PROFESSIONAL DEVELOPMENT SEMINAR SERIES

GPS-140
National Electric Code (NEC)

NEC REQUIREMENTS FOR GENERATORS

(Based on NEC 2005 with limited 2008 commentary)

AIA certified Continuing Education Units (CEU) Available

The Presenters

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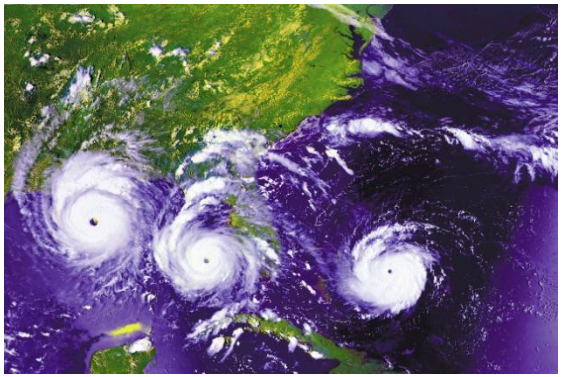
Where will you find generators?

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 Power (NEC 705)
- Critical Power Systems (NEC 708 – 2008)



What are the key codes and standards for generators?

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

What are the key codes and standards for generators?

- **National Fire Protection Association (NFPA)**
  - Mission is to reduce fire risks
  - 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 Electric Code
  - 99 Health Care Facilities
  - 110 Standard for Emergency & Standby Power Systems

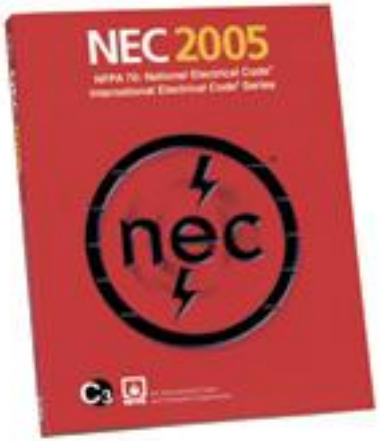
What are the key codes and standards for generators?

- **Underwriters Laboratories (UL)**
  - Focused on product safety and usability
  - UL does not “approve”
  - AHJ often use UL listing as “approved for use”

- **Power Generation related UL standards**
  - 2200 Stationary Engine Generators
  - 1008 Automatic Transfer Switches
  - 891 Dead Front Panel Board
  - 142 Liquid Storage Tanks

What are the key codes and standards for generators?

