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Ohio Board of Building Standards
Building on the Code Education Series

Common Electrical Code Topics

Generators
Transformers and Transformer Vaults
Health Care Facilities

March 27, 2015

Presentation Handout

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OHIO BOARD OF BUILDING STANDARDS

BUILDING ON THE CODE

Common Electrical Code Topics

Generators
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Health Care Facilities

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Part I
Generators
Article 445

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Article 445 Generators

445.1 Scope. This article contains installation and other requirements for generators.

Generator Uses

Fire Pumps - Article 695
Emergency Systems - Article 700
Legally Required Systems - Article 701
Optional Standby Systems - Article 702
Interconnected Electric Power Production Sources - Article 705
Critical Operations Power Systems – Article 708

Automatic vs. Manual Transfer Switches
Separately Derived Systems

Fire Pumps Article - 695

695.1 Scope.

(A) Covered. This article covers the installation of the following:
(1) Electric power sources and interconnecting circuits
(2) Switching and control equipment dedicated to fire pump drivers
(B) Not Covered. This article does not cover the following:
(1) The performance, maintenance, and acceptance testing of the fire pump system, and the internal wiring of the components of the system
(2) The installation of pressure maintenance (jockey or makeup) pumps
(3) Transfer equipment upstream of the fire pump transfer switches

695.2 Definitions.
Fault-Tolerant External Control Circuits. Those control circuits either entering or leaving the fire pump controller enclosure, which if broken, disconnected, or shorted will not prevent the controller from starting the fire pump from all other internal or external means and may cause the controller to start the pump under these conditions.
On-Site Power Production Facility. The normal supply of electric power for the site that is expected to be constantly producing power.
On-Site Standby Generator. ***A facility producing electric power on site as the alternate supply of electric power. It differs from an on-site power production facility, in that it is not constantly producing power.***

Article 695.3

695.3 Power Source(s) for Electric Motor-Driven Fire Pumps. Electric motor-driven fire pumps shall have a reliable source of power.
(A) Individual Sources. Where reliable, and where capable of carrying indefinitely the sum of the locked-rotor current of the fire pump motor(s) and the pressure maintenance pump motor(s) and the full-load current of the associated fire pump accessory equipment when connected to this power supply, the power source for an electric motor driven fire pump shall be one or more of the following.

(1) Electric Utility Service Connection. A fire pump shall be permitted to be supplied by a separate service, or from a connection located ahead of and not within the same cabinet, enclosure, vertical switchgear section, or vertical switchboard section as the service disconnecting means. The connection shall be located and arranged so as to minimize the possibility of damage by fire from within the premises and from exposing hazards. A tap ahead of the service disconnecting means shall comply with 230.82(5). The service equipment shall comply with the labeling requirements in 230.2 and the location requirements in 230.72(B).

(2) On-Site Power Production Facility. A fire pump shall be permitted to be supplied by an on-site power production facility. The source facility shall be located and protected to minimize the possibility of damage by fire.

Article 695.3 (B)

(B) Multiple Sources. If reliable power cannot be obtained from a source described in 695.3(A), power shall be supplied by one of the following:
(1) Individual Sources. An approved combination of two or more of the sources from 695.3(A).
(2) Individual Source and On-site Standby Generator. An approved combination of one or more of the sources in 695.3(A) and an on-site standby generator complying with 695.3(D).

Exception to (B)(1) and (B)(2): An alternate source of power shall not be required where a back-up engine-driven or back-up steam turbine-driven fire pump is installed.

Article 695.3 (D) & (E) &(F)

(D) On-Site Standby Generator as Alternate Source. An on-site standby generator(s) used as an alternate source of power shall comply with (D)(1) through (D)(3).
(1) Capacity. The generator shall have sufficient capacity to allow normal starting and running of the motor(s) driving the fire pump(s) while supplying all other simultaneously operated load(s).
Automatic shedding of one or more optional standby loads in order to comply with this capacity requirement shall be permitted.
(2) Connection. A tap ahead of the generator disconnecting means shall not be required.
(3) Adjacent Disconnects. The requirements of 430.113 shall not apply.
(E) Arrangement. All power supplies shall be located and arranged to protect against damage by fire from within the premises and exposing hazards.
Multiple power sources shall be arranged so that a fire at one source does not cause an interruption at the other source.
(F) Transfer of Power. Transfer of power to the fire pump controller between the individual source and one alternate source shall take place within the pump room.

(1) Power Source Selection. Selection of power source shall be performed by a transfer switch listed for fire pump service.
(2) Overcurrent Device Selection. An instantaneous trip circuit breaker shall be permitted in lieu of the overcurrent devices specified in 695.4(B)(2)(a)(1), provided that it is part of a transfer switch assembly listed for fire pump service that complies with 695.4(B)(2)(a)(2).

Article 695.4

695.4 Continuity of Power. Circuits that supply electric motor–driven fire pumps shall be supervised from inadvertent disconnection as covered in 695.4(A) or (B).
(A) Direct Connection. The supply conductors shall directly connect the power source to a listed fire pump controller, a **listed** combination fire pump controller and power transfer switch, or a **listed** fire pump power transfer switch.
(B) Connection Through Disconnecting Means and Overcurrent Device.
(1) Number of Disconnecting Means.
(a) *General.* A single disconnecting means and associated overcurrent protective device(s) shall be permitted to be installed between the fire pump power source(s) and one of the following:
(1) A listed fire pump controller
(2) A listed fire pump power transfer switch
(3) A listed combination fire pump controller and power transfer switch
(b) *Feeder Sources.* For systems installed under the provisions of 695.3(C) only, additional disconnecting means and the associated overcurrent protective device(s) shall be permitted as required to comply with other provisions of this *Code*.
(c) *On-Site Standby Generator.* Where an on-site standby generator is used to supply a fire pump, an additional disconnecting means and an associated overcurrent protective device(s) shall be permitted.

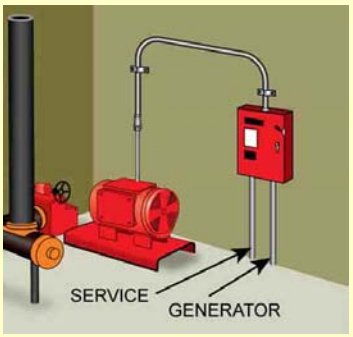
Article 695.4 cont.

(2) Overcurrent Device Selection. Overcurrent devices shall comply with 695.4(B)(2)(a) or (b).
(a) ***Individual Sources.*** Overcurrent protection for individual sources shall comply with 695.4(B)(2)(a)(1) or (2).
(1) **Overcurrent protective device(s)** shall be rated to carry indefinitely the sum of the locked-rotor current of the largest fire pump motor and the pressure maintenance pump motor(s) and the full-load current of all of the other pump motors and associated fire pump accessory equipment when connected to this power supply. Where the locked-rotor current value does not correspond to a standard overcurrent device size, the next standard overcurrent device size shall be used in accordance with 240.6. The requirement to carry the locked rotor currents indefinitely shall not apply to conductors or devices other than overcurrent devices in the fire pump motor circuit(s).
(2) **Overcurrent protection** shall be provided by an assembly **listed** for fire pump service and complying with the following:
a. ***The overcurrent protective device shall not open within 2 minutes at 600 percent of the full-load current of the fire pump motor(s).***
b. ***The overcurrent protective device shall not open with a re-start transient of 24 times the full-load current of the fire pump motor(s).***

Article 695.4 (B)(2) cont. &(3)

c. ***The overcurrent protective device shall not open within 10 minutes at 300 percent of the full-load current of the fire pump motor(s).***
d. The trip point for circuit breakers shall not be field adjustable.
(b) ***On-Site Standby Generators.*** Overcurrent protective devices between an on-site standby generator and a fire pump controller shall be selected and sized to allow for instantaneous pickup of the full pump room load, but shall not be larger than the value selected to comply with 430.62 to provide short-circuit protection only.

(3) Disconnecting Means. All disconnecting devices that are unique to the fire pump loads shall comply with items (a) through (e).
(a) *Features and Location — Normal Power Source.* The disconnecting means for the normal power source shall comply with all of the following:
(1) Be identified as suitable for use as service equipment.
(2) Be lockable in the closed position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed.
(3) Not be located within the same enclosure, panel board, switchboard, switchgear, or motor control center, with or without common bus, that supplies loads other than the fire pump.
(4) Be located sufficiently remote from other building or other fire pump source disconnecting means such that inadvertent operation at the same time would be unlikely.



Article 695.4 (B)(3) cont.

(b) *Features and Location — **On-Site Standby Generator.*** The disconnecting means for an on-site standby generator(s) used as the alternate power source shall be installed in accordance with 700.10(B)(5) for emergency circuits and shall be lockable in the closed position. The provision for locking or adding a lock to the disconnecting means shall be installed on or at the switch or circuit breaker used as the disconnecting means and shall remain in place with or without the lock installed.
(c) ***Disconnect Marking.*** The disconnecting means shall be marked "Fire Pump Disconnecting Means." The letters shall be at least 25 mm (1 in.) in height, and they shall be visible without opening enclosure doors or covers.

(d) ***Controller Marking.*** A placard shall be placed adjacent to the fire pump controller, stating the location of this disconnecting means and the location of the key (if the disconnecting means is locked).
(e) ***Supervision.*** The disconnecting means shall be supervised in the closed position by one of the following methods:
(1) Central station, proprietary, or remote station signal device
(2) Local signaling service that causes the sounding of an audible signal at a constantly attended point
(3) Locking the disconnecting means in the closed position
(4) Sealing of disconnecting means and approved weekly recorded inspections when the disconnecting means are located within fenced enclosures or in buildings under the control of the owner

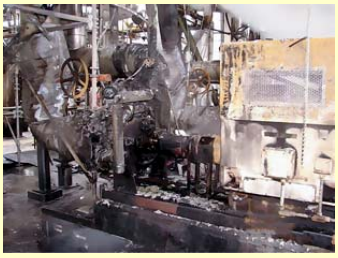
Article 695.6 (C)

C) Overload Protection. Power circuits shall not have automatic protection against overloads. Except for protection of transformer primaries provided in 695.5(C)(2), branch-circuit and feeder conductors shall be protected against short circuit only. Where a tap is made to supply a fire pump, the wiring shall be treated as service conductors in accordance with 230.6. The applicable distance and size restrictions in 240.21 shall not apply.
Exception No. 1: Conductors between storage batteries and the engine shall not require overcurrent protection or disconnecting means.

Exception No. 2: For an on-site standby generator(s) *rated to produce continuous current in excess of 225 percent of the full-load amperes of the fire pump motor, the conductors between the on-site generator(s) and the combination fire pump transfer switch controller or separately mounted transfer switch shall be installed in accordance with A(695.6)(2). The protection provided shall be in accordance with the short-circuit current rating of the combination fire pump transfer switch controller or separately mounted transfer switch.*

Article 695.7

695.7 Voltage Drop.
(A) Starting. The voltage at the fire pump controller line terminals shall not drop more than 15 percent below normal (controller-rated voltage) under motor starting conditions.
Exception: This limitation shall not apply for emergency run mechanical starting.
(B) Running. The voltage at the load terminals of the fire pump controller shall not drop more than 5 percent below the voltage rating of the motor connected to those terminals
when the motor is operating at 115 percent of the full-load current rating of the motor.
695.10 Listed Equipment. Diesel engine fire pump controllers, electric fire pump controllers, electric motors, fire pump power transfer switches, foam pump controllers, and limited service controllers shall be listed for fire pump service.



Voltage Drop in fire pump Circuits can cause failures

Article 695.12

(A)Controllers and Transfer Switches. Electric motor driven fire pump controllers and power transfer switches shall be located as close as practicable to, and within sight of, the motors that they control.
(B) Engine-Drive Controllers. Engine-drive fire pump controllers shall be located as close as is practical to, and within sight of, the engines that they control.
(C) Storage Batteries. Storage batteries for fire pump engine drives shall be supported above the floor, secured against displacement, and located where they are not subject
to physical damage, flooding with water, excessive temperature, or excessive vibration.
(D) Energized Equipment. All energized equipment parts shall be located at least 300 mm (12 in.) above the floor level.
(E) Protection Against Pump Water. Fire pump controller and power transfer switches shall be located or protected so that they are not damaged by water escaping from pumps or pump connections.
(F) Mounting. All fire pump control equipment shall be mounted in a substantial manner on noncombustible supporting
structures.

Article 695.14 (F)

(F) Generator Control Wiring Methods. Control conductors installed between the fire pump power transfer switch and the standby generator supplying the fire pump during normal power loss shall be kept entirely independent of all other wiring. They shall be protected to resist potential damage by fire or structural failure. They shall be permitted to be routed through a building(s) using one of the following methods:
(1) Be encased in a minimum 50 mm (2 in.) of concrete.
(2) Be protected by a fire-rated assembly listed to achieve a minimum fire rating of 2 hours and dedicated to the fire pump circuits.
(3) Be a listed electrical circuit protective system with a minimum 2-hour fire rating. The installation shall comply with any restrictions provided in the listing of the electrical circuit protective system used.

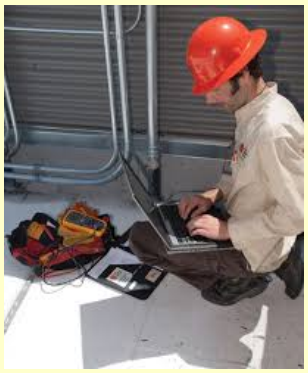
Article 700 Emergency Systems

700.2 Definitions.
Emergency Systems. Those systems legally required and classed as emergency by municipal, state, federal, or other codes, or by any governmental agency having jurisdiction. These systems are intended to automatically supply illumination, power, or both, to designated areas and equipment in the event of failure of the normal supply or in the event of accident to elements of a system intended to supply, distribute, and control power and illumination essential for safety to human life.

Emergency systems are generally installed in places of assembly 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 for such functions as 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 life safety or health hazards, and similar functions.

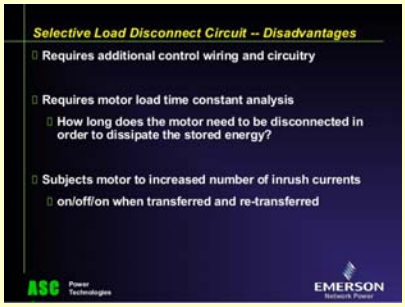
Article 700.3

700.3 Tests and Maintenance.
(A) Conduct or Witness Test. ***The authority having jurisdiction shall conduct or witness a test of the complete system upon installation and periodically afterward.***
(B) Tested Periodically. Systems shall be tested periodically on a schedule acceptable to the authority having jurisdiction to ensure the systems are maintained in proper operating condition.
(C) Battery Systems Maintenance. Where battery systems or unit equipment's are involved, including batteries used for starting, control, or ignition in auxiliary engines, the authority having jurisdiction shall require periodic maintenance.
(D) Written Record. A written record shall be kept of such tests and maintenance.
(E) Testing Under Load. *Means for testing all emergency lighting and power systems during maximum anticipated load conditions shall be provided.*



Article 700.4

700.4 Capacity.
(A) Capacity and Rating. An emergency system shall have adequate capacity and rating for all loads to be operated simultaneously. The emergency system equipment shall be suitable for the maximum available fault current at its terminals.
(B) Selective Load Pickup, Load Shedding, and Peak Load Shaving. The alternate power source shall be permitted to supply emergency, legally required standby, and optional standby system loads where the source has adequate capacity or where automatic selective load pickup and load shedding is provided as needed to ensure adequate power to
(1) the emergency circuits, (2) the legally required standby circuits, and (3) the optional standby circuits, in that order of priority. The alternate power source shall be permitted to be used for peak load shaving, provided these conditions are met.
Peak load shaving operation shall be permitted for satisfying the test requirement of 700.3(B), provided all other conditions of 700.3 are met.
A portable or temporary alternate source shall be available whenever the emergency generator is out of service for major maintenance or repair.



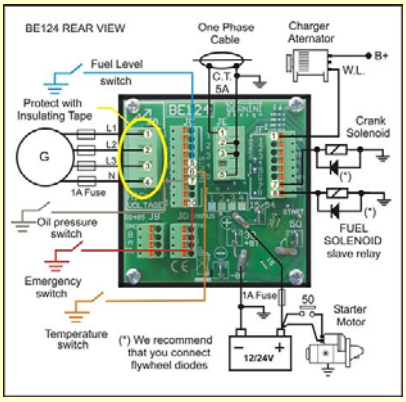
Article 700.5

700.5 Transfer Equipment.
(A) General. Transfer equipment, including automatic transfer switches, shall be automatic, identified for emergency use, and approved by the authority having jurisdiction. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and emergency sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705.
(B) Bypass Isolation Switches. Means shall be permitted to bypass and isolate the transfer equipment. Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.
(C) Automatic Transfer Switches. Automatic transfer switches shall be electrically operated and mechanically held. Automatic transfer switches, rated 1000 VAC and below, shall be listed for emergency system use.
(D) Use. Transfer equipment shall supply only emergency loads.

Article 700.10 (D)(3)

(3) Generator Control Wiring. Control conductors installed between the transfer equipment and the emergency generator shall be kept entirely independent of all other wiring and shall meet the conditions of 700.10(D)(1).

700.10(D) Fire Protection. ***Emergency systems shall meet the additional requirements in (D)(1) through (D)(3) in assembly occupancies for not less than 1000 persons or in buildings above 23 m (75 ft) in height.***
(1) Feeder-Circuit Wiring. Feeder-circuit wiring shall meet one of the following conditions:
(1) Be installed in spaces or areas that are fully protected by an approved automatic fire suppression system
(2) ***Be a listed electrical circuit protective system with a minimum 2-hour fire rating***
(3) Be protected by a listed thermal barrier system for electrical system components with a minimum 2-hour fire rating
(4) Be protected by a listed fire-rated assembly that has a minimum fire rating of 2 hours and contains only emergency wiring circuits
(5) Be encased in a minimum of 50 mm (2 in.) of concrete



Article 700.12

700.12 General Requirements. Current supply shall be such that, in the event of failure of the normal supply to, or within, the building or group of buildings concerned, emergency lighting, emergency power, or both shall be available within the time required for the application **but not to exceed 10 seconds.**

In selecting an emergency source of power, consideration shall be given to the occupancy and the type of service to be rendered, whether of minimum duration, as for evacuation of a theater, or longer duration, as for supplying emergency power and lighting due to an indefinite period of current failure from trouble either inside or outside the building.

(B) Generator Set.
(1) Prime Mover-Driven. For a generator set driven by a prime mover acceptable to the authority having jurisdiction and sized in accordance with 700.4, means shall be provided for automatically starting the prime mover on failure of the normal service and for automatic transfer and operation of all required electrical circuits. ***A time-delay feature permitting a 15-minute setting shall be provided to avoid retransfer in case of short-time reestablishment of the normal source.***

(5) Auxiliary Power Supply. Generator sets that require more than **10 seconds to develop power** shall be permitted if an auxiliary power supply energizes the emergency system until the generator can pick up the load.
(6) Outdoor Generator Sets. Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

Exception: For installations under single management, 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 set disconnecting means shall not be required to be located within sight of the building or structure served.

