

GPS 140 NEC Requirements for Generators





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Key Code References

WHERE WILL YOU FIND GENERATORS?

Q1) Where will you find generators?

- Healthcare (*NEC 517*)
- Fire Pumps (*NEC 695*)
- Emergency Life Safety (*NEC 700*)
- Legally Required Standby (*NEC 701*)
- Optional Standby (*NEC 702*)
- Interconnected Electric Power (*NEC705*)
- Critical Operations Power Systems (*NEC708*)



WHERE WILL YOU FIND GENERATORS?

- **Emergency Systems (*NEC 700 & NEC 517*)**
 - Loads essential for safety of human life
 - ◆ Exit lights, egress lighting, egress elevators
 - ◆ Fire monitoring and exhaust fans
 - ◆ Healthcare life safety and critical circuits
- **Legally Required Standby (*NEC 701*)**
 - Loads that could create hazards, hamper rescue or fire fighting
 - ◆ Elevators, communication & lighting systems
 - ◆ Hazardous industrial processes (heating & refrigeration)
 - ◆ Ventilation and smoke removal
 - ◆ Sewage disposal



WHERE WILL YOU FIND GENERATORS?

Optional Standby (*NEC 702*)

- **Laboratories (drugs)**
 - Experiments in process
 - Inventory
- **Radio & TV stations**
 - Advertising
 - Non-emergency broadcast
- **Data centers**
 - Uptime availability
- **Food storage & processing**
 - Spoilage of product
 - Inability to ship
- **Internet service providers**
 - Customer satisfaction
- **Communications companies**
 - 911 function battery backed
 - Up-time marketability
- **Gaming industry**
 - Revenue

WHERE WILL YOU FIND GENERATORS?

Optional Standby (*NEC 702*)

- **Process industries**
 - Clean up costs
- **Restaurants**
 - Lost revenue
 - Customer experience
- **Lodging industry**
 - Security & guest services
- **Retail industry**
 - Storm supplies
- **Grocery chains**
 - Revenue loss
 - Perishables
- **Banks / Financial inst.**
 - Mission critical
 - Online banking
 - Security
- **Schools**

WHAT ARE THE KEY CODES & STANDARDS FOR GENERATORS?

Q2) What are the key codes and standards for generators?



WHAT ARE THE KEY CODES & STANDARDS FOR GENERATORS?

- **National Fire Protection Association (NFPA)**
 - Independent standards organization
 - Mission is to reduce fire risks
 - Standards developed with the ANSI process
 - Standards typically adopted into state statutes
 - Require compliance for AHJ approval

- **Generator related NFPA standards**
 - 20 Installation of Fire Pumps
 - 37 Installation & Use of Stationary Engines
 - 54 National Fuel Gas Code
 - 58 LP Gas Code
 - 70 *National Electrical Code*
 - 99 Health Care Facilities
 - 110 Standard for Emergency & Standby Power Systems



WHAT ARE THE KEY CODES & STANDARDS FOR GENERATORS?

- **Underwriters Laboratories (UL) & Intertek (ETL)**
 - Develops standards & test procedures
 - Administers the application of the UL & ETL marks
 - Focused on product safety and usability
 - UL & ETL do not “approve”
 - AHJ often use UL ETL listing as “approved for use”
- **Power Generation related standards**
 - 2200 Stationary Engine Generators
 - 1008 Automatic Transfer Switches
 - 891 Dead Front Panel Board
 - 142 Liquid Storage Tanks



WHAT ARE THE KEY CODES & STANDARDS FOR GENERATORS?

- **Generator related *NEC* articles**

- *NEC* 100 Definitions
- *NEC* 215 & 225 Feeders
- *NEC* 240 Overcurrent Protection
- *NEC* 250 Grounding
- *NEC* 445 Generators
- *NEC* 517 Healthcare
- *NEC* 695 Fire Pumps
- *NEC* 700 Emergency Systems
- *NEC* 701 Legally Required Standby
- *NEC* 702 Optional Standby
- *NEC* 705 Interconnected Electric Power Sources
- *NEC* 708 Critical Operations Power Systems



WHAT ARE THE KEY CODES & STANDARDS FOR GENERATORS?

- **Key cross references**

- *NEC 700* (Emergency Systems)
 - ◆ *NEC 517* (health care - wiring & installation)
 - ◆ NFPA 99 (health care - performance & maintenance)
 - ◆ NFPA 101 (life safety code)
 - ◆ NFPA 110 (standard for emergency and standby power systems)
- *NEC 517* (Health Care Facilities)
 - ◆ NFPA 99
 - ◆ Type I & II classified NFPA 110, Level 1, Type 10, Class X
 - ◆ Type III classified NFPA 110, Level 2, Type 10, Class X
- NFPA 99 (Health Care Facilities)
 - ◆ NFPA 110



WHAT IS A GENERATOR?

Q3) What is a generator?

- Prime mover (engine) & alternator



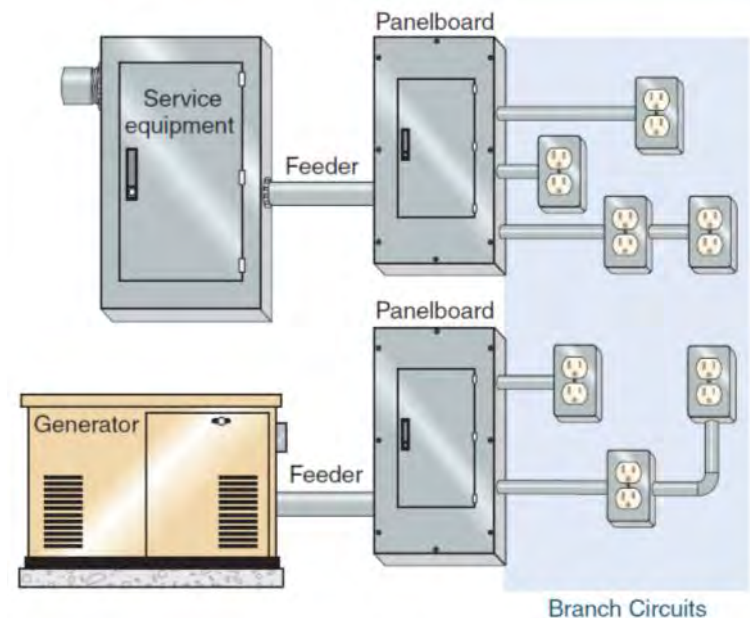
WHAT IS A GENERATOR?

