

Mike Holt's Illustrated Guide to

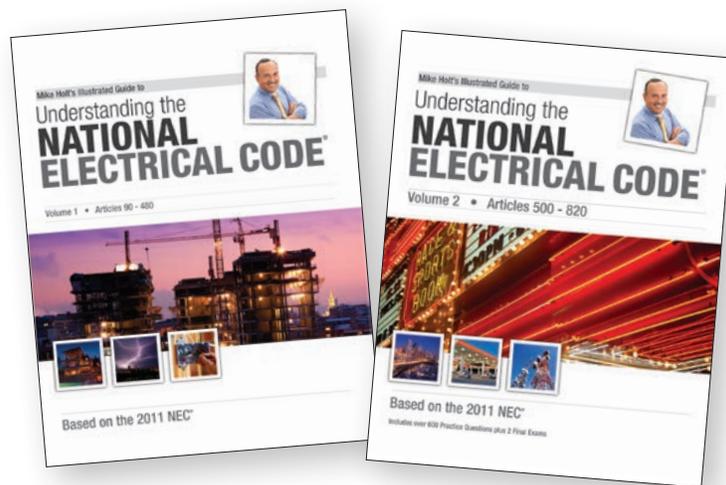
NEC® Requirements for Generators and Standby Power Systems

Rule 220.87, Articles 445, 700, 701, and 702

Based on the 2011 NEC®



Extracted from Mike Holt's Illustrated Guides to
Understanding the NEC® • Volumes 1 and 2



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1.11.13

I dedicate this book to the
Lord Jesus Christ,
my mentor and teacher.

Proverbs 16:3



Introduction

This small booklet contains a small sample of the 2011 *NEC* rules related to generators. As a continued service to the industry, we are making this available at no charge. If you have any suggestions on how it can be improved, please let me know by emailing me at Mike@MikeHolt.com.

God bless,



Mike Holt



ARTICLE 220

Branch-Circuit, Feeder, and Service Calculations

INTRODUCTION TO ARTICLE 220—BRANCH-CIRCUIT, FEEDER, AND SERVICE CALCULATIONS

This five-part article focuses on the requirements for calculating the minimum size of branch circuit, feeder, and service conductors.

Part I describes the layout of Article 220 and provides a table of where other types of load calculations can be found in the *NEC*. Part II provides requirements for branch-circuit calculations and for specific types of branch circuits. Part III covers the requirements for feeder and service calculations, using what's commonly called the standard method of calculation. Part IV provides optional calculations that can be used in place of the standard calculations provided in Parts II and III—if your installation meets certain requirements. Farm Load Calculations are discussed in Part V of the article.

In many cases, either the standard method (Part III) or the optional method (Part IV) can be used; however, these two methods don't yield identical results. In fact, sometimes these two answers may be diverse enough to call for different service sizes. There's nothing to say that either answer is right or wrong. If taking an exam, read the instructions carefully to be sure which method the test wants you to use. As you work through Article 220, be sure to study the illustrations to help you fully understand it. Also be sure to review the examples in Annex D of the *NEC* to provide more practice with these calculations.

220.87 Determining Existing Loads. The calculation of a feeder or service load for existing installations can be based on:

(1) The maximum demand data for one year.

Ex: If the maximum demand data for one year isn't available, the maximum power demand over a 15-minute period continuously recorded over a minimum 30-day period using a recording ammeter or power meter connected to the highest loaded phase, based on the initial loading at the start of the recording is permitted. The recording must be taken when the building or space is occupied based on the larger of the heating or cooling equipment load.

ARTICLE 445

Generators

INTRODUCTION TO ARTICLE 445—GENERATORS

This article contains the electrical installation, and other requirements, for generators. These requirements include such things as where generators can be installed, nameplate markings, conductor ampacity, and disconnecting means.

Generators are basically motors that operate in reverse—they produce electricity when rotated, instead of rotating when supplied with electricity. Article 430, which covers motors, is the longest article in the *NEC*. Article 445, which covers generators, is one of the shortest. At first, this might not seem to make sense. But you don't need to size and protect conductors to a generator. You do need to size and protect them to a motor.

Generators need overload protection, and it's necessary to size the conductors that come from the generator. But these considerations are much more straightforward than the equivalent considerations for motors. Before you study Article 445, take a moment to read the definition of "Separately Derived System" in Article 100.

445.1 Scope. Article 445 contains the installation and other requirements for generators.

Author's Comment: Generators, associated wiring, and equipment must be installed in accordance with the following requirements depending on their use:

- Article 695, Fire Pumps
- Article 700, Emergency Systems
- Article 701, Legally Required Standby Systems
- Article 702, Optional Standby Systems

445.11 Marking. Each generator must be provided with a nameplate indicating the manufacturer's name, rated frequency, power factor, number of phases, rating in kilowatts or kilovolt amperes, volts and amperes corresponding to the rating, RPM, insulation class and rated ambient temperature or rated temperature rise, and time rating.

445.12 Overcurrent Protection.

(A) Generators. Generators must be protected from **overload** by inherent design, circuit breakers, fuses, or other identified overcurrent protective means.

445.13 Ampacity of Conductors. The ampacity of the conductors from the generator to distribution devices containing overcurrent protection must not be less than 115 percent of the nameplate current rating of the generator. **Figure 445-1**

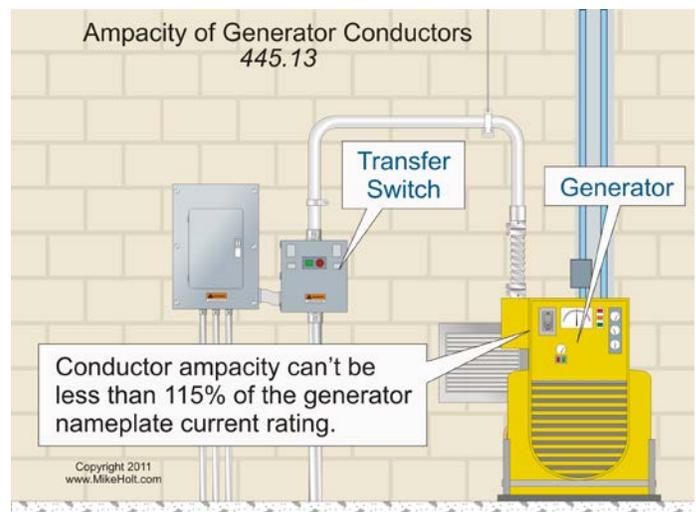


Figure 445-1

Generators that aren't a separately derived system must have the neutral conductor sized to: **Figure 445-2**

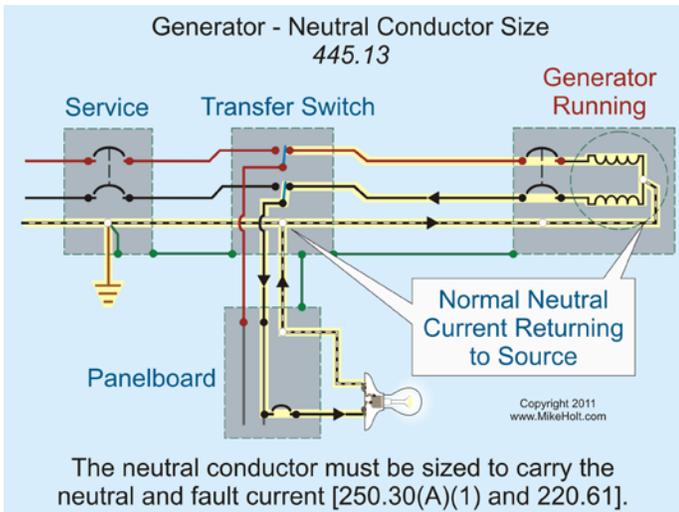


Figure 445-2

- Carry the maximum unbalanced current as determined by 220.61.
- Serve as the low-impedance fault current path.

Author's Comment: If the feeder conductors from the generator terminate in a transfer switch that doesn't open the neutral conductor, the generator isn't considered a separately derived system [250.30 Note 1]. **Figure 445-3.** A neutral-to-case bond isn't permitted at the generator. Under this condition, the neutral conductor from the normal power to the transfer switch, and the neutral conductor from the generator to the transfer switch, are required to provide the low-impedance fault current path back to the power source. **Figure 445-4**

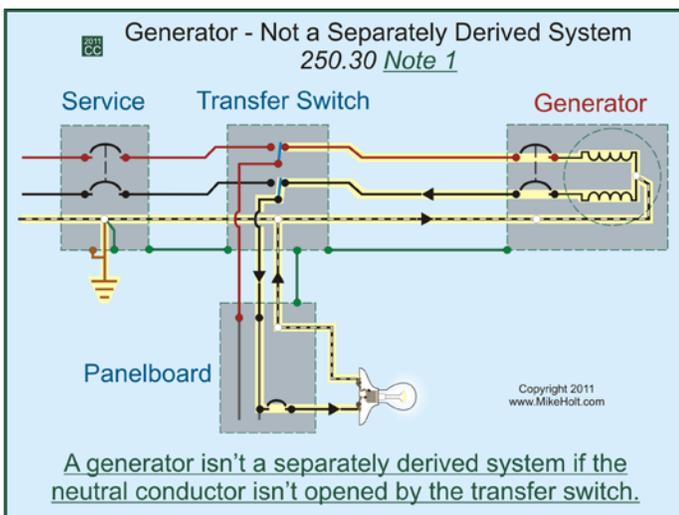


Figure 445-3

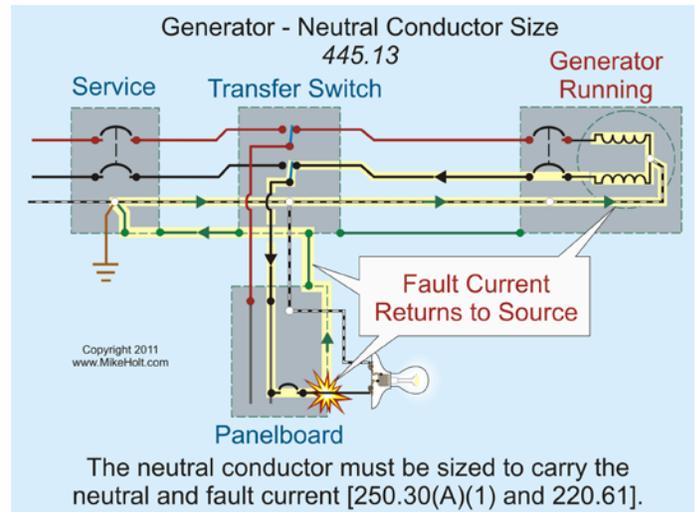


Figure 445-4

Separately derived system generators must have the neutral conductor sized not less than required to carry the maximum unbalanced current as determined by 220.61.

