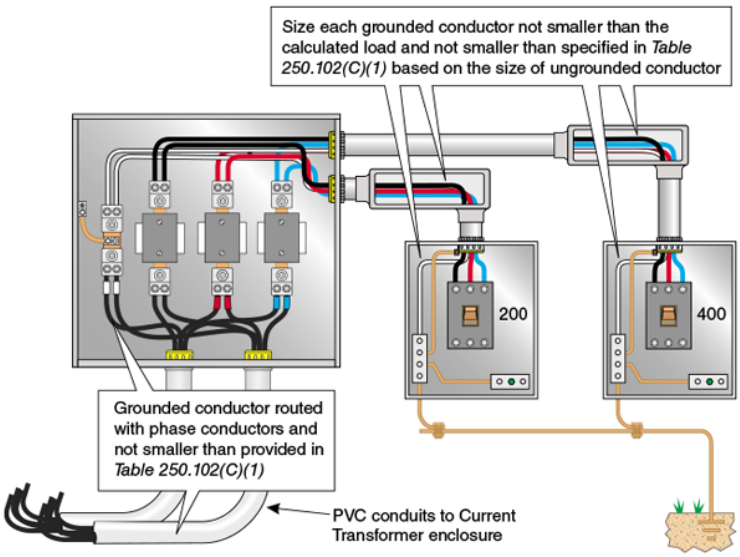
250.24(C)(2) Sizing for Parallel runs in two or more raceways

The grounded conductor shall also be installed in parallel. The size of the grounded in each raceway, or cable, shall be based on the total CM area of the parallel ungrounded conductors in the raceway, or cable, but not smaller than 1/0 AWG





Example

350 kcmil aluminum service lateral conductors in each conduit

- Table 250.102(C)(1) = 2 AWG copper or 1/0 aluminum
- Compare to size required by load calculation
- Minimum 1/0 AWG for parallel grounded conductor installations
- Install largest required conductor

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Example

3/0 AWG copper conductors to 200 ampere service disconnect

- Table 250.102(C)(1) requires 4 AWG copper or #2 AWG aluminum grounded conductor
- Larger conductor may be required by load calculation

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More Requirements

- For service-entrance conductors larger than 1100 kcmil copper or 1750 kcmil aluminum, the grounded system conductor must be not smaller than 12½ percent of the area of the largest service-entrance phase conductor
- This presumes all service conductors are in a single raceway such as a wireway

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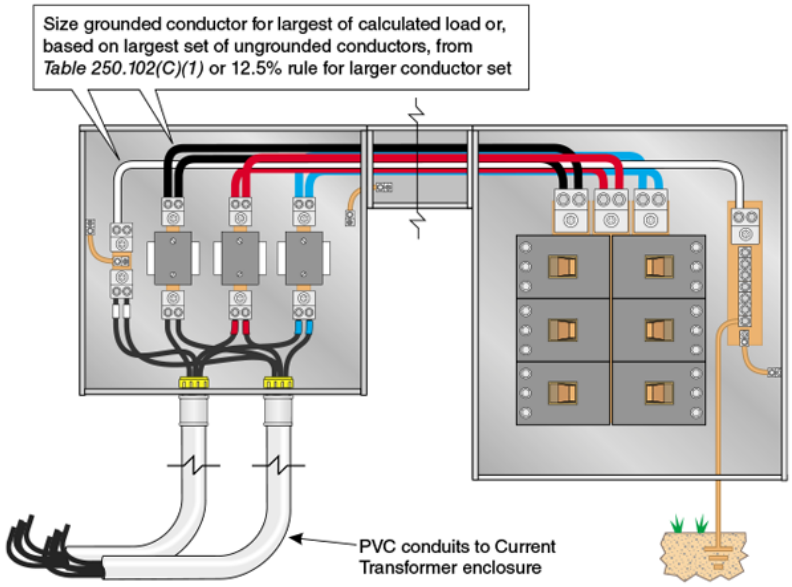

Example

- Add together the circular mil area of the largest set of service-entrance conductors
- Multiply this value by 0.125 (12½ percent)
- The result is the minimum size of grounded (neutral) conductor

- Go to Table 8 of Chapter 9

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Example

Table 250.102(C)(1) can be used for conductor sizes covered by the table

- 800 ampere service with 2 sets of 500 kcmil service conductors
- 500 kcmil × 2 = 1000 kcmil
- Table 250.102(C)(1) requires 2/0 AWG copper main bonding, or system bonding conductor

58

Example

For ungrounded conductors larger than 1100 kcmil copper or 1750 kcmil aluminum

- 1200 ampere service
- Four 350-kcmil service conductors
- 4 × 350 kcmil = 1400 kcmil (1,400,000 cm)
- 1,400,000 cm × 0.125 = 175,000 cm
- Next standard size 4/0 AWG (211,600 cm) (Table 8 of Chapter 9)

59

Parallel Service-Entrance Conductors

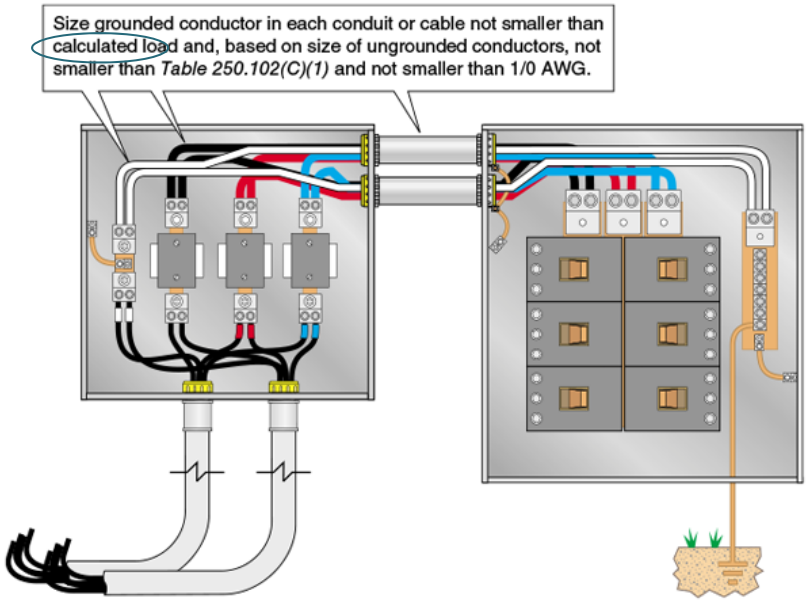
Service Ampere Rating	Total Area of Ungrounded Conductors	Minimum Area of Grounded Conductor	Minimum Size of Grounded Conductor
1000	(3) 400 kcmil = 1200 kcmil	150,000 cm	3/0
1200	(4) 350 kcmil = 1400 kcmil	175,000 cm	4/0
1600	(5) 400 kcmil = 2000 kcmil	250,000 cm	250 kcmil
2000	(6) 400 kcmil = 2400 kcmil	300,000 cm	300 kcmil

60

250.24(C)(2) Parallel Conductors

- Applies where two or more raceways are installed
- Grounded conductor in each raceway sized on the circular mil area of the ungrounded conductor **in the raceway**
- Minimum size 1/0 AWG
- Table 250.102(C)(1) used for sizing, or calculated load whichever is larger

61

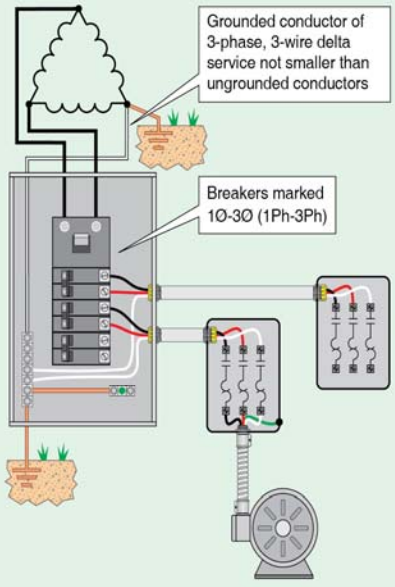


250.24(C)(3) Grounded Conductor for 3-Ph, 3-Wire (Delta connected service)

- The grounded conductor for a 3-phase, 3-wire, delta connected service (corner ground) is required to have an ampacity not less than the ungrounded conductors
- Applies to corner-grounded delta-connected 3-phase systems.
- Grounded conductor treated like a neutral for a 120/240 volt single phase system

63

Grounded Conductor for 3-Phase, 3-Wire Service



64

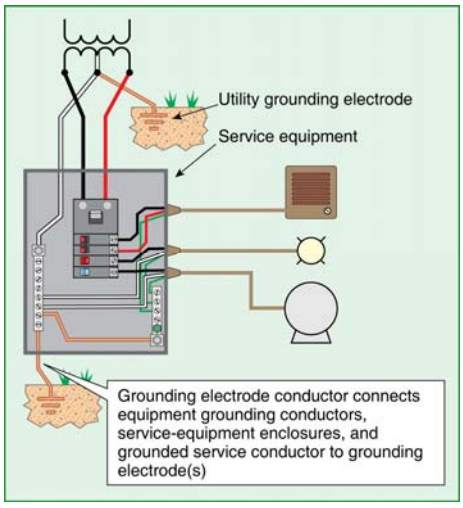
250.24(D) Grounding Electrode Conductor

- A grounding electrode conductor is required to be used to connect the equipment grounding conductors, the service-equipment enclosures and, where the system is grounded, the grounded service conductor to the grounding electrode(s) required by Part III of Article 250.
- Size conductor per 260.66 (both the written article and the table)
- High-impedance grounded neutral system connections are grounded in accordance with 250.36

65

250.24(D) Grounding Electrode Conductor

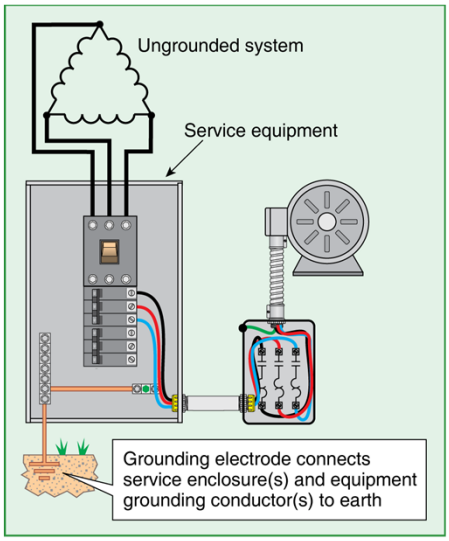
- 250.21 for grounding electrode connection
- 250.50 for grounding electrode system
- 250.52 for grounding electrode descriptions
- 250.64 for installation rules
- 250.66 for sizing