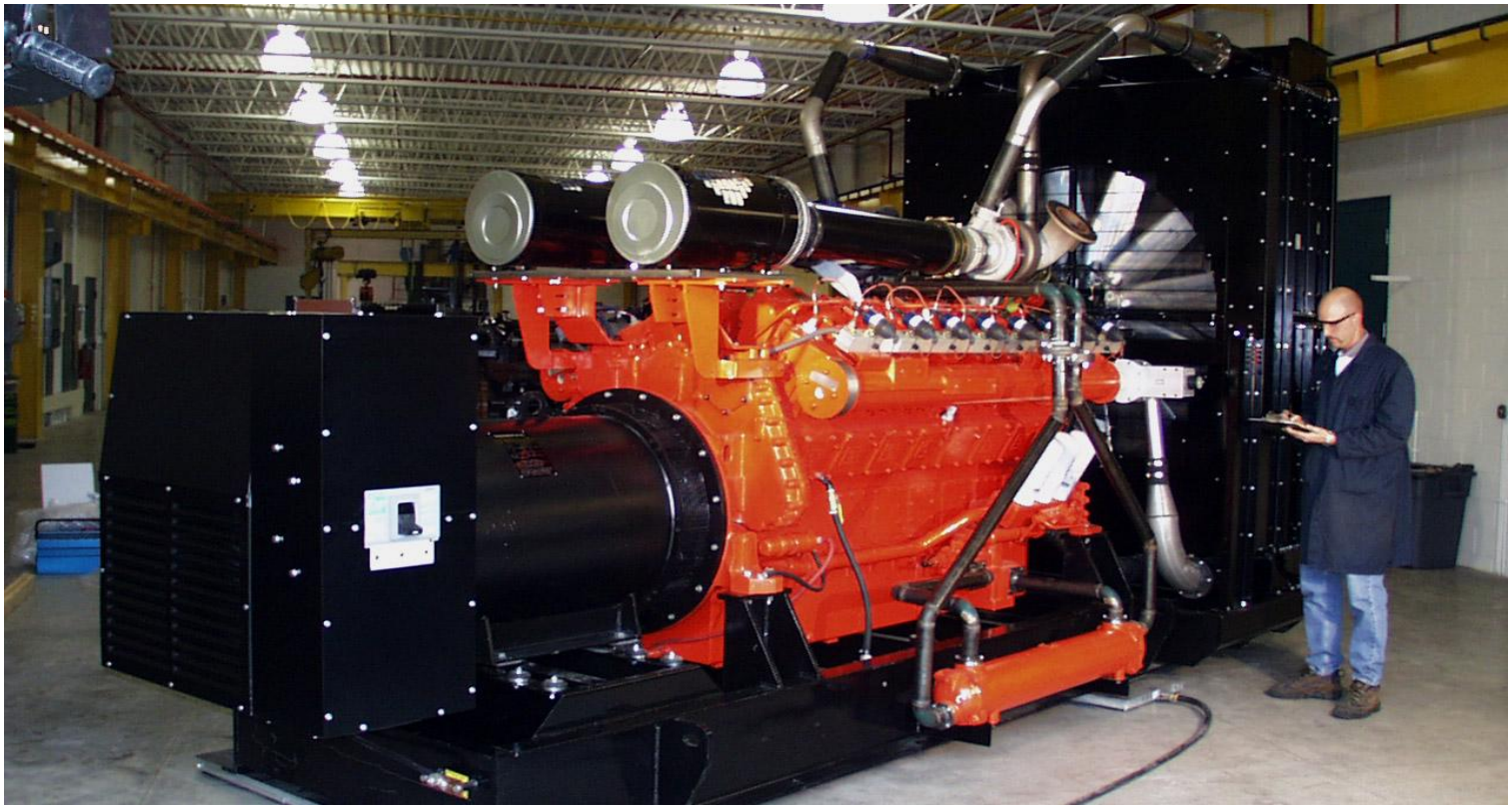
- **Generator related *NEC* articles**
  - *NEC* 100 Definitions
  - *NEC* 215 & 225 Feeders
  - *NEC* 240 Overcurrent Protection
  - *NEC* 250 Grounding
  - *NEC* 445 Generators
  - *NEC* 517 Healthcare
  - *NEC* 695 Fire Pumps
  - *NEC* 700 Emergency Systems
  - *NEC* 701 Legally Required Standby
  - *NEC* 702 Optional Standby
  - *NEC* 705 Interconnected Electric Power Sources
  - *NEC* 708 "2008" Critical Power Systems



What is a generator?

Q3) What is a generator?

- Prime mover (engine) & alternator



What is a generator?

Generator Cabling - Feeder or Service?

- 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

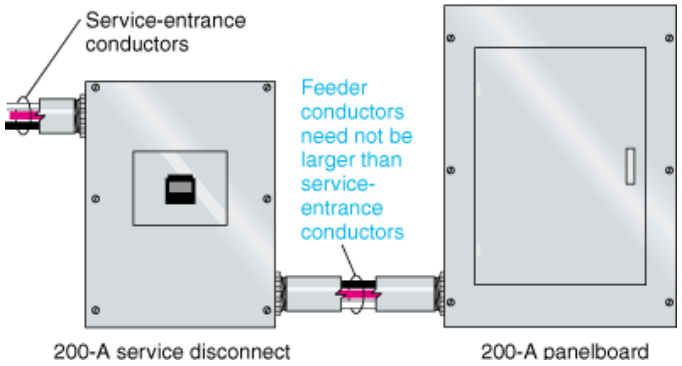
Feeder (*NEC* 100)

"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 conductors and equipment for delivering electric energy **from the serving utility** to the wiring system of the premises served."

Handbook:

"If electric energy is **supplied by other than the serving utility**, the supplied conductors and equipment are **considered feeders**, not a service."

What is the required generator size?

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

- Emergency System (*NEC* 700.5)
  - "Carry the **entire load connected** to the emergency system at one time"
- Legally Required Standby (*NEC* 701.6) & Optional Standby (*NEC* 702.5)
  - "Supply of all **equipment intended to be operated** at one time"
  - Sizing based on **NEC 220** or AHJ approved method (NEC 702.5 (2008))
- Health Care Facilities (*NEC* 517.30 D)
  - "Meet the **demand of the essential load at any given time**."

How quickly must the generator startup?

Q5) How quickly must a generator startup and transfer?