Generator Cabling - Feeder or Service?

The generator cabling is considered a feeder. It does not matter if the generator is separately derived or not. Reference the feeder articles (*NEC* 215 & 225) when installing generators.

Feeder (*NEC* 100)

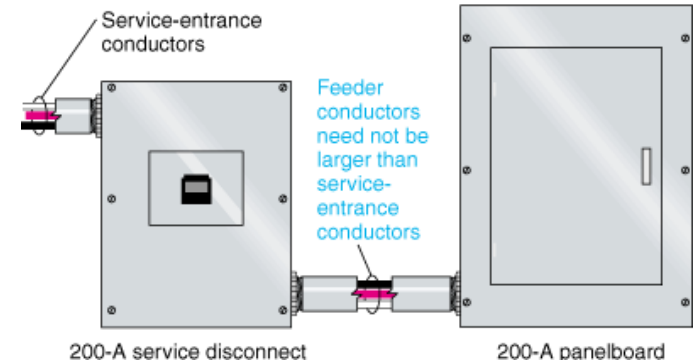
“All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device.”



WHAT IS A GENERATOR?

Generator Cabling - Feeder or Service?

The generator cabling is not a service.
Only the utility can be a service.



Service (*NEC 100*)

“The point of connection between the facilities of the serving utility and the premises wiring.”

The definition of service was modified for the 1999 Code to state that electric energy to a service can be supplied only by the serving utility. If electric energy is supplied by other than the serving utility, the supplied conductors and equipment are considered feeders, not a service.”



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Generator Requirements

WHAT IS THE REQUIRED GENERATOR SIZE (CAPACITY)?

Q4) What is the required generator size (capacity)?

- NEC 700.4 (Emergency System)
 - ◆ “...adequate capacity and rating to safely carry, at one time, the entire load connected to it.”

- NEC 701.4 (Legally Required Standby)
 - ◆ “in accordance with article 220 or by another approved method”

- NEC 702.4 (Optional Standby)
 - ◆ “... in accordance with article 220 or by another approved method”
 - ◆ Assuming PE stamp will meet AHJ approval

- NEC 517.30 D (Health Care Facilities)
 - ◆ “... to meet the maximum actual demand likely to produced...”
 - ◆ “NEC 700.4 & NEC 701.4 shall not be applied to hospitals”
 - ◆ Practical sizing based on actual demand likely

HOW QUICKLY MUST A GENERATOR STARTUP & TRANSFER?

Q5) How quickly must a generator startup and transfer?

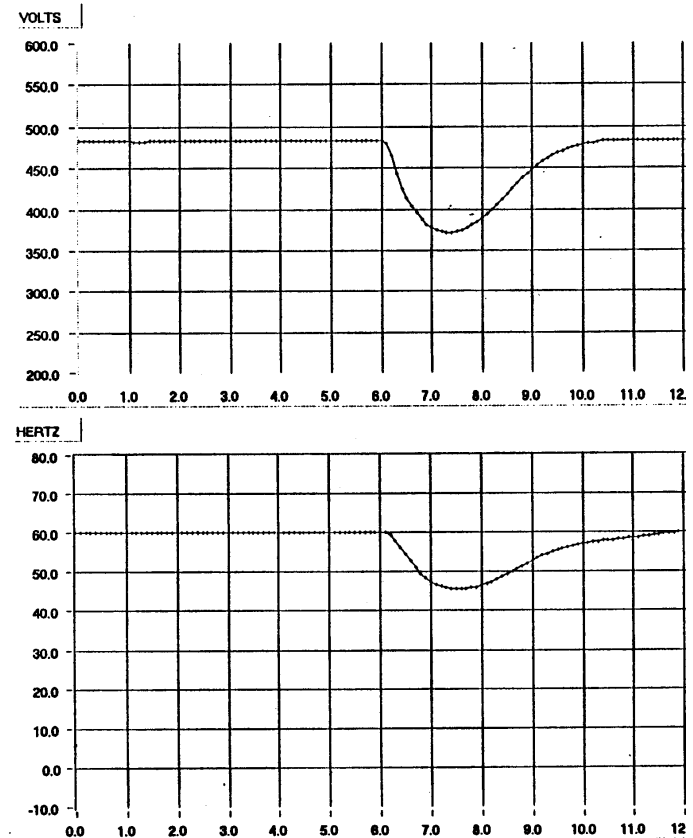
- **No defined start-up time**
 - NEC 702 (Optional Standby)
- **10 sec start-up time**
 - NEC 700.12 (Emergency Systems – General Requirements)
 - NFPA 20, 9.6.2.1 (Fire Pumps)
 - NEC 517.31, & NFPA 99 6.5.3.1 (Health Care Facilities)
 - ◆ Critical & life safety loads
- **60 sec start-up time**
 - NEC 701.12 (Legally Required Standby)
- **Variably defined start-up**
 - NFPA 110 4.1 (Emergency & Standby Power Systems)



WHAT TRANSIENT LIMITS ARE REQUIRED BY THE NEC?