Author's Comment: If the feeder conductors from the generator terminate in a transfer switch that opens the neutral conductor, the generator is considered a separately derived system [Article 100]. **Figure 445-5.** A neutral-to-case connection (system bonding jumper) is required at the generator [250.30(A)(1)] to provide a low-impedance fault current path back to the power source. **Figure 445-6**

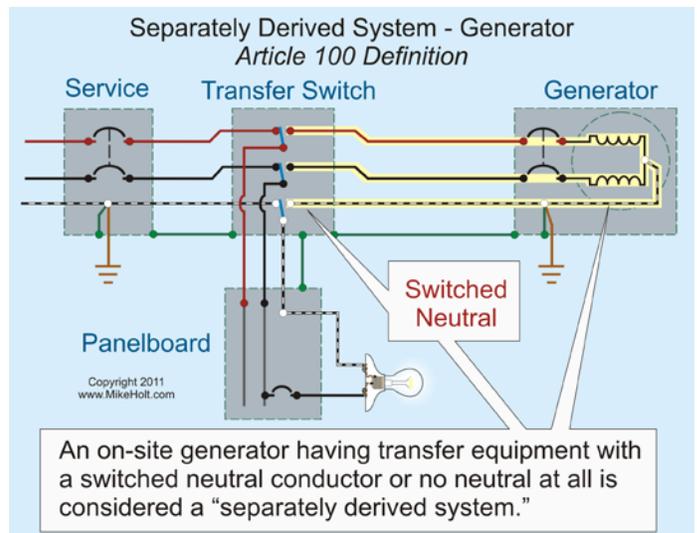


Figure 445-5

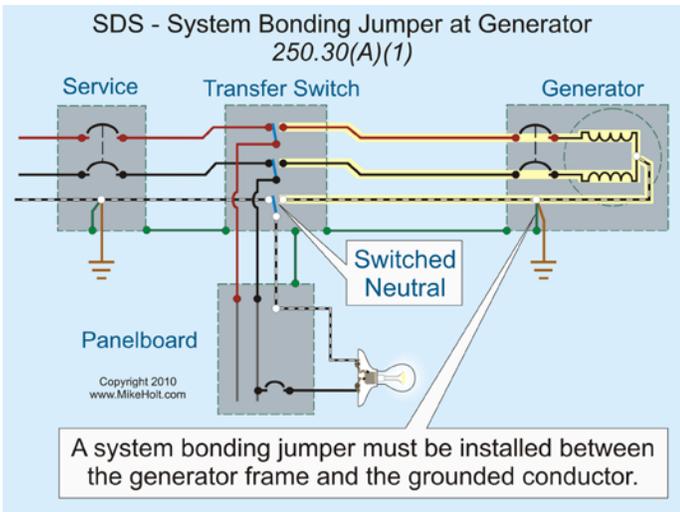


Figure 445-6

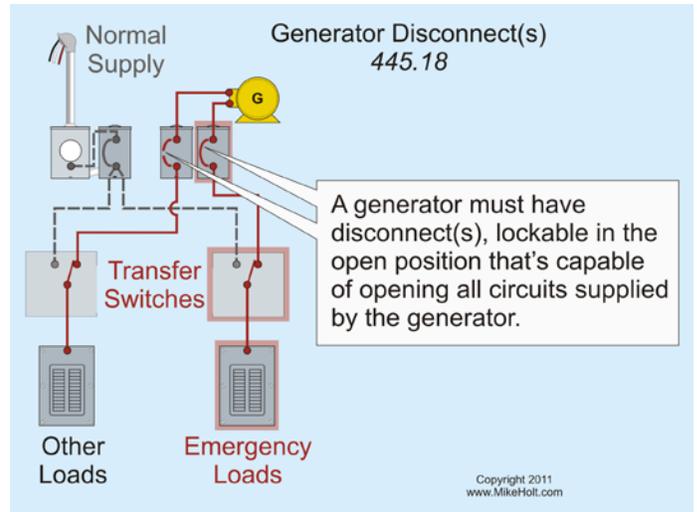


Figure 445-7

445.18 Disconnecting Means. Generators must have one or more disconnecting means that disconnects all power, except where:

Figure 445-7

- (1) The driving means for the generator can be readily shut down, and
- (2) The generator isn't arranged to operate in parallel with another generator or other source of voltage.



CAUTION: *If one generator is used to supply emergency, legally required, as well as optional standby power, then there must be at least two transfer switches; one for emergency power and another for legally required as well as optional stand-by power [700.6(D)].*

445.19 Generators Supplying Multiple Loads. A single generator is permitted to supply more than one load.

ARTICLE 700

Emergency Systems

INTRODUCTION TO ARTICLE 700—EMERGENCY SYSTEMS

Emergency systems are legally required, often as a condition of an operating permit for a given facility. The authority having jurisdiction makes the determination as to whether such a system is necessary for a given facility and what it must entail. Sometimes, it simply provides power for exit lighting and exit signs upon loss of main power or in the case of fire. Its purpose isn't to provide power for normal business operations, but rather to provide lighting and controls essential for human life safety.

The general goal is to keep the emergency operation as reliable as possible. The emergency system must be able to supply all emergency loads simultaneously. When the emergency supply also supplies power for other nonemergency loads, the emergency loads take priority over the other loads, and those other loads must be subject to automatic load pickup and load shedding to support the emergency loads if the emergency system doesn't have adequate capacity and rating for all loads simultaneously.

As you study Article 700, keep in mind that emergency systems are essentially lifelines for people. The entire article is based on keeping those lifelines from breaking.

PART I. GENERAL

700.1 Scope. Article 700 applies to the installation, operation, and maintenance of emergency systems. These consist of circuits and equipment intended to supply illumination or power within 10 seconds [700.12] when the normal electrical supply is interrupted. **Figure 700-1**

Note 3: Emergency systems are generally installed where artificial illumination is required for safe exiting and for panic control in buildings subject to occupancy by large numbers of persons, such as hotels, theaters, sports arenas, health care facilities, and similar institutions.

Emergency systems may also provide power to maintain life, fire detection and alarm systems, elevators, fire pumps, public safety communications systems, industrial processes where current interruption would produce serious life safety or health hazards, and similar functions.

Note 4: For specific locations where emergency lighting is required, see NFPA 101, *Life Safety Code*.

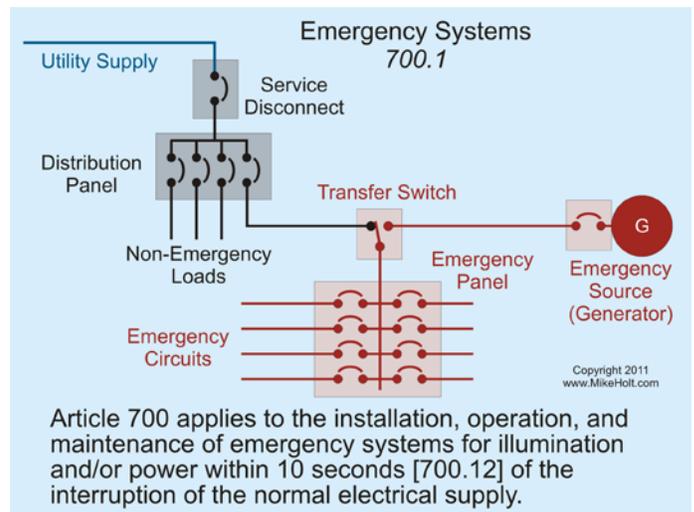


Figure 700-1

700.2 Definitions.

Emergency Systems. Emergency systems are those systems legally required and classed as emergency by a governmental agency having jurisdiction. These systems are intended to automatically supply illumination and/or power essential for safety to human life. **Figure 700-2**

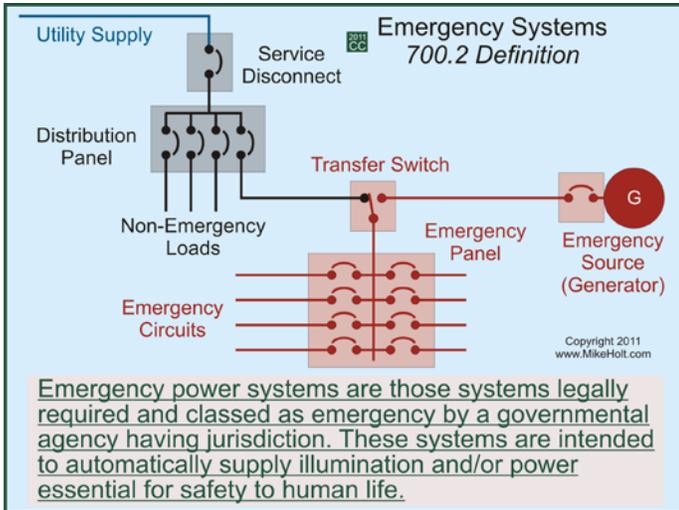


Figure 700-2

Relay, Automatic Load Control. A device used to energize switched or normally off lighting equipment from an emergency supply in the event of loss of the normal supply and to de-energize or return the equipment to normal status when the normal supply is restored.