66

250.24(E) Ungrounded System Grounding Connections

- Metal enclosures for service equipment and equipment grounding conductors required to be connected to grounding electrode system
- Results in "case ground"



67

250.24(E) Ungrounded System Grounding Connections

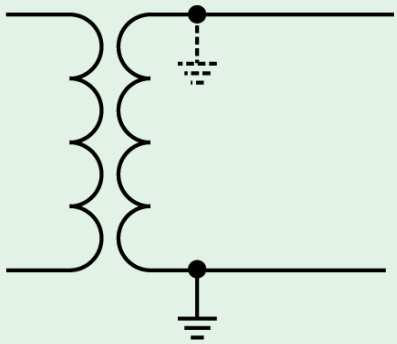
Size grounding electrode conductor according to 250.66 based on the size of the largest ungrounded system conductor

68

250.26 Conductor to be Grounded – AC Systems

1. Single-phase, 2-wire – one conductor

- Typically 120-volt systems



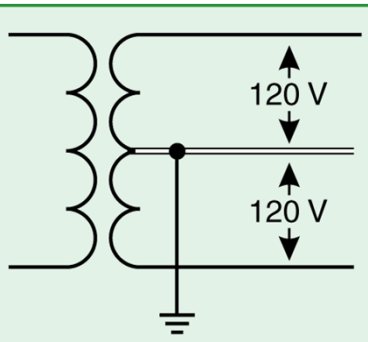
(1) 1-phase, 2-wire - one conductor (either one)

69

250.26 Conductor to be Grounded – AC Systems

2. Single-phase, 3-wire – the neutral conductor

- Typically 120/240 volt, 1-phase, 3-wire



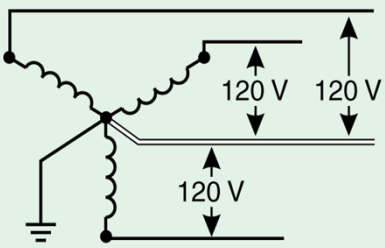
(2) 1-phase, 3-wire - the neutral conductor

70

250.26 Conductor to be Grounded – AC Systems

3. Multiphase systems having one wire common to all phases - the common neutral conductor

- Typically 3-phase, 4-wire wye systems



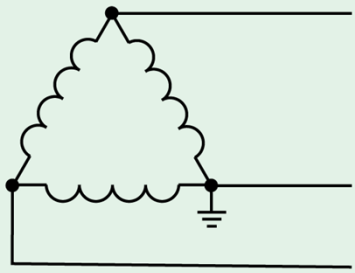
(3) Multiphase systems with one wire common to all phases - the common wire

71

250.26 Conductor to be Grounded – AC Systems

4. Multiphase systems where one phase is grounded – one phase conductor

- Typically 3-phase, 3-wire delta connected systems



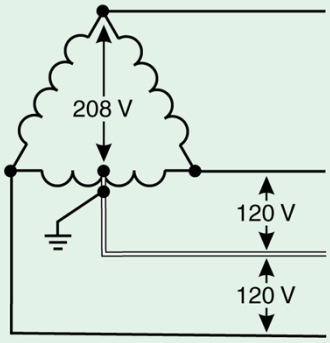
(4) Multiphase systems with one grounded phase - one phase conductor

72

250.26 Conductor to be Grounded – AC Systems

5. Multiphase systems in which one phase is used as in (2) Single phase – the neutral conductor

- Typically 120/240 volt, 3-phase, 4-wire systems

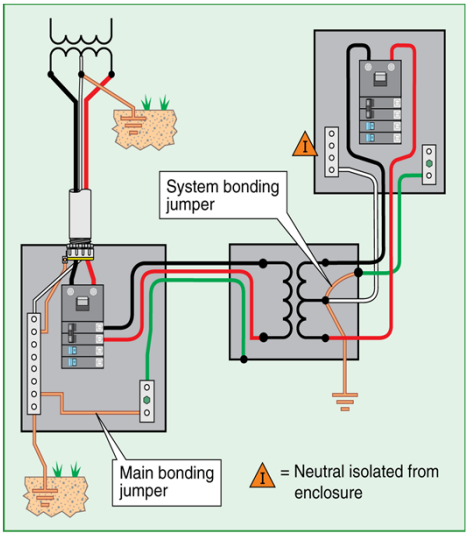


(5) Multiphase systems used as in (2) - the neutral conductor

73

250.28 Main and System Bonding Jumpers

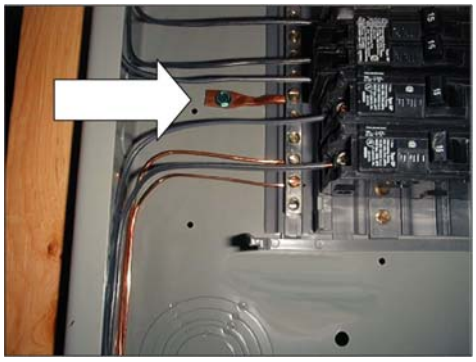
- The main bonding jumper shall be copper or other corrosion resistant material- a wire, bus, (green) screw, or….
- Sized as per 250.28(D) 1-3
- Main bonding jumpers are installed at the service
- System bonding jumpers are installed at separately derived systems
- Perform identical functions



74

250.28(A) Material

- Permitted to be of copper or other corrosion-resistant material
- Permitted to consist of a wire, bus, screw or similar suitable conductor



75

Main Bonding Jumper in Listed Equipment

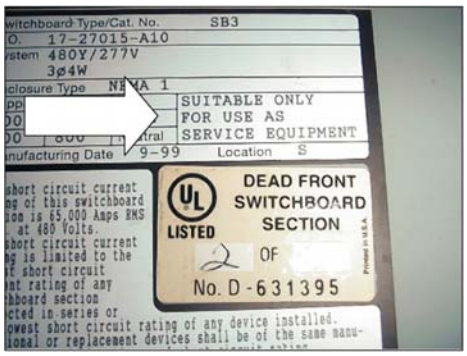
Category	UL Product Category
Panelboards	UL 67, Panelboards
Switchboards	UL 891, Dead-front Switchboards
Power Outlets	UL 231, Power Outlets
Motor Control	UL 845, Electric Motor Control Centers
Enclosed Switches	UL 98, Enclosed Switches

76

Suitable Only for Use as Service Equipment

- Neutral terminal bar bonded to the enclosure
- Typically, not permitted at the "feeder" position
- May be acceptable at disconnecting means for separately derived system

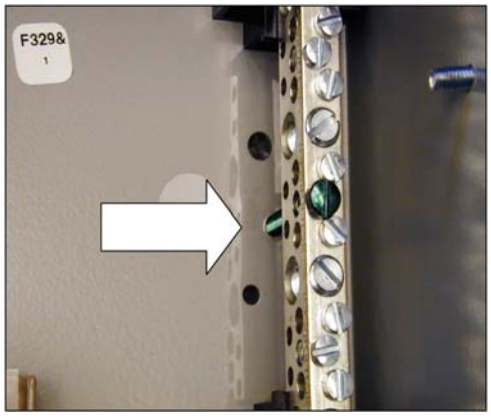
See UL White book at: ul.com/whitebook (NJAV) and (WEVZ)



77

250.28(B) Construction

Where a main bonding jumper is a screw only, it is required to have a green finish that is visible with the screw installed



78

250.28(C) Attachment

Attach main bonding jumpers in compliance with the general rules for making grounding and bonding connections as provided in 250.8

79

250.28(D)(1) Size of main or system bonding jumpers

(1) Main bonding jumpers and system bonding jumpers -Generally, not smaller than given in Table 250.102C1

- For supply conductors larger than 1100 kcmil copper or 1750 kcmil aluminum, size not smaller than 12½ percent of the area of the largest phase conductor
- The bonding jumper in listed service equipment can be used without calculation

80

250.28(D)(2) Main Bonding Jumper for Service with More than One Enclosure

- If the service consists of more than a single enclosure as permitted in 230.71(A), the main bonding jumper for each enclosure is required to be sized in accordance with 250.28(D)(1) based upon the largest ungrounded service conductor serving that enclosure
- Manufacturer-provided main bonding jumper for listed equipment can be installed without calculation

81

250.28(D)(3) Separately Derived System with More Than One Enclosure

- If a separately derived system supplies more than one enclosure, the system bonding jumper must be installed at either the source of the separate system, or first system disconnecting means
- If at the first disconnecting means, use main bonding jumper supplied for listed enclosure or size according to 250.28(D)(1)
- If at the source, size system bonding jumper per 250.28(D)(1) based on the sum of circular mil area of derived ungrounded conductors for one phase

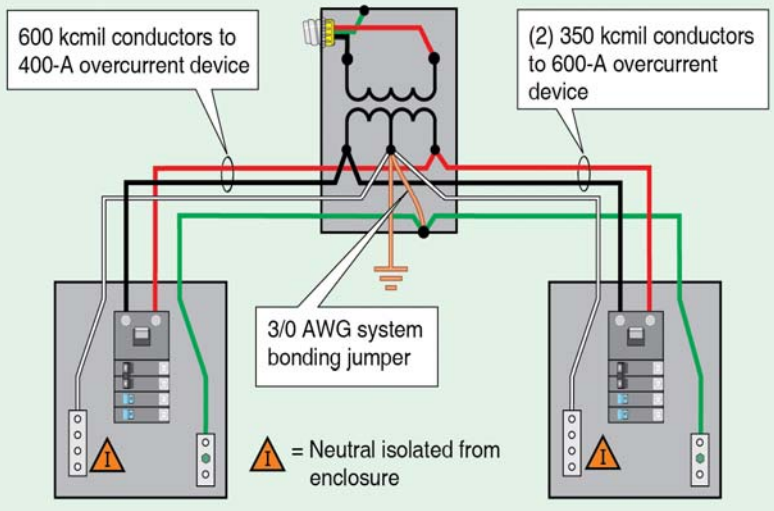
82

Example: More than one enclosure

Feeder	Derived Conductors	Number Per Phase	Circular Mil Area
400 Ampere	600 kcmil	1	600 kcmil
600 Ampere	350 kcmil	2	700 kcmil
		Total area	1300 kcmil
System Bonding Jumper 12½ Percent of 1300 kcmil			162,500 cm (3/0)

83

Separately Derived System With More Than One Enclosure



250.30 Grounding Separately Derived Systems

- Definition of term in Article 100
- To comply with 250.30(A) for grounded systems, or as provided in 250.30(B) for ungrounded systems
- Separately derived systems shall comply with 250.20, 250.21, 250.22, and 250.26
- Multiple separately derived systems that are connected in parallel shall be installed in accordance with 250.30.