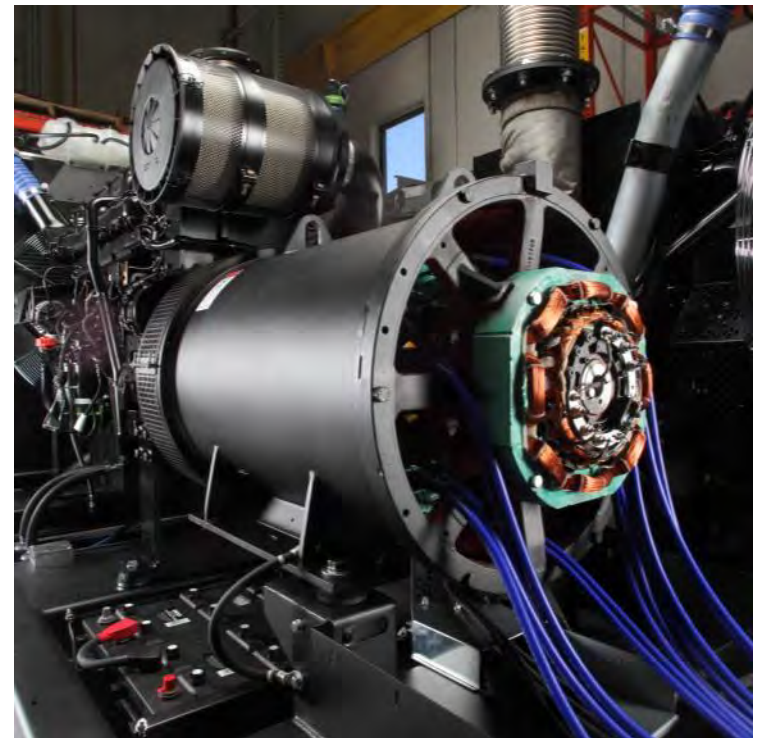
Q6) What transient (voltage & frequency) limits are required by the *NEC*?

- **Undefined load transients**
 - *NEC* 700 (Emergency Systems)
 - *NEC* 701 (Legally Required Standby)
 - *NEC* 702 (Optional Standby)
- **Transients acceptable to the load**
 - NFPA 110 5.6.9.8



WHAT TRANSIENT LIMITS ARE REQUIRED BY THE NEC?

- **What items affect load transients?**
 - Size of load and its characteristics
 - Motor starting codes and starting methods
 - Engine size & fuel type (frequency dips)
 - Alternator size (voltage dips)



WHAT ALARMS & INSTRUMENTATION ARE REQUIRED?

Q7) What alarms and instrumentation are required?

- **NEC 700 (Emergency Systems)**
 - Malfunction, carrying load, battery charger failure, ground fault indication (conditional)
- **NEC 701 (Legally Required Standby)**
 - Malfunction, carrying load, battery charger failure, ground fault indication (conditional)
- **NEC 702 (Optional Standby)**
 - Malfunction, carrying load
- **NFPA 110, 5.6.5**
(Emergency & Standby Systems - Control Functions)
 - Alarms & instrumentation



WHAT ALARMS & INSTRUMENTATION ARE REQUIRED?

Table 5.6.5.2 Safety Indications and Shutdowns

Indicator Function (at Battery Voltage)	Level 1		
	CV	S	RA
(a) Overcrank	X	X	X
(b) Low water temperature	X	NA	X
(c) High engine temperature pre-alarm	X	NA	X
(d) High engine temperature	X	X	X
(e) Low lube oil pressure	X	X	X
(f) Overspeed	X	X	X
(g) Low fuel main tank	X	NA	X
(h) Low coolant level	X	O	X
(i) EPS supplying load	X	NA	NA
(j) Control switch not in automatic position	X	NA	X
(k) High battery voltage	X	NA	NA
(l) Low cranking voltage	X	NA	X
(m) Low voltage in battery	X	NA	NA
(n) Battery charger ac failure	X	NA	NA
(o) Lamp test	X	NA	NA
(p) Contacts for local and remote common alarm	X	NA	X
(q) Audible alarm silencing switch	NA	NA	X
(r) Low starting air pressure	X	NA	NA
(s) Low starting hydraulic pressure	X	NA	NA
(t) Air shutdown damper when used	X	X	X
(u) Remote emergency stop	NA	X	NA

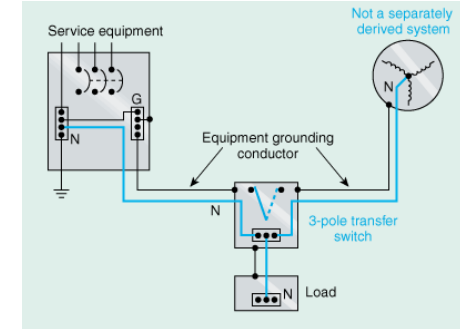
CV: Control panel-mounted visual. S: Shutdown of EPS indication. RA: Remote audible. X: Required. O: Optional



WHAT ARE THE GENERATOR SIGNAGE REQUIREMENTS?

Q8) What are the generator signage requirements?

- **NEC 700, 701, & 702 (all generator applications)**
 - Generator on-site sign
 - ◆ Located at the service
 - ◆ Generator type & location indicated
 - Generator grounding sign
 - ◆ Indicate all sources connected to the grounding electrode
 - ◆ Only applies if connection point is remote from the generator
 - ◆ Point where the grounding conductor connects to grounding electrode conductor
 - ◆ Typically at the service
- **NEC 445 (updated manufacturer marking & instruction requirements)**
 - Clarified nameplate requirements
 - Alternator reactance information
 - Alternator bonding (frame or external)





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Disconnect & Generator Breaker Requirements

WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

Q9) What are the requirements for disconnects?

In practice, we see some markets require a disconnect at building entry and other market accept the internal generator breaker. This is an area of the code that has a strong local jurisdiction component. The following slides will explore the codes verbiage on this topic.

Q9a) Does the *NEC* require a generator disconnect (breaker)?

Q9b) What are the generator breaker accessibility requirements?

Q9c) Is a disconnect required at the point of building entry (additional disconnect)?

Q9d) Are there any exceptions to adding an additional disconnect?

Q9e) What are the requirements for “within sight of”?