- **10 sec start-up time**
  - Emergency Systems (*NEC* 700.12)
  - Fire Pumps (NFPA 20, 9.6.2.1)
  - Health Care Facilities (NEC 517.31, & NFPA 99 3-4.3.1)
- **60 sec start-up time**
  - Legally Required Standby *(NEC* 701.11)
- **No defined start-up time**
  - Optional Standby (*NEC* 702)

General Points Summary

- NFPA & UL are key codes & standards
- Generator is considered a feeder – not service
- Generator sizing & start time based on load classification

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DISCONNECT REQUIREMENTS

What are the requirements for disconnect?

Q6) What are the requirements for disconnect?

Q6a) Does the *NEC* require a generator disconnect (breaker)?

Q6b) Is a disconnect required at the point of building entry (additional disconnect)?

Q6c) Are there any exceptions to adding an additional disconnect?

This is an area of the code that is not overly clear. The following slides will explore the codes verbiage on this topic.

What are the requirements for disconnect?

Q6a) Does the *NEC* require a generator disconnect (breaker)?

- *NEC* preference & market norm includes a generator output breaker
- Disconnect at the generator may be optional

Disconnecting Means Required for Generators (*NEC* 445.18)

"**Generators shall be equipped with a disconnect(s) 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:

(1) The driving means for the generator can be **readily shut down**; and
(2) The generator is **not** arranged to operate **in parallel** with another generator or other source of voltage."

What are the requirements for disconnect?

Q6b) Is a disconnect required at the point of building entry?

- A disconnect is required at the point of building entrance (*NEC* 225.32)

Outside Feeders (*NEC* 225)

- Requires a disconnect (*NEC* 225.31)
- Location (*NEC* 225.32)

"... 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:

- An additional disconnect is required in addition to the generator breaker
- Unless exempted in another part of the code

What are the requirements for disconnect?

Q6c) Are there any exceptions to adding an additional disconnect?

- Yes, chapter 7 allows the disconnect to be relocated
- This may allow the generator breaker to function as the required disconnect

Outdoor Generator Sets

- *NEC* 700.12(B)(6), *NEC* 701.11(B)(5), *NEC* 702.11

"Where an outdoor housed generator set is equipped with a **readily accessible disconnecting** means 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."

Is it the generator or the generator disconnect that must be visible from the building?

- This is an area of local interpretation (what needs to be visible)

Disconnect Summary

- **Generator disconnect may be optional**
- **Building disconnect is required**
- **A generator disconnect may meet the building disconnect requirements**

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?

Q7) What are the requirements for generator cabling?

- Size to the generator breaker (or)
- Size to 445.13
  - Size to 115% of the generator rating

Generator - Ampacity of Conductors (*NEC* 445.13)

"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…"

What are the requirements for separation of circuits?

Q8) What are the requirements for separation of circuits?

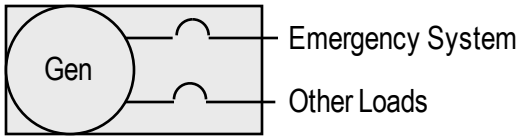
- The emergency system wiring must be separated
- Emergency system breaker may be in a separate vertical section (NEC 2008) (or)
- Emergency system breaker may be located in the generator connection box

Emergency Systems – Wiring (NEC 700.9)

"… **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."

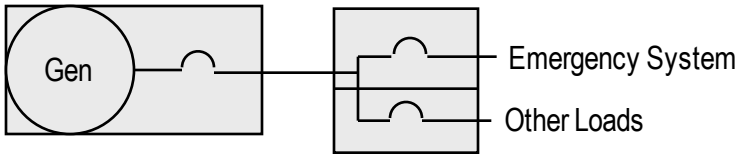
What are the requirements for separation of circuits?

- **Emergency system breaker at generator**



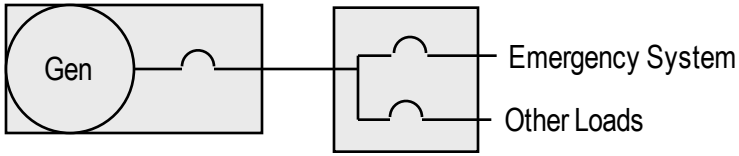
NEC 2005 & 2008

- **Emergency system breaker in separate vertical section**



NEC 2008 Separate Sections

- **Emergency system breaker in same section (interpretation)**



NEC 2005 Single Section
(Interpretation)

What are the requirements for coordination?

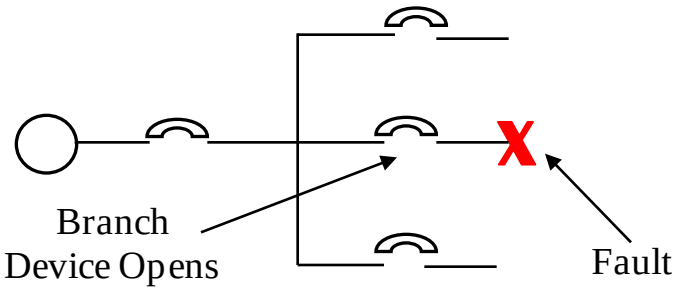
Q9) What are the requirements for coordination?