700.3 Tests and Maintenance. Emergency system testing consists of acceptance testing and operational testing.

(A) Conduct or Witness Test. To ensure that the emergency system meets or exceeds the original installation specifications, the authority having jurisdiction must conduct or witness an acceptance test of the emergency power system upon completion.

(B) Periodic Testing. Emergency systems must be periodically tested to ensure that adequate maintenance has been performed and that the systems are in proper operating condition.

Author's Comment: Running the emergency system under load is often considered an acceptable method of operational testing.

(C) Battery Systems Maintenance. If batteries are used, the authority having jurisdiction is to require periodic maintenance.

(D) Written Record. A written record must be kept of all required tests [700.4(A) and (B)] and maintenance [700.4(C)].

Author's Comment: The NEC doesn't specify the required record retention period.

700.4 Capacity.

(A) Capacity and Rating. An emergency system must have adequate capacity to carry all emergency loads expected to operate simultaneously.

(B) Load Shedding. If an alternate power supply has adequate capacity, it's permitted to supply emergency loads [Article 700], legally required standby loads [Article 701], and optional standby system loads [Article 702]. If the alternate power supply doesn't have adequate capacity to carry the entire load, it must have automatic selective load pickup and load shedding to ensure adequate power in the following order of priority:

- (1) The emergency circuits,
- (2) The legally required standby circuits, and
- (3) The optional standby circuits.

A temporary alternate source of power must be available whenever the emergency generator is out of service for more than a few hours for maintenance or repair.

700.5 Transfer Equipment.

(A) General. Transfer equipment must be automatic, identified for emergency use, and approved by the authority having jurisdiction.

(C) Automatic Transfer Switches. Automatic transfer switches must be electrically operated, mechanically held, and listed for emergency power system use. **Figure 700-3**

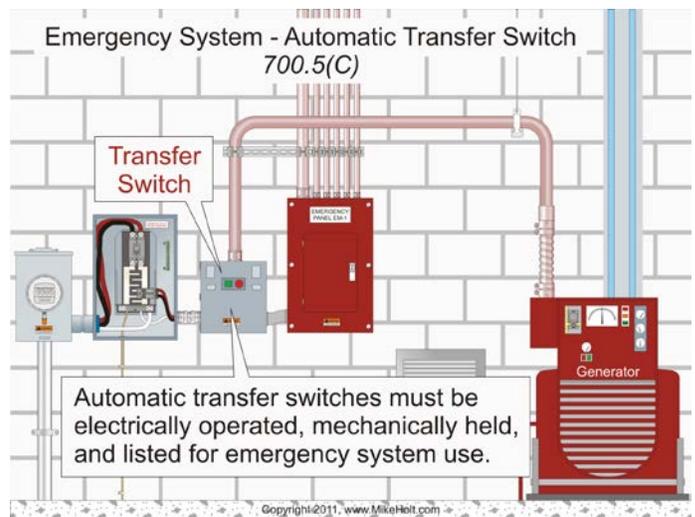


Figure 700-3

(D) Use. Transfer equipment must supply only emergency loads.

Figure 700-4

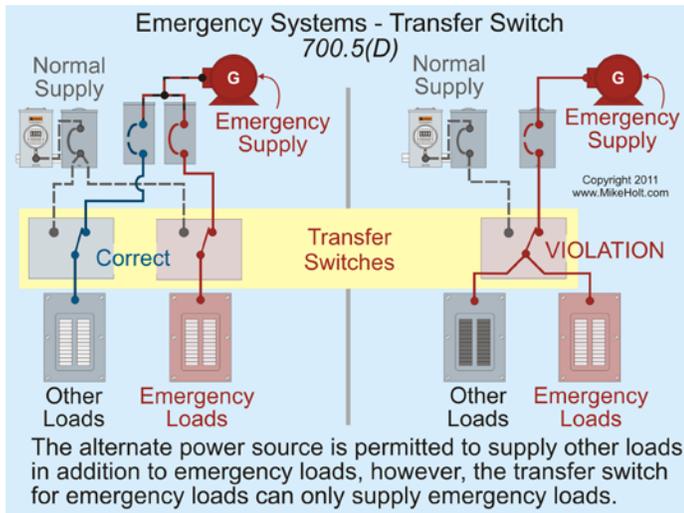


Figure 700-4

Author's Comment: Multiple transfer switches are required where a single generator is used to supply both emergency loads and other loads.

700.7 Signs.

(A) **Emergency Sources.** A sign must be placed at the service-entrance equipment indicating the type and location of on-site emergency power sources. **Figure 700-5**

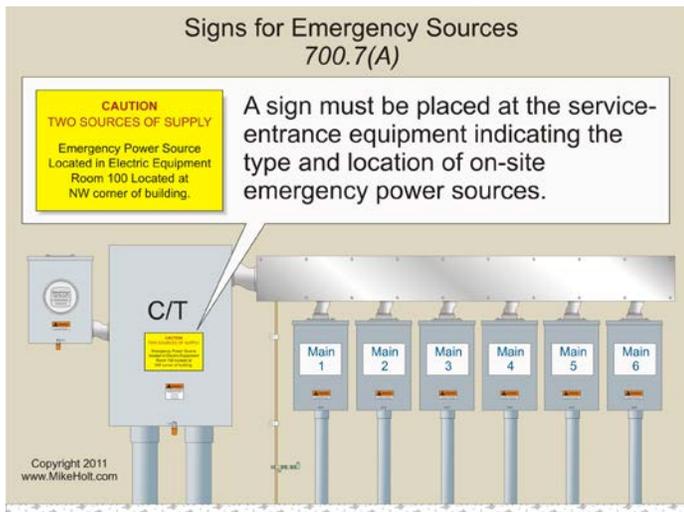


Figure 700-5

PART II. CIRCUIT WIRING

700.10 Wiring.

(A) **Identification.** Boxes and enclosures, including transfer switches, generators, and power panels for emergency circuits must be permanently marked as components of an emergency power system. **Figure 700-6**

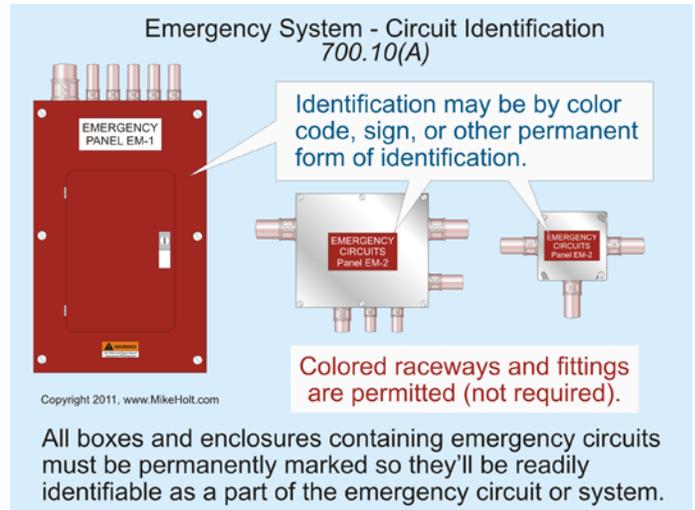


Figure 700-6

(B) **Wiring.** To ensure that a fault on the normal wiring circuits won't affect the performance of emergency wiring or equipment, all wiring to emergency loads must be kept entirely independent of all other wiring, except:

- (1) Wiring in transfer equipment. **Figure 700-7**
- (2) Luminaires supplied from two sources of power.
- (3) A junction box attached to luminaires supplied from two sources of power.
- (4) Wiring within a common junction box attached to unit equipment, containing only the branch circuit supplying the unit equipment and the emergency circuit supplied by the unit equipment.
- (5) Wiring from an emergency source is permitted to supply any combination of emergency, legally required, or optional standby loads in accordance with (a), (b), and (c).
 - a. From separate vertical switchboard sections or from individual disconnects mounted in separate enclosures.
 - b. By single or multiple feeders without overcurrent protection at the source.

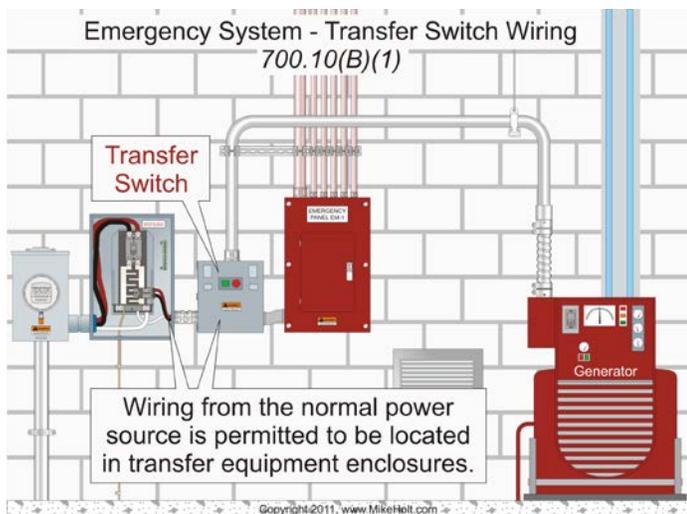


Figure 700-7

Ex to (5)(b): Overcurrent protection is permitted at the source or for the equipment, provided the overcurrent protection is selectively coordinated with the downstream overcurrent protection.