85

Article 100 definition: Separately Derived Systems

"An electrical source, other than a service, having no direct connection(s) to circuit conductors of any other electrical source other than those established by grounding and bonding connections."

86

Example for Transformers

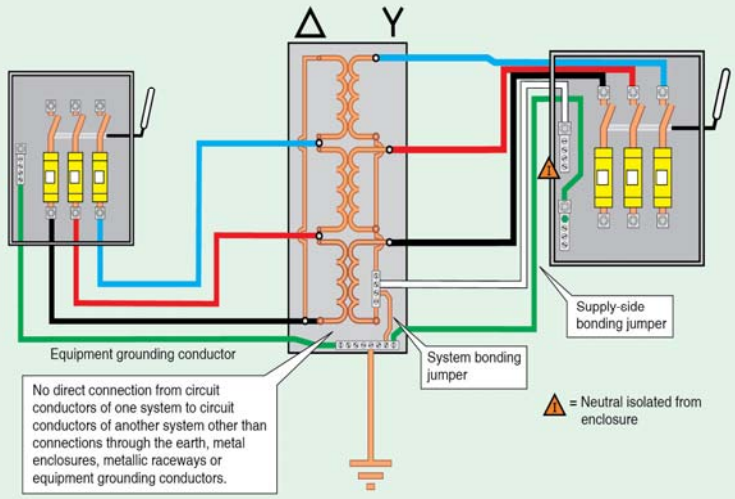
- Verify there is no connecting jumper from primary to secondary in the transformer
- A connection will commonly exist from

the grounding of the service-supplied system through the equipment grounding conductor connected to the frame of the transformer through the system bonding jumper to the neutral of the separately derived system

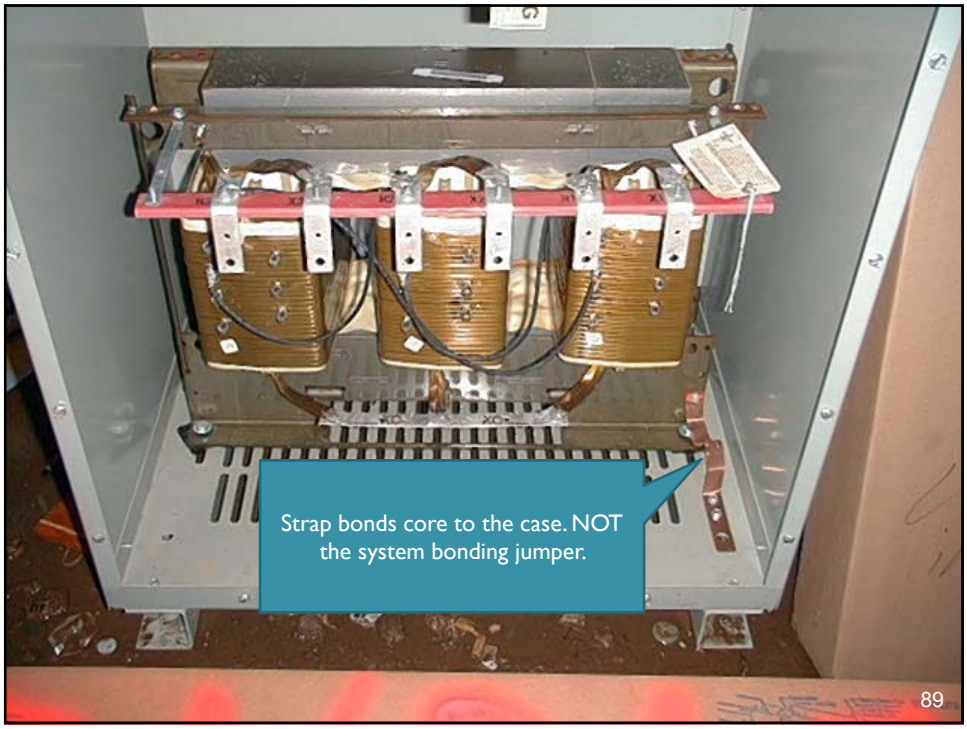
Grounding of the case

87

Transformer-Type Separately Derived System



88

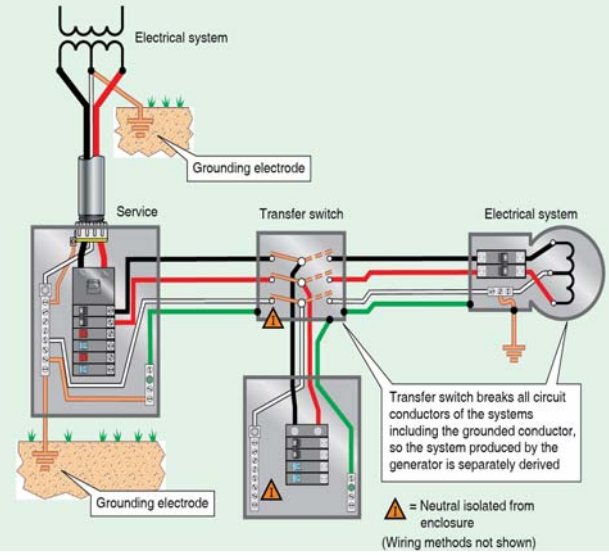


Here's How for Generators

- Look in the transfer switch
- If the neutral is switched, the system supplied is separately derived
- If the neutral is not switched, the system supplied is not separately derived

90

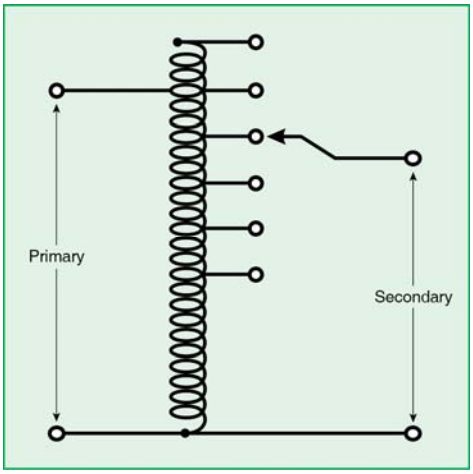
Generator-Type Separately Derived System



91

Autotransformers

- Autotransformer has a conductor that is common to both primary and secondary
- Cannot be a separately derived system



92

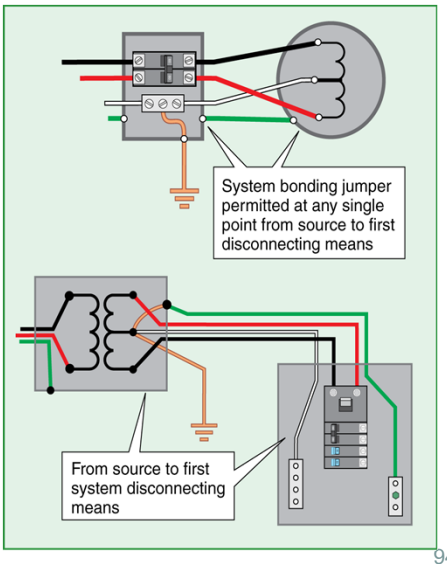
250.30(A) Grounded Systems

- A separately derived system that is grounded must comply with the rules in (A)(1) - (A)(8)
- A grounding to grounded connection is not generally permitted on the load side of the grounding point of the separately derived system
- Load-side grounding permitted under specific rules in 250.32 and 250.142

93

250.30(A)(1) System Bonding Jumper

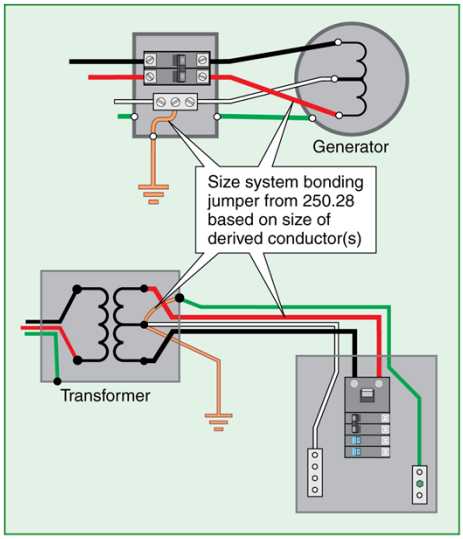
- Unspliced system bonding jumper required
- Comply with 250.28(A) through (D)
- Locate it from source to first disconnecting means
- Must remain within originating enclosure
- If outside, comply with 250.30(C)



94

250.30(A)(1) Size of System Bonding Jumper

- Size system bonding jumper based on size of ungrounded derived conductors Table 250.102(C)(1)
- If Bonding jumper is furnished with listed service equipment - permitted without calculation of size