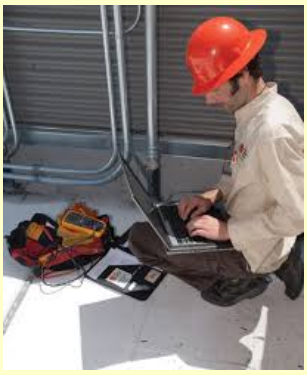
Article 701 Legally Required Standby Systems

701.2 Definition.
Legally Required Standby Systems. Those systems required and so classed as legally required standby by municipal, state, federal, or other codes or by any governmental agency having jurisdiction. These systems are intended to automatically supply power to selected loads (other than those classed as emergency systems) in the event of failure of the normal source.

Legally required standby systems are typically installed to serve loads, such as heating and refrigeration systems, communications systems, ventilation and smoke removal systems, sewage disposal, lighting systems, and industrial processes, that, when stopped during any interruption of the normal electrical supply, could create hazards or hamper rescue or fire-fighting operations.

Article 701.3

701.3 Tests and Maintenance.
(A) Conduct or Witness Test. ***The authority having jurisdiction shall conduct or witness a test of the complete system upon installation.***
(B) Tested Periodically. Systems shall be tested periodically on a schedule and in a manner acceptable to the authority having jurisdiction to ensure the systems are maintained in proper operating condition.
(C) Battery Systems Maintenance. Where batteries are used for control, starting, or ignition of prime movers, the authority
having jurisdiction shall require periodic maintenance.
(D) Written Record. A written record shall be kept on such tests and maintenance.
(E) Testing Under Load. ***Means for testing legally required standby systems under load shall be provided.***



Article 701.4

701.4 Capacity and Rating. A legally required standby system shall have adequate capacity and rating for the supply of all equipment intended to be operated at one time. Legally required standby system equipment shall be suitable for the maximum available fault current at its terminals.
The legally required standby alternate power source shall be permitted to supply both legally required standby and optional standby system loads under either of the following conditions:
(1) Where the alternate source has adequate capacity to handle all connected loads
(2) Where automatic selective load pickup and load shedding is provided that will ensure adequate power to the legally required standby circuits

Article 701.5

701.5 Transfer Equipment.
(A) General. Transfer equipment, including automatic transfer switches, shall be automatic and identified for standby use and approved by the authority having jurisdiction. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and alternate sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705.
(B) Bypass Isolation Switches. Means to bypass and isolate the transfer switch equipment shall be permitted.
Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.
(C) Automatic Transfer Switches. Automatic transfer switches Shall be electrically operated and mechanically held. Automatic Transfer switches, rated 1000 VAC and below, shall be listed For emergency use.

Article 701.6

701.6 Signals. Audible and visual signal devices shall be provided, where practicable, for the purposes described in 701.6(A), (B), (C), and (D).
(A) Derangement. To indicate derangement of the standby source.
(B) Carrying Load. To indicate that the standby source is carrying load.
(C) Not Functioning. To indicate that the battery charger is not functioning.
(D) Ground Fault. To indicate a ground fault in solidly grounded wye, legally required standby systems of more than 150 volts to ground and circuit-protective devices rated 1000 amperes or more. The sensor for the ground fault signal devices shall be located at, or ahead of, the main system disconnecting means for the legally required standby source, and the maximum setting of the signal devices shall be for a ground-fault current of 1200 amperes.

Instructions on the course of action to be taken in event of indicated ground fault shall be located at or near the sensor location.

Article 701.7

701.7 Signs.
(A) Mandated Standby. A sign shall be placed at the service entrance indicating type and location of on-site legally required standby power sources.
Exception: A sign shall not be required for individual unit equipment as specified in 701.12(G).
(B) Grounding. Where removal of a grounding or bonding connection in normal power source equipment interrupts the grounding electrode conductor connection to the alternate power source(s) grounded conductor, a warning sign shall be installed at the normal power source equipment stating:

WARNING
SHOCK HAZARD EXISTS IF GROUNDING ELECTRODE CONDUCTOR OR BONDING JUMPER CONNECTION IN THIS EQUIPMENT IS REMOVED WHILE ALTERNATE SOURCE(S) IS ENERGIZED.

Article 701.12(B)

(B) Generator Set.
(1) Prime Mover-Driven. For a generator set driven by a prime mover acceptable to the authority having jurisdiction and sized in accordance with 701.4, means shall be provided for automatically starting the prime mover upon failure of the normal service and for automatic transfer and operation of all required electrical circuits. A time-delay feature permitting a 15-minute setting shall be provided to avoid retransfer in case of short-time re-establishment of the normal source.
(2) Internal Combustion Engines as Prime Mover. Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided with an on-premises fuel supply sufficient for not less than 2 hours of full-demand operation of the system. Where power is needed for the operation of the fuel transfer pumps to deliver fuel to a generator set day tank, the pumps shall be connected to the legally required standby power system.
(3) Dual Supplies. Prime movers shall not be solely dependent on a public utility gas system for their fuel supply or on a municipal water supply for their cooling systems. Means shall be provided for automatically transferring one fuel supply to another where dual fuel supplies are used.

Exception: Where acceptable to the authority having jurisdiction, the use of other than on-site fuels shall be permitted where there is a low probability of a simultaneous failure of both the off-site fuel delivery system and power from the outside electrical utility company.

Article 701.12(B)(5)

(5) Outdoor Generator Sets. Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

Article 702 Optional Standby Systems

702.2 Definition.
Optional Standby Systems. Those systems intended to supply power to public or private facilities or property where life safety does not depend on the performance of the system. These systems are intended to supply on-site generated power to selected loads either automatically or manually.

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, could cause discomfort, serious interruption of the process, damage to the product or process, or the like.

Article 702.5

702.5 Transfer Equipment. Transfer equipment shall be suitable for the intended use and designed and installed so as to prevent the inadvertent interconnection of normal and alternate sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705.
Transfer equipment, located on the load side of branch circuit protection, shall be permitted to contain supplemental overcurrent protection having an interrupting rating sufficient for the available fault current that the generator can deliver. The supplementary overcurrent protection devices shall be part of a listed transfer equipment.
Transfer equipment shall be required for all standby systems subject to the provisions of this article and for which an electric utility supply is either the normal or standby source.

Exception: Temporary connection of a portable generator without transfer equipment shall be permitted where conditions of maintenance and supervision ensure that only qualified persons service the installation and where the normal supply is physically isolated by a lockable disconnecting means or by disconnection of the normal supply conductors.

There are two main types of transfer switches: manual and automatic. Below is a brief description of the two and main differences between them.

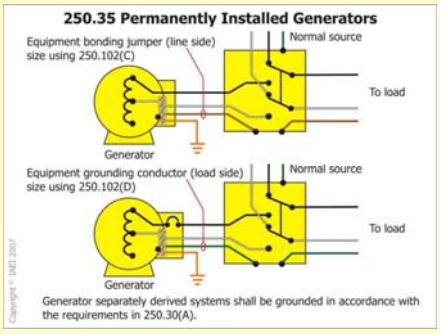
Automatic Transfer Switches

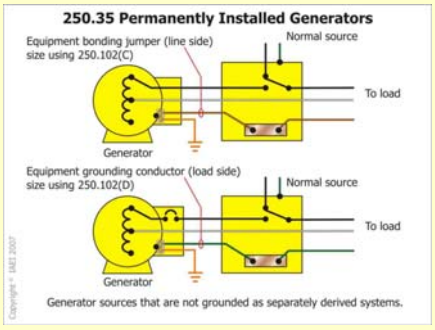
Automatic transfer switches, on the other hand, do not require any mechanical action. These automatically transfer power from one source to another. They are extremely convenient to use and do not need to be toggled manually. Such switches are perfect for places where even a brief power outage can cause losses to the system. As the transfer of power supply is almost instantaneous and automatic, the supply trips only for a second, allowing the appliances to continue functioning. Although these switches are more expensive than manual switches, they are easy to install, since they come in a pre-assembled box. For installation, you simply have to plug in the wires as mentioned in the installation manual. On the downside, automatic transfer switches are not as durable as the manual ones. They have a complex transfer mechanism that may burn out if there is a lot of load on the alternate sources of power. For instance, if heavy machinery is being operated when the power outage happens, the transfer switch may trip and the wiring may burn out. In this case, the switch has to be completely replaced.

Manual Transfer Switches

Manual transfer switches are simple toggle type switches or knobs that can be manually turned on or off to transfer the source of power to the back-up. These switches are essentially used in areas where the power outages are brief and occasional. Since they have to be turned on and off mechanically, they are best installed in places where a power outage would not cause a loss or damage to the electrical appliances and systems that are attached to the power supply. Manual transfer switches are not very easy to install, and it takes a qualified technician to install the switch into your electrical mainframes. However, these switches are quite cheap and are durable.

Separately Derived System. 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.

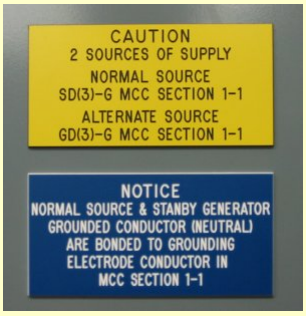




Article 702.7

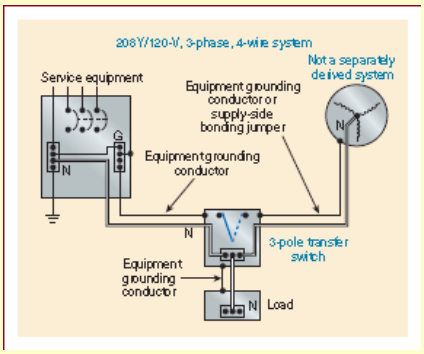
702.7 Signs.
(A) Standby. A sign shall be placed at the service-entrance equipment that indicates the type and location of on-site optional standby power sources. A sign shall not be required for individual unit equipment for standby illumination.
(B) Grounding. Where removal of a grounding or bonding connection in normal power source equipment interrupts the grounding electrode conductor connection to the alternate power source(s) grounded conductor, a warning sign shall be installed at the normal power source equipment stating:

WARNING
SHOCK HAZARD EXISTS IF GROUNDING ELECTRODE CONDUCTOR OR BONDING JUMPER CONNECTION IN THIS EQUIPMENT IS REMOVED WHILE ALTERNATE SOURCE(S) IS ENERGIZED.



Article 702.11

702.11 Portable Generator Grounding.
(A) Separately Derived System. Where a portable optional standby source is used as a separately derived system, it shall be grounded to a grounding electrode in accordance with 250.30.
(B) Non-separately Derived System. Where a portable optional standby source is used as a non-separately derived system, the equipment grounding conductor shall be bonded to the system grounding electrode.



Example of 250.30

Article 702.12

(A) Permanently Installed Generators and Portable Generators Greater Than 15 kW. Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.

(B) Portable Generators 15 kW or Less. Where a portable generator, rated 15 kW or less, is installed using a flanged inlet or other cord- and plug-type connection, a disconnecting means shall not be required where ungrounded conductors serve or pass through a building or structure.

Article 705
Interconnected Electric Power Production Sources

Generators. Generators shall be protected in accordance with 705.130.

III. Generators
705.130 Overcurrent Protection. Conductors shall be protected in accordance with Article 240. Equipment and conductors connected to more than one electrical source shall have overcurrent devices located so as to provide protection from all sources. Generators shall be protected in accordance with 445.12.
705.143 Synchronous Generators. Synchronous generators in a parallel system shall be provided with the necessary equipment to establish and maintain a synchronous condition.

Article 708
Critical Operations Power Systems (COPS)

708.1 Scope. The provisions of this article apply to the installation, operation, monitoring, control, and maintenance
of the portions of the premises wiring system intended to supply, distribute, and control electricity to designated critical operations areas (DCOA) in the event of disruption to elements of the normal system.
Critical operations power systems are those systems so classed by municipal, state, federal, or other codes by any governmental agency having jurisdiction or by facility engineering documentation establishing the necessity for such a system. These systems include but are not limited to power systems, HVAC, fire alarm, security, communications, and signaling for designated critical operations areas.

Critical operations power systems are generally installed in vital infrastructure facilities that, if destroyed or incapacitated, would disrupt national security, the economy, public health or safety; and where enhanced electrical infrastructure for continuity of operation has been deemed necessary by governmental authority.

Article 708.4

708.4 Risk Assessment. Risk assessment for critical operations power systems shall be documented and shall be conducted in accordance with 708.4(A) through (C).
(A) Conducting Risk Assessment. In critical operations power systems, risk assessment shall be performed to identify hazards, the likelihood of their occurrence, and the vulnerability of the electrical system to those hazards.
(B) Identification of Hazards. Hazards to be considered at a minimum shall include, but shall not be limited to, the following:
(1) Naturally occurring hazards (geological, meteorological, and biological)
(2) Human-caused events (accidental and intentional)

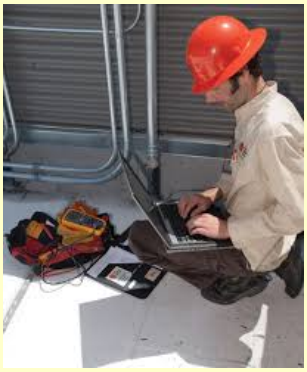
(C) Developing Mitigation Strategy. Based on the results of the risk assessment, a strategy shall be developed and implemented to mitigate the hazards that have not been sufficiently mitigated by the prescriptive requirements of this *Code*.


Risk Assessment

Potential Hazard	Who is at risk?	Existing Control Measures	Risk Rating	Preventative Measures	Responsibilities

Article 708.6

708.6 Testing and Maintenance.
(A) Conduct or Witness Test. The authority having jurisdiction shall conduct or witness a test of the complete system upon installation and periodically afterward.
(B) Tested Periodically. Systems shall be tested periodically on a schedule acceptable to the authority having jurisdiction to ensure the systems are maintained in proper operating condition.
(C) Maintenance. The authority having jurisdiction shall require a documented preventive maintenance program for critical operations power systems.
(D) Written Record. A written record shall be kept of such tests and maintenance.
(E) Testing Under Load. Means for testing all critical power systems during maximum anticipated load conditions shall be provided.



Article 708.8

708.8 Commissioning.
(A) Commissioning Plan. A commissioning plan shall be developed and documented.
(B) Component and System Tests. The installation of the equipment shall undergo component and system tests to ensure that, when energized, the system will function properly.
(C) Baseline Test Results. A set of baseline test results shall be documented for comparison with future periodic maintenance testing to identify equipment deterioration.
(D) Functional Performance Tests. A functional performance test program shall be established, documented, and executed upon complete installation of the critical system in order to establish a baseline reference for future performance requirements.

Article 708.20(F)

(F) Generator Set.
(1) Prime Mover-Driven. Generator sets driven by a prime mover shall be provided with means for automatically starting the prime mover on failure of the normal service. ***A time-delay feature permitting a minimum 15-minute setting shall be provided to avoid retransfer in case of short-time reestablishment of the normal source*.**
(2) Power for fuel transfer pumps. Where power is needed for the operation of the fuel transfer pumps to deliver fuel to a generator set day tank, this pump shall be connected to the COPS.
(3) Dual Supplies. Prime movers shall not be solely dependent on a public utility gas system for their fuel supply or municipal water supply for their cooling systems. Means shall be provided for automatically transferring from one fuel supply to another where dual fuel supplies are used.
(4) Battery Power and Dampers. Where a storage battery is used for control or signal power or as the means of starting the prime mover, it shall be suitable for the purpose and shall be equipped with an automatic charging means independent of the generator set. Where the battery charger is required for the operation of the generator set, it shall be connected to the COPS. Where power is required for the operation of dampers used to ventilate the generator set, the dampers shall be connected to the COPS.

Article 708.20(F) cont.

(5) Outdoor Generator Sets.
(a) ***Permanently Installed Generators and Portable Generators Greater Than 15 kW.*** Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnecting means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors serve or pass through the building or structure. Where the generator supply conductors terminate at a disconnecting means in or on a building or structure, the disconnecting means shall meet the requirements of 225.36.
(b) ***Portable Generators 15 kW or Less***. Where a portable generator, rated 15 kW or less, is installed using a flanged inlet or other cord-and plug-type connection, a disconnecting means shall not be required where ungrounded conductors serve or pass through a building or structure.
(6) Means for Connecting Portable or Vehicle-Mounted Generator. Where the COPS is supplied by a single generator, a means to connect a portable or vehicle-mounted generator shall be provided.
(7) On-Site Fuel Supply. Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided. The on-site fuel supply shall be secured and protected in accordance with the risk assessment.

Article 708.22

708.22 Capacity of Power Sources.
(A) Capacity and Rating. A COPS shall have capacity and rating for all loads to be operated simultaneously for continuous operation with variable load for an unlimited number of hours, except for required maintenance of the power source. A portable, temporary, or redundant alternate power source shall be available for use whenever the COPS power source is out of service for maintenance or repair.
(B) Selective Load Pickup, Load Shedding, and Peak Load Shaving. The alternate power source shall be permitted to supply COPS emergency, legally required standby, and optional loads where the source has adequate capacity or where automatic selective load pickup and load shedding is provided as needed to ensure adequate power to (1) the COPS and emergency circuits, (2) the legally required standby circuits, and (3) the optional standby circuits, in that order of priority. The alternate power source shall be permitted to be used for peak load shaving, provided these conditions are met. Peak load-shaving operation shall be permitted for satisfying the test requirement of 708.6(B), provided all other conditions of 708.6 are met.
(C) Duration of COPS Operation. The alternate power source shall be capable of operating the COPS for a minimum of 72 hours at full load of DCOA with a steady-state voltage within ±10 percent of nominal utilization voltage.

Critical Operation Power System
Future design

Article 708.24

708.24 Transfer Equipment.
(A) General. Transfer equipment, including automatic transfer switches, shall be automatic and identified for emergency use. Transfer equipment shall be designed and installed to prevent the inadvertent interconnection of normal and critical operations sources of supply in any operation of the transfer equipment. Transfer equipment and electric power production systems installed to permit operation in parallel with the normal source shall meet the requirements of Article 705.
(B) Bypass Isolation Switches. Means shall be permitted to bypass and isolate the transfer equipment. Where bypass isolation switches are used, inadvertent parallel operation shall be avoided.
(C) Automatic Transfer Switches. Where used with sources that are not inherently synchronized, automatic transfer switches shall comply with (C)(1) and (C)(2).
(1) Automatic transfer switches shall be listed for emergency use.
(2) Automatic transfer switches shall be electrically operated and mechanically held.
(D) Use. Transfer equipment shall supply only COPS loads.