- c. Legally required and optional standby circuits don't originate from the same vertical switchboard section, panelboard enclosure, or individual disconnect enclosure as emergency circuits.

Author's Comment: Separation of the circuits served by a generator source for emergency, legally required, and optional standby circuits may be accomplished by running feeders from a single generator to individual overcurrent devices or to a distribution switchboard that separates emergency circuits in different vertical sections from other loads.

(C) Wiring Design and Location. Emergency wiring circuits must be designed and located to minimize the hazards that might cause failure due to flooding, fire, icing, vandalism, and other adverse conditions.

PART III. SOURCES OF POWER

700.12 General Requirements. In the event of failure of the normal supply to the building/structure, emergency power must be available within 10 seconds. Emergency equipment must be designed and located so as to minimize the hazards that might cause complete failure due to flooding, fires, icing, and vandalism. The emergency power supply must be one of the following:

(A) Storage Battery. Storage batteries must be of suitable rating and capacity to supply and maintain the total load for a period of 1½ hours, without the voltage applied to the load falling below 87½ percent of normal.

(B) Generator Set.

(1) Prime Mover-Driven. A generator approved by the authority having jurisdiction and sized in accordance with 700.5 must have means to automatically start the prime mover when the normal service fails.

(2) Internal Combustion Engines as Prime Movers. If internal combustion engines are used as the prime mover, an on-site fuel supply must be provided for not less than 2 hours of full-demand operation of the system. **Figure 700-8**

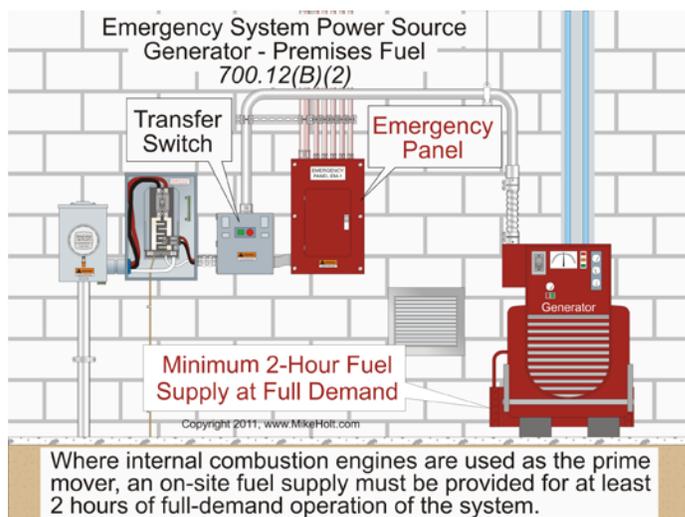


Figure 700-8

(6) Outdoor Generator Sets. If a generator located outdoors is equipped with a readily accessible disconnecting means located within sight of the building/structure, an additional disconnecting means isn't required on or at the building/structure for the generator feeder conductors that serve or pass through the building/structure. **Figure 700-9**

Author's Comment: According to Article 100, within sight means that it's visible and not more than 50 ft from one to the other.

Ex: Where conditions of maintenance and supervision ensure that only qualified persons will monitor and service the installation and where documented safe switching procedures are established and maintained for disconnection, the generator disconnecting means isn't required to be located within sight of the building or structure served.

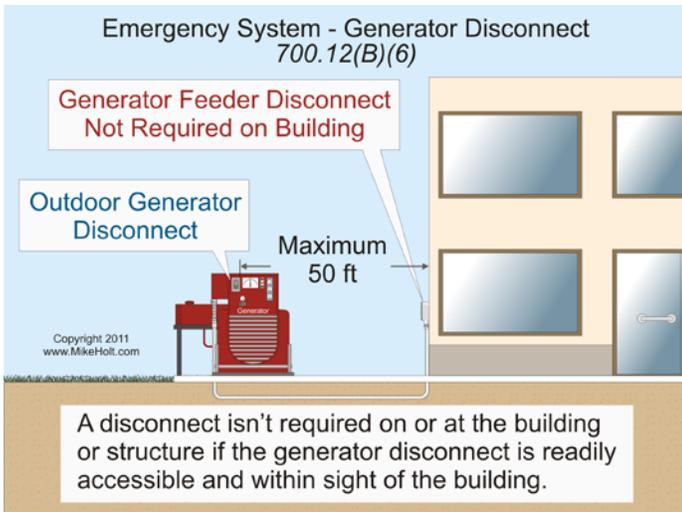


Figure 700-9

(C) Uninterruptible Power Supplies. Uninterruptible power supplies serving as the emergency power source must comply with the applicable requirements of 700.12(A) and (B).

(F) Unit Equipment. Individual unit equipment (an emergency lighting battery pack) must consist of the following: **Figure 700-10**

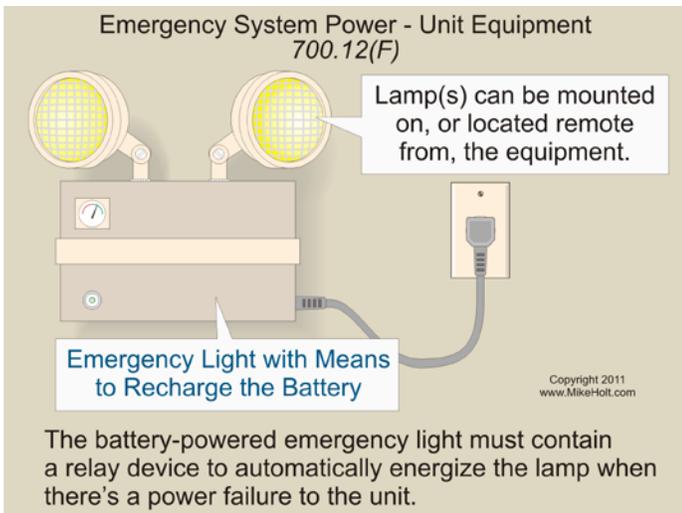


Figure 700-10

- (1) A rechargeable battery,
- (2) A battery charging means,
- (3) Provisions for one or more lamps mounted on the equipment, or terminals for remote lamps (or both), and

- (4) A relaying device arranged to energize the lamps automatically upon failure of the supply to the unit equipment. Emergency lighting battery pack equipment must be permanently fixed in place. Flexible cord-and-plug connection (a locking receptacle isn't required) is permitted for emergency lighting battery pack equipment designed for this purpose, provided the cord doesn't exceed 3 ft.

The branch-circuit wiring that supplies emergency lighting battery pack equipment must be the same branch-circuit wiring that supplies the normal lighting in the area, but the emergency lighting battery pack equipment must be connected ahead of any local switches. The branch circuit that feeds the emergency lighting battery pack equipment must be clearly identified at the distribution panel in accordance with 110.22(A) and 408.4. **Figure 700-11**

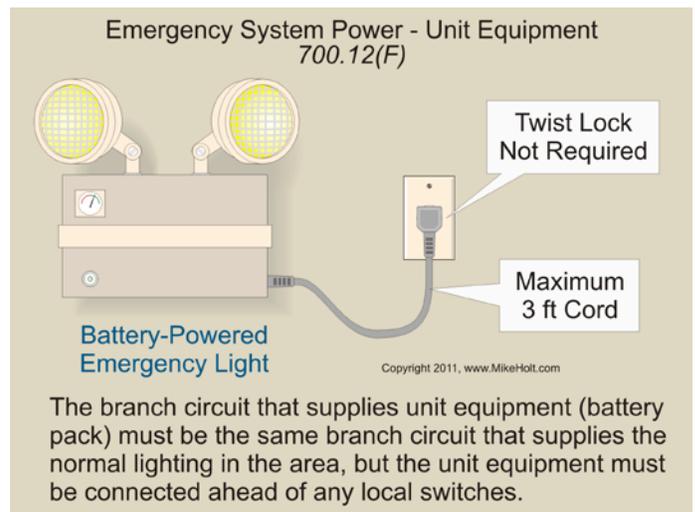


Figure 700-11

Author's Comment: There are two reasons why the emergency lighting battery packs must be connected ahead of the switch controlling the normal area lighting: (1) in the event of a power loss to the lighting circuit, the emergency battery lighting packs will activate and provide emergency lighting for people to exit the building, and (2) the emergency lighting battery packs won't turn on when the switch controlling normal lighting is turned off.



CAUTION: Individual unit equipment must not be connected to the emergency circuit, because it won't operate when normal power is lost, since the equipment is being supplied by the emergency power system

Ex 2: Power for remote heads providing the exterior lighting of an exit door can be supplied by the unit equipment serving the area immediately inside the exit door.

PART IV. CIRCUITS FOR LIGHTING AND POWER

700.15 Loads on Emergency Branch Circuits. Emergency circuits must supply only emergency loads.

700.16 Emergency Illumination. Emergency lighting systems must be designed and installed so that the failure of any individual lighting element, such as the burning out of a lamp, won't leave in total darkness any space that requires emergency illumination.

Author's Comment: This means that a single remote head is never sufficient for an area. A minimum of two lighting heads is always required. This is why individual unit equipment (sometimes called "lunchboxes" in the field) always has two lighting heads.

PART VI. OVERCURRENT PROTECTION

700.25 Accessibility. The branch-circuit overcurrent devices for emergency circuits must be accessible to authorized persons only.

700.26 Ground-Fault Protection of Equipment. The alternate power supply for emergency systems isn't required to have ground-fault protection of equipment, but 700.7(D) requires ground-fault indication of the emergency power supply.

700.27 Coordination. Overcurrent devices for emergency systems must be selectively coordinated with all supply-side overcurrent devices.

Author's Comment: Selective coordination means the overcurrent protection scheme confines the interruption to a particular area rather than to the whole system. For example, if a short circuit or ground fault occurs with selective coordination, the only breaker/fuse that will open is the one protecting just that branch circuit. Without selective coordination, an entire floor of a building can go dark. See Article 100 for the definition of the term "Coordination, Selective."