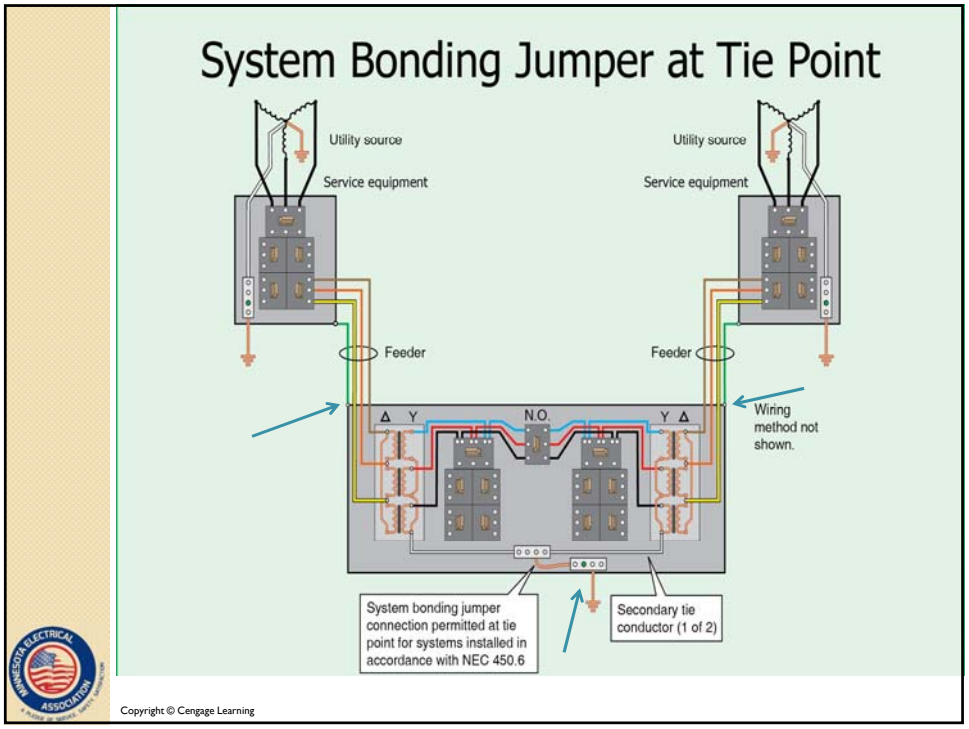


95

250.30(A)(1) Ex. No. 1

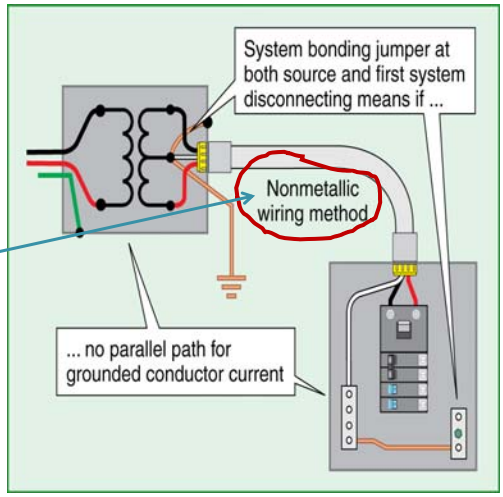
- A single system bonding jumper connection at the tie point is permitted for systems installed in accordance with 450.6 (secondary tie points)
- This equipment is commonly double-ended equipment supplied from two separately derived systems.
- The neutral of the two systems is tied together by this connection

96



250.30(A)(1) Ex. 2

Bonding jumper at both source and first overcurrent device permitted where a parallel path is not established



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98

250.30(A)(1)(a) System Bonding Jumper at Source

The system bonding jumper is required to connect the grounded conductor to the supply-side bonding jumper and the normally non–current-carrying metal enclosure.

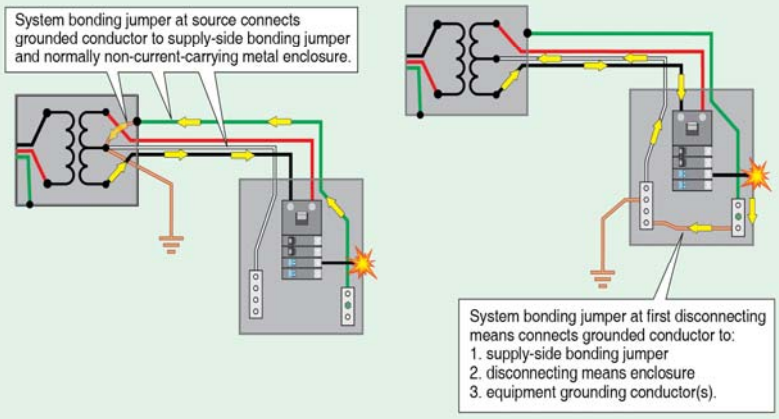
99

250.30(A)(1)(b) System Bonding Jumper at First Disconnecting Means

The system bonding jumper is required to connect the grounded conductor to the supply-side bonding jumper, the disconnecting means enclosure, and the equipment grounding conductor(s).

100

Location of System Bonding Jumper



101

250.30(A)(2) Supply-Side Bonding Jumper

If the source of a separately derived system and the first disconnecting means are located in separate enclosures, a supply-side bonding jumper shall be installed with the circuit conductors from the source enclosure to the first disconnecting means.

102

250.30(A)(2) Supply-Side Bonding Jumper

A supply-side bonding jumper shall not be required to be larger than the derived ungrounded conductors.

103

250.30(A)(2) Supply-Side Bonding Jumper

The supply side bonding jumper shall be permitted to be of –nonflexible- metal raceway type or of the wire or bus type as follows:

(a) A supply-side bonding jumper of the wire type shall comply with 250.102(C), based on the size of the derived ungrounded conductors.

104

250.30(A)(2) Supply-Side Bonding Jumper

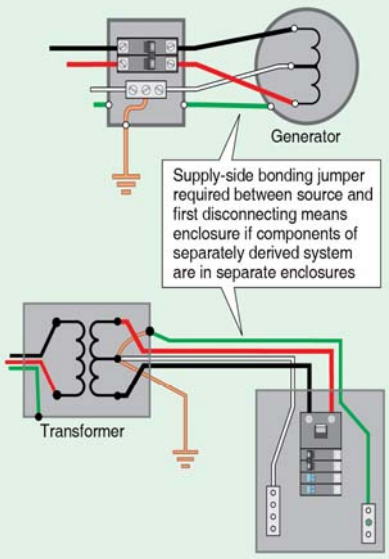
(b) A supply-side bonding jumper of the bus type shall have a cross-sectional area not smaller than a supply-side bonding jumper of the wire type as determined in 250.102(C).

Exception: A supply-side bonding jumper shall not be required between enclosures for installations made in compliance with 250.30(A)(1), Exception No. 2.

105

Requirements for Supply-Side Bonding Jumper

- Size supply-side bonding jumper of wire type from 250.102(C).
- Size supply-side bonding jumper of bus type not smaller than cross-sectional area of wire type.



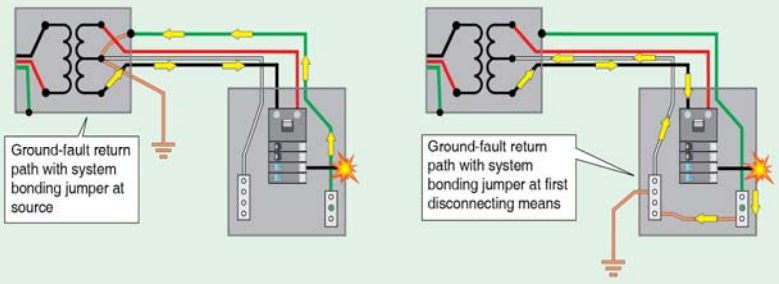
106

Table 2-3

Wiring Method	Size	Max OCP	Length	NEC Reference
FMC	All	20 A	6 ft (1.8 m)	250.118 (5)
LFMC	3/8 & ½	20 A	6 ft (1.8 m)	250.118 (6)
LFMC	¾ thru 1¼	60 A	6 ft (1.8 m)	250.118 (6)
LFMC	Larger than 1¼	Not permitted	Not permitted	250.118 (6)

107

Ground-Fault Return Path

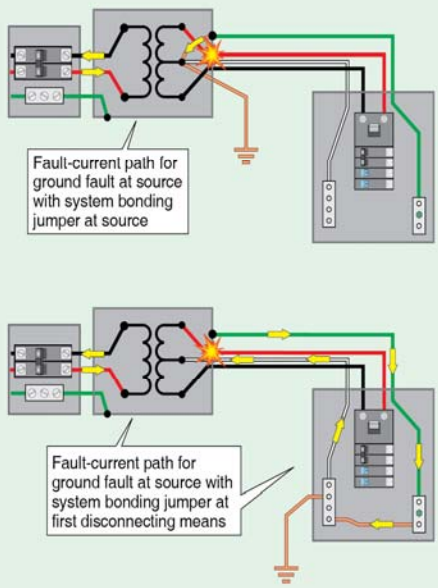


Over Supply-Side Bonding Jumper

Over Neutral

108

Clearing Ground-Faults at Source of Separately Derived System

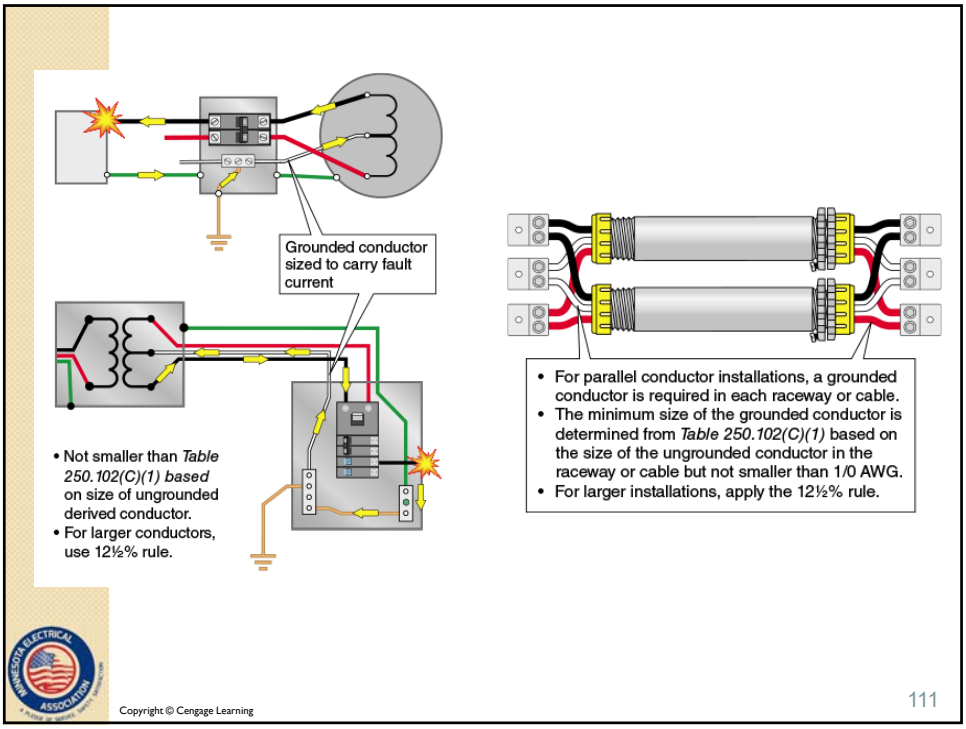


109

250.30(A)(3) Grounded Conductor

- (A)(3)(a) Rules identical to sizing grounded conductor for service
  - Ensures conductor is adequate for carrying fault current
  - Also, size for calculated load
- (A)(3)(b) Rules identical to sizing grounded conductors for services when installed in parallel
- Table 250.102C1