Article 708.54

708.54 Selective Coordination. Critical operations power system(s) overcurrent devices shall be selectively coordinated with all supply-side overcurrent protective devices. Selective coordination shall be selected by a licensed professional engineer or other qualified persons engaged primarily in the design, installation, or maintenance of electrical systems. The selection shall be documented and made available to those authorized to design, install, inspect, maintain, and operate the system.

Exception: Selective coordination shall not be required between two overcurrent devices located in series if no loads are connected in parallel with the downstream device.

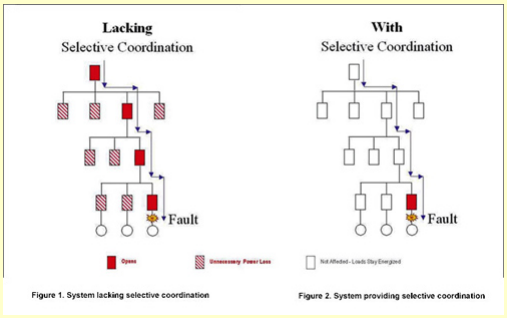


Figure 1. System lacking selective coordination

Figure 2. System providing selective coordination

Article 708.64

708.64 Emergency Operations Plan. A facility with a COPS shall have documented an emergency operations plan. The plan shall consider emergency operations and response, recovery, and continuity of operations.

Example of a major Data Centers Strategy
: Qualify your data center as a
"Critical Operations Data System" [CODS]
1. Make sure which version of NFPA 70 is adopted in your locale !
2. Specifically refer to NFPA 70 Article 645.2 Definitions as your basis of requesting status as a CODS
3.Provide justification based on impact to public safety, emergency management, national security or business continuity. Site impact on the economy to justify a financial argument.
4. Comply with NFPA 70 Article 708 "Critical Operations Power Systems".
5. Obtain classification documentation from the AHJ based on your facility engineering documentation necessitating the classification.
6. Include a plan that clearly identifies the AHJ's participation in commissioning and testing programs.

NEC Article 708
Critical Operations Power Systems (COPS)

Addresses homeland security issues for "Mission Critical" facilities

The systems must continue to operate during the full duration of an emergency and beyond.

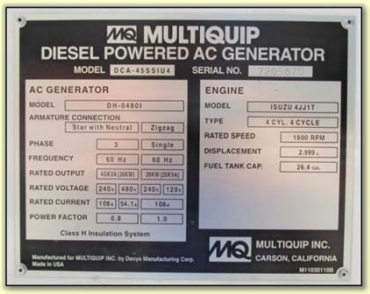
Article 445.10 Location

445.10 Location. Generators shall be of a type suitable for the locations in which they are installed. They shall also meet the requirements for motors in 430.14.

Article 445.11 Marking

445.11 Marking. Each generator shall be provided with a nameplate giving the manufacturer's name, the rated frequency, the number of phases if of ac, the rating in kilowatts or kilovolt-amperes, the normal volts and amperes corresponding to the rating, the rated revolutions per minute, and the rated ambient temperature or rated temperature rise.
Nameplates for all stationary generators and portable generators rated more than 15 kW shall also give the power factor, the sub-transient and transient impedances, the insulation system class, and the time rating.
Marking shall be provided by the manufacturer to indicate whether or not the generator neutral is bonded to the generator frame.

Where the bonding of a generator is modified in the field, additional marking shall be required to indicate whether the generator neutral is bonded to the generator frame.



Article 445.12

445.12 Overcurrent Protection.
(A) Constant-Voltage Generators. Constant-voltage generators, except ac generator exciters, shall be protected from overload by inherent design, circuit breakers, fuses, protective relays, or other identified overcurrent protective means suitable for the conditions of use.
(B) Two-Wire Generators. Two-wire, dc generators shall be permitted to have overcurrent protection in one conductor only if the overcurrent device is actuated by the entire current generated other than the current in the shunt field. The overcurrent device shall not open the shunt field.
(C) 65 Volts or Less. Generators operating at 65 volts or less and driven by individual motors shall be considered as protected by the overcurrent device protecting the motor if these devices will operate when the generators are delivering not more than 150 percent of their full-load rated current.

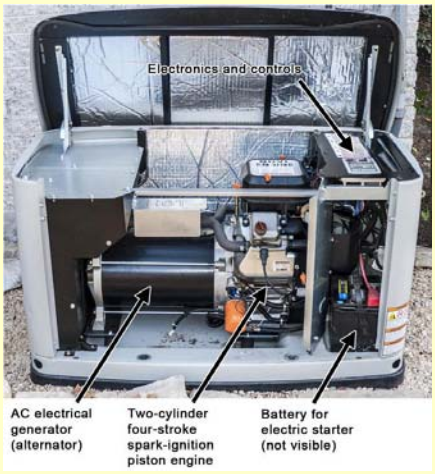
Article 445.13

445.13 Ampacity of Conductors. The ampacity of the conductors from the generator terminals to the first distribution device(s) containing overcurrent protection shall not be less than 115 percent of the nameplate current rating of the generator. It shall be permitted to size the neutral conductors in accordance with 220.61. Conductors that must carry ground-fault currents shall not be smaller than required by 250.30(A). Neutral conductors of dc generators that must carry ground-fault currents shall not be smaller than the minimum required size of the largest conductor.

Exception: Where the design and operation of the generator prevent overloading, the ampacity of the conductors shall not be less than 100 percent of the nameplate current rating of the generator.

Article 445.14

445.14 Protection of Live Parts. Live parts of generators operated at more than 50 volts to ground shall not be exposed to accidental contact where accessible to unqualified persons.



Article 445.16

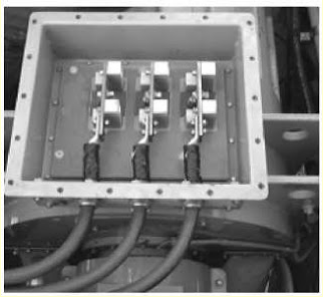
445.16 Bushings. Where field-installed wiring passes through an opening in an enclosure, a conduit box, or a barrier, a bushing shall be used to protect the conductors from the edges of an opening having sharp edges. The bushing shall have smooth, well-rounded surfaces where it may be in contact with the conductors. If used where oils, grease, or other contaminants may be present, the bushing shall be made of a material not deleteriously affected.

PLEASE NOTE: Reference
300.4(G) Insulated Fittings. Where raceways contain 4 AWG or larger insulated circuit conductors, and these conductors enter a cabinet, a box, an enclosure, or a raceway, the conductors shall be protected by an identified fitting providing a smoothly rounded insulating surface, unless the conductors are separated from the fitting or raceway by identified insulating material that is securely fastened in place.
Exception: *Where threaded hubs or bosses that are an integral part of a cabinet, box, enclosure, or raceway provide a smoothly rounded or flared entry for conductors.*
Conduit bushings constructed wholly of insulating material shall not be used to secure a fitting or raceway. The insulating fitting or insulating material shall have a temperature rating not less than the insulation temperature rating of the installed conductors.

Article 445.17

445.17 Generator Terminal Housings. Generator terminal housings shall comply with 430.12. Where a horsepower rating is required to determine the required minimum size of the generator terminal housing, the full-load current of the generator shall be compared with comparable motors in Table 430.247 through Table 430.250. The higher horsepower rating of Table 430.247 and Table 430.250 shall be used whenever the generator selection is between two ratings.

Exception: This section shall not apply to generators rated over 600 volts.



Article 445.18

445.18 Disconnecting Means Required for Generators. Generators shall be equipped with a disconnect(s), lockable in the open position by means of which the generator and all protective devices and control apparatus are able to be disconnected entirely from the circuits supplied by the generator except where the following conditions apply:
(1) Portable generators are cord- and plug-connected, or
(2) Both of the following conditions apply:
a. The driving means for the generator can be readily shut down, is rendered incapable of restarting, and is lockable in the OFF position in accordance with 110.25.
b. The generator is not arranged to operate in parallel with another generator or other source of voltage.

Article 445.20

445.20 Ground-Fault Circuit-Interrupter Protection for Receptacles on 15-kW or Smaller Portable Generators.
All 125-volt, single-phase, 15- and 20-ampere receptacle outlets that are a part of a 15-kW or smaller portable generator either shall have ground-fault circuit-interrupter protection for personnel integral to the generator or receptacle or shall not be available for use when the 125/250-volt locking-type receptacle is in use. If the generator does not have a 125/250-volt locking-type receptacle, this requirement shall not apply.

PART II
ARTICLE 450
Transformers and Transformer Vaults (Including Secondary Ties)

Instructors

Joseph J Cenzori
City of Parma

Jack Bené
Electro Specialties

450.3 Overcurrent Protection

(A) Transformers over 1000 Volts, Nominal
(B) Transformers 1000 Volts, Nominal or Less
(C) Voltage Potential Transformers

TABLE 450.3(A) *Maximum Rating or Setting of Overcurrent Protection for Transformers Over 1000 Volts (as a Percentage of Transformer-Rated Current)*

		Primary Protection over 1000 Volts		Secondary Protection (See Note 2.)		
				Over 1000 Volts		1000 Volts or Less
Location Limitations	Transformer Rated Impedance	Circuit Breaker (See Note 4.)	Fuse Rating	Circuit Breaker (See Note 4.)	Fuse Rating	Circuit Breaker or Fuse Rating
Any location	Not more than 6%	600% (See Note 1.)	300% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	125% (See Note 1.)
	More than 6% and not more than 10%	400% (See Note 1.)	300% (See Note 1.)	250% (See Note 1.)	225% (See Note 1.)	125% (See Note 1.)
Supervised locations only (See Note 3.)	Any	300% (See Note 1.)	250% (See Note 1.)	Not required	Not required	Not required
	Not more than 6%	600%	300%	300% (See Note 5.)	250% (See Note 5.)	250% (See Note 5.)
	More than 6% and not more than 10%	400%	300%	250% (See Note 5.)	225% (See Note 5.)	250% (See Note 5.)

Notes to TABLE 450.3(A)

1. Where the required fuse rating or circuit breaker setting does not correspond to a standard rating or setting, a higher rating or setting that does not exceed the following shall be permitted:

   a. The **next higher standard rating or setting** for fuses and circuit breakers 1000 volts and below, or

   b. The next higher commercially available rating or setting for fuses and circuit breakers above 1000 volts.

240.6 Standard Ampere Ratings

(A) Fuses and Fixed-Trip Circuit Breakers. The standard ampere ratings for fuses and inverse time circuit breakers shall be considered 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000, and 6000 amperes.

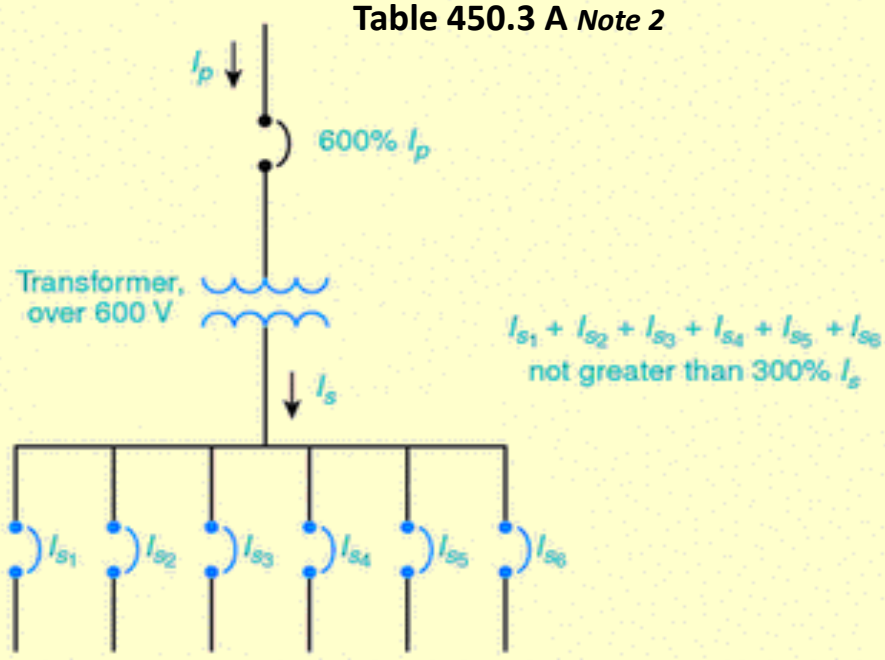
Additional standard ampere ratings for fuses shall be 1, 3, 6, 10, and 601. The use of fuses and inverse time circuit breakers with nonstandard ampere ratings shall be permitted.

Notes to TABLE 450.3(A)

2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than **six circuit breakers or six sets of fuses** grouped in one location.

Where multiple overcurrent devices are utilized, the **total** of all the device ratings **shall not exceed** the allowed value of a single overcurrent device. If both circuit breakers and fuses are used as the overcurrent device, the total of the device ratings shall not exceed that allowed for fuses.

Table 450.3 A *Note 2*



Notes to TABLE 450.3(A)

3. A supervised location is a location where conditions of maintenance and supervision ensure that only **qualified persons** monitor and service the transformer installation.

4. **Electronically actuated fuses** that may be set to open at a specific current shall be set in accordance with settings for circuit breakers.

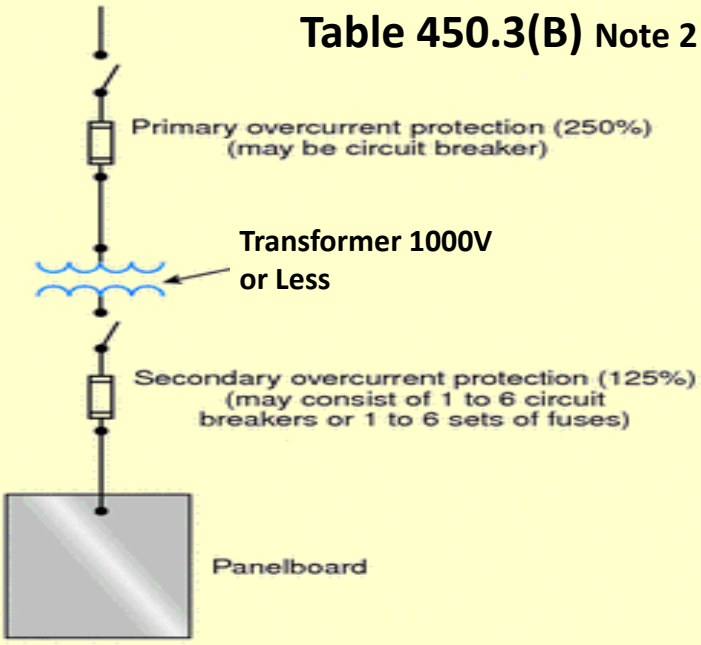
5. A transformer equipped with a coordinated thermal overload protection by the manufacturer shall be permitted to have separate secondary protection omitted.

TABLE 450.3(B) *Maximum Rating or Setting of Overcurrent Protection for Transformers 1000 Volts and Less (as a Percentage of Transformer-Rated Current)*

	Primary Protection			Secondary Protection (See Note 2.)	
Protection Method	Currents of 9 Amperes or More	Currents Less Than 9 Amperes	Currents Less Than 2 Amperes	Currents of 9 Amperes or More	Currents Less Than 9 Amperes
Primary only protection	125% (See Note 1.)	167%	300%	Not required	Not required
Primary and secondary protection	250% (See Note 3.)	250% (See Note 3.)	250% (See Note 3.)	125% (See Note 1.)	167%

Primary and Secondary Overcurrent Protection

Table 450.3(B) Note 2



Transformers kVA = 9 Amps or More

Transformer Voltage	480V 3Ph	480V 1Ph	208V 3P	240V 3Ph	120V 1Ph
kVA	7.5	4.3	3.2	3.1	1.1

Primary Protection = 125% or next higher standard rating

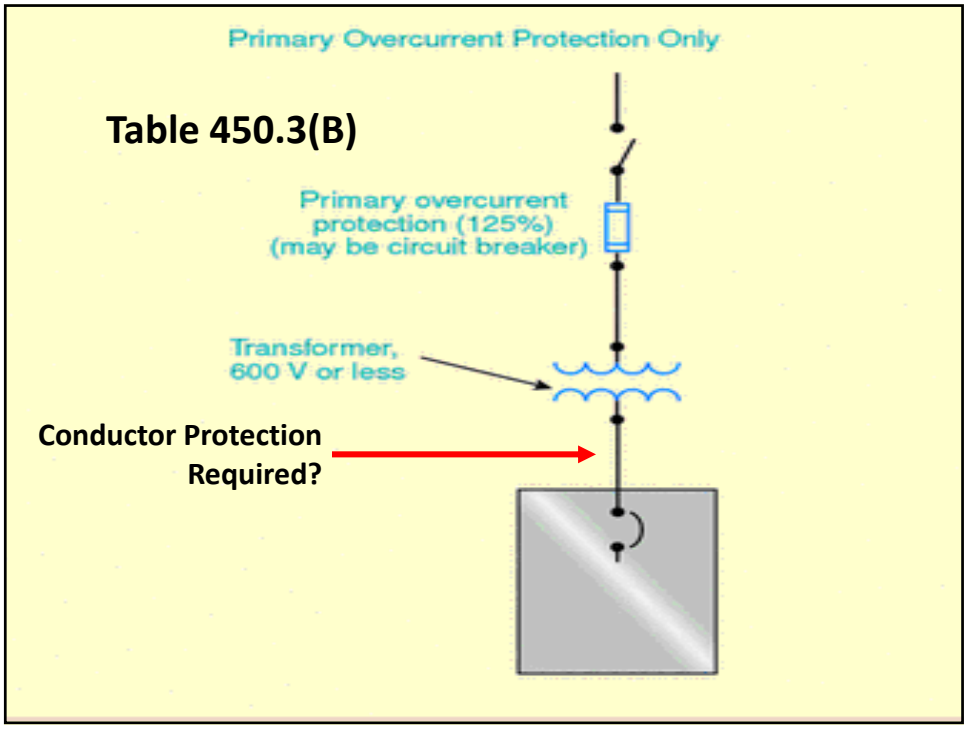
Notes to Table 450-3(b)

1.Where 125 percent of this current does not correspond to a standard rating of a fuse or nonadjustable circuit breaker, a higher rating that does not exceed the **next higher standard rating** shall be permitted.

2. Where secondary overcurrent protection is required, the secondary overcurrent device shall be permitted to consist of not more than **six circuit breakers or six sets of fuses grouped in one location**. Where multiple overcurrent devices are utilized, the total of all the device ratings shall **not exceed** the allowed value of a **single overcurrent device**.

Notes to Table 450-3(b)

3. A transformer equipped with coordinated thermal **overload protection** by the manufacturer and arranged to interrupt the primary current shall be permitted to have primary overcurrent protection rated or set at a current value that is not more than **six times the rated current** of the transformer for transformers having not more than 6 percent impedance and not more than four times the rated current of the transformer for transformers having more than 6 percent but not more than 10 percent impedance.