- 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 applications

Emergency System – Coordination (NEC 700.27)

Legally Required Standby – Coordination (NEC 701.18)

"… over-current devices **shall be selectively coordinated** with all supply side over-current protective devices"



Cabling & Coordination Summary

- Generator cabling can be sized at 115% of output
- Emergency circuits need to be separated
- Emergency and legally required circuits need selective coordination

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GROUNDING & GROUND FAULT

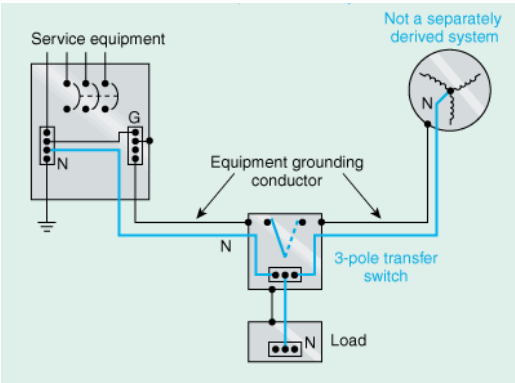
What are the grounding requirements for the generator?

Q10) What are the grounding requirements for the generator?

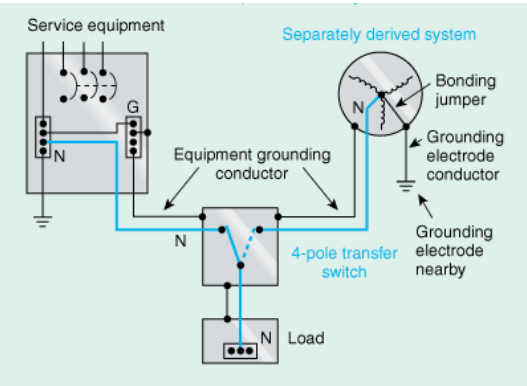
- Generator systems can be separately derived (4 pole ATS)
- Generator systems can be non-separately derived (3 pole ATS)

Grounding & Bonding - Separately Derived Systems (NEC 250.20 (D))

"FPN 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."



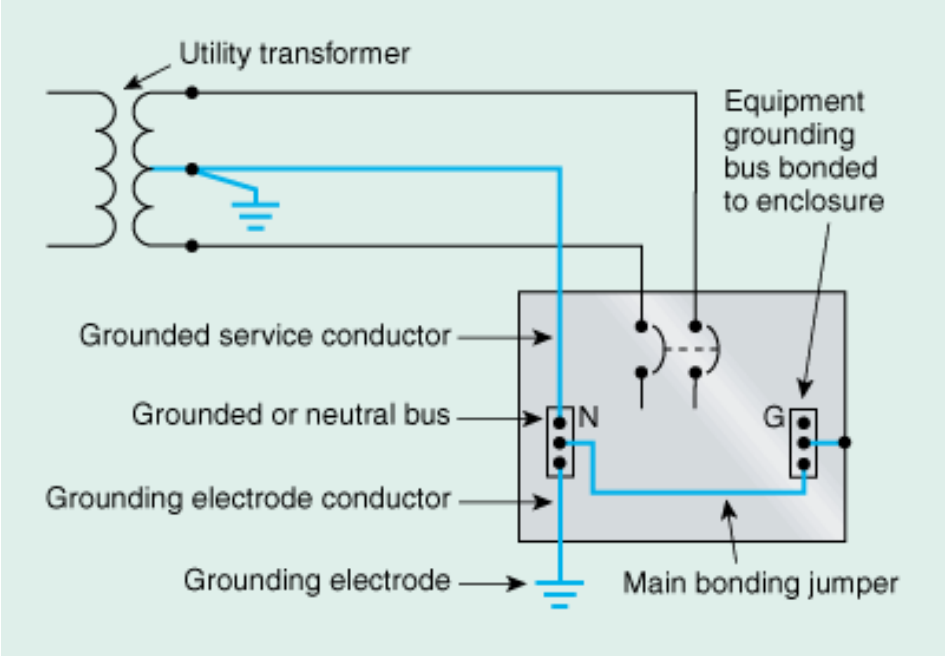
3-Pole, Neutral Not Switched



4-Pole, Switched Neutral