Q9f) What are the requirements for “readily accessible”?

WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

Q9a) Does the *NEC* require a generator disconnect (breaker)?

- The generator (itself) does not need a disconnect (conditional)
 - ◆ Generator must have shutdown provisions (internal & external E-Stop)
 - ◆ *NEC* seems to have a preference for including a generator breaker
 - ◆ Market norm is to utilize a generator breaker
 - ◆ UL2200 may require some generators to have a disconnect (conditional on UL testing process)

***NEC* 445.18 Disconnecting Means Required for Generators**

“Generators other than cord-&-plug portable generators shall have one or more disconnecting means ...”

“The provisions to shutdown the prime mover shall be permitted to satisfy the requirements of 445.18(A)” A lockable E-stop is allowed instead of disconnect.

WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

Q9b) What is the generator's breaker accessibility requirement?

- Generator breakers sometimes get higher due to sub-base fuel tanks
- If the generator breaker is **not**, the disconnect for building entry
 - NEC 404.8 exception #2 allows the generator breaker to be higher than 6' 7"

NEC 404.8 Accessibility and Grouping

“**Location.** All switches and circuit breakers used as switches shall be located.... not more than 2.0 m (6 ft 7 in.) above the floor or working platform.”

“**Exception No. 2:** Switches and circuit breakers installed adjacent to motors, appliances, or other equipment that they supply shall be permitted to be located higher than 2.0m (6 ft. 7 in.) and to be accessible by portable means.”

WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

Q9c) Is a disconnect required at the point of building entry?

- NEC 225.32 requires a disconnect at the point of building entrance

NEC 225 Outside Feeders

- NEC 225.31 Requires a disconnect
- NEC 225.32 Location

“... The disconnecting means shall be at a readily accessible location nearest the point of entrance of the conductors. For the purposes of this section, the requirements in 230.6 shall be permitted to be utilized.”

This seems to imply that an additional disconnect is required in addition to the generator breaker... **unless exempted in another part of the code.**

WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

Q9d) Are there any exceptions to adding an additional disconnect?

- Yes, chapter 7 allows the disconnect to be relocated.
- This is an area of local interpretation (what needs to be visible).
- This would allow the generator breaker to function as the required disconnect.

NEC 700.12(B)(6) Outdoor Generator Sets

NEC 701.12(B)(5) Outdoor Generator Sets

NEC 702.12 Outdoor Generator Sets

“Where an outdoor housed generator set is equipped with a readily accessible disconnecting means in accordance with 445.18, and the disconnect means is located within sight of the building or structure supplied, an additional disconnecting means shall not be required where ungrounded conductors pass through the building or structure.”

What needs to be visible? Building or Disconnect

Where are you standing? At disconnect or at building

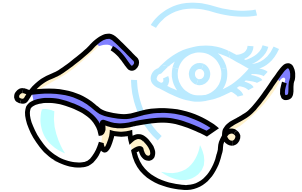
How is generator “box” any different than a disconnect box?



WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

Q9e) What is “within sight of”?

Visible and not more than 15 m (50 ft) distance from each other.



Q9f) What is “readily accessible”?

“Accessible, Readily (Readily Accessible). Capable of being reached quickly for operation, renewal or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, and so forth.”

Handbook:

“... The definition of readily accessible does not preclude the use of a locked door for service equipment or rooms containing service equipment, provided those for whom ready access is necessary have a key (or lock combination) available.”

WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

What if the generator is more than 50' from building?

“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.”

Generator Disconnect Summary:

In the market, we see significant variations on the use of an additional disconnect at the point of entry of the generator cabling. Ultimately this is an issue that is largely affected by local norms and AHJ interpretation and preferences.



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Cabling & Coordination

WHAT ARE THE REQUIREMENTS FOR GENERATOR CABLING?

Q10) What are the requirements for generator cabling?

- Size to the generator breaker (or)
- Size to 445.13
 - ◆ Size to 115% of the generator rating (or)
 - ◆ Size to 100% of the generator rating (if generator has overload protection)

NEC 445.13 (Generator - 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...”

“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.”

Generators may be protected against overload via the control system.

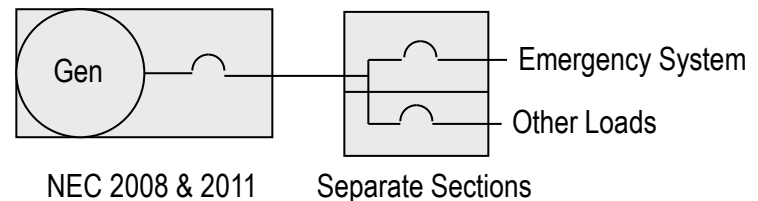
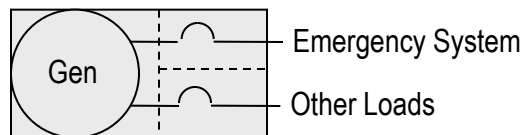
WHAT ARE THE REQUIREMENTS FOR SEPARATION OF CIRCUITS?

Q11) What are the requirements for separation of circuits?

- The emergency system wiring must be separated
- Emergency system breaker must be in a separate vertical section (NEC 2008) (or)
- Emergency system breaker must be located in the generator connection box

NEC 700.10 (Emergency Systems – Wiring)

- “... Wiring from an emergency source OR emergency source distribution overcurrent protection to emergency loads shall be kept entirely independent of all other wiring and equipment, unless otherwise permitted”



WHAT ARE THE REQUIREMENTS FOR COORDINATION?

Q12) What are the requirements for coordination?