240.4 Protection of Conductors

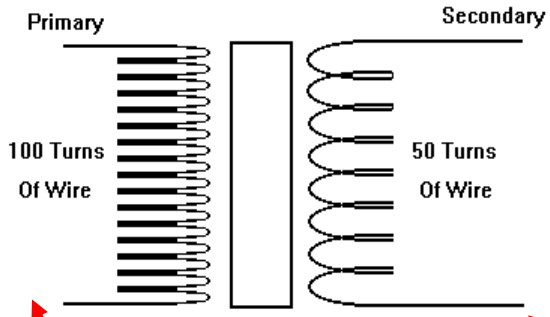
(F) **Transformer Secondary Conductors.** Single-phase (other than 2-wire) and multiphase (other than delta-delta, 3-wire) transformer secondary conductors **shall not be considered to be protected** by the primary overcurrent protective device. Conductors supplied by the secondary side of a single-phase transformer having a **2-wire (single-voltage) secondary, or a three-phase, delta-delta** connected transformer having a 3-wire (single-voltage) secondary, shall be permitted to be protected by overcurrent **protection provided on the primary (supply) side of the transformer,**

240.4 Protection of Conductors

…….. provided this protection is in accordance with 450.3 and does not exceed the value determined by multiplying the secondary conductor ampacity by the **secondary-to-primary transformer voltage ratio**.

Turns Ratio

480V 240V



2 : 1 Turns Ratio

1/0 @ 150A

Max Overcurrent Device

240.21 Location in Circuit

(6) Secondary Conductors Not over 7.5 m (25 ft) Long.

Where the length of secondary conductor does not exceed 7.5 m (25 ft) and complies with all of the following:

(1) The secondary conductors shall have an ampacity that is not less than the value of ***the primary-to-secondary*** *voltage ratio multiplied by* ***one-third of the rating of the overcurrent*** *device protecting the primary of the transformer.*

75 kVA: 480-120/208 = 2 X .33 X 125 = 83 amp

(2) The secondary conductors ***terminate in a single circuit breaker or set of fuses that*** *limit the load current to not more than the conductor ampacity that is permitted by 310.15.*

(3) The secondary conductors are protected from physical damage by being enclosed in an approved raceway or by other approved means.

240.21 Location in Circuit

(6) Secondary Conductors Not over 7.5 m (25 ft) Long.

480-240 (Delta-Delta) -75 kVA

Primary: 90 Amp
Primary OCD: 1.25 X 90 = 113 therefore 125 Amp Fuse

Secondary: 180 Amp
Secondary Conductor: 1.25 X 180 = 225 amp min or 4/0 AWG at 230 Amp

Secondary/Primary Turns Ratio: 230A X 0.5 = 115A

Violation Primary OCD Exceeds Turns Ratio X Secondary Conductor

SINGLE PHASE TRANSFORMERS

FULL LOAD AMPERES AND MAXIMUM OVER CURRENT PROTECTION
FOR VOLTAGES OF 120 THRU 600

Overcurrent

KVA		120V	208V	240V	277V	380V	440V	480V	600V	
.050	Full Load Amps	.4	.2	.2	.2	.1	.1	.1	.1	
	Over Current Prot. Amps	1.2	.6	.6	.6	.3	.3	.3	.3	
.100	Full Load Amps	.8	.5	.4	.3	.2	.2	.2	.2	
	Over Current Prot. Amps	2.4	1.5	1.2	.9	.6	.6	.6	.5	
.150	Full Load Amps	1.2	.7	.6	.5	.4	.3	.3	.3	
	Over Current Prot. Amps	3.6	2.1	1.8	1.5	1.2	.9	.9	.9	
.250	Full Load Amps		1.2	1.	.9	.6	.5	.5	.4	300%
	Over Current Prot. Amps		3.6	3.	2.7	1.8	1.5	1.5	1.2	
.500	Full Load Amps				1.8	1.3	1.1	1.	.8	
	Over Current Prot. Amps				5.4	3.9	3.3	3.	2.4	
.750	Full Load Amps					1.9	1.7	1.6	1.3	
	Over Current Prot. Amps					5.7	5.1	4.8	3.9	
1.0	Full Load Amps								1.7	
	Over Current Prot. Amps								5.1	
.050	Full Load Amps	.4	.2	.2	.2	.1	.1	.1	.1	
	Over Current Prot. Amps	.7	.3	.3	.3	.2	.2	.2	.2	
.100	Full Load Amps	.8	.5	.4	.3	.2	.2	.2	.2	
	Over Current Prot. Amps	1.3	.8	.7	.5	.3	.3	.3	.3	
.150	Full Load Amps	1.2	.7	.6	.5	.4	.3	.3	.3	
	Over Current Prot. Amps	2.	1.2	1.	.8	.7	.5	.5	.5	
.250	Full Load Amps	2.	1.2	1.	.9	.6	.5	.5	.4	
	Over Current Prot. Amps	3.3	2.	1.7	1.5	1.	.8	.8	.7	
.500	Full Load Amps	4.2	2.4	2.1	1.8	1.3	1.1	1.	.8	
	Over Current Prot. Amps	7.	4.	3.5	3.	2.2	2.	1.7	1.3	
.750	Full Load Amps	6.3	3.6	3.1	2.7	2.0	1.7	1.6	1.3	
	Over Current Prot. Amps	10.5	6.	5.2	4.5	3.3	3.	2.7	2.2	167%
1.0	Full Load Amps	8.3	4.8	4.2	3.6	2.6	2.3	2.1	1.7	
	Over Current Prot. Amps	13.9	8.	7.	6.	4.3	4.	3.5	2.8	
1.5	Full Load Amps	12.5	7.2	6.2	5.4	3.9	3.4	3.1	2.5	
	Over Current Prot. Amps	20.	12.	10.4	9.	6.5	6.	5.2	4.2	
2.	Full Load Amps	16.7	9.6	8.3	7.2	5.2	4.5	4.2	3.3	
	Over Current Prot. Amps	25.	15.	13.9	12.	8.7	7.5	7.	5.5	
3.	Full Load Amps	25.	14.4	12.5	10.8	7.9	6.8	6.2	5.	
	Over Current Prot. Amps	35.	20.	20.	15.	13.2	12.	10.4	8.4	
5.	Full Load Amps	41.	24.	20.8	18.	13.1	11.3	10.4	8.3	
	Over Current Prot. Amps	60.	30.	30.	25.	20.	15.	15.	13.9	
7.5	Full Load Amps	62.	36.	31.	27.	19.7	17.	15.6	12.5	
	Over Current Prot. Amps	80.	45.	40.	35.	25.	25.	20.	20.	
10.	Full Load Amps	83.	48.	41.	36.	26.	23.	20.8	16.7	
	Over Current Prot. Amps	110.	60.	60.	45.	35.	30.	30.	25.	
15.	Full Load Amps	125.	72.	62.	54.	39.	34.	31.	25.	
	Over Current Prot. Amps	175.	90.	80.	70.	50.	45.	40.	35.	
25.	Full Load Amps	208.	120.	104.	90.	65.	57.	52.	41.	
	Over Current Prot. Amps	300.	150.	150.	125.	90.	70.	70.	60.	
37.5	Full Load Amps	312.	180.	156.	135.	98.	85.	78.	62.	
	Over Current Prot. Amps	400.	225.	200.	175.	125.	110.	100.	80.	125%
50.	Full Load Amps	416.	240.	208.	180.	131.	114.	104.	83.	
	Over Current Prot. Amps	600.	300.	300.	225.	175.	150.	150.	110.	
75.	Full Load Amps	625.	360.	312.	270.	197.	170.	156.	125.	
	Over Current Prot. Amps	800.	450.	400.	350.	250.	225.	200.	175.	
100.	Full Load Amps	833.	480.	416.	361.	263.	227.	208.	166.	
	Over Current Prot. Amps	1200.	600.	600.	500.	350.	300.	300.	225.	
167.	Full Load Amps	1391.	802.	695.	602.	439.	379.	347.	278.	
	Over Current Prot. Amps	2000.	1200.	1000.	800.	600.	500.	450.	350.	
250.	Full Load Amps	2083.	1201.	1041.	902.	657.	568.	520.	416.	
	Over Current Prot. Amps	3000.	1600.	1600.	1200.	1000.	700.	700.	600.	

THREE PHASE TRANSFORMERS

FULL LOAD AMPERES AND MAXIMUM OVER CURRENT PROTECTION
FOR VOLTAGES OF 208 THRU 600

Overcurrent

KVA		208V.	240V.	380V.	440V	480V.	600V.	
3.	Full Load Amps	8.3	7.2	4.6	3.9	3.6	2.9	
	Over Current Prot. Amps	13.9	12.	7.7	7.	6.	4.8	
6.	Full Load Amps	16.5	14.4	9.1	7.8	7.2	5.8	167%
	Over Current Prot. Amps	25.	20.	15.	15.	12.	9.6	
9.	Full Load Amps	25.	21.6	13.7	11.8	10.8	8.6	
	Over Current Prot. Amps	35.	30.	20.	15.	15.	14.4	
15.	Full Load Amps	41.	36.	22.8	19.6	18.	14.4	
	Over Current Prot. Amps	60.	45.	30.	25.	25.	20.	
22.5	Full Load Amps	62.	54.	34.2	29.	27.	21.6	
	Over Current Prot. Amps	80.	70.	45.	40.	35.	30.	
30.	Full Load Amps	83.	72.	45.6	39.	36.	28.	
	Over Current Prot. Amps	110.	90.	60.	50.	45.	35.	
45.	Full Load Amps	124.	108.	68.4	59.	54.	43.	
	Over Current Prot. Amps	175.	150.	90.	80.	70.	60.	
75.	Full Load Amps	208.	180.	114.	98.	90.	72.	
	Over Current Prot. Amps	300.	225.	150.	125.	125.	90.	
112.5	Full Load Amps	312.	270.	171.	147.	135.	108.	125%
	Over Current Prot. Amps	400.	350.	225.	200.	175.	150.	
150.	Full Load Amps	416.	360.	228.	196.	180.	144.	
	Over Current Prot. Amps	600.	450.	300.	250.	225.	200.	
225.	Full Load Amps	624.	541.	342.	294.	270.	216.	
	Over Current Prot. Amps	800.	700.	450.	400.	350.	300.	
300.	Full Load Amps	832.	721.	456.	392.	360.	288.	
	Over Current Prot. Amps	1200.	1000.	600.	500.	450.	400.	
500.	Full Load Amps	1387.	1202.	760.	655.	601.	481.	
	Over Current Prot. Amps	2000.	1600.	1000.	800.	800.	700.	

VI. Motor Control Circuits

430.72 Overcurrent Protection

C) Control Circuit Transformer.

Primary Fuses

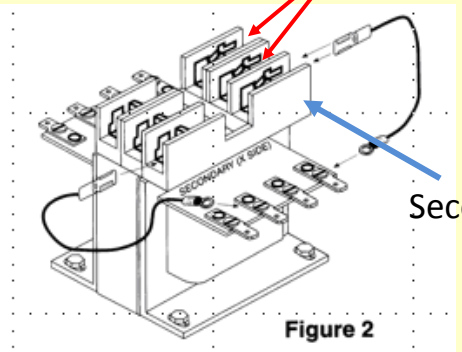


Figure 2

Secondary Fuse

VI. Motor Control Circuits

430.72 Overcurrent Protection

C) Control Circuit Transformer. Where a motor control circuit transformer is provided, the transformer shall be protected in accordance with 430. 72(C)(1), (C)(2), (C)(3), (C)(4), or (C)(5).

(4) Primary Less Than 2 Amperes. Where the control circuit transformer rated primary current is **less than 2 amperes,** an overcurrent device rated or set at not more than **500 percent of the rated primary current** shall be permitted in the primary circuit

750 vA or Less @ 480V

Dry Type Transformers

Effect of Ambient Air Temperatures Affects Overcurrent Protection

Maximum Ambient Temperature	Maximum Percentage of Loading
40°C (104°F)	100%
50°C (122°F)	92%
60°C (140°F)	84%

Example: 150 kVA X .92 = 138 kVA

Transformer Inrush

Affects Overcurrent Protection

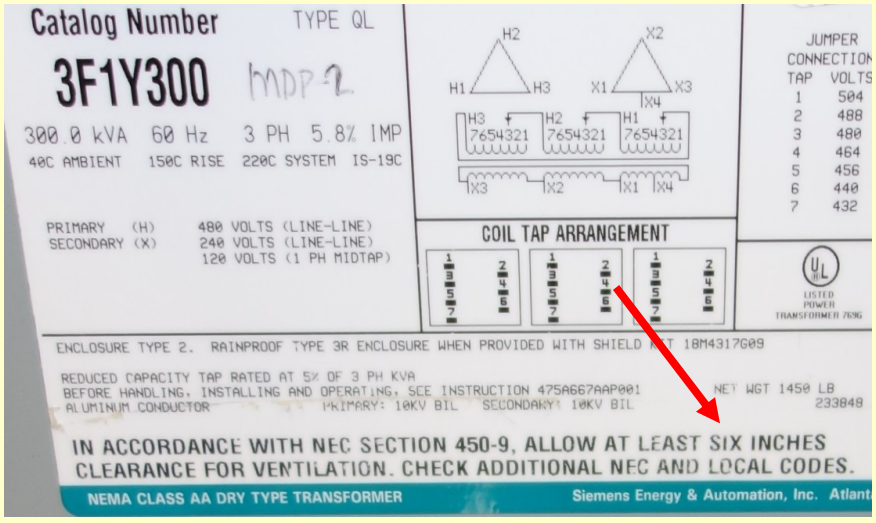
- Affects the primary circuit only.
- Dramatically affects the sizing of the primary overcurrent device.
- Vary by transformer construction and size.
  - 50-500 vA moderate inrush
  - 750 vA – 10 kVA high inrush
  - >10 kVA moderate inrush
    - The individual design has more influence then the above values.

450.9 Ventilation

The ventilation shall dispose of the transformer full-load heat losses without creating a temperature rise that is in excess of the transformer rating.

Transformers with **ventilating openings** shall be installed so that the ventilating openings are not blocked by walls or other obstructions. The required clearances shall be **clearly marked** on the transformer.

450.9 Ventilation



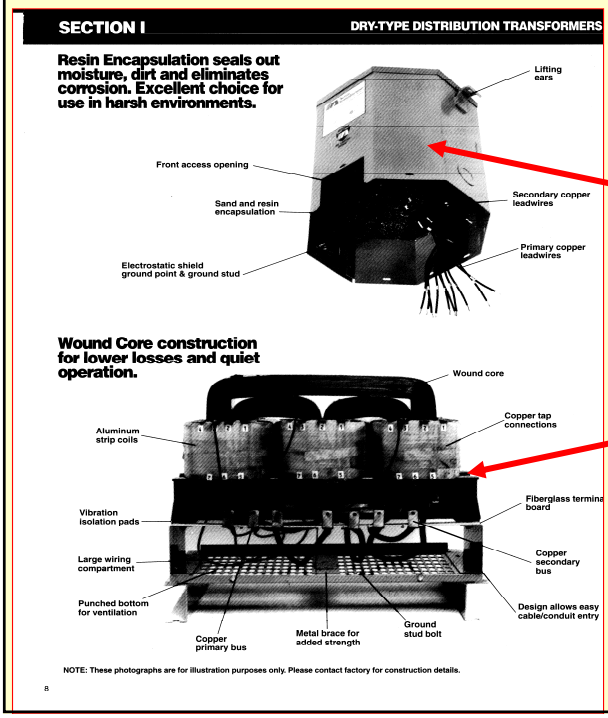
450.9 Ventilation

.

Informational Note No. 1: See ANSI/IEEE C57.12.00-1993, *General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers*, and ANSI/IEEE C57.12.01-1989, *General Requirements for Dry-Type Distribution and Power Transformers*.\

Informational Note No. 2: Additional losses may occur in some transformers where **nonsinusoidal currents** are present, resulting in increased heat in the transformer above its rating. See ANSI/IEEE C57.110-1993, *Recommended Practice for Establishing Transformer Capability When Supplying Nonsinusoidal Load Currents*, where transformers are utilized with nonlinear loads.

Ventilated Construction



Encapsulated
Typically <=15 kVA

Ventilated
Typically > 15 kVA

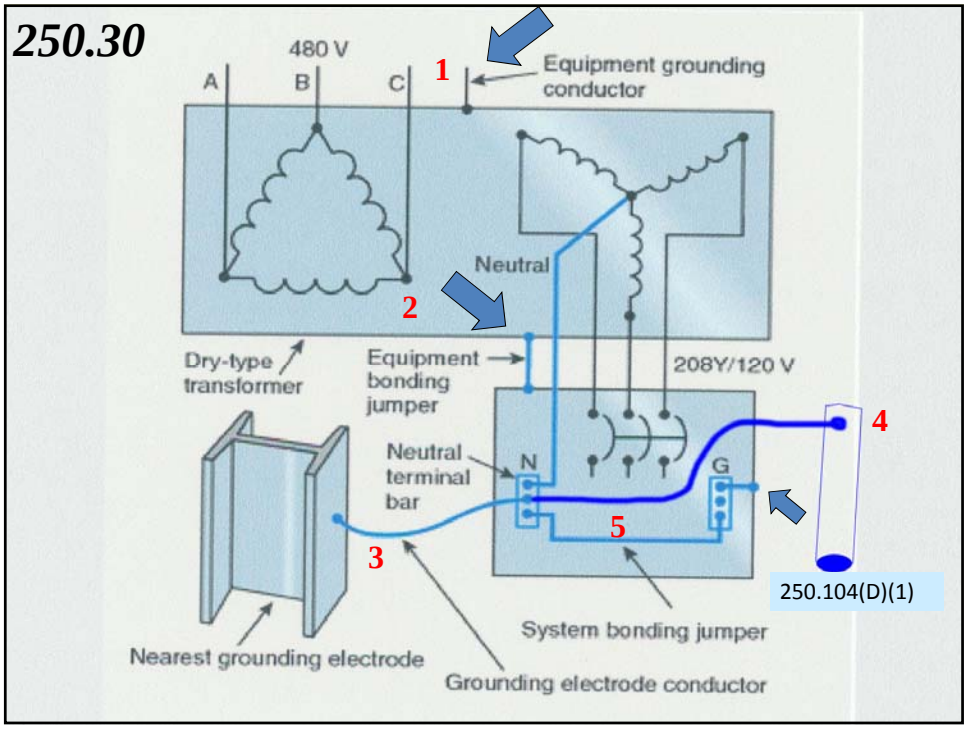
450.10 Grounding

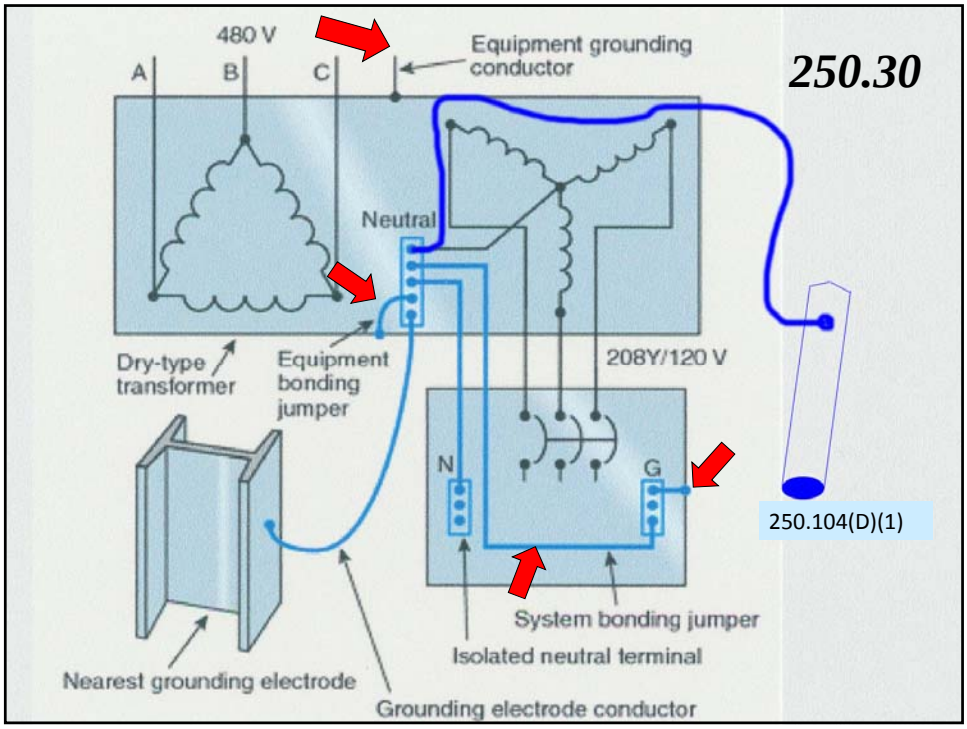
(A) Dry-Type Transformer Enclosures.
Where separate **equipment grounding conductors** and supply-side bonding jumpers a re installed, a terminal bar for all grounding and bonding conductor connections shall be secured inside the transformer enclosure. The terminal bar shall be bonded to the enclosure in accordance with 250.12 and shall not be installed on or over any vented portion of the enclosure.