110



111

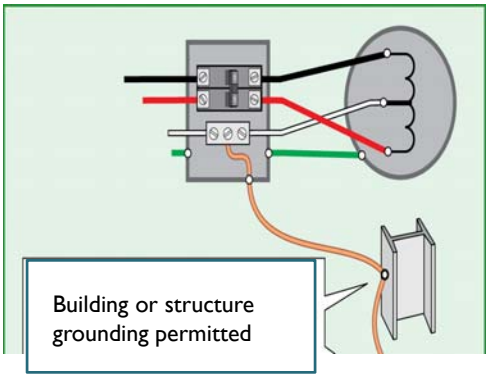
250.30(A)(4) Grounding Electrode

- The building or structure grounding electrode system shall be used as the grounding electrode for a separately derived system. If located outdoors, the grounding electrode shall be in accordance with 250.30 (C) (Outdoor Source)
- * Exception: If the SDS originates in equipment that is listed and identified for use as service equipment, the grounding electrode used for the service is permitted to be used as the GE for the SDS

112

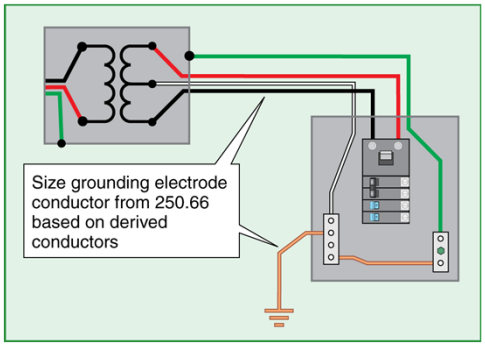
250.30(A)(4) Grounding Electrode

- Primary purpose is bonding electrical structures or equipment that is likely to become energized
- Rules for water pipe electrode apply
- Rules for structural metal also apply



250.30(A)(4) GEC, Single Separately Derived System

- Connect grounded conductor of separately derived system to grounding electrode
- Connect at same point where system bonding jumper is connected



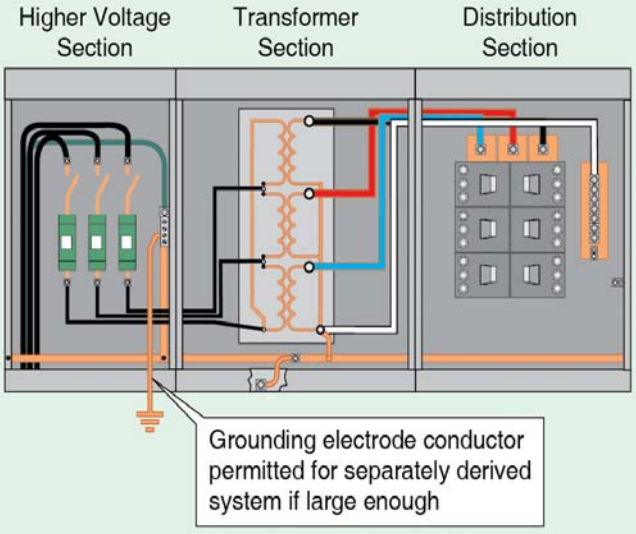
Example

Assume 600-ampere panelboard

- Two 350 kcmil THWN conductors connected in parallel
- 310 amperes × 2 = 620 amperes
- 350 kcmil × 2 = 700 kcmil
- Table 250.66 requires 2/0 AWG copper grounding electrode conductor

115

Grounding Electrode Conductor Size



116

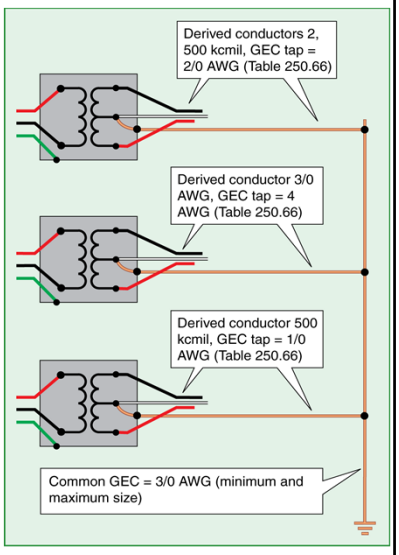
Example

- Determine the minimum size of the grounding electrode conductor for the derived system.
- Determine the size of equipment grounding bus and grounding electrode conductor for the primary section.
- Verify conductors are appropriate for grounding electrode conductor.

117

Common GEC

- Common grounding electrode and tap conductors permitted
- Connect taps at same point system bonding jumper is connected
- This subsection acts as exception to 250.30(A)(5)
- Common GEC based on 250.30 A(6)(a)(1) a wire type conductor not smaller than 3/0 cu



118

250.30(A)(6)(a) Size of Common and Tap Grounding Electrode Conductor

(1) Minimum size permitted for common wire type GEC is 3/0 copper or 250 kcmil aluminum (Also is the maximum size required by this section)

- Size tap conductors from 250.66 based upon the size of the derived ungrounded conductors

(2) A metal water pipe that complies with 250.68 (C)(1) The metal water piping system is allowed to serve as a grounding electrode if connected within 5 ft of the entrance * with exceptions

119

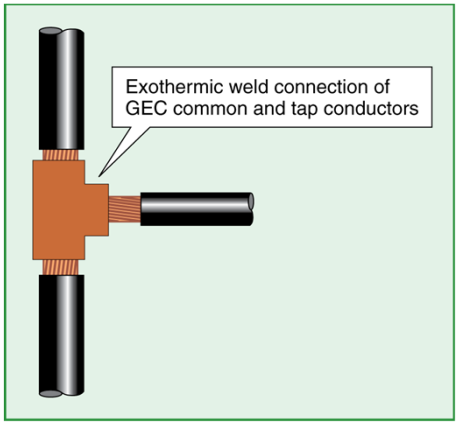
250.30(A)(6)(b) Tap Conductor size

Each tap conductor from the SDS to the Common GEC is sized as per 250.66 based on the derived ungrounded conductors

* See exceptions for service rated equipment

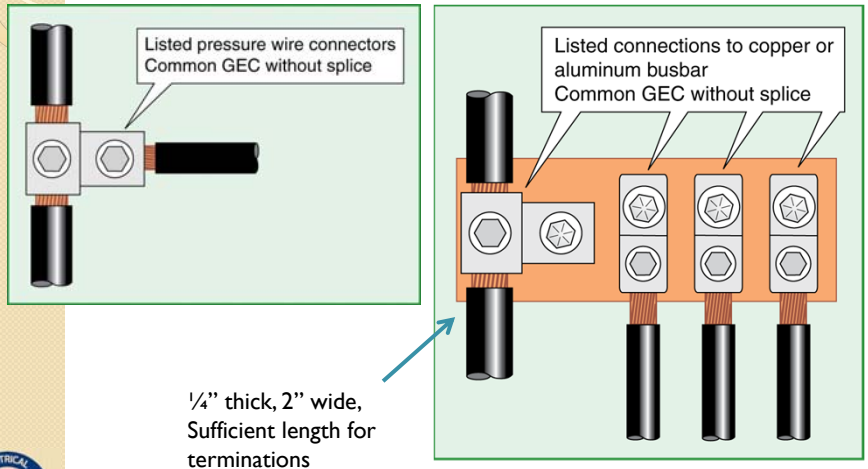
120

250.30(A)(6)(c) Connections



121

250.30(A)(6)(c) Connections



122

250.30(A)(7) Installation (8) Bonding

(7) Comply with 250.64(A), (B), (C) and (E)

- (A) Aluminum conductors
- (B) Installation rules
- (C) Unbroken unless installed in compliance with rules
- (E) Bonding of ferrous metal raceways that enclose grounding electrode conductor

(8) Structural steel and metal pipes shall be connected to the grounded conductor of a SDS

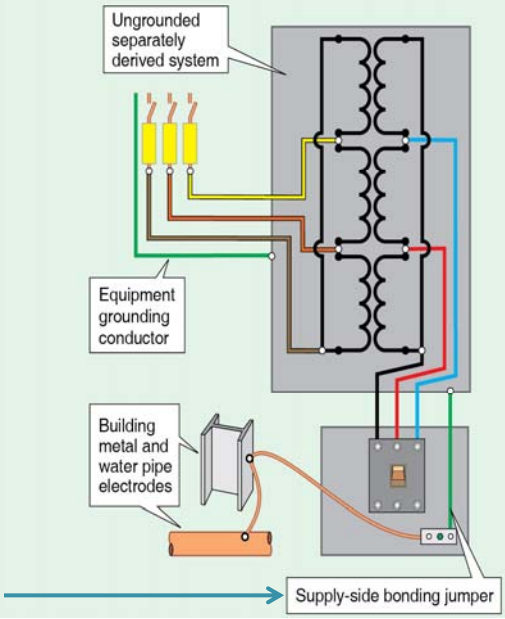
123

250.30(B) Ungrounded Systems

1. Grounding electrode conductor based on size of ungrounded derived conductor
2. Except for portable and vehicle-mounted generators, the grounding electrode is required to comply with 250.30(A)(4)
3. Install supply-side bonding jumper between the source of the separately derived system and the first disconnecting means in compliance with 250.30(A)(2)