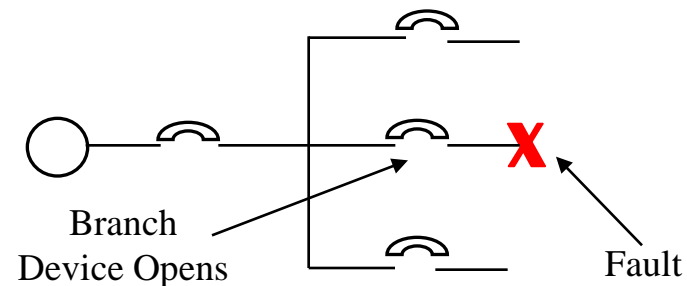
- A fault in the optional standby circuit shall not trip the other circuits
- Goal is to maintain continuity of power to emergency and legally required loads
- Not required for optional standby (*NEC 702* only) applications
- Hospital essential systems coordination in first .1 sec not required (*NEC 517.31(G)*)

NEC 700.32 (Emergency System – Coordination)

and

NEC 701.32 (Legally Required Standby – Coordination)

“... over-current devices shall be selectively coordinated with all supply side over-current protective devices”





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Grounding & Ground Fault

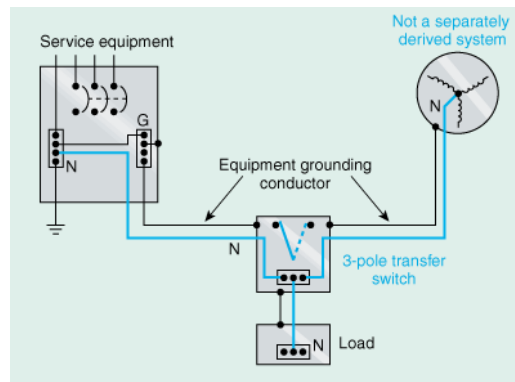
WHAT ARE THE GROUNDING REQUIREMENTS FOR THE GENERATOR?

Q13) What are the grounding requirements for the generator?

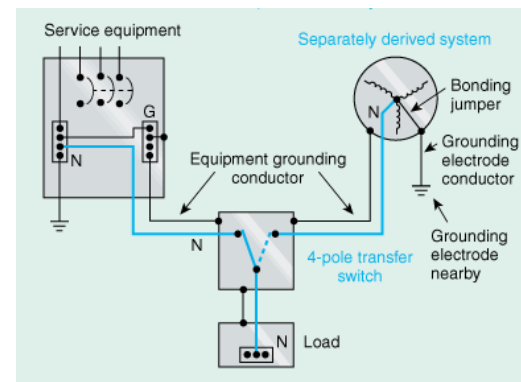
- Generator systems can be separately derived (4 pole ATS)
- Generator systems can be non-separately derived (3 pole ATS)

NEC 250.30 (Grounding Separately Derived Alternating-Current Systems)

“Informational Note 1: An alternate ac power source such as an on-site generator is not a separately derived system if the neutral is solidly interconnected to a service-supplied system neutral.”



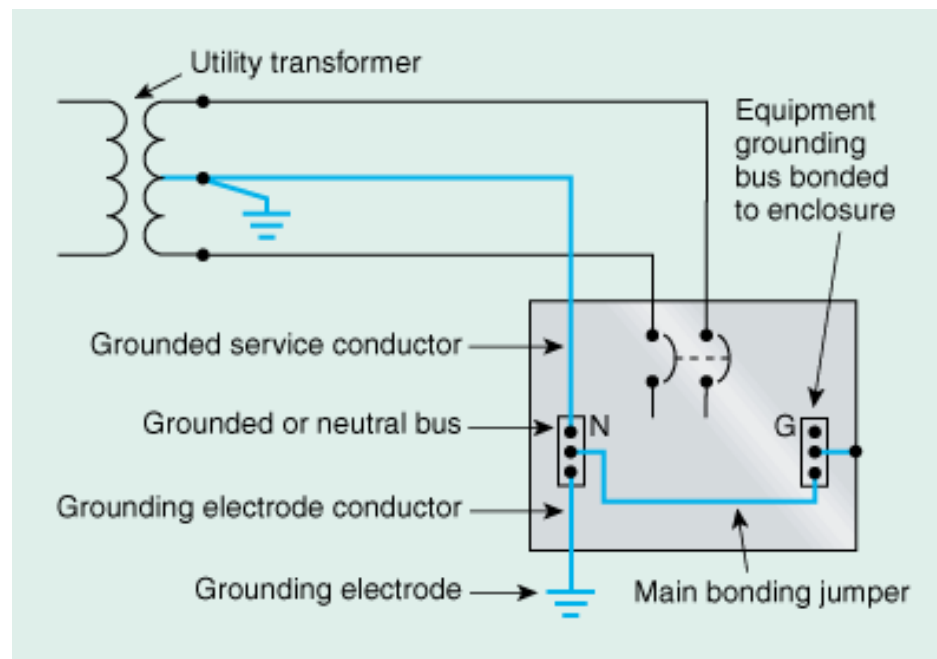
3-Pole, Neutral Not Switched



4-Pole, Switched Neutral

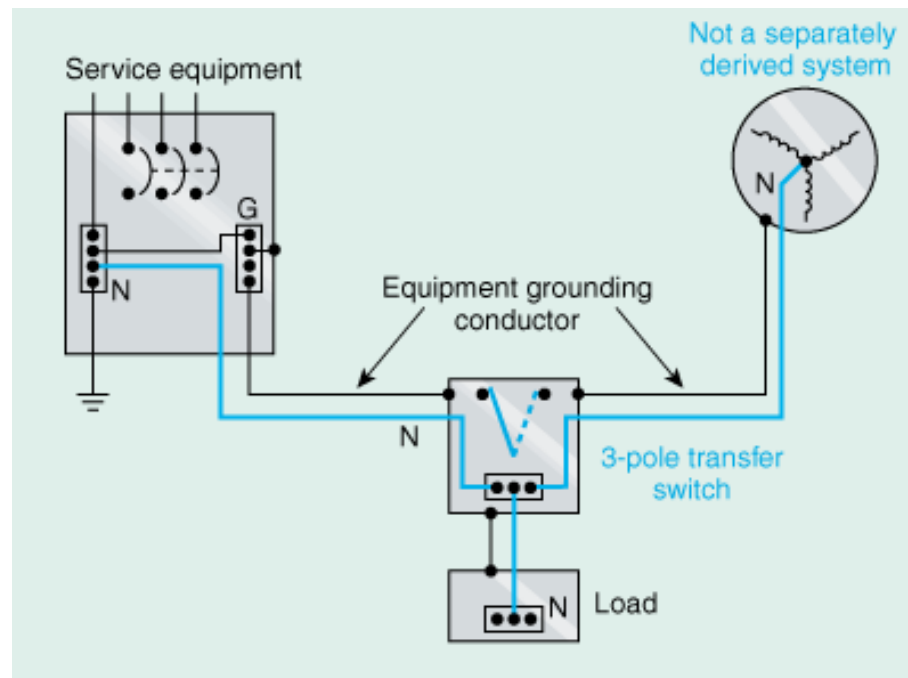
WHAT ARE THE GROUNDING REQUIREMENTS FOR THE GENERATOR?