Exception: *Where a dry-type transformer is equipped with* ***wire-type connections (leads),*** *the grounding and bonding connections shall be permitted to be connected together using any of the methods in 250.8 and shall be bonded to the enclosure if of metal.*

450.10 Grounding

(B) Other Metal Parts. Where grounded, exposed non–current carrying metal parts of transformer installations, including fences, guards, and so forth, shall be grounded and bonded under the conditions and in the manner specified for electrical equipment and other exposed metal parts in Parts V, VI, and VII of Article 250.



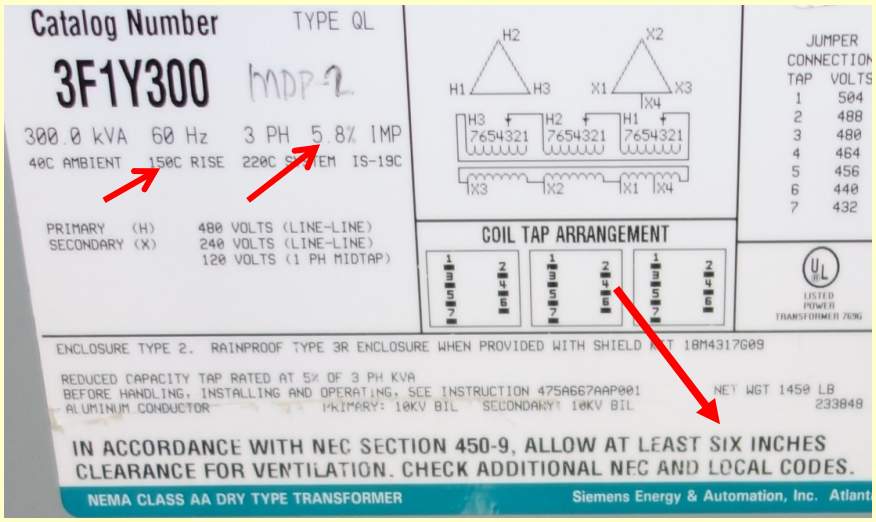


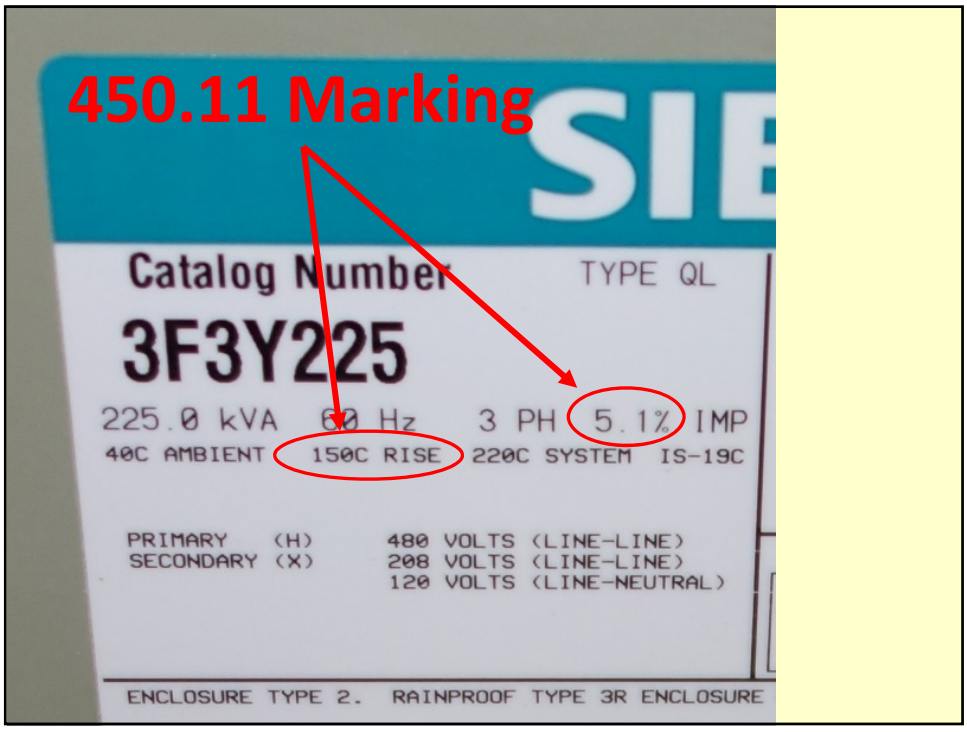
450.11 Marking

(**A) General.** Each transformer shall be provided with a nameplate giving the following information:

(1) Name of manufacturer
(2) Rated kilovolt-amperes
(3) Frequency
(4) Primary and secondary voltage
(5) **Impedance** of transformers 25 kVA and larger
(6) Required **clearances** for transformers with ventilating openings
(7) Amount and kind of insulating liquid where used
(8) For dry-type transformers, **temperature class** for the insulation system

450.11 Marking





450.11 Marking - What is Impedance?

Full Load Amps = short circuit current
% Impedance

150 kVA FLA (@ 208V) = 416A
Impedance = 4%

416/.04 = 10,400 amperes

450.11 Marking - Insulation Class

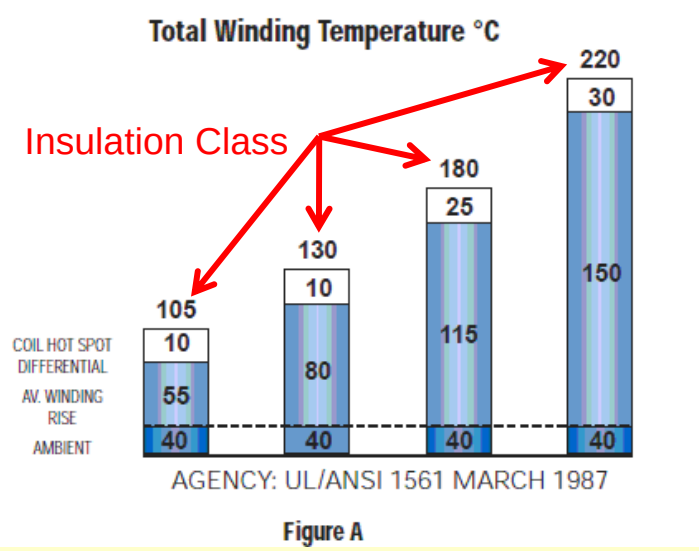


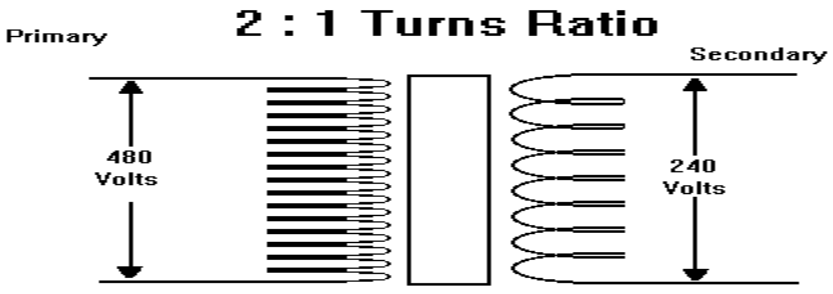
Figure A

450.11 Marking

(B) Source Marking. A transformer shall be permitted to be supplied at the marked secondary voltage, provided that the installation is in accordance with the manufacturer's instructions.

Source marking - VOLTAGE RATIO

480V pri 240V sec



❑Reverse Connections

- ❑ Exceptions
  - ❑ Small transformers with compensation windings.
    - ❑ Results in lower output voltage
    - ❑ Typically 5% lower at no load output.

Example:
A small kVA single phase 480 V - 240V transformer has a no load voltage of 250V. At full load the voltage is 240V . If reverse connected, the load voltage will be lower than acceptable

❑Reverse Connections

- ❑ Exceptions
  - ❑ Manufacturers that utilize a scot-tee connection cannot be reversed connected – consult manufacturer.

450.13 Accessibility

All transformers and transformer vaults shall be readily accessible to qualified personnel for inspection and maintenance or shall meet the requirements of 450.13(A) or 450.13(B).

(A) Open Installations. Dry-type transformers 1000 volts, nominal, or less, located in the open on walls, columns, or structures, shall not be required to be readily accessible.

450.13 Accessibility

(B) Hollow Space Installations. Dry-type transformers 1000 volts, nominal, or less and not exceeding 50 kVA shall be permitted in hollow spaces of buildings not permanently closed in by structure, provided they meet the ventilation requirements of 450.9 and separation from combustible materials requirements of 450.21(A). Transformers so installed shall not be required to be readily accessible.

450.21 Dry-Type Transformers Installed Indoors

(A) Not over 112.5 kVA.
Dry-type transformers installed indoors and rated 112½ kVA or less shall have a separation of at least 300 mm **(12 in.)** from combustible material unless separated from the combustible material by a fire-resistant, heat-insulated barrier.

Exception: This rule shall not apply to transformers rated for 1000 volts, nominal, or less that are **completely enclosed, except for ventilating openings***.*

450.14 Disconnecting Means

Transformers, other than Class 2 or Class 3 transformers, shall have a disconnecting means located either **in sight of the transformer** or in a remote location. Where located in a remote location, the disconnecting means shall be lockable in accordance with 110.25, and its **location shall be field marked on the transformer**.

450.26 Oil-Insulated Transformers Installed Indoors

Oil-insulated transformers installed indoors shall be installed in a vault constructed as specified in Part III of t his article.

Exception No. 1: Where the total capacity does not exceed 112½ kVA, the vault specified in Part III of this article shall be permitted to be constructed of reinforced concrete that is not less than 100 mm (4 in.) thick.

450.27 Oil-Insulated Transformers Installed Outdoors

Combustible material, combustible buildings, and parts of buildings, fire escapes, and door and window openings shall be safeguarded from fires originating in oil-insulated transformers installed on roofs, attached to or adjacent to a building or combustible material. In cases where the transformer installation presents a fire hazard, one or more of the following safeguards shall be applied according to the degree of hazard involved:

(1) Space separations
(2) Fire-resistant barriers
(3) Automatic fire suppression systems
(4) Enclosures that confine the oil of a ruptured transformer tank

450.27 Oil-Insulated Transformers Installed Outdoors

Oil enclosures shall be permitted to consist of fire-resistant dikes, curbed areas or basins, or trenches filled with coarse, crushed stone. Oil enclosures shall be provided with trapped drains where the exposure and the quantity of oil involved are such that removal of oil is important.

III. Transformer Vaults

450.41 Location

Vaults shall be located where they can be ventilated to the outside air without using flues or ducts wherever such an arrangement is practicable.

450.42 Walls, Roofs, an d Floors

The walls and roofs of vaults shall be constructed of materials that have approved structural strength for the conditions with a minimum **fire resistance of 3 hours.** The floors of vaults in contact with the earth shall be of concrete that is not less than 100 mm **(4 in.) thick**, but, where the vault is constructed with a vacant space or other stories below it, **the floor shall have approved structural strength for the load imposed thereon and a minimum fire resistance of 3 hours**. For the purposes of this section, studs and wallboard construction shall **not be permitted**.

Exception: Where transformers are protected with automatic sprinkler, water spray, carbon dioxide, or halon, construction of 1-hour rating shall be permitted

450.43 Doorways

Vault doorways shall be protected in accordance with 450.43(A), (B), and (C).

(A)Type of Door. Each doorway leading into a vault from the building interior shall be provided with a tight-fitting door that has a minimum fire rating of **3 hours**. The authority having jurisdiction shall be permitted to require such a door for an exterior wall opening where conditions warrant.

*Exception: Where transformers are protected with **automatic** sprinkler, water spray, carbon dioxide, or halon, construction of **1-hour rating shall be permitted**.*

450.43 Doorways

Vault doorways shall be protected in accordance with 450.43(A), (B), and (C).

(B) Sills. A door sill or curb that is of an approved height that **will confine the oil** from the largest transformer within the vault shall be provided, and in no case shall the height be less than 100 mm **(4 in.).**

(C) Locks. Doors shall be equipped with locks, and doors shall be kept locked, access being allowed only to **qualified persons.** Personnel doors shall **swing out** and be equipped with **panic bars, pressure plates**, or other devices that are normally latched but open under simple pressure.

450.45 Ventilation Openings

Where required by 450.9, openings for ventilation shall be provided in accordance with 450.45(A) through (F).

(A) Location. Ventilation openings shall be located as far as possible from doors, windows, fire escapes, and combustible material.

(B) Arrangement. A vault ventilated by natural circulation of air shall be permitted to have roughly half of the total area of openings required for **ventilation** in one or more openings **near the floor** and the remainder in one or more openings in the roof or in the sidewalls near the roof, or all of the area required for ventilation shall be permitted in one or more openings in or near the roof.

450.45 Ventilation Openings

Where required by 450.9, openings for ventilation shall be provided in accordance with 450.45(A) through (F).

(C) Size. For a vault ventilated by natural circulation of air to an outdoor area, the combined net area of all ventilating openings, after deducting the area occupied by screens, gratings, or louvers, shall not be less than 1900 **mm^2 ($3\ in^2$) per kVA of transformer** capacity in service, and in no case shall the net area be less than $0.1 m^2$ ($1\ ft^2$) for any capacity under 50 kVA.

450.45 Ventilation Openings

Where required by 450.9, openings for ventilation shall be provided in accordance with 450.45 (A) through (F).

(D) Covering. Ventilation openings shall be covered with durable gratings, screens, or louvers, according to the treatment required in order to avoid unsafe conditions.

(E) Dampers. All ventilation openings to the indoors shall be provided with **automatic closing fire dampers** that operate in response to a vault fire. Such dampers shall possess a standard fire rating of not less than **1-½ hours**.

450.45 Ventilation Openings

Where required by 450.9, openings for ventilation shall be provided in accordance with 450.45 (A) through (F).

(F) Ducts. Ventilating ducts shall be constructed of fire resistant material.

450.46 Drainage

Where practicable, vaults containing **more than 100 kVA transformer** capacity shall be provided with a **drain** or other means that will carry off any accumulation of oil or water in the vault unless local conditions make this impracticable. The floor shall be pitched to the drain where provided.

450.47 Water Pipes and Accessories

Any pipe or duct system foreign to the electrical installation **shall not enter or pass through a transformer vault.** Piping or other facilities provided for vault fire protection, or for transformer cooling, shall not be considered foreign to the electrical installation

Part III
Health Care Facilities

Instructors

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City of Parma

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ARTICLE 517
Health Care Facilities

517.1 Scope. The provisions of this article shall apply to electrical construction and installation criteria in health care facilities that provide services to human beings.

The requirements in Parts II and III not only apply to single-function buildings but are also intended to be individually applied to their respective forms of occupancy within a multifunction building (e.g., a doctor's examining room located within a limited care facility would be required to meet the provisions of 517.10).

Article 517.2 Definitions

Several definitions in Article 517 were revised, deleted or added as a result of the re-organization of the make-up of the "Essential Electrical System" of a hospital.

In an effort to coordinate the *NEC (and in particular, Article 517)* with NFPA 99 *(Health Care Facilities Code)*, several Article 517 definitions had to be revised, deleted, or added.

The re-organization of the make-up of the "Essential Electrical System" of a hospital eliminated the term "emergency system," leaving only the essential system with the three separate branches - *the critical, life safety and the equipment branch*.

In some definitions, the word "room" was changed to "space" and the word "area" was changed to "location" to remain consistent with NFPA 99

Article 517.10 Applicability.

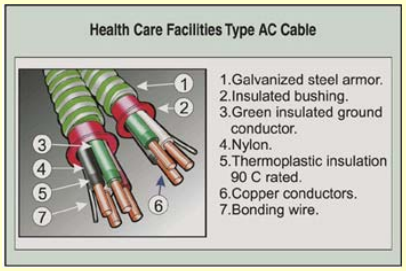
(A) Applicability. Part II shall apply to patient care space of all health care facilities.
(B) Not Covered. Part II shall not apply to the following:
(1) Business offices, corridors, waiting rooms, and the like in clinics, medical and dental offices, and outpatient facilities
(2) Areas of nursing homes and limited care facilities wired in accordance with Chapters 1 through 4 of this *Code* where these areas are used exclusively as patient sleeping rooms

Article 517.12 Wiring Methods.

Except as modified in this article, wiring methods shall comply with the applicable provisions of Chapters 1 through 4 of this *Code*.

517.13(A) Grounding of Receptacles and Fixed Electrical Equipment in Patient Care Areas.