124

Ungrounded System Grounding Electrode and GEC



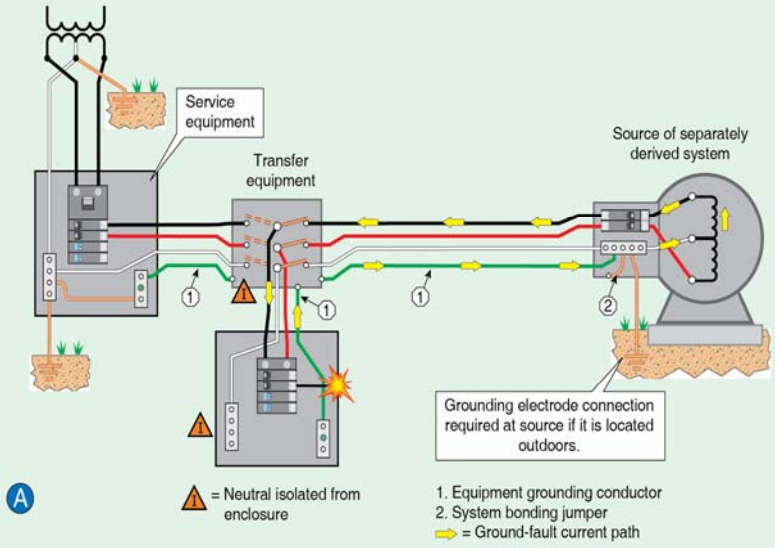
125

250.30(C) Outdoors Source

- If the source of the separately derived system is located outside the building or structure supplied, a grounding electrode connection shall be made at the source location to one or more grounding electrodes in compliance with 250.50. In addition, the installation shall comply with 250.30(A) for grounded systems or with 250.30(B) for ungrounded systems. (previous slides)
- This rule requires the system bonding jumper to also be located at the outdoor source.
- * See exception for impedance grounded systems

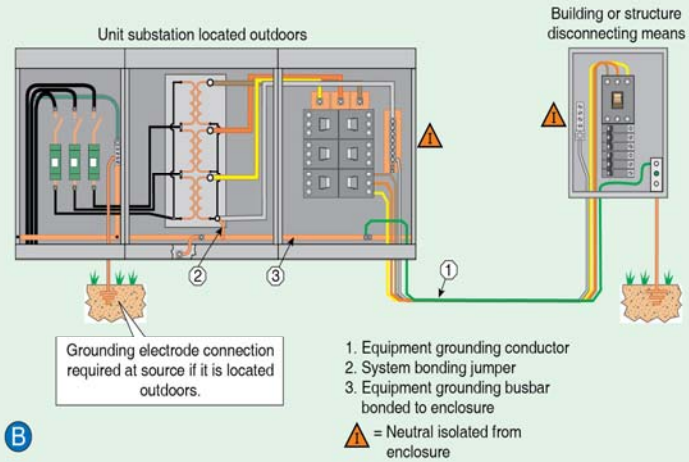
126

Outdoor Source for SDS



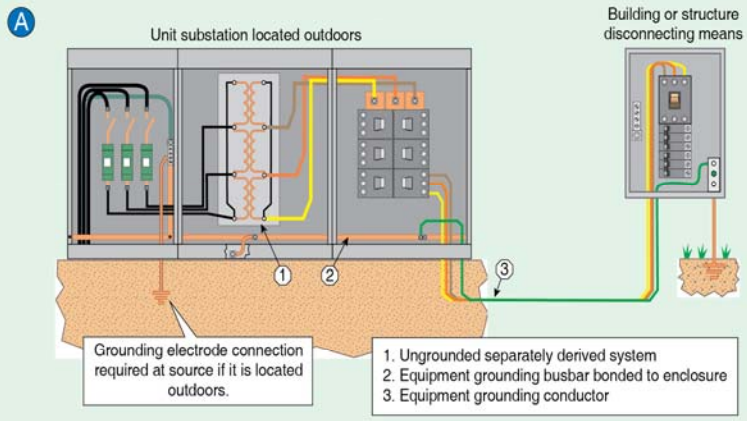
127

Outdoor Source for SDS

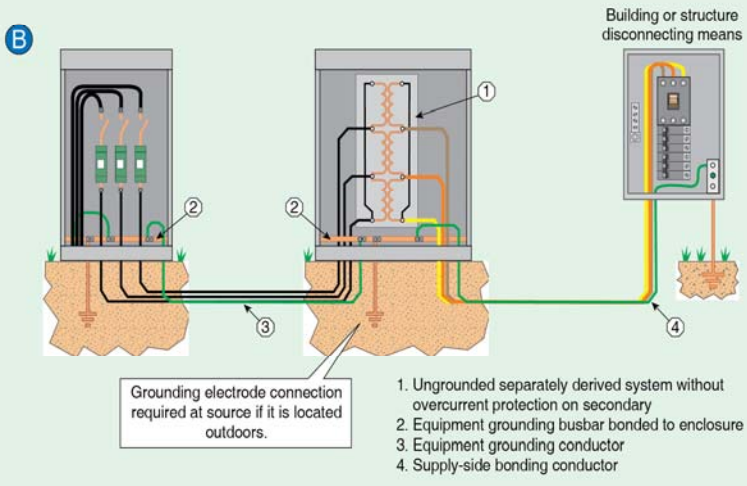


128

Outdoor Source for Ungrounded SDS



Outdoor Source for Ungrounded SDS



250.32 Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s)

- Bond all grounding electrodes, installed as per Part III of Art 250, together at building or structure to form grounding electrode system
- Connect at building disconnecting means in accordance with 250.32(B) or (C) (following)
- Install grounding electrode(s) if none exist
- See 250.52(A) for description of grounding electrodes required to be used

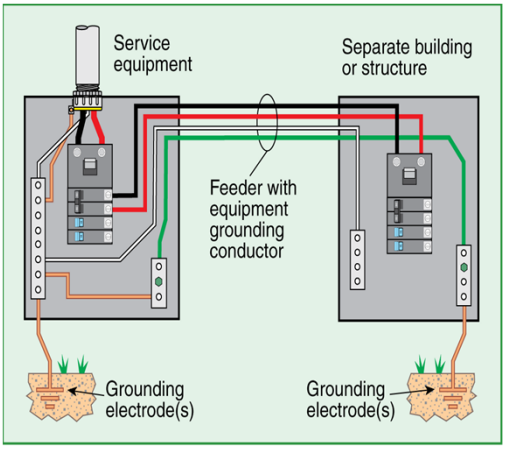
* See exception for a building with only one branch circuit.

131

250.32 Buildings or Structures Supplied by a Feeder(s) or Branch Circuit(s)

(A) Bond all grounding electrodes together to form grounding electrode system

- Connect in accordance with 250.32(B) or (C)
- If no grounding electrodes, install per 250.50

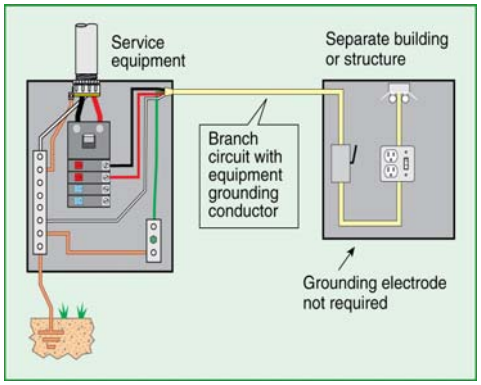


132

250.32(A) Exception- One Branch Circuit

Grounding electrode system not required if building or structure is supplied by only one branch circuit and the branch circuit includes an equipment grounding conductor

Multiwire branch circuit considered one branch circuit



133

Table 2-4

Voltage	No. Current-Carrying Conductors	Common Designation (w/g)
120	2	120 V, 2 Wire
120/240*	2	120/240 V, 3-wire
208Y/120**	3 or 4	208Y/120 V, 3-phase, 4-wire

134

250.32(B)(1) Grounded Systems Supplied by a feeder or branch circuit

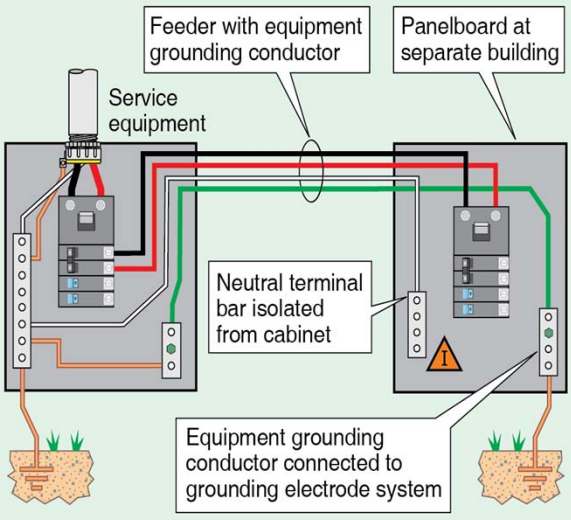
- Connection of grounding electrode at building or structure disconnecting means must be to equipment grounding conductor terminal bar or metal enclosure for disconnecting means

* Exception: Connecting neutral conductor to enclosure or grounding electrode is now limited to existing buildings or structures

- Isolate the neutral conductor at the remote building or structure. Do not connect to grounding electrode

135

Grounded Systems



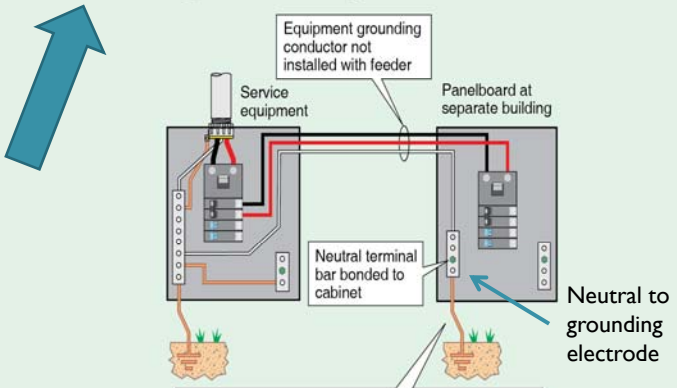
136

250.32(B)(1) Exception: Grounded Systems

- *Applies to installations made in compliance with previous editions of the NEC that permitted such connection.*
- *Grounded conductor run with the supply to the building or structure disconnecting means is permitted to serve as ground-fault return path if all conditions continue to be met.*

137

Existing Buildings or Structures



138

250.32(B)(2) Supplied by Separately Derived System (SDS)

- (a) *With Overcurrent Protection.* *If overcurrent protection* is provided where the conductors originate, the installation shall comply with 250.32(B)(1). (previous slides)
- The general rules require an equipment grounding conductor be installed with the feeder or branch circuit to serve as the ground-fault return path.
- The equipment grounding conductor connects to the building or structure disconnecting means and to the grounding electrode.

139

250.32(B)(2) Supplied by Separately Derived System

- (b) *Without Overcurrent Protection.* *If overcurrent* protection is not provided where the conductors originate, the installation shall comply with 250.30(A). If installed, the supply-side bonding jumper shall be connected to the building or structure disconnecting means and to the grounding electrode(s).
- In addition to these rules for grounding or bonding, the requirements for overcurrent protection in 240.21(C) must be complied with.