- **Bonding - Neutral conductor to Grounding conductor**
 - Single point of neutral bonding per system
 - ◆ Main bonding jumper
 - ◆ Connects the facility's neutral system to the facility's ground system



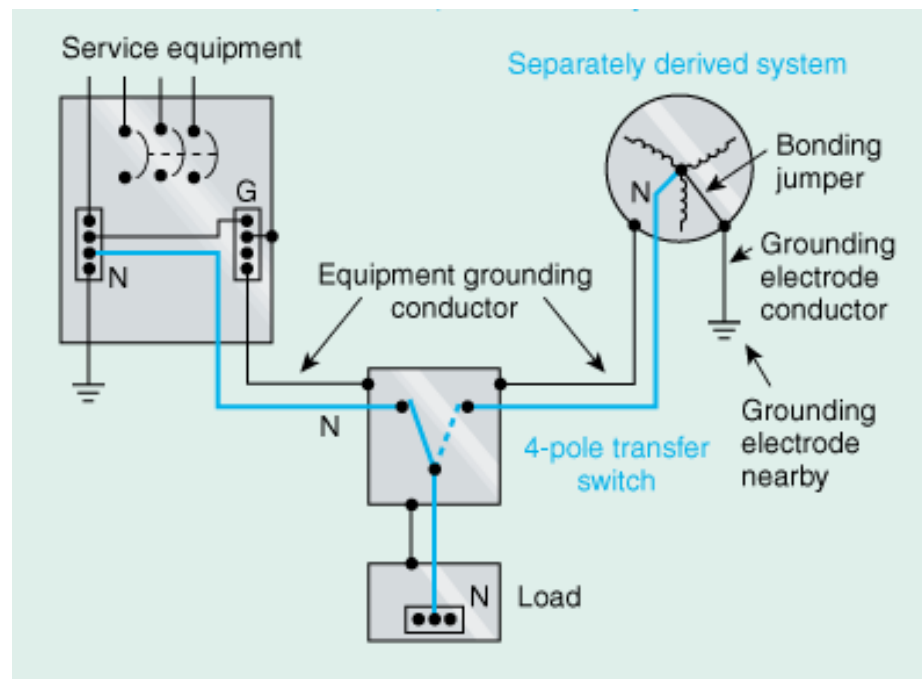
WHAT ARE THE GROUNDING REQUIREMENTS FOR THE GENERATOR?

- **Non-separately derived system (3 pole ATS)**
 - Generator neutral bonded to system ground at the service
 - Generator frame requires equipment grounding conductor
 - ◆ Ground rod at generator is not adequate



WHAT ARE THE GROUNDING REQUIREMENTS FOR THE GENERATOR?

- **Separately derived system (4 Pole ATS)**
 - Generator neutral bonded to system ground at the generator
 - Generator frame requires equipment grounding connection to ATS
 - ◆ Grounding electrode(s) needs to be “nearby”



ARE GENERATORS REQUIRED TO HAVE GFI OR GFP?

Q14) Are generators required to have GFI or GFP?

- Emergency generators (480v, 1000amps) require GFI
- **NEC 700.6 (D) (Emergency Systems – Ground Fault)**
 - “To indicate a ground fault in solidly grounded wye emergency 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 emergency 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 the event of indicated ground fault shall be located at or near the sensor location.”

ARE GENERATORS REQUIRED TO HAVE GFI OR GFP?