Wiring in patient care areas shall comply with 517.13(A) and (B).
(A) Wiring Methods. All branch circuits serving patient care areas shall be provided with an effective ground-fault current path by installation in a metal raceway system, or a cable having a metallic armor or sheath assembly. The metal raceway system, or metallic cable armor, or sheath assembly shall itself qualify as an equipment grounding conductor in accordance with 250.118.



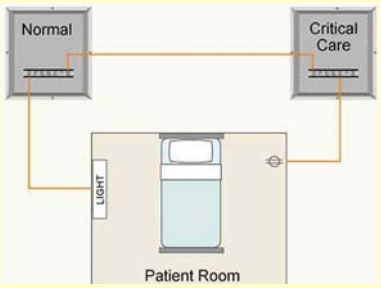
517.13(B) Grounding of Receptacles and Fixed Electrical Equipment in Patient Care Areas.

(B) Insulated Equipment Grounding Conductor.
(1) General. The following shall be directly connected to an insulated copper equipment grounding conductor that is installed with the branch circuit conductors in the wiring methods as provided in 517.13(A).
(1) The grounding terminals of all receptacles.
(2) Metal boxes and enclosures containing receptacles.
(3) All non–current-carrying conductive surfaces of fixed electrical equipment likely to become energized that are subject to personal contact, operating at over 100 volts.
Exception: *An insulated equipment bonding jumper that directly connects to the equipment grounding conductor is permitted to connect the box and receptacle(s) to the equipment grounding conductor.*
Exception No. 1 to (3): *Metal faceplates shall be permitted to be connected to the equipment grounding conductor by means of a metal mounting screw(s) securing the faceplate to a grounded outlet box or grounded wiring device.*
Exception No. 2 to (3): *Luminaires more than 2.3 m (71⁄2 ft) above the floor and switches located outside of the patient care vicinity shall be permitted to be connected to an equipment grounding return path complying with 517.13(A).*

(2) Sizing. Equipment grounding conductors and equipment bonding jumpers shall be sized in accordance with 250.122.

Article 517.14 Panelboard Bonding.

The equipment grounding terminal buses of the normal and essential branch-circuit panelboards serving the same individual patient care vicinity shall be connected together with an insulated continuous copper conductor not smaller than 10 AWG. Where two or more panelboards serving the same individual patient care vicinity are served from separate transfer switches on the essential electrical system, the equipment grounding terminal buses of those panelboards shall be connected together with an insulated continuous copper conductor not smaller than 10 AWG. This conductor shall be permitted to be broken in order to terminate on the equipment grounding terminal bus in each panelboard.



Article 517.16 Use of Isolated Ground Receptacles

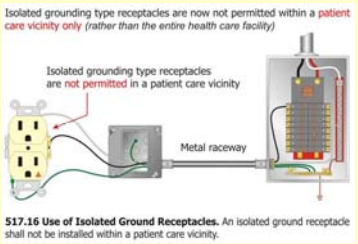
Revision will now prohibit isolated grounding type receptacles within a patient care vicinity only *(rather than the entire health care facility).*

Previous language at 517.16 prohibited isolated ground receptacles in the entire health care facility.

NFPA 99 *(Health Care Facilities Code)* affirms the use of isolated ground receptacles in health care facilities while continuing to forbid their use only within patient care vicinities.

Listed cord-and-plug-connected medical equipment used in health care facilities outside of patient care vicinities *(typically at nurses' monitoring stations)* often require connection to isolated ground receptacles.

The concern with isolated ground receptacles within a patient care vicinity is the assurance of the equipment grounding conductor redundancy requirement of 517.13(A) and (B) for wiring methods at a patient care vicinity.



517.16 Use of Isolated Ground Receptacles. An isolated ground receptacle shall not be installed within a patient care vicinity.

Article 517.16 Use of Isolated Ground Receptacles.

An isolated ground receptacle shall not be installed within a patient care vicinity.

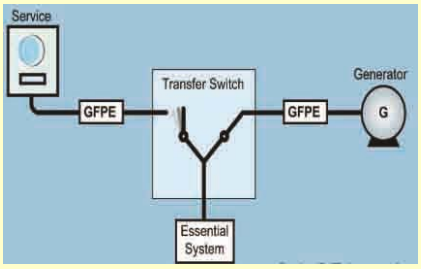
Article 517.17 Ground-Fault Protection.

(A) Applicability. The requirements of 517.17 shall apply to hospitals, and other buildings (including multiple occupancy buildings) with critical care space or utilizing electrical life-support equipment, and buildings that provide the required essential utilities or services for the operation of critical care space or electrical life-support equipment.

(B) Feeders. Where ground-fault protection is provided for operation of the service disconnecting means or feeder disconnecting means as specified by 230.95 or 215.10, an additional step of ground-fault protection shall be provided in all next level feeder disconnecting means downstream toward the load. Such protection shall consist of overcurrent devices and current transformers or other equivalent protective equipment that shall cause the feeder disconnecting means to open.

The additional levels of ground-fault protection shall not be installed on the load side of an essential electrical system transfer switch.

(C) Selectivity. Ground-fault protection for operation of the service and feeder disconnecting means shall be fully selective such that the feeder device, but not the service device, shall open on ground faults on the load side of the feeder device. Separation of ground-fault protection time-current characteristics shall conform to manufacturer's recommendations and shall consider all required tolerances and disconnect operating time to achieve 100 percent selectivity.



Article 517.18(A) Patient Bed Location (General Care Areas)

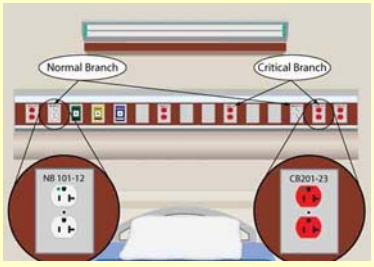
All receptacles or the cover plate supplied from the critical branch required to have a distinctive color or marking so as to be readily identifiable.

Marking is also to indicate the panelboard and branch circuit number supplying them.

This change is a continuation to align Article 517 with NFPA 99 *(Health Care Facilities Code).*

The term "emergency system" was removed from Article 517 to once again be consistent with NFPA 99.

Removes confusion with these circuits in health care facilities with those circuits described in Article 700 for "Emergency Systems."



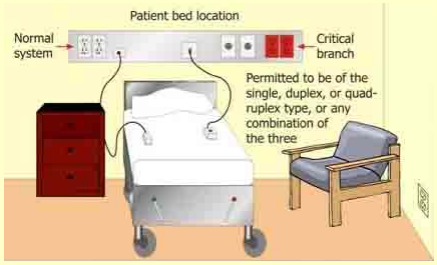
Article 517.18(B) Patient Bed Location Receptacles (General Care Areas)

The minimum number of receptacles required for general care area patient bed locations of health care facilities was increased from four to eight receptacles.

Aliens the *NEC* with NFPA 99 *(Health Care Facilities Code).*

NFPA 99 Section 6.3.2.2.6.2 requires each patient bed location in general care areas, where considered a Category 2 application, to be provided with a minimum of eight receptacles.

Category 2 is facility systems in which failure of such equipment is likely to cause minor injury to patients or caregivers.



517.19(B) Patient Bed Location Receptacles (Critical Care Areas)

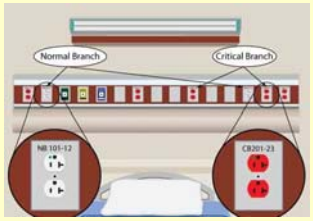
The minimum number of receptacles required for critical care area patient bed locations of health care facilities was increased from six to fourteen receptacles.
The systems required to supply at least one of these receptacles was changed from the emergency system to the critical branch as the term "emergency system" has been removed for Article 517.
NFPA 99 Section 6.3.2.2.6.2 requires each patient bed location in critical care areas, where considered a Category 1 application, to be provided with a minimum of fourteen receptacles.
Category 1 covers facility systems in which failure of such equipment or system is likely to cause major injury or death of patients or caregivers

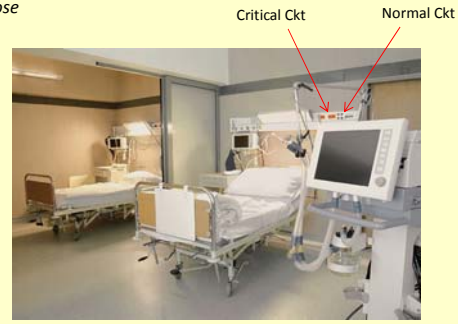
Article 517.18 (C) General Care Areas.

C) Designated General Care Pediatric Locations. Receptacles that are located within the patient rooms, bathrooms, playrooms, and activity rooms of pediatric units, other than nurseries, shall be listed tamper-resistant or shall employ a listed tamper-resistant cover.

Article 517.19 Critical Care Areas.

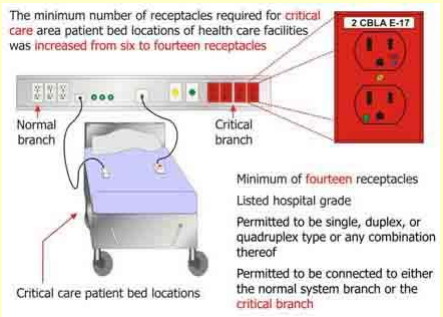
(A) Patient Bed Location Branch Circuits. Each patient bed location shall be supplied by at least two branch circuits, one or more from the critical branch and one or more circuits from the normal system. At least one branch circuit from the critical branch shall supply an outlet(s) only at that bed location. All branch circuits from the normal system shall be from a single panelboard. Critical branch receptacles shall be identified and shall also indicate the panelboard and circuit number supplying them.
The branch circuit serving patient bed locations shall not be part of a multiwire branch circuit.
Exception No. 1: Branch circuits serving only specialpurpose receptacles or equipment in critical care spaces shall be permitted to be served by other panelboards.
Exception No. 2: Critical care space served from two separate critical branch transfer switches shall not be required to have circuits from the normal system.





Article 517.19 (B) Patient Bed Location Receptacles.

(1) Minimum Number and Supply. Each patient bed location shall be provided with a minimum of 14 receptacles, at least one of which shall be connected to either of the following:
(1) The normal system branch circuit required in 517.19(A)
(2) A critical branch circuit supplied by a different transfer switch than the other receptacles at the same patient bed location
(2) Receptacle Requirements. The receptacles required in 517.19(B)(1) shall be permitted to be single, duplex, or quadruplex type or any combination thereof. All receptacles shall be listed "hospital grade" and shall be so identified. The grounding terminal of each receptacle shall be connected
to the reference grounding point by means of an insulated copper equipment grounding conductor.



Article 517.19(C) Operating Room Receptacles

New 517.19(C) was added requiring a minimum number of thirty-six receptacles in an operating room of health care facilities.

At least twelve of the thirty-six receptacles required to be connected to either the normal system branch or the critical branch circuit supplied by a different transfer switch than the other receptacles at the same location.

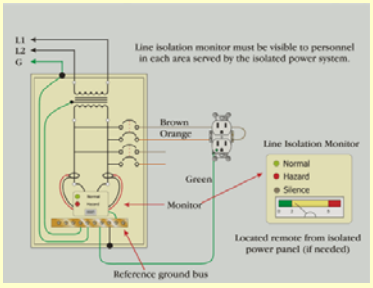
These receptacles are permitted to be of the single or duplex types or a combination of both.

All receptacles shall be listed hospital grade and so identified.

NFPA 99 Section 6.3.2.2.6.2 requires each operating room to be provided with a minimum of thirty-six receptacles.

Article 517.20 Wet Procedure Locations.

(A) Receptacles and Fixed Equipment. Wet procedure location patient care areas shall be provided with special protection against electric shock by one of the following means:
(1) Power distribution system that inherently limits the possible ground-fault current due to a first fault to a low value, without interrupting the power supply
(2) Power distribution system in which the power supply is interrupted if the ground-fault current does, in fact, exceed a value of 6 mA
Exception: Branch circuits supplying only listed, fixed, therapeutic and diagnostic equipment shall be permitted to be supplied from a grounded service, single- or 3-phase system, provided that
(a) Wiring for grounded and isolated circuits does not occupy the same raceway, and
(b) All conductive surfaces of the equipment are connected to an insulated copper equipment grounding conductor.
(B) Isolated Power Systems. Where an isolated power system is utilized, the isolated power equipment shall be listed as isolated power equipment, and the isolated power system shall be designed and installed in accordance with 517.160.



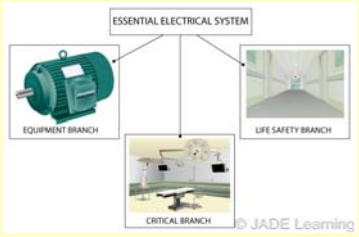
Article 517.30 Essential Electrical Systems for Hospitals.

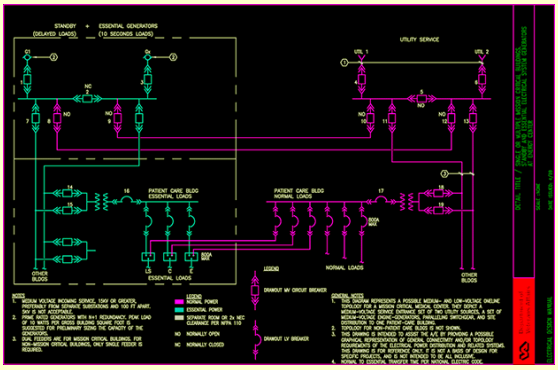
(A) Applicability. The requirements of Part III, 517.30 through 517.35, shall apply to hospitals where an essential electrical system is required.

For performance, maintenance, and testing requirements of essential electrical systems in hospitals, see NFPA 99-2012, *Health Care Facilities Code*.

For installation of centrifugal fire pumps, see NFPA 20-2013, *Standard for the Installation of Stationary Fire Pumps for Fire Protection*.

For additional information, see NFPA 99-2012, *Health Care Facilities Code*.





Article 517.30(B) Essential Electrical Systems for Hospitals

The use of and term, "Emergency Systems" has been eliminated from Article 517 leaving only the essential system with the three separate branches:

Critical branch

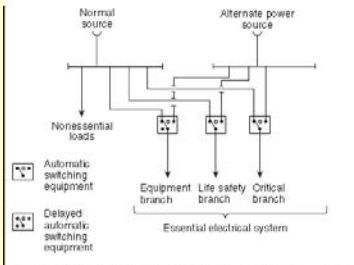
Life safety branch

Equipment branch

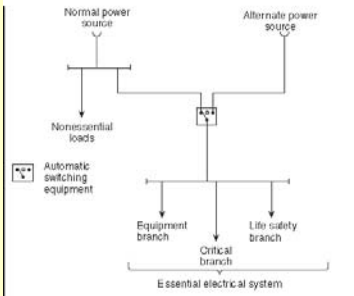
The diagram in Figure 517.30, No. 1 had been re-worked to reflect these changes as well.

In an effort to correlate the requirements of the *NEC* and in particular, Article 517 with NFPA 99 *(Health Care Facilities Code)*, 517.30(B) was re-organized for the make-up of the essential system of a hospital.

The term "Emergency System" is no longer used in Article 517, removing major confusion resulting from the previous use of the word "emergency" in similar, yet sometimes quite different, ways in Article 517 from Article 700.



Informational Note Figure 517.30, No. 1 Hospital — Minimum Requirement (greater than 150 kVA) for Transfer Switch Arrangement.



Informational Note Figure 517.30, No. 2 Hospital — Minimum Requirement (150 kVA or less) for Transfer Switch Arrangement.

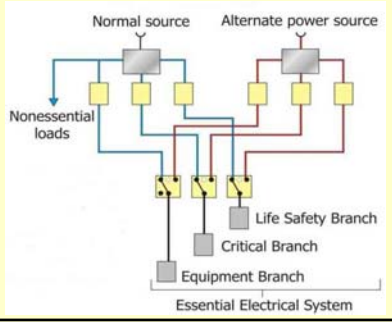
Article 517.30 Cont.

(C) Wiring Requirements.
(1) Separation from Other Circuits. The life safety branch and critical branch of the essential electrical system shall be kept entirely independent of all other wiring and equipment and shall not enter the same raceways, boxes, or cabinets with each other or other wiring.
Where general care locations are served from two separate transfer switches on the essential electrical system in accordance with 517.18(A), Exception No. 3, the general care circuits from the two separate systems shall be kept independent of each other.
Where critical care locations are served from two separate transfer switches on the essential electrical system in accordance with 517.19(A), Exception No. 2, the critical care circuits from the two separate systems shall be kept independent of each other.
Wiring of the life safety branch and the critical branch shall be permitted to occupy the same raceways, boxes, or cabinets of other circuits not part of the branch where such wiring complies with one of the following:
(1) Is in transfer equipment enclosures
(2) Is in exit or emergency luminaires supplied from two sources
(3) Is in a common junction box attached to exit or emergency luminaires supplied from two sources
(4) Is for two or more circuits supplied from the same branch and same transfer switch
The wiring of the equipment branch shall be permitted to occupy the same raceways, boxes, or cabinets of other circuits that are not part of the essential electrical system.

(2) Isolated Power Systems. Where isolated power systems are installed in any of the areas in 517.33(A)(1) and (A)(2), each system shall be supplied by an individual circuit serving no other load.
(3) Mechanical Protection of the Essential Electrical System. The wiring of the life safety and critical branches shall be mechanically protected. Where installed as branch circuits in patient care spaces, the installation shall comply with the requirements of 517.13(A) and (B). The following wiring methods shall be permitted:
(1) Nonflexible metal raceways, Type MI cable, Type RTRC marked with the suffix –XW, or Schedule 80 PVC conduit. Nonmetallic raceways shall not be used for branch circuits that supply patient care areas.
(2) Where encased in not less than 50 mm (2 in.) of concrete, Schedule 40 PVC conduit, flexible nonmetallic or jacketed metallic raceways, or jacketed metallic cable assemblies listed for installation in concrete. Nonmetallic raceways shall not be used for branch circuits that supply patient care areas.

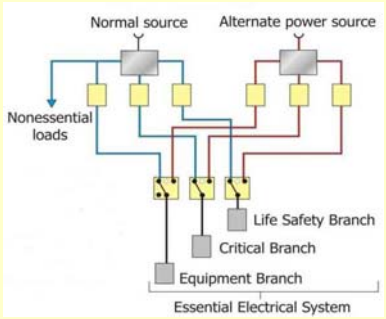
Article 517.30(G) Coordination (Essential Electrical Systems)

Overcurrent protective devices serving the essential electrical system of a health care facility are now required to be "coordinated" for the period of time that a fault's duration extends beyond 0.1 second.
Exception exist for this new rule for transformer primary and secondary OCPD, where only one overcurrent protective device exists on the transformer secondary.
Another exception for overcurrent protective devices of the same ampere rating installed in series.
It should be noted that this new requirement is not full selective coordination but only requires "coordination" for fault events that exceed 0.1 seconds.