ARTICLE 701

Legally Required Standby Systems

INTRODUCTION TO ARTICLE 701—LEGALLY REQUIRED STANDBY SYSTEMS

In the hierarchy of electrical systems, Article 700 Emergency Systems receives first priority. Taking the number two spot are Legally Required Standby Systems, which fall under Article 701. Legally required standby systems must supply standby power in 60 seconds or less after a power loss, instead of the 10 seconds or less required for emergency systems.

Article 700 basically applies to systems or equipment required to protect people who are in an emergency and trying to get out, while Article 701 basically applies to systems or equipment needed to aid the people responding to the emergency. For example, Article 700 lighting provides an exit path. But, Article 701 lighting might illuminate the fire hydrants and switchgear areas.

PART I. GENERAL

701.1 Scope. The provisions of Article 701 apply to the installation, operation, and maintenance of legally required standby systems consisting of circuits and equipment intended to supply illumination or power when the normal electrical supply or system is interrupted.

Author's Comment: Legally required standby systems provide electric power to aid in firefighting, rescue operations, control of health hazards, and similar operations.

701.2 Definitions.

Legally Required Standby Systems. Legally required standby systems are those systems classified as legally required by any governmental agency having jurisdiction. These systems are intended to automatically supply power to selected loads (other than those classed as emergency loads) in the event of failure of the normal power source.

Note: Legally required standby systems typically supply loads such as heating and refrigeration systems, communications systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes that, when stopped, could create hazards, or hamper rescue or firefighting operations.

701.3 Tests and Maintenance. Legally required standby system testing consists of acceptance testing and operational testing. Written records of both types of testing and maintenance must be maintained.

(A) Conduct or Witness Test. To ensure that the legally required standby system meets or exceeds the original installation specification, the authority having jurisdiction must conduct or witness an acceptance test of the legally required system upon completion of the installation.

(B) Periodic Testing. Legally required standby systems must be periodically tested to ensure that adequate maintenance has been performed and that the systems are in proper operating condition.

Author's Comment: Running the legally required standby system to power the loads of the facility is often considered an acceptable method of operational testing.

(C) Battery Systems Maintenance. If batteries are used, the authority having jurisdiction must require periodic maintenance.

(D) Written Record. A written record must be kept of all required tests and maintenance.

Author's Comment: The *NEC* doesn't specify the required record retention period.

701.4 Capacity and Rating. A legally required standby system must have adequate capacity to carry all loads expected to operate simultaneously. The legally required standby alternate power supply is permitted to supply legally required standby and optional standby system loads if:

- (1) The alternate power supply has adequate capacity to handle all connected loads
- (2) There's automatic selective load pickup and load shedding to ensure adequate power to the legally required standby circuits

701.5 Transfer Equipment.

(A) **General.** Transfer equipment must be listed for emergency use.

Author's Comment: Legally required standby systems and optional standby systems can be on the same transfer switch, but emergency systems must have their own [700.6(D)].

(C) **Automatic Transfer Switch.** Automatic transfer switches must be electrically operated, mechanically held, and listed for emergency use. **Figure 701-1**

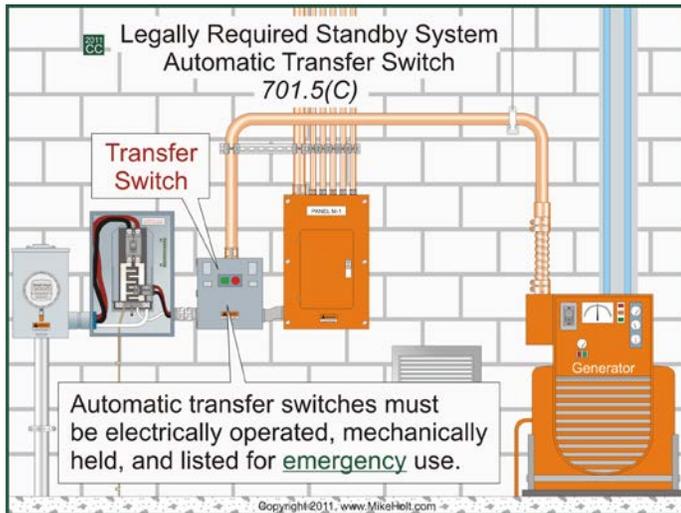


Figure 701-1

701.7 Signs.

(A) **Mandated Standby.** A sign must be placed at the service-entrance equipment indicating type and location of on-site legally required standby power sources. **Figure 701-2**

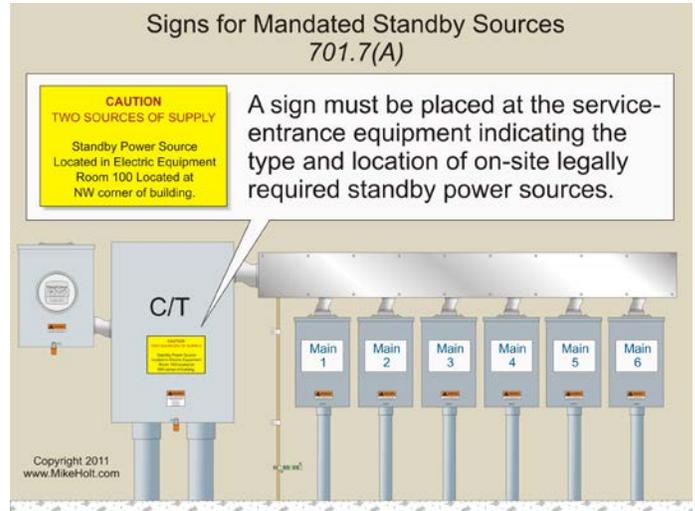


Figure 701-2

PART III. SOURCES OF POWER

701.12 General Requirements. If the normal supply fails, legally required standby power must be available within 60 seconds. The supply system for the legally required standby power supply must be one of the following:

(A) **Storage Battery.** Storage batteries must be of suitable rating and capacity to supply and maintain the total load for a period of 1½ hours, without the voltage applied to the load falling below 87½ percent of normal.

(B) **Generator Set.**

(1) **Prime Mover-Driven.** A generator approved by the authority having jurisdiction and sized in accordance with 701.6 must have the means to automatically start the prime mover on failure of the normal service.

(2) **Internal Combustion Engines as Prime Movers.** If internal combustion engines are used as the prime mover, an on-site fuel supply must be provided for not less than 2 hours of full-demand operation of the system. **Figure 701-3**

(5) **Outdoor Generator Sets.** If a generator located outdoors is equipped with a readily accessible disconnecting means located within sight of the building/structure, an additional disconnecting means isn't required on or at the building/structure for the generator feeder conductors that serve or pass through the building/structure. **Figure 701-4**

PART II. CIRCUIT WIRING

701.10 Wiring. Legally required standby system wiring is permitted to occupy the same raceways, cables, boxes, and cabinets with other general wiring.

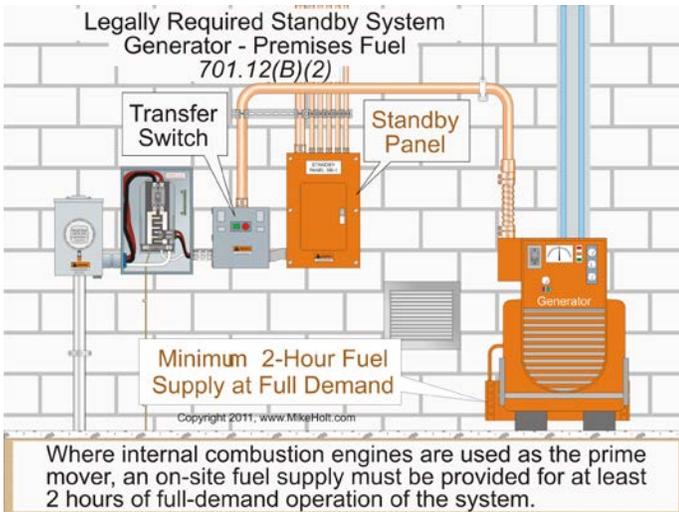


Figure 701-3

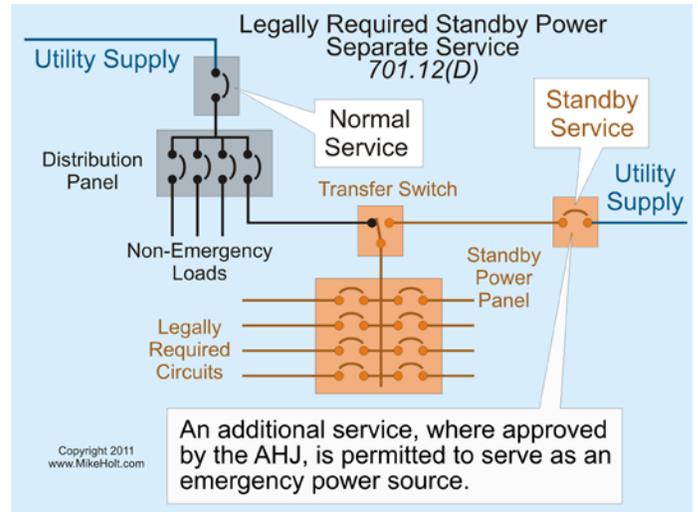


Figure 701-5

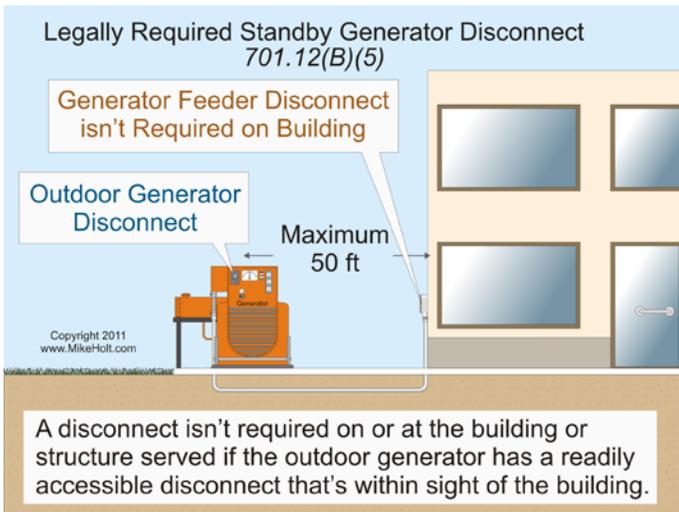


Figure 701-4

Author's Comment: According to Article 100, within sight means that it's visible and not more than 50 ft from one to the other.