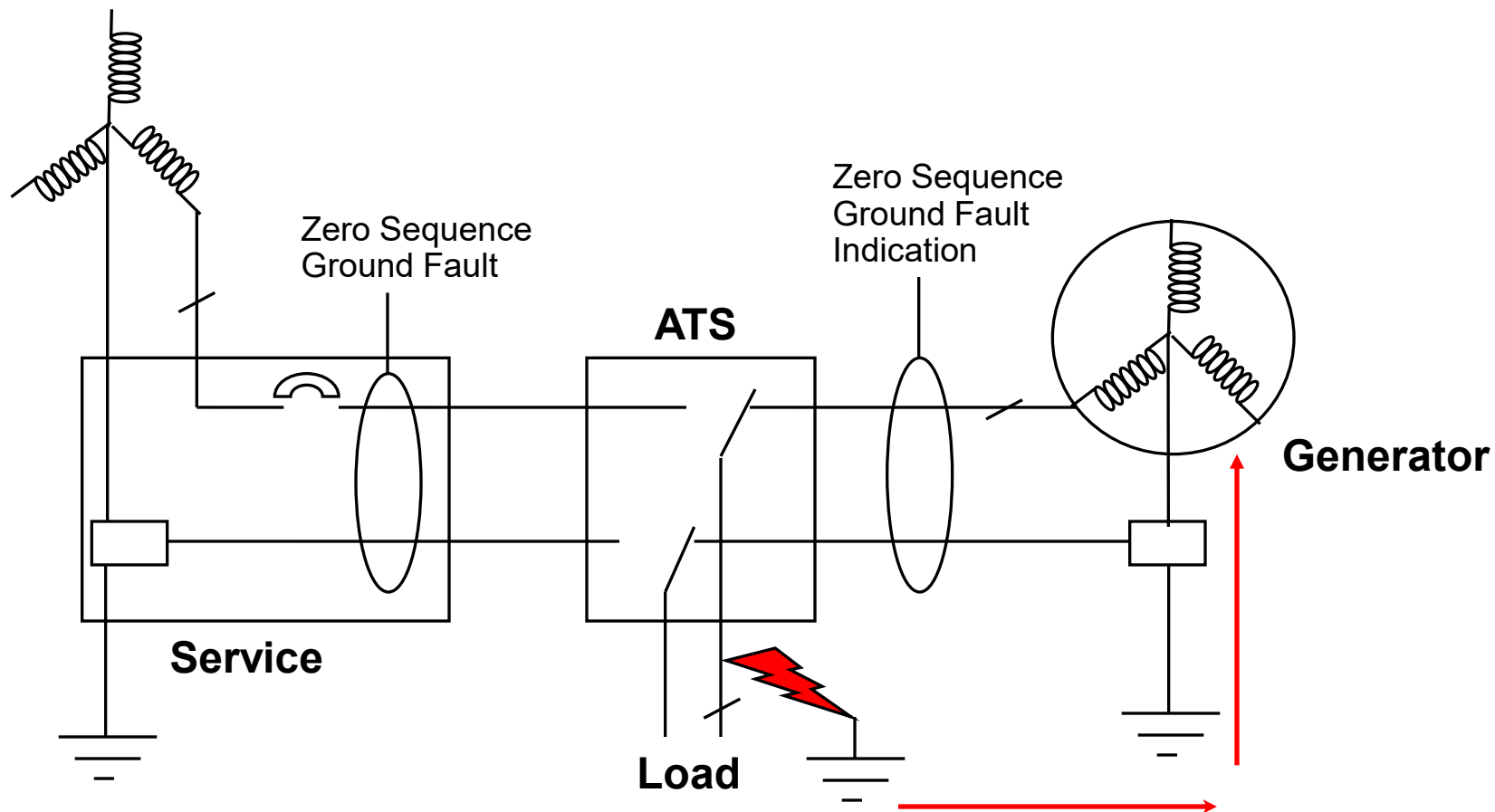
Q14) Are generators required to have GFI or GFP?

- Legally required generators do not require GFI or GFP
- Optional standby generators typically don't include GFP
- Optional standby (480v, 1000 amps) could be required to include GFP

- **NEC 701.31 (Legally Required Standby -- Ground-Fault Protection of Equipment)**
 - “The alternate source for legally required standby systems shall not be required to provide ground-fault protection of equipment with automatic disconnecting means.

- **NEC 702 (Optional Standby)**
 - No comment on GFP or GFI
 - **NEC 215.10 Feeder Ground-Fault Protection of Equipment**
 - ◆ “Each feeder disconnect rated 1000 amperes or more and installed on solidly grounded wye electrical systems of more than 150 volts to ground, but not exceeding 600 volts phase-to-phase, shall be provided with ground-fault protection of equipment in accordance with the provisions of 230.95.”
 - ◆ Not required for the more important *NEC 700* & *NEC 701* loads
 - ◆ Area of local interpretation

ARE GENERATORS REQUIRED TO HAVE GFI OR GFP?





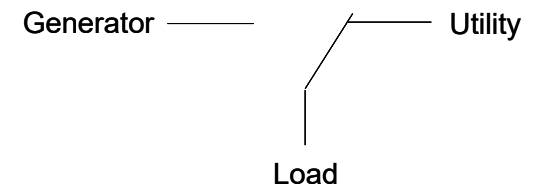
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Transfer Switches

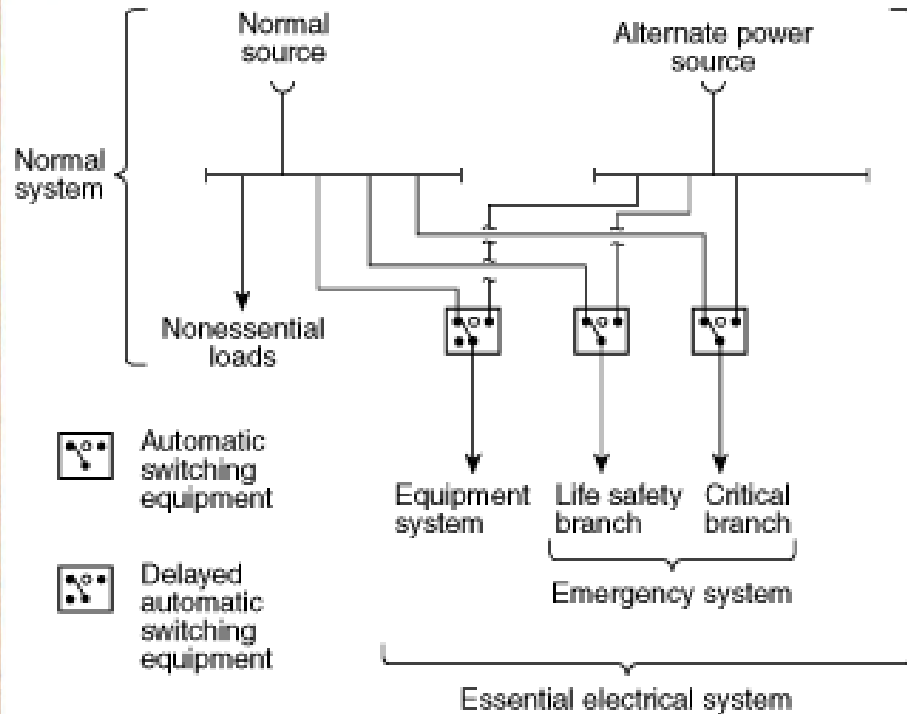
WHAT ARE THE CODE REQUIREMENTS FOR TRANSFER SWITCHES?