140

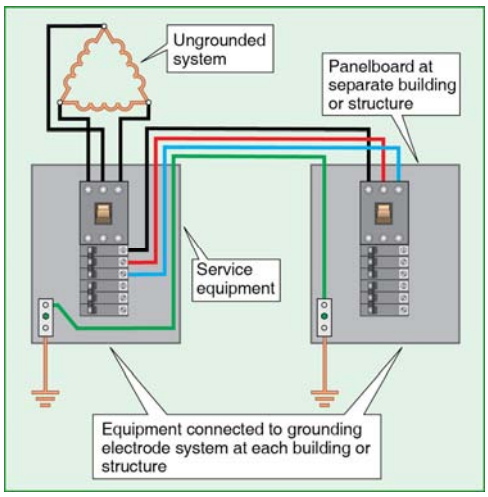
250.32(C) Ungrounded Systems supplied by feeders or branch circuits to separate buildings

- (C)(1) Supplied by a Feeder or Branch Circuit
- (C)(2) Supplied by a Separately Derived System

141

250.32(C)(1) Ungrounded Systems

- Install equipment grounding conductor
- Connect the grounding electrode conductor to the disconnecting means



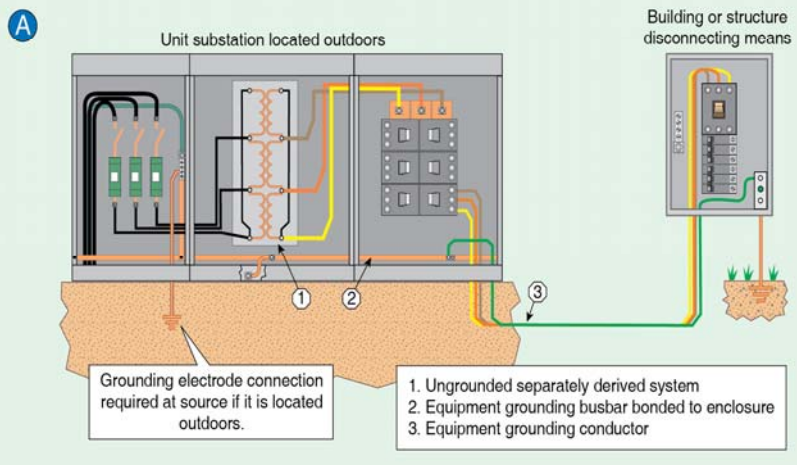
142

250.32(C)(2) Ungrounded Systems Supplied by Separately Derived System

(a) Ungrounded *With Overcurrent Protection. If overcurrent protection* is provided where the conductors originate, the installation shall comply with 250.32(B)(1).

143

Building or Structure Supplied by Ungrounded Separately Derived System



144

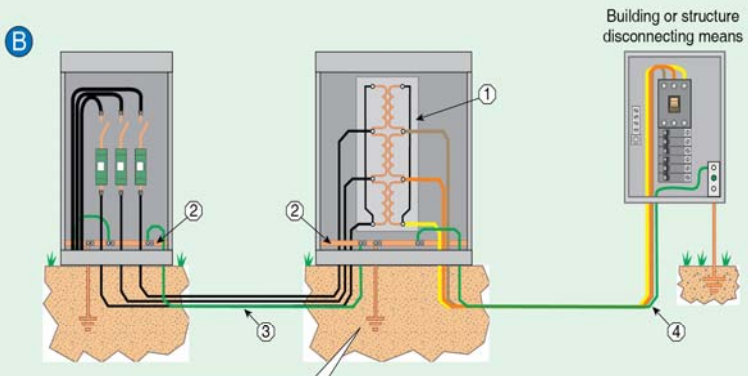
250.32(C)(2) Ungrounded Systems Supplied by Separately Derived System

(b) Ungrounded *Without Overcurrent Protection*. *If overcurrent* protection is not provided where the conductors originate, - the installation shall comply with 250.30(A).

If installed, the supply-side bonding jumper shall be connected to the building or structure disconnecting means and to the grounding electrode(s).

145

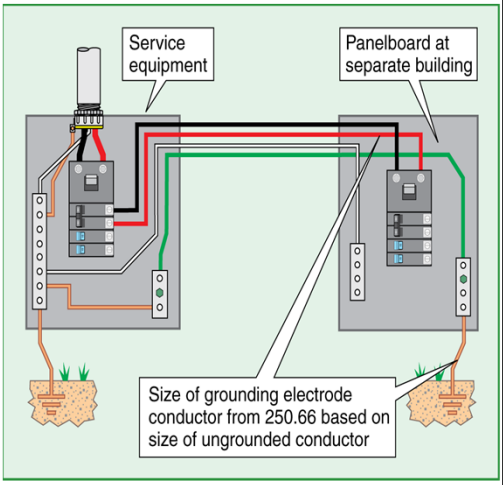
Building or Structure Supplied by Ungrounded Separately Derived System



146

250.32(E) Grounding Electrode Conductor

Size from 250.66 based on size of feeder or branch circuit conductor that supplies a building or structure



147

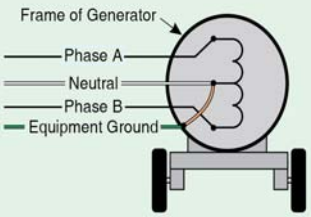
250.34 Portable and Vehicle-Mounted Generators

The frame is not required to be connected to a grounding electrode if:

1. The generator supplies only equipment mounted on the generator
2. Non-current-carrying parts are bonded to the frame

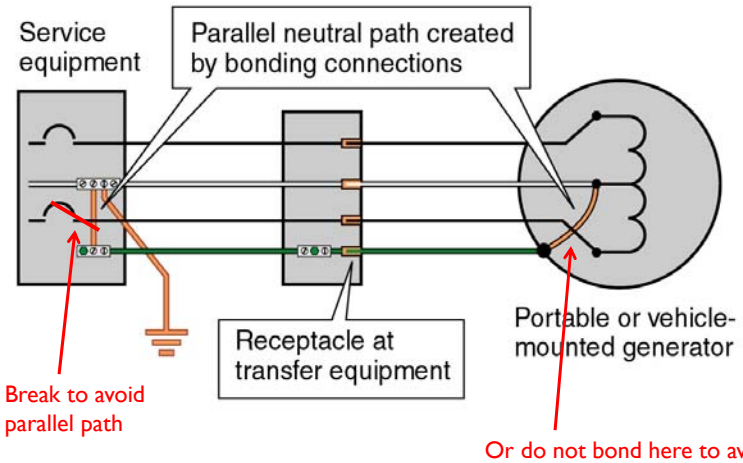
148

Grounding of Portable Generators



149

Connection of Portable or Vehicle-Mounted Generator



150

Violates switched neutral rule for generator connection

151

250.34(B) Vehicle-Mounted Generators (no grounding electrode required)

Not required to be connected to grounding electrode if:

1. Frame of generator bonded to frame of vehicle
2. Equipment supplied by cord-and-plug connection
3. Non-current-carrying parts connected to frame

152

250.34(C) Grounded Conductor Bonding

- A system conductor that is required to be grounded by 250.26 must be bonded to the generator frame where the generator is a component of a separately derived system
- Provides path for ground-fault current to return to the source (generator)
- See 250.30 for portable generators supplying fixed wiring systems

153

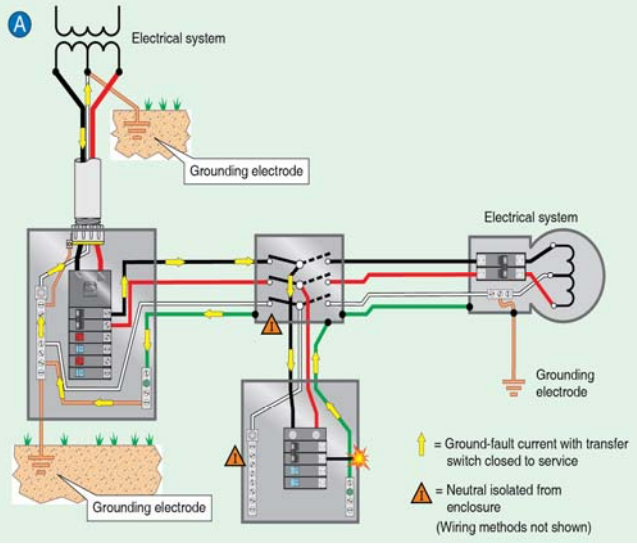
250.35, Permanently Installed Generators

- A conductor that provides an effective ground-fault current path is required to be installed with the supply conductors from a permanently installed generator(s) to the first disconnecting means in accordance with (A) or (B). (below)

A. If the generator is a component of a separately derived system, comply with 250.30

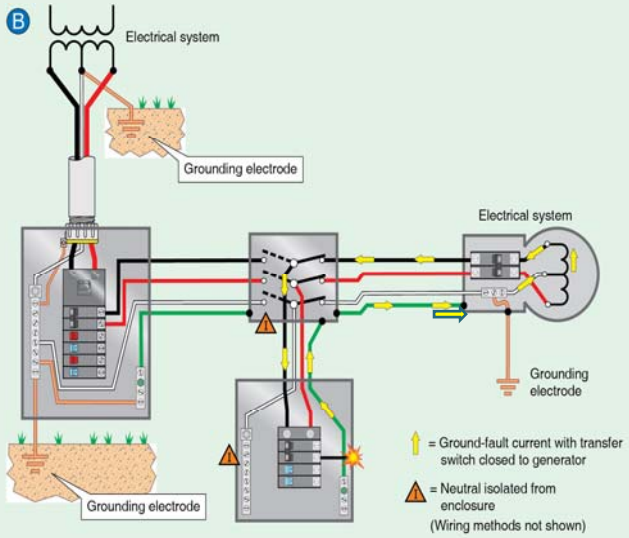
154

Permanently Installed Generator Supplying Separately Derived System



155

Permanently Installed Generator Supplying Separately Derived System



156

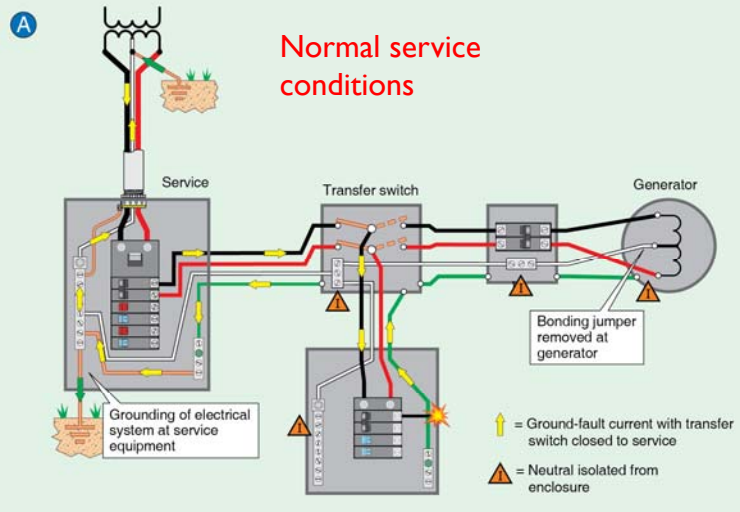
250.35, Permanently Installed Generators