(C) Uninterruptible Power Supplies. Uninterruptible power supplies serving as the legally required standby power source must comply with 701.12(A) and (B).

(D) Separate Service. If approved by the authority having jurisdiction, an additional service installed in accordance with Article 230 is permitted to serve as a legally required source of power. **Figure 701-5**

To minimize the possibility of simultaneous interruption of the legally required standby supply, a separate service drop or lateral must be electrically and physically separated from all other service conductors.

(E) Connection Ahead of Service Disconnecting Means. If approved by the authority having jurisdiction, connection ahead of, but not within, the same cabinet, enclosure, or vertical switchboard section as the service disconnecting means is permitted. **Figure 701-6**

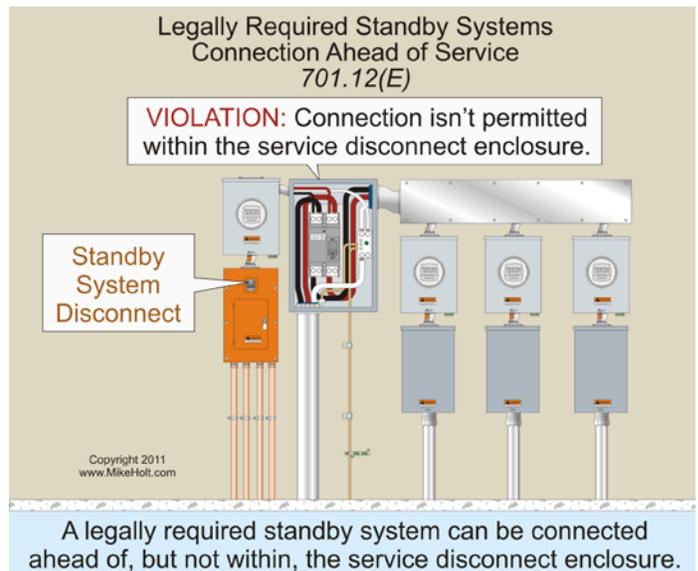


Figure 701-6

To prevent simultaneous interruption of supply, the legally required standby service disconnecting means must be sufficiently separated from the normal service disconnection means.

Note: See 230.82 for equipment permitted on the supply side of a service disconnecting means.

PART IV. OVERCURRENT PROTECTION

701.25 Accessibility. The branch-circuit overcurrent devices for legally required standby circuits must be accessible to authorized persons only.

701.26 Ground-Fault Protection of Equipment. The alternate source for legally required standby systems isn't required to have ground-fault protection of equipment. It must have ground-fault indication.

701.27 Coordination. Overcurrent devices for legally required standby systems must be selectively coordinated with all supply-side overcurrent devices.

Author's Comment: See the definition of "Coordination, Selective" in Article 100.

ARTICLE 702

Optional Standby Systems

INTRODUCTION TO ARTICLE 702—OPTIONAL STANDBY SYSTEMS

Taking third priority after Emergency and Legally Required Systems, Optional Standby Systems protect public or private facilities or property where life safety doesn't depend on the performance of the system. These systems aren't required for rescue operations.

Suppose a glass plant loses power. Once glass hardens in the equipment—which it will do when process heat is lost—the plant is going to suffer a great deal of downtime and expense before it can resume operations. An optional standby system can prevent this loss.

You'll see these systems in facilities where loss of power can cause economic loss or business interruptions. Data centers can lose millions of dollars from a single minute of lost power. A chemical or pharmaceutical plant can lose an entire batch from a single momentary power glitch. In many cases, the lost revenue can't be recouped.

This article also applies to the installation of optional standby generators in homes, farmsteads, small businesses and many other applications where standby power isn't legally required.

PART I. GENERAL

702.1 Scope. The systems covered by Article 702 consist of those permanently installed, including prime movers, and those arranged for a connection to a premises wiring system from a portable alternate power supply. **Figure 702-1**

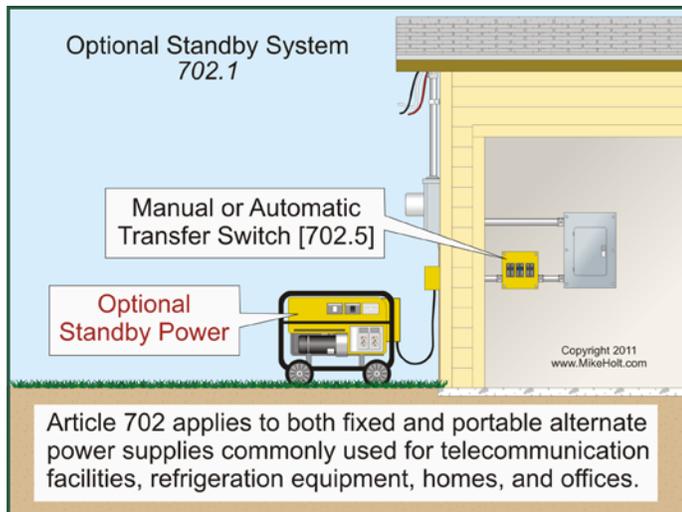


Figure 702-1

Author's Comment: A portable generator that provides temporary power, like those used on construction sites, doesn't fall within the scope of Article 702 unless the generator is permanently connected to the premises wiring. **Figure 702-2**

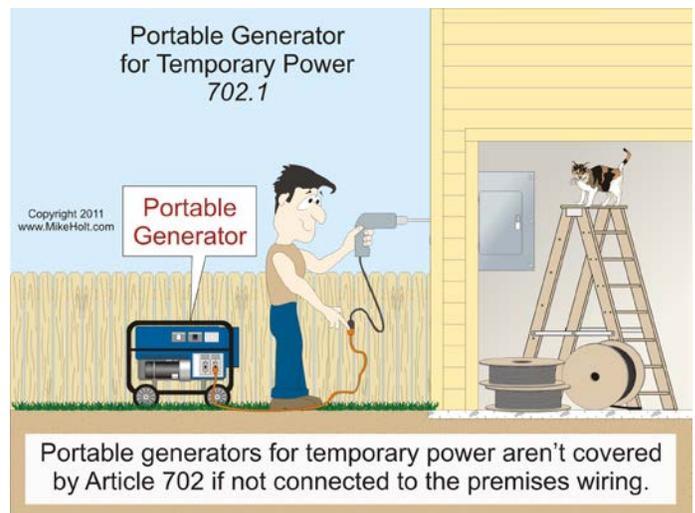


Figure 702-2

702.2 Definition.

Optional Standby Systems. Optional standby systems are intended to supply power to public or private facilities or property where life safety doesn't depend on the performance of the system. Optional standby systems are intended to supply on-site generated power to selected loads either automatically or manually.

Note: Optional standby systems are typically installed to provide an alternate source of electric power for such facilities as industrial and commercial buildings, farms and residences, and to serve loads such as heating and refrigeration systems, data processing and communications systems, and industrial processes that, when stopped during any power outage, can cause discomfort, economic loss, serious interruption of the process, damage to the product or process, or the like.

702.4 Capacity and Rating.

(B) System Capacity. The calculated load on the standby source must be in accordance with Article 220 or by a method approved by the authority having jurisdiction.

(1) Manual Transfer Equipment. The optional standby power source must have adequate capacity for all equipment intended to operate at one time as determined by the user.

Author's Comment: When a manual transfer switch is used, the user of the optional standby system selects the loads to be connected to the system, which determines the system kVA/kW rating.

(2) Automatic Transfer Equipment.

(a) Full Load. The optional standby power source must have adequate capacity to supply the full load transferred. **Figure 702-3**

Author's Comment: For a new installation, the load is determined by Article 220 or an alternate method approved by the AHJ. For existing facilities, the maximum demand data for one year or the average power demand of a 15-minute period over a minimum of 30 days can be used to size the power source [220.87]. **Figure 702-4**

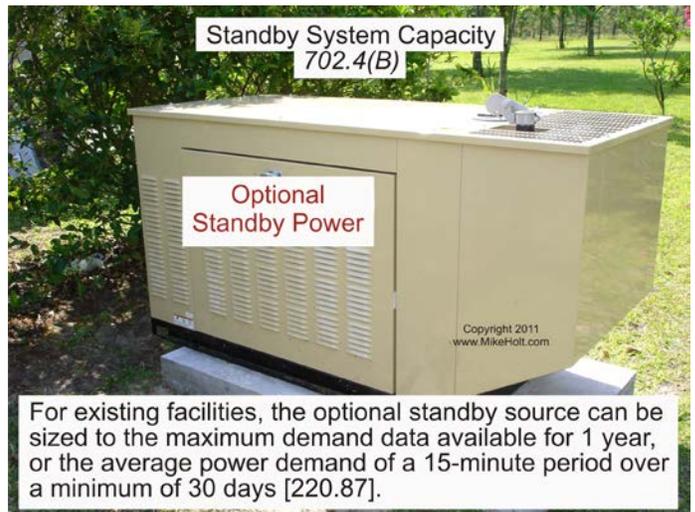
Standby System Capacity - Automatic Transfer Equipment
702.4(B)(2)(a)



The optional standby power source must have adequate capacity to supply the full load transferred.