Q15) What are the code requirements for transfer switches?

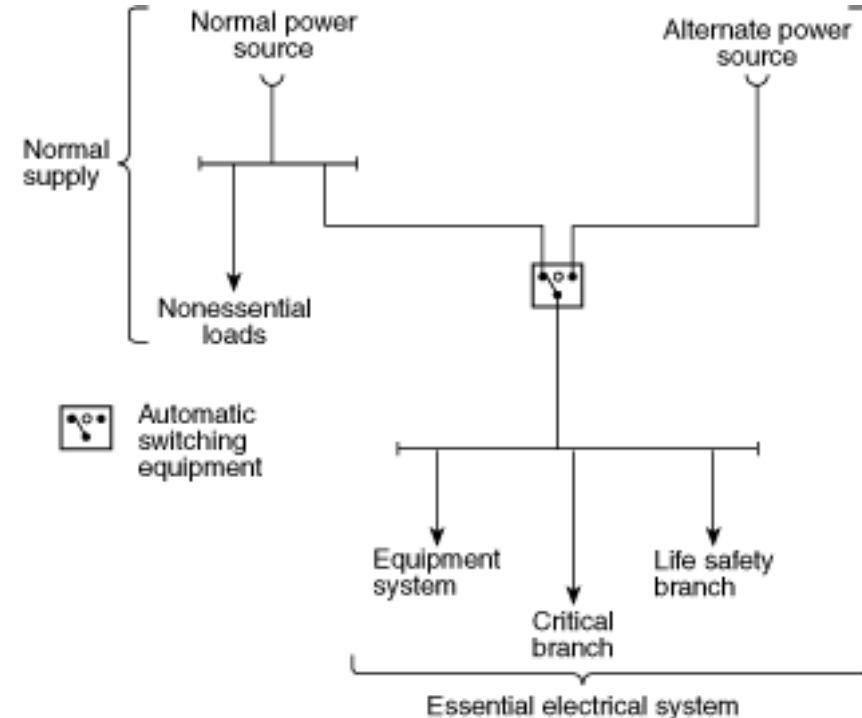
- **NEC 700.5 (Emergency Systems – Transfer Equipment)**
and
- **NEC 701.5 (Legally Required Standby – Transfer Equipment)**
 - Automatic
 - Approved (listed)
 - Mechanically held
 - Interlocked against inadvertent grid interconnect
 - Dedicated to emergency loads (*NEC 700* only)
 - Bypass Isolation allowed
 - Grid paralleling allowed
- **NEC 517.31 (Healthcare)**
 - Separation of loads (life safety, critical and equipment)
 - Priority loading
 - Load shedding



WHAT ARE THE CODE REQUIREMENTS FOR TRANSFER SWITCHES?



Hospital — Greater than 150 kVA



Hospital — Less than 150 kVA



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Fire Pumps (NEC 695 and NFPA 20)

WHAT SIZE IS THE GENERATOR BREAKER FOR A FIRE PUMP?

Q16) What size is the generator breaker for a fire pump?

- We have seen multiple requests for magnetic only breakers.
 - We have seen multiple requests for breakers at 7x running amps.
 - We feel this is a misinterpretation of *NEC* 695 requirements.
- **Code is confusing, resulting in this behavior**
 - *NEC* 695.4(B)(2)(a) (Fire Pumps - Overcurrent Device Selection)
Individual Sources -- Utility
 - “set to indefinitely carry the sum of locked rotor current”



WHAT SIZE IS THE GENERATOR BREAKER FOR A FIRE PUMP?

- **NEC 695 is also confusing on the issue of overload**
 - NEC defines overload protection very specifically
 - Overload protection is defined in 430.32 (limited to 125% of rated)
 - If overcurrent protection is larger than 125% of rated amps
 - ◆ The circuit has no protection against overload (based on the NEC definition).
 - ◆ The circuit has short circuit protection only.
- **Example of verbiage that causes misinterpretation**
 - **NEC 695.6(C)** (Fire Pump - Power Wiring - Overload Protection)

“Power circuits shall not have automatic protection against overloads. ... branch circuits and feeder conductors shall be protected against short circuit only.”

WHAT SIZE IS THE GENERATOR BREAKER FOR A FIRE PUMP?

- **NEC 695 specifies the requirements for the generator**
 - Sized for normal starting & running
 - Not sized for locked rotor amps

NEC 695.3(D)(1) (Fire Pumps – Generator Capacity)

“Generator Capacity. The generator shall have sufficient capacity to allow normal starting and running

Handbook:

Only the sources specified in 695.3(A)(1) through (3) are required to be capable of indefinitely carrying the locked-rotor current of the fire pump motor. On-site standby generators are required only to be capable of carrying the starting and running current of the fire pump motor.

WHAT SIZE IS THE GENERATOR BREAKER FOR A FIRE PUMP?

- **NEC 695 defines the size of the generator's fire pump breaker**
 - Generator's fire pump breaker is between 125% to 250% of rated amps
 - This provides no overload protection (>125%)
 - NEC 430 limits the maximum size to 250%
- **NEC 695.4(B)(2)(b) (Fire Pumps - Overcurrent Device Selection)**
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.”



WHAT ARE OTHER REQUIREMENTS FOR FIRE PUMPS?

Q17) What are other requirements for fire pumps?

- **Voltage dip limited to 15% for normal starting**
 - Mechanical over-ride starting must be supported (15% voltage dip does not apply)
- **ATS must be fire pump rated**
- **Generator breaker**
 - Separation of circuits
 - Locked closed
- **Generator must meet requirements for NFPA 110 Level 1**
 - Reliable fuel (AHJ may require on-site fuel)
 - NFPA 110 testing, maintenance and recording requirements





Questions?