Article 517.31 Branches Requiring Automatic Connection.

Those functions of patient care depending on lighting or appliances that are connected to the essential electrical system shall be divided into the life safety branch and the critical branch, as described in 517.32 and 517.33.
The life safety and critical branches shall be installed and connected to the alternate power source so that all functions supplied by these branches specified here shall be automatically restored to operation within 10 seconds after interruption of the normal source.



Article 517.32 Life Safety Branch.

No functions other than those listed in 517.32(A) through (H) shall be connected to the life safety branch. The life safety branch of the essential electrical system shall supply power for the following lighting, receptacles, and equipment.

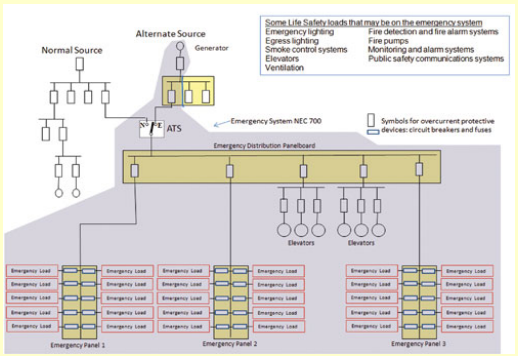
(A) Illumination of Means of Egress. Illumination of means of egress, such as lighting required for corridors, passageways, stairways, and landings at exit doors, and all necessary ways of approach to exits. Switching arrangements to transfer patient corridor lighting in hospitals from general illumination circuits to night illumination circuits shall be permitted, provided only one of two circuits can be selected and both circuits cannot be extinguished at the same time.

(B) Exit Signs. Exit signs and exit directional signs.

(C) Alarm and Alerting Systems. Alarm and alerting systems including the following:
(1) Fire alarms
(2) Alarms required for systems used for the piping of nonflammable medical gases
(3) Mechanical, control, and other accessories required for effective life safety systems operation shall be permitted to be connected to the life safety branch.

(D) Communications Systems. Hospital communications systems, where used for issuing instructions during emergency conditions.

(E) Generator Set and Transfer Switch Locations. Task illumination battery charger for battery-powered lighting unit(s) and selected receptacles at the generator set and essential transfer switch locations.
(F) Generator Set Accessories. Generator set accessories as required for generator performance. Loads dedicated to a specific generator, including the fuel transfer pump(s), ventilation fans, electrically operated louvers, controls, cooling system, and other generator accessories essential for generator operation, shall be connected to the life safety branch or to the output terminals of the generator with overcurrent protective devices.
(G) Elevators. Elevator cab lighting, control, communications, and signal systems.
(H) Automatic Doors. Automatically operated doors used for building egress.



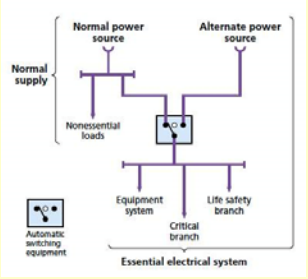
Article 517.33 Critical Branch.

(A) Task Illumination and Selected Receptacles. The critical branch of the essential electrical system shall supply power for task illumination, fixed equipment, selected receptacles, and special power circuits serving the following areas and functions related to patient care:

(1) Critical care areas that utilize anesthetizing gases — task illumination, selected receptacles, and fixed equipment
(2) The isolated power systems in special environments
(3) Patient care areas — task illumination and selected receptacles in the following:
a. Infant nurseries
b. Medication preparation areas
c. Pharmacy dispensing areas
d. Selected acute nursing areas
e. Psychiatric bed areas (omit receptacles)
f. Ward treatment rooms
g. Nurses' stations (unless adequately lighted by corridor luminaires)
(4) Additional specialized patient care task illumination and receptacles, where needed
(5) Nurse call systems
(6) Blood, bone, and tissue banks
(7) Telephone and data equipment rooms and closets
(8) Task illumination, selected receptacles, and selected power circuits for the following:
a. General care beds (at least one duplex receptacle in each patient bedroom)
b. Angiographic labs
c. Cardiac catheterization labs
d. Coronary care units
e. Hemodialysis rooms or areas
f. Emergency room treatment areas (selected)
g. Human physiology labs
h. Intensive care units
i. Postoperative recovery rooms (selected)
(9) Additional task illumination, receptacles, and selected power circuits needed for effective hospital operation. Single-phase fractional horsepower motors shall be permitted to be connected to the critical branch.

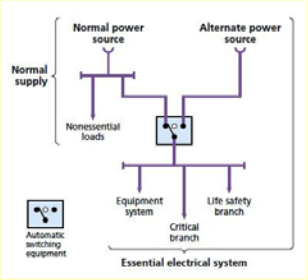
(B) Subdivision of the Critical Branch. It shall be permitted to subdivide the critical branch into two or more branches.

It is important to analyze the consequences of supplying an area with only critical care branch power when failure occurs between the area and the transfer switch. Some proportion of normal and critical power or critical power from separate transfer switches may be appropriate.



Article 517.34 Equipment Branch Connection to Alternate Power Source.

The equipment branch shall be installed and connected to the alternate power source such that the equipment described in 517.34(A) is automatically restored to operation at appropriate time-lag intervals following the energizing of the essential electrical system. Its arrangement shall also provide for the subsequent connection of equipment described in 517.34(B).
Exception: For essential electrical systems under 150 kVA, deletion of the time-lag intervals feature for delayed automatic connection to the equipment system shall be permitted



Article 517.34(A)

(A) Equipment for Delayed Automatic Connection. The following equipment shall be permitted to be arranged for delayed automatic connection to the alternate power source:

(1) Central suction systems serving medical and surgical functions, including controls. Such suction systems shall be permitted on the critical branch.

(2) Sump pumps and other equipment required to operate for the safety of major apparatus, including associated control systems and alarms.

(3) Compressed air systems serving medical and surgical functions, including controls. Such air systems shall be permitted on the critical branch.

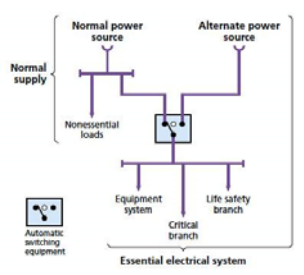
(4) Smoke control and stair pressurization systems, or both.

(5) Kitchen hood supply or exhaust systems, or both***, if required to operate during a fire in or under the hood.***

(6) Supply, return, and exhaust ventilating systems for airborne infectious/isolation rooms, protective environment rooms, exhaust fans for laboratory fume hoods, nuclear medicine areas where radioactive material is used, ethylene oxide evacuation, and anesthesia evacuation. ***Where delayed automatic connection is not appropriate, such ventilation systems shall be permitted to be placed on the critical branch.***

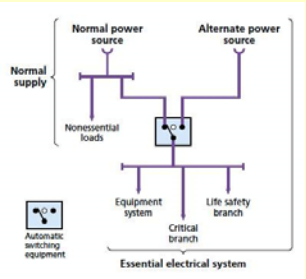
(7) Supply, return, and exhaust ventilating systems for operating and delivery rooms.

(8) Supply, return, exhaust ventilating systems and/or air conditioning systems serving telephone equipment rooms and closets and data equipment rooms and closets.



Article 517.34(A) Exception

Exception: Sequential delayed automatic connection to the alternate power source to prevent overloading the generator shall be permitted where engineering studies indicate it is necessary.



Article 517.34(B)

(B) Equipment for Delayed Automatic or Manual Connection.
The following equipment shall be permitted to be arranged for either delayed automatic or manual connection
to the alternate power source:
(1) Heating equipment to provide heating for operating, delivery, labor, recovery, intensive care, coronary care, nurseries, infection/isolation rooms, emergency treatment spaces, and general patient rooms and pressure maintenance (jockey or make-up) pump(s) for waterbased fire protection systems.

Exception: Heating of general patient rooms and infection/isolation rooms during disruption of the normal source shall not be required under any of the following conditions:

(1) The outside design temperature is higher than (20°F).

(2) The outside design temperature is lower than (20°F), and where a selected room(s) is provided for the needs of all confined patients, only such room(s) need to be heated.

(3) The facility is served by a dual source of normal power.

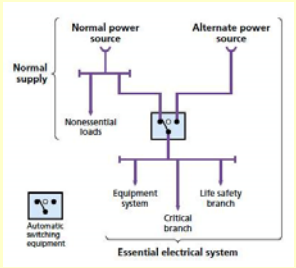
(2) An elevator(s) selected to provide service to patient, surgical, obstetrical, and ground floors during interruption of normal power. In instances where interruption of normal power would result in other elevators stopping between floors, throw-over facilities shall be provided to allow the temporary operation of any elevator for the release of patients or other persons who may be confined between floors.
(3) Hyperbaric facilities.
(4) Hypobaric facilities.
(5) Automatically operated doors
(6) Minimal electrically heated autoclaving equipment shall be permitted to be arranged for either automatic or manual connection to the alternate source.
(7) Controls for equipment listed in 517.34.
(8) Other selected equipment shall be permitted to be served by the equipment system

Article 517.34(C)

(C) AC Equipment for Non-delayed Automatic Connection.
Generator accessories, including but not limited to, the transfer fuel pump, electrically operated louvers, and other generator accessories essential for generator operation, shall be arranged for automatic connection to the alternate power source.

Article 517.35 Sources of Power.

(A) Two Independent Sources of Power. Essential electrical systems shall have a minimum of two independent sources of power: a normal source generally supplying the entire electrical system and one or more alternate sources for use when the normal source is interrupted.
(B) Alternate Source of Power. The alternate source of power shall be one of the following:
(1) Generator(s) driven by some form of prime mover(s) and located on the premises
(2) Another generating unit(s) where the normal source consists of a generating unit(s) located on the premises
(3) An external utility service when the normal source consists of a generating unit(s) located on the premises
(4) A battery system located on the premises



(C) Location of Essential Electrical System Components. Careful consideration shall be given to the location of the spaces housing the components of the essential electrical system to minimize interruptions caused by natural forces common to the area (e.g., storms, floods, earthquakes, or hazards created by adjoining structures or activities). Consideration shall also be given to the possible interruption of normal electrical services resulting from similar causes as well as possible disruption of normal electrical service due to internal wiring and equipment failures. Consideration shall be given to the physical separation of the main feeders of the alternate source from the main feeders of the normal electrical source to prevent possible simultaneous interruption.

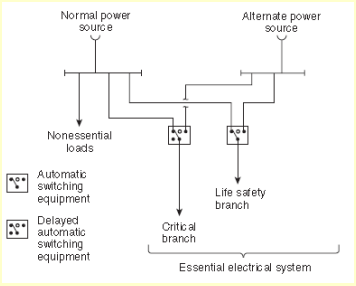
Article 517.40 (A) Essential Electrical Systems for Nursing Homes and Limited Care Facilities.

(A) Applicability. The requirements of Part III, 517.40(C) through 517.44, shall apply to nursing homes and limited care facilities.
Exception: *The requirements of Part III, 517.40(C) through 517.44, shall not apply to freestanding buildings used as nursing homes and limited care facilities, provided that the following apply:*
(a) Admitting and discharge policies are maintained that preclude the provision of care for any patient or resident who may need to be sustained by electrical life support equipment.
(b) No surgical treatment requiring general anesthesia is offered.
(c) An automatic battery-operated system(s) or equipment is provided that shall be effective for at least 1 1⁄2 hours and is otherwise in accordance with 700.12 and that shall be capable of supplying lighting for exit lights, exit corridors, stairways, nursing stations, medical preparation areas, boiler rooms, and communications areas. This system shall also supply power to operate all alarm systems.

Article 517.40 (B) & (C) Essential Electrical Systems for Nursing Homes and Limited Care Facilities.

(B) Inpatient Hospital Care Facilities. For those nursing homes and limited care facilities that admit patients who need to be sustained by electrical life support equipment, the essential electrical system from the source to the portion of the facility where such patients are treated shall comply with the requirements of Part III, 517.30 through 517.35.

(C) Facilities Contiguous or Located on the Same Site with Hospitals. Nursing homes and limited care facilities that are contiguous or located on the same site with a hospital shall be permitted to have their essential electrical systems supplied by that of the hospital.

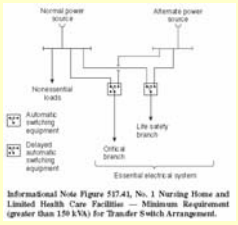


Article 517.41 (A) & (B) & (C) Essential Electrical Systems.

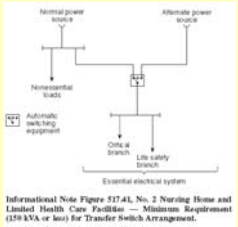
(A) General. Essential electrical systems for nursing homes and limited care facilities shall be comprised of two separate branches capable of supplying a limited amount of lighting and power service, which is considered essential for the protection of life safety and effective operation of the institution during the time normal electrical service is interrupted for any reason. These two separate branches shall be the life safety branch and the critical branch.

(B) Transfer Switches. The number of transfer switches to be used shall be based on reliability, design, and load considerations. Each branch of the essential electrical system shall be served by one or more transfer switches. One transfer switch shall be permitted to serve one or more branches or systems in a facility with a maximum demand on the essential electrical system of 150 kVA.

(C) Capacity of System. The essential electrical system shall have adequate capacity to meet the demand for the operation of all functions and equipment to be served by each branch at one time.



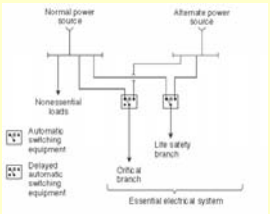
Informational Note Figure 517.41, No. 1 Nursing Home and Limited Health Care Facilities — Minimum Requirement (greater than 150 kVA) for Transfer Switch Arrangement.



Informational Note Figure 517.41, No. 2 Nursing Home and Limited Health Care Facilities — Minimum Requirement (150 kVA or less) for Transfer Switch Arrangement.

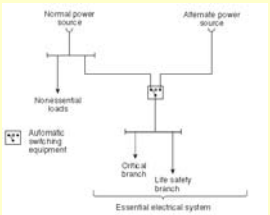
Article 517.41 (D) & (E) Essential Electrical Systems.

(D) Separation from Other Circuits. The life safety branch shall be kept entirely independent of all other wiring and equipment and shall not enter the same raceways, boxes, or cabinets with other wiring except as follows:
(1) In transfer switches
(2) In exit or emergency luminaires supplied from two sources
(3) In a common junction box attached to exit or emergency luminaires supplied from two sources
The wiring of the critical branch shall be permitted to occupy the same raceways, boxes, or cabinets of other circuits that are not part of the life safety branch.



Informational Note Figure 517.41, No. 1 Nursing Home and Limited Health Care Facilities — Minimum Requirement (greater than 150 kVA) for Transfer Switch Arrangement.

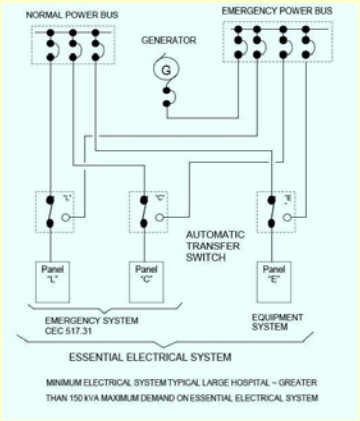
(E) Receptacle Identification. The cover plates for the electrical receptacles or the electrical receptacles themselves supplied from the essential electrical system shall have a distinctive color or marking so as to be readily identifiable.
Nonlocking-type, 125-volt, 15- and 20-ampere receptacles shall have an illuminated face or an indicator light to indicate that there is power to the receptacle.



Informational Note Figure 517.41, No. 2 Nursing Home and Limited Health Care Facilities — Minimum Requirement (150 kVA or less) for Transfer Switch Arrangement.

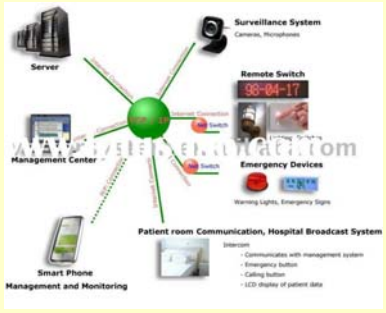
Article 517.42 (A) Automatic Connection to Life Safety Branch.

The life safety branch shall be installed and connected to the alternate source of power so that all functions specified herein shall be automatically restored to operation within 10 seconds after the interruption of the normal source. No functions other than those listed in 517.42(A) through (G) shall be connected to the life safety branch. The life safety branch shall supply power for the following lighting, receptacles, and equipment.
(A) Illumination of Means of Egress. Illumination of means of egress as is necessary for corridors, passageways, stairways, landings, and exit doors and all ways of approach to exits. Switching arrangement to transfer patient corridor lighting from general illumination circuits shall be permitted, providing only one of two circuits can be selected and both circuits cannot be extinguished at the same time.



Article 517.42 (B),(C),(D),(E),(F),(G) Automatic Connection to Life Safety Branch.

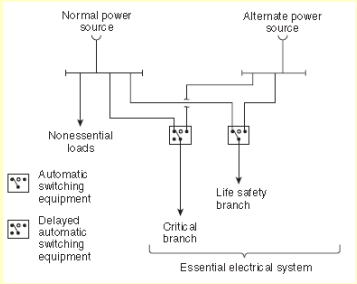
(B) Exit Signs. Exit signs and exit directional signs.
(C) Alarm and Alerting Systems. Alarm and alerting systems, including the following:
(1) Fire alarms
(2) Alarms required for systems used for the piping of nonflammable medical gases
(D) Communications Systems. Communications systems, where used for issuing instructions during emergency conditions.
(E) Dining and Recreation Areas. Sufficient lighting in dining and recreation areas to provide illumination to exit ways.
(F) Generator Set Location. Task illumination and selected receptacles in the generator set location.
(G) Elevators. Elevator cab lighting, control, communications, and signal systems.



Article 517.43(A) Connection to Critical Branch.

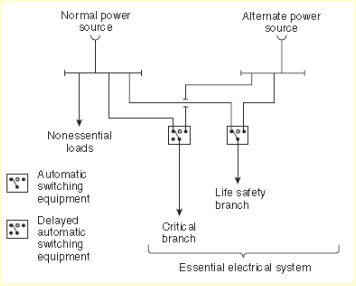
The critical branch shall be installed and connected to the alternate power source so that the equipment listed in 517.43(A) shall be automatically restored to operation at appropriate time-lag intervals following the restoration of the life safety branch to operation. Its arrangement shall also provide for the additional connection of equipment listed in 517.43(B) by either delayed automatic or manual operation.
Exception: For essential electrical systems under 150 kVA, deletion of the time-lag intervals feature for delayed automatic connection to the equipment branch shall be permitted.