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Figure 702-3



For existing facilities, the optional standby source can be sized to the maximum demand data available for 1 year, or the average power demand of a 15-minute period over a minimum of 30 days [220.87].

Figure 702-4

702.5 Transfer Equipment. A transfer switch is required for all fixed or portable optional standby systems.

Ex: Temporary connection of a portable generator without transfer equipment is permitted where written safety procedures are in place and conditions of maintenance and supervision ensure that only qualified persons will service the installation, and where the normal supply is physically isolated by a lockable disconnecting means or by the disconnection of the normal supply conductors.

702.7 Signs.

(A) Standby Power Sources. A sign that indicates the type and location of on-site optional standby power sources must be placed at the service-entrance equipment. **Figure 702-5**

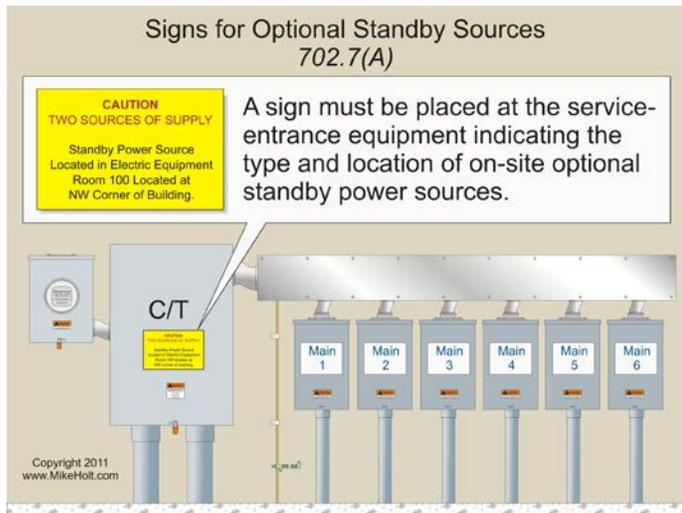


Figure 702-5

PART II. CIRCUIT WIRING

702.10 Wiring. Optional standby system wiring can occupy the same raceways, cables, boxes, and cabinets with other general wiring.

702.12 Outdoor Generator Sets. If a generator located outdoors is equipped with a readily accessible disconnecting means located within sight of the building/structure, an additional disconnecting means isn't required on or at the building/structure for the generator feeder conductors that serve or pass through the building/structure. **Figure 702-6**

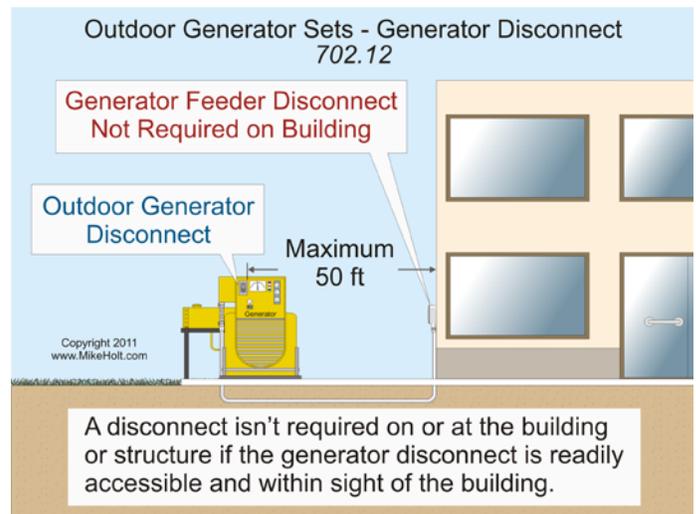


Figure 702-6

Author's Comment: According to Article 100, within sight means that it's visible and not more than 50 ft from one to the other.

Practice Questions



Please use the 2011 *Code* book to answer the following questions.

ARTICLE 445—Generators

- Article 445 contains installation and other requirements for generators.
 - True
 - False
- Constant-voltage generators, except ac generator exciters, shall be protected from overcurrent by _____ or other acceptable overcurrent protective means suitable for the conditions of use.
 - inherent design
 - circuit breakers
 - fuses
 - any of these
- Separately derived system generators must have the _____ conductor sized not smaller than required to carry the maximum unbalanced current as determined by 220.61.
 - neutral
 - grounding
 - a and b
 - none of these

ARTICLE 700— Emergency Systems

- Emergency systems are generally installed where artificial illumination is required for safe exiting and for panic control in buildings occupied by large numbers of persons, such as _____ and similar institutions.
 - hotels
 - theaters and sports arenas
 - health care facilities
 - all of these
- Emergency systems may provide power for ventilation where essential to maintain life, fire detection and alarm systems, elevators, fire pumps, public safety communications systems, industrial processes where current interruption would produce serious _____.
 - production slowdowns
 - life safety or health hazards
 - a and b
 - a or b
- Emergency systems are those systems legally required and classed as emergency by a governmental agency having jurisdiction. These systems are intended to automatically supply illumination and/or power essential for _____.
 - community activity
 - safety to human life
 - public recreation
 - police and emergency services exclusively
- The _____ shall conduct or witness an acceptance test of the complete emergency system upon installation and periodically afterward.
 - electrical engineer
 - authority having jurisdiction
 - qualified person
 - manufacturer's representative
- Where batteries are used for _____ in auxiliary engines of emergency systems, the authority having jurisdiction shall require periodic maintenance.
 - starting
 - control or ignition
 - a and b
 - none of these
- A written record shall be kept of required tests and maintenance on emergency systems.
 - True
 - False

7. Means for testing all emergency lighting and power systems during maximum anticipated load conditions shall be provided.
 - (a) True
 - (b) False

8. An emergency system shall have adequate capacity and rating for _____ to be operated simultaneously.
 - (a) 80% of the loads
 - (b) all loads
 - (c) 125% of the load
 - (d) none of these

9. A portable or temporary alternate source _____ whenever the emergency generator is out of service for major maintenance or repair.
 - (a) shall not be required
 - (b) is recommended
 - (c) shall be available
 - (d) shall be avoided

10. Emergency transfer equipment, including transfer switches, shall be _____.
 - (a) automatic
 - (b) identified for emergency use
 - (c) approved by the authority having jurisdiction
 - (d) all of these

11. Automatic transfer switches shall be _____.
 - (a) electrically operated
 - (b) mechanically held
 - (c) listed for emergency system use if rated 600V ac and below
 - (d) all of these

12. An emergency transfer switch shall supply _____.
 - (a) emergency loads
 - (b) computer equipment
 - (c) UPS equipment
 - (d) all of these

13. When practicable, audible and visual signal devices for an emergency system shall be provided to indicate _____.
 - (a) that the battery is carrying load
 - (b) derangement of the emergency source
 - (c) that the battery charger is not functioning
 - (d) all of these

14. A sign shall be placed at the service-entrance equipment indicating the type and location of on-site emergency power sources.
 - (a) True
 - (b) False

15. Wiring from an emergency source or emergency source distribution overcurrent protection to emergency loads shall be kept independent of all other wiring and equipment except in _____.
 - (a) transfer equipment enclosures
 - (b) exit or emergency luminaires supplied from two sources
 - (c) load control relay supplying emergency or exit luminaires or a common junction box attached to exit or emergency luminaires supplied from two sources
 - (d) all of these

16. Wiring from an emergency source can supply any combination of emergency, legally required, or optional loads, provided the conductors _____.
 - (a) terminate in separate vertical sections of a switchboard
 - (b) terminate in the same vertical section of a switchboard
 - (c) terminate in junction box identified for emergency use
 - (d) are identified as emergency conductors

17. Emergency circuit wiring shall be designed and located to minimize the hazards that might cause failure because of _____.
 - (a) flooding
 - (b) fire
 - (c) icing
 - (d) all of these

18. In the event of failure of the normal supply to the building/structure, emergency power shall be available within _____ seconds.
 - (a) 5
 - (b) 10
 - (c) 30
 - (d) 60

19. Emergency equipment must be designed and located so as to minimize the hazards that might cause complete failure due to _____.
 (a) flooding
 (b) fires
 (c) icing, and vandalism
 (d) all of these
20. A storage battery supplying emergency lighting and power shall maintain not less than 87½ percent of normal voltage at total load for a period of at least _____ hour(s).
 (a) 1
 (b) 1½
 (c) 2
 (d) 2½
21. Where an internal-combustion engine is used as the prime mover for an emergency system, an on-site fuel supply shall be provided for not less than _____ hours of full-demand operation of the system.
 (a) 2
 (b) 3
 (c) 4
 (d) 5
22. If a generator for emergency system power located outdoors is equipped with a readily accessible disconnecting means located within sight (within 50 ft) of the building/structure, an additional disconnecting means isn't required on or at the building/structure for the generator feeder conductors that serve or pass through the building/structure.
 (a) True
 (b) False
23. For an emergency system power generator installed outdoors, where conditions of maintenance and supervision ensure that only qualified persons will monitor and service the installation and where documented safe switching procedures are established and maintained for disconnection, the generator disconnecting means is not required to be located within sight of the building or structure served.
 (a) True
 (b) False
24. Unit equipment for emergency systems shall be on the same branch circuit that serves the normal lighting in the area and connected _____ any local switches.
 (a) with
 (b) ahead of
 (c) after
 (d) downstream of
25. In emergency systems, only appliances and lamps required for emergency use, shall be supplied by _____.
 (a) emergency circuits
 (b) multiwire branch circuits
 (c) HID-rated circuit breakers
 (d) a and b
26. Emergency lighting systems shall be designed and installed so that the failure of any individual lighting element, such as the burning out of a lamp, will not leave in total darkness any space that requires emergency illumination.
 (a) True
 (b) False
27. Manual switches controlling emergency circuits shall be convenient to authorized persons responsible for their _____.
 (a) maintenance
 (b) actuation
 (c) inspection
 (d) evaluation
28. Branch-circuit overcurrent devices in emergency circuits shall be accessible to _____ only.
 (a) the authority having jurisdiction
 (b) authorized persons
 (c) the general public
 (d) qualified persons
29. The alternate source for emergency systems shall have ground-fault protection of equipment.
 (a) True
 (b) False