(B) Non-Separately Derived System. If the generator is not installed as a separately derived system, a supply-side bonding jumper must be installed between the generator equipment grounding terminal and the equipment grounding terminal, bar or bus

Size according to 250.102(C 1) based on the size of conductors supplied by generator

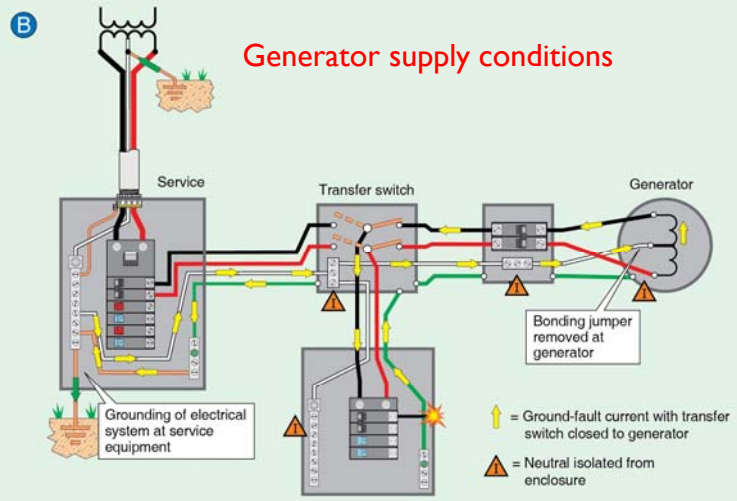
157

Permanently Installed Generator Supplying Not Separately Derived system



158

Permanently Installed Generator Supplying Not separately derived system



159

Example:

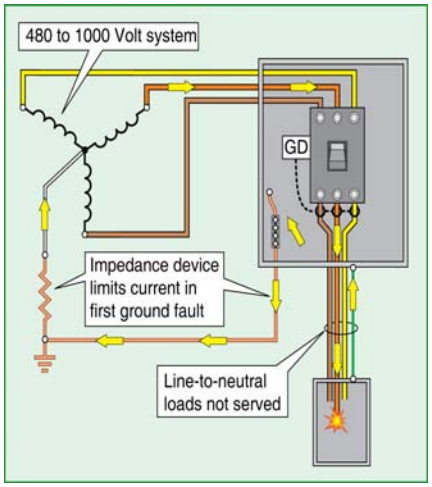
- 800 ampere overcurrent device with 2 600kcmil copper conductors in parallel from generator to distribution panelboard
- Line side: Size bonding jumper in each raceway based on Table 250.102(C)(1) = 1/0 CU or 3/0 AL

160

250.36 High-Impedance Grounded Neutral Systems

Permitted where:

1. Qualified persons service the installation
2. Ground detectors are installed
3. Line-to neutral loads are not served



161

250.36(A) Grounding Impedance Location

- Grounding impedance installed between grounding electrode and the system neutral
- If the neutral point is not available, the grounding impedance shall be installed between the grounding electrode conductor and the neutral point derived from a grounding transformer
- Provides "controlled" path for neutral current to return to the source
- Limits current from first ground fault to the value of the impedance device

162

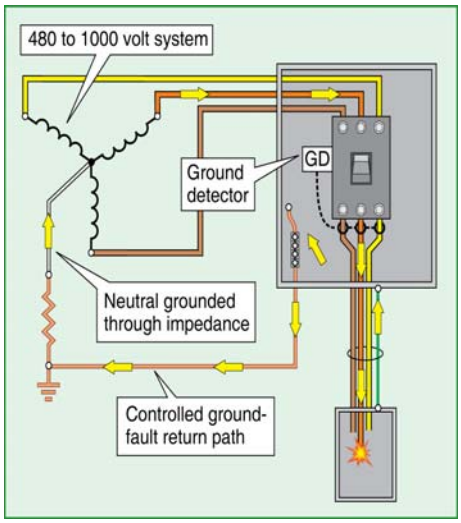
250.36(B) Grounded Conductor

- Must be fully insulated to maintain "controlled" return path
- Minimum size not less than maximum current rating of impedance device and shall in no case be smaller than #8 AWG copper or #6 AWG aluminum

163

250.36(C) System Grounding Connection

- System neutral conductor is not permitted to be connected to ground except through the grounding impedance
- Provides "controlled" return path



164

250.36(D) Conductor Routing

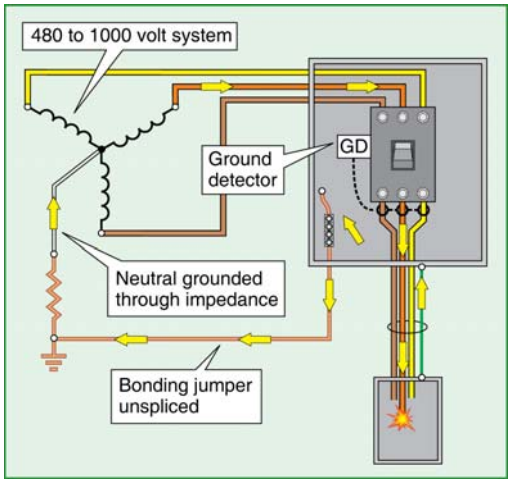
The conductor that connects the neutral point of the transformer to the grounding impedance is:

- Permitted to be installed in separate raceway from phase conductors
- Impedance devices are typically located in a separate enclosure adjacent to distribution equipment

165

250.36(E) Equipment Bonding Jumper

- Equipment bonding jumper to be an unspliced conductor
- Run from first disconnecting means to grounded side of grounding impedance



166

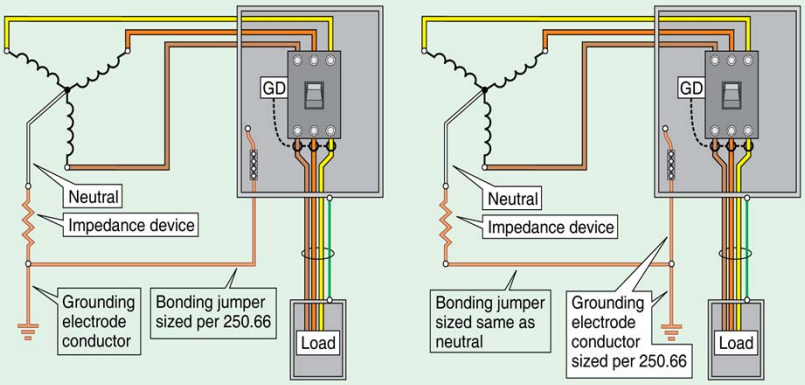
250.36(G) Equipment Bonding Jumper Size

1. If the grounding electrode connection is made at the grounding impedance, the equipment grounding jumper is sized per 250.66 based on the size of the service-entrance conductors or derived conductors

2. If connected at first system disconnecting means, sized the same as the neutral conductor in 250.36(B) (As above)

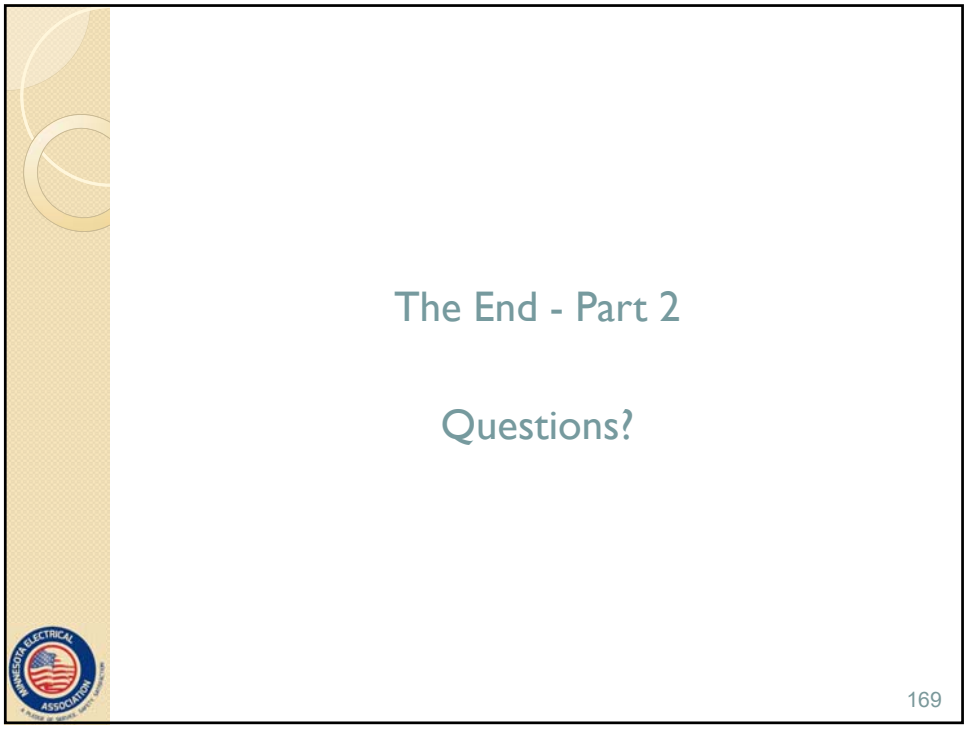
167

Size of Equipment Bonding Jumper



Connection point of grounding Electrode Conductor

168


The End - Part 2
Questions?
169