(A) Delayed Automatic Connection. The following equipment shall be permitted to be connected to the critical branch and shall be arranged for delayed automatic connection to the alternate power source:
(1) Patient care areas — task illumination and selected receptacles in the following:
a. Medication preparation areas
b. Pharmacy dispensing areas
c. Nurses' stations (unless adequately lighted by corridor luminaires)
(2) Sump pumps and other equipment required to operate for the safety of major apparatus and associated control systems and alarms
(3) Smoke control and stair pressurization systems
(4) Kitchen hood supply and/or exhaust systems, if required to operate during a fire in or under the hood
(5) Supply, return, and exhaust ventilating systems for airborne infectious isolation rooms



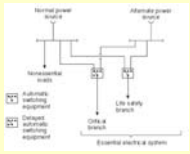
Article 517.43(B) Connection to Critical Branch.

(B) Delayed Automatic or Manual Connection. The following equipment shall be permitted to be connected to the critical branch and shall be arranged for either delayed automatic or manual connection to the alternate power source:
(1) Heating equipment to provide heating for patient rooms.
Exception: Heating of general patient rooms during disruption of the normal source shall not be required under any of the following conditions:
(1) The outside design temperature is higher than −6.7°C (20°F).
(2) The outside design temperature is lower than −6.7°C (20°F) and where a selected room(s) is provided for the needs of all confined patients, only such room(s) need be heated.
(3) The facility is served by a dual source of normal power as described in 517.44(C), Informational Note.



Article 517.44 (A),(B)Sources of Power.

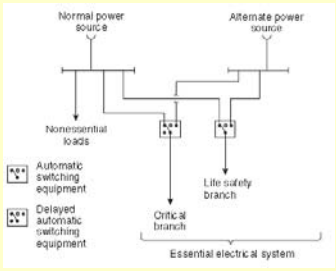
(A) Two Independent Sources of Power. Essential electrical systems shall have a minimum of two independent sources of power: a normal source generally supplying the entire electrical system and one or more alternate sources for use when the normal source is interrupted.
(B) Alternate Source of Power. The alternate source of power shall be a generator(s) driven by some form of prime mover(s) and located on the premises.
Exception No. 1: Where the normal source consists of generating units on the premises, the alternate source shall be either another generator set or an external utility service.
Exception No. 2: Nursing homes or limited care facilities meeting the requirement of 517.40(A) and other health care facilities meeting the requirement of 517.45 shall be permitted to use a battery system or self-contained battery integral with the equipment.



Article 517.44 (C) Sources of Power.

(C) Location of Essential Electrical System Components. Careful consideration shall be given to the location of the spaces housing the components of the essential electrical system to minimize interruptions caused by natural forces common to the area (e.g., storms, floods, earthquakes, or hazards created by adjoining structures or activities). Consideration shall also be given to the possible interruption of normal electrical services resulting from similar causes as well as possible disruption of normal electrical service due to internal wiring and equipment failures.

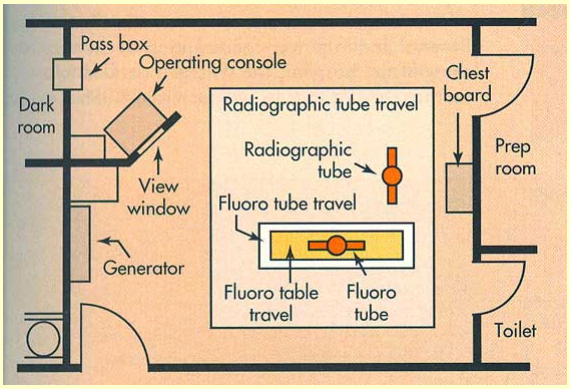
Facilities in which the normal source of power is supplied by two or more separate central station-fed services experience greater than normal electrical service reliability than those with only a single feed. Such a dual source of normal power consists of two or more electrical services fed from separate generator sets or a utility distribution network that has multiple power input sources and is arranged to provide mechanical and electrical separation so that a fault between the facility and the generating sources will not likely cause an interruption of more than one of the facility service feeders.



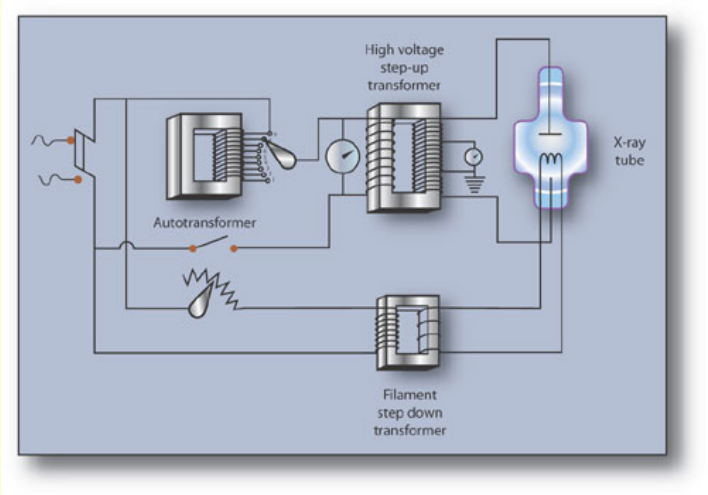
X-Ray Installations

Radiation safety and performance requirements of several classes of X-ray equipment are regulated under Public Law 90-602 and are enforced by the Department of Health and Human Services.

517.70 Applicability. Nothing in this part shall be construed as specifying safeguards against the useful beam or stray X-ray radiation.



Basic X Ray Machine Schematic



Article 517.71 Connection to Supply Circuit.

(A) Fixed and Stationary Equipment. Fixed and stationary X-ray equipment shall be connected to the power supply by means of a wiring method complying with applicable requirements of Chapters 1 through 4 of this *Code*, as modified by this article.
Exception: Equipment properly supplied by a branch circuit rated at not over 30 amperes shall be permitted to be supplied through a suitable attachment plug and hard service cable or cord.
(B) Portable, Mobile, and Transportable Equipment. Individual branch circuits shall not be required for portable, mobile, and transportable medical X-ray equipment requiring
a capacity of not over 60 amperes.
(C) Over 1000-Volt Supply. Circuits and equipment operated on a supply circuit of over 1000 volts shall comply with Article 490.

Article 517.72 Disconnecting Means.

(A) Capacity. A disconnecting means of adequate capacity for at least 50 percent of the input required for the momentary
rating or 100 percent of the input required for the long-time rating of the X-ray equipment, whichever is greater, shall be provided in the supply circuit.
(B) Location. The disconnecting means shall be operable from a location readily accessible from the X-ray control.
(C) Portable Equipment. For equipment connected to a 120-volt branch circuit of 30 amperes or less, a grounding type attachment plug and receptacle of proper rating shall be permitted to serve as a disconnecting means.

Article 517.73 Rating of Supply Conductors and Overcurrent Protection.

(A) Diagnostic Equipment.

(1) Branch Circuits. The ampacity of supply branchcircuit conductors and the current rating of overcurrent protective devices shall not be less than 50 percent of the momentary rating or 100 percent of the long-time rating, whichever is greater.
(2) Feeders. The ampacity of supply feeders and the current rating of overcurrent protective devices supplying two or more branch circuits supplying X-ray units shall not be less than 50 percent of the momentary demand rating of the largest unit plus 25 percent of the momentary demand rating of the next largest unit plus 10 percent of the momentary demand rating of each additional unit. Where simultaneous biplane examinations are undertaken with the X-ray units, the supply conductors and overcurrent protective devices shall be 100 percent of the momentary demand rating of each X-ray unit.

The minimum conductor size for branch and feeder circuits is also governed by voltage regulation requirements. For a specific installation, the manufacturer usually specifies minimum distribution transformer and conductor sizes, rating of disconnecting means, and overcurrent protection.

Article 517.73 Rating of Supply Conductors and Overcurrent Protection.

(B) Therapeutic Equipment. The ampacity of conductors and rating of overcurrent protective devices shall not be less than 100 percent of the current rating of medical X-ray therapy equipment.

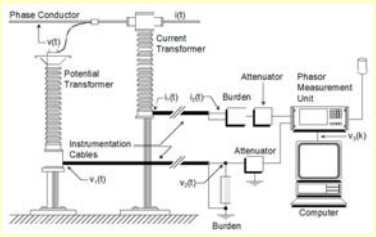
The ampacity of the branch-circuit conductors and the ratings of disconnecting means and overcurrent protection for X-ray equipment are usually designated by the manufacturer for the specific installation

Article 517.74 Control Circuit Conductors.

(A) Number of Conductors in Raceway. The number of control circuit conductors installed in a raceway shall be determined in accordance with 300.17.

(B) Minimum Size of Conductors. Size 18 AWG or 16 AWG fixture wires as specified in 725.49 and flexible cords shall be permitted for the control and operating circuits of X-ray and auxiliary equipment where protected by not larger than 20-ampere overcurrent devices.

300.17 Number and Size of Conductors in Raceway. The number and size of conductors in any raceway shall not be more than will permit dissipation of the heat and ready installation or withdrawal of the conductors without damage to the conductors or to their insulation.



Article 517.76 Transformers and Capacitors.

Transformers and capacitors that are part of X-ray equipment shall not be required to comply with Articles 450 and 460. Capacitors shall be mounted within enclosures of insulating material or grounded metal.

Article 517.77 Installation of High-Tension X-Ray Cables.

Cables with grounded shields connecting X-ray tubes and image intensifiers shall be permitted to be installed in cable trays or cable troughs along with X-ray equipment control and power supply conductors without the need for barriers to separate the wiring.

Article 517.78 Guarding and Grounding.

(A) High-Voltage Parts. All high-voltage parts, including X-ray tubes, shall be mounted within grounded enclosures. Air, oil, gas, or other suitable insulating media shall be used to insulate the high-voltage from the grounded enclosure. The connection from the high-voltage equipment to X-ray tubes and other high-voltage components shall be made with high-voltage shielded cables.
(B) Low-Voltage Cables. Low-voltage cables connecting to oil-filled units that are not completely sealed, such as transformers, condensers, oil coolers, and high-voltage switches, shall have insulation of the oil-resistant type.
(C) Non–Current-Carrying Metal Parts. Non–currentcarrying metal parts of X-ray and associated equipment (controls, tables, X-ray tube supports, transformer tanks, shielded cables, X-ray tube heads, etc.) shall be connected to an equipment grounding conductor in the manner specified in Part VII of Article 250, as modified by 517.13(A) and (B).

Communications, Signaling Systems, Data Systems, Fire Alarm Systems, and Systems Less Than 120 Volts, Nominal
Article 517.80 Patient Care Areas.

Equivalent insulation and isolation to that required for the electrical distribution systems in patient care areas shall be provided for communications, signaling systems, data system circuits, fire alarm systems, and systems less than 120 volts, nominal. Class 2 and Class 3 signaling and communications systems and power-limited fire alarm systems shall not be required to comply with the grounding requirements of 517.13, to comply with the mechanical protection requirements of 517.30(C)(3)(5), or to be enclosed in raceways, unless otherwise specified by Chapter 7 or 8.
Secondary circuits of transformer-powered communications or signaling systems shall not be required to be enclosed in raceways unless otherwise specified by Chapter 7 or 8.

Communications, Signaling Systems, Data Systems, Fire Alarm Systems, and Systems Less Than 120 Volts, Nominal Article 517.80 Patient Care Areas.

One of the major objectives of the requirements in Article 517 is to minimize patients' exposure to any level of current that could compromise their well-being. In general, circuits covered under Part VI are required to provide insulation and isolation equivalent to that required for the electrical power distribution system. The equivalent insulation and isolation required by 517.80 is for protection of patients from any shock hazard that could result from inadvertent contact with energized circuit conductors or parts associated with the limited energy systems.

Nurse call, intercom, speaker, cable television, and fire alarm systems are examples of the types of circuits covered by this requirement.

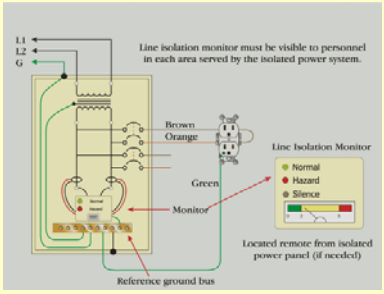
Some classes of limited energy circuits, including Class 2 and Class 3 remote control and signaling circuits as well as powerlimited fire alarm circuits that are installed in patient care spaces, are not required to comply with the same grounding or mechanical protection requirements as power and lighting circuits. This does not remove applicable installation requirements, such as the use of a raceway, if specified in Chapter 7 or Chapter 8.

VII. Isolated Power Systems Article 517.160 Isolated Power Systems.

(A) Installations.

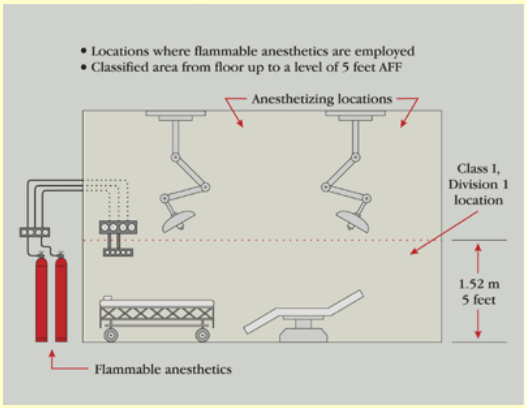
(1) Isolated Power Circuits. Each isolated power circuit shall be controlled by a switch or circuit breaker that has a disconnecting pole in each isolated circuit conductor to simultaneously disconnect all power. Such isolation shall be accomplished by means of one or more isolation transformers, by means of generator sets, or by means of electrically isolated batteries. Conductors of isolated power circuits shall not be installed in cables, raceways, or other enclosures containing conductors of another system.

(2) Circuit Characteristics. Circuits supplying primaries of isolating transformers shall operate at not more than 600 volts between conductors and shall be provided with proper overcurrent protection. The secondary voltage of such transformers shall not exceed 600 volts between conductors of each circuit. All circuits supplied from such secondaries shall be ungrounded and shall have an approved overcurrent device of proper ratings in each conductor. Circuits supplied directly from batteries or from motor generator sets shall be ungrounded and shall be protected against overcurrent in the same manner as transformer-fed secondary circuits. If an electrostatic shield is present, it shall be connected to the reference grounding point.



Isolated Power Systems
Article 517.160 Isolated Power Systems. Continued

(3) Equipment Location. The isolating transformers, motor generator sets, batteries and battery chargers, and associated primary or secondary overcurrent devices shall not be installed in hazardous (classified) locations. The isolated secondary circuit wiring extending into a hazardous anesthetizing location shall be installed in accordance with 501.10.



Isolated Power Systems
Article 517.160 Isolated Power Systems. Continued

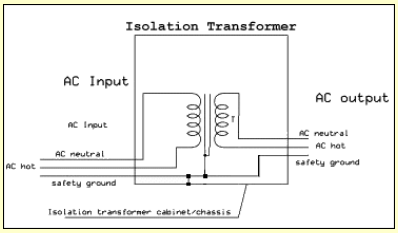
(4) Isolation Transformers. An isolation transformer shall not serve more than one operating room except as covered in (A)(4)(a) and (A)(4)(b).
For purposes of this section, anesthetic induction rooms are considered part of the operating room or rooms served by the induction rooms.

(a) *Induction Rooms.* Where an induction room serves more than one operating room, the isolated circuits of the induction room shall be permitted to be supplied from the isolation transformer of any one of the operating rooms served by that induction room.
(b) *Higher Voltages.* Isolation transformers shall be permitted to serve single receptacles in several patient areas where the following apply:
(1) The receptacles are reserved for supplying power to equipment requiring 150 volts or higher, such as portable X-ray units.
(2) The receptacles and mating plugs are not interchangeable with the receptacles on the local isolated power system.

Isolated Power Systems
Article 517.160 Isolated Power Systems.
Continued

(5) Conductor Identification. The isolated circuit conductors shall be identified as follows:
(1) Isolated Conductor No. 1 — Orange with at least one distinctive colored stripe other than white, green, or gray along the entire length of the conductor
(2) Isolated Conductor No. 2 — Brown with at least one distinctive colored stripe other than white, green, or gray along the entire length of the conductor

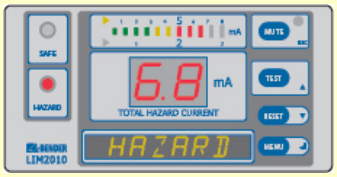
For 3-phase systems, the third conductor shall be identified as yellow with at least one distinctive colored stripe other than white, green, or gray along the entire length of the conductor.
Where isolated circuit conductors supply 125-volt, single-phase, 15- and 20-ampere receptacles, the striped orange
conductor(s) shall be connected to the terminal(s) on the receptacles that are identified in accordance with 200.10(B) for connection to the grounded circuit conductor.



(6) Wire-Pulling Compounds. Wire-pulling compounds that increase the dielectric constant shall not be used on the secondary conductors of the isolated power supply.

Isolated Power Systems
Article 517.160 Isolated Power Systems.
Continued

(B) Line Isolation Monitor.
(1) Characteristics. In addition to the usual control and overcurrent protective devices, each isolated power system shall be provided with a continually operating line isolation monitor that indicates total hazard current. The monitor shall be designed such that a green signal lamp, conspicuously visible to persons in each area served by the isolated power system, remains lighted when the system is adequately isolated from ground. An adjacent red signal lamp and an audible warning signal (remote if desired) shall be energized when the total hazard current (consisting of possible resistive and capacitive leakage currents) from either isolated conductor to ground reaches a threshold value of 5 mA under nominal line voltage conditions. The line monitor shall not alarm for a fault hazard of less than 3.7 mA or for a total hazard current of less than 5 mA.
Exception: A system shall be permitted to be designed to operate at a lower threshold value of total hazard current. A line isolation monitor for such a system shall be permitted to be approved, with the provision that the fault hazard current shall be permitted to be reduced but not to less than 35 percent of the corresponding threshold value of the total hazard current, and the monitor hazard current is to be correspondingly reduced to not more than 50 percent of the alarm threshold value of the total hazard current.



Isolated Power Systems
Article 517.160 Isolated Power Systems.
Continued

(2) Impedance. The line isolation monitor shall be designed to have sufficient internal impedance such that, when properly connected to the isolated system, the maximum internal current that can flow through the line isolation monitor, when any point of the isolated system is grounded, shall be 1 mA.

(3) Ammeter. An ammeter calibrated in the total hazard current of the system (contribution of the fault hazard current plus monitor hazard current) shall be mounted in a plainly visible place on the line isolation monitor with the "alarm on" zone at approximately the center of the scale. *Exception: The line isolation monitor shall be permitted to be a composite unit, with a sensing section cabled to a separate display panel section on which the alarm or test functions are located.*

It is desirable to locate the ammeter so that it is conspicuously visible to persons in the anesthetizing location.

COMMON ELECTRICAL CODE TOPICS PRESENTATION

Presented By

Instructors of the Ohio Chapter

International Association of Electrical Inspectors

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