30. Overcurrent devices for emergency systems _____ all supply-side overcurrent devices.
- (a) shall be selectively coordinated with
 - (b) can be selectively coordinated with
 - (c) shall be the same amperage as
 - (d) shall be a higher amperage than

ARTICLE 701— Legally Required Standby Systems

1. A legally required standby system is intended to automatically supply power to _____ in the event of failure of the normal source.
- (a) those systems classed as emergency systems
 - (b) selected loads
 - (c) a and b
 - (d) none of these
2. The _____ shall conduct or witness a test of the complete legally required standby system upon installation.
- (a) electrical engineer
 - (b) authority having jurisdiction
 - (c) qualified person
 - (d) manufacturer’s representative
3. Legally required standby systems that are tested upon installation and found to be acceptable to the authority having jurisdiction shall not be required to undergo any future tests unless the equipment is modified.
- (a) True
 - (b) False
4. Where batteries are used for _____ of prime movers of legally required standby systems, the authority having jurisdiction shall require periodic maintenance.
- (a) control
 - (b) starting or ignition
 - (c) a and b
 - (d) none of these

5. A written record shall be kept of required tests and maintenance on legally required standby systems.
- (a) True
 - (b) False
6. Testing legally required standby system lighting and power systems during maximum anticipated load conditions shall be avoided so as not to tax the standby system unnecessarily.
- (a) True
 - (b) False
7. A legally required standby system shall have adequate capacity and rating for _____ that are expected to operate simultaneously on the standby system.
- (a) all of the loads
 - (b) 80% of the loads
 - (c) 125% of the loads
 - (d) none of these
8. Legally required standby system equipment shall be suitable for _____ at its terminals.
- (a) the maximum available fault current
 - (b) the maximum overload current only
 - (c) the minimum fault current
 - (d) a one-hour rating
9. Transfer equipment for legally required systems, including automatic transfer switches, shall be _____.
- (a) automatic
 - (b) identified for standby use
 - (c) approved by the authority having jurisdiction
 - (d) all of these
10. Means to bypass and isolate transfer switch equipment shall not be permitted on legally required standby systems.
- (a) True
 - (b) False

11. Automatic transfer switches on legally required standby systems shall be electrically operated and _____ held.
 - (a) electrically
 - (b) mechanically
 - (c) gravity
 - (d) any of these

12. Audible and visual signal devices shall be provided on legally required standby systems, where practicable, to indicate _____.
 - (a) derangement of the standby source
 - (b) that the standby source is carrying load
 - (c) that the battery charger is not functioning
 - (d) all of these

13. A sign shall be placed at the service equipment indicating the _____ of on-site legally required standby power sources.
 - (a) type
 - (b) location
 - (c) manufacturer
 - (d) a and b

14. Legally required standby system wiring can occupy the same raceways, cables, boxes, and cabinets with other general-purpose wiring.
 - (a) True
 - (b) False

15. A generator set for a legally required standby system shall _____.
 - (a) have means for automatically starting the prime mover
 - (b) have 2 hours of fuel supply for full demand operation available on-site if the prime mover is an internal combustion engine
 - (c) not be solely dependent on a public utility gas system unless acceptable to the AHJ
 - (d) all of these

16. Where acceptable to the authority having jurisdiction, connections ahead of and not within the same cabinet, enclosure, or vertical switchboard section as the service disconnecting means shall be permitted for _____ standby service.
 - (a) emergency
 - (b) legally required
 - (c) optional
 - (d) all of these

17. Individual unit equipment for legally required standby illumination shall be permanently fixed in place. Flexible cord-and-plug connection shall be permitted, provided the cord does not exceed _____ in length.
 - (a) 12 in.
 - (b) 18 in.
 - (c) 3 ft
 - (d) 6 ft

18. The branch-circuit overcurrent devices for legally required standby systems shall be accessible only to _____.
 - (a) the authority having jurisdiction
 - (b) authorized persons
 - (c) the general public
 - (d) qualified persons

19. The alternate source for legally required standby systems shall not be required to have ground-fault protection of equipment.
 - (a) True
 - (b) False

20. Overcurrent devices for legally required standby systems shall be _____ with all supply-side overcurrent devices.
 - (a) series rated
 - (b) selectively coordinated
 - (c) installed in parallel
 - (d) any of these

ARTICLE 702—Optional Standby Systems

1. Article 702 applies to _____ generators used for backup power to public or private facilities or property where life safety does not depend on the performance of the system.
 - (a) permanently installed
 - (b) portable
 - (c) a and b
 - (d) none of these

2. Optional standby systems are typically installed to provide an alternate source of power for _____.
 - (a) data processing and communication systems
 - (b) emergency systems for health care facilities
 - (c) emergency systems for hospitals
 - (d) none of these

3. Optional standby systems utilizing automatic transfer equipment shall have adequate capacity and rating for the supply of _____.
 - (a) all emergency lighting and power loads
 - (b) the load, as calculated in Article 220
 - (c) 100 percent of the appliance loads and 50 percent of the lighting loads
 - (d) 100 percent of the lighting loads and 75 percent of the appliance loads

4. A transfer switch shall be required for all fixed or portable optional standby systems for buildings or structures at which an electric utility is either the normal or standby source, unless permitted by an exception.
 - (a) True
 - (b) False

5. For optional standby systems, the temporary connection of a portable generator without transfer equipment shall be permitted where conditions of maintenance and supervision ensure that only qualified persons will service the installation, and where the normal supply is physically isolated by _____.
 - (a) a lockable disconnecting means
 - (b) the disconnection of the normal supply conductors
 - (c) an extended power outage
 - (d) a or b

6. Audible and visual signal devices shall be provided on optional standby systems to indicate _____, where practicable.
 - (a) derangement of the optional standby source
 - (b) that the optional standby source is carrying load
 - (c) that the battery charger is not functioning
 - (d) a and b

7. A sign shall be placed at the service-entrance equipment indicating the _____ of on-site optional standby power sources.
 - (a) type
 - (b) location
 - (c) manufacturer
 - (d) a and b

8. Optional standby system wiring is permitted to occupy the same raceways, cables, boxes, and cabinets with other general wiring.
 - (a) True
 - (b) False

9. If the transfer switch for a portable generator switches the _____ conductor, then it is being used as a separately derived system and the portable generator shall be grounded in accordance with 250.30.
 - (a) phase
 - (b) equipment grounding
 - (c) grounded
 - (d) all of these

10. Where a generator for an optional standby system is installed outdoors and equipped with a readily accessible disconnecting means located _____, an additional disconnecting means is not required where ungrounded conductors serve or pass through the building or structure.
 - (a) inside the building or structure
 - (b) within sight of the building or structure
 - (c) inside the generator enclosure
 - (d) a or c

Practice Question Answers

ARTICLE 455—Generators

1. (a) 445.1
2. (d) 445.12(A)
3. (a) 445.13

ARTICLE 700—Emergency Systems

1. (d) 700.2 Note
2. (b) 700.2 Note
3. (b) 700.2 Definitions—Emergency Systems
4. (b) 700.3(A)
5. (c) 700.3(C)
6. (a) 700.3(D)
7. (a) 700.3(E)
8. (b) 700.4(A)
9. (c) 700.4(B)
10. (d) 700.5(A)
11. (d) 700.5(C)
12. (a) 700.5(D)
13. (d) 700.6(A),(B), and (C)
14. (a) 700.7(A)
15. (d) 700.10(B)(1),(2), and (3)
16. (a) 700.10(B)(5)(a)
17. (d) 700.10(C)
18. (b) 700.12
19. (d) 700.12
20. (b) 700.12(A)
21. (a) 700.12(B)(2)
22. (a) 700.12(B)(6)
23. (a) 700.12(B)(6) Ex
24. (b) 700.12(F)
25. (a) 700.15
26. (a) 700.16
27. (b) 700.21
28. (b) 700.25
29. (b) 700.26
30. (a) 700.27

ARTICLE 701—Legally Required Standby Systems

1. (b) 701.2
2. (b) 701.3(A)
3. (b) 701.3(B)
4. (c) 701.3(C)
5. (a) 701.3(D)
6. (b) 701.3(E)
7. (a) 701.4
8. (a) 701.4
9. (d) 701.5(A)
10. (b) 701.5(B)
11. (b) 701.5(C)
12. (d) 701.6(A),(B), and (C)
13. (d) 701.7(A)
14. (a) 701.1
15. (d) 701.12(B)(1),(2), (3), and (3)Ex
16. (b) 701.12(E)
17. (c) 701.12(G)
18. (b) 701.25
19. (a) 701.26
20. (b) 701.27 Coordination

ARTICLE 702—Optional Standby Systems

1. (c) 702.1 and 702.2
2. (a) 702.2 Note
3. (b) 702.4(B)
4. (a) 702.5
5. (d) 702.5 Ex
6. (d) 702.6(1) and (2)
7. (d) 702.7(A)
8. (a) 702.1
9. (c) 702.11(A)
10. (b) 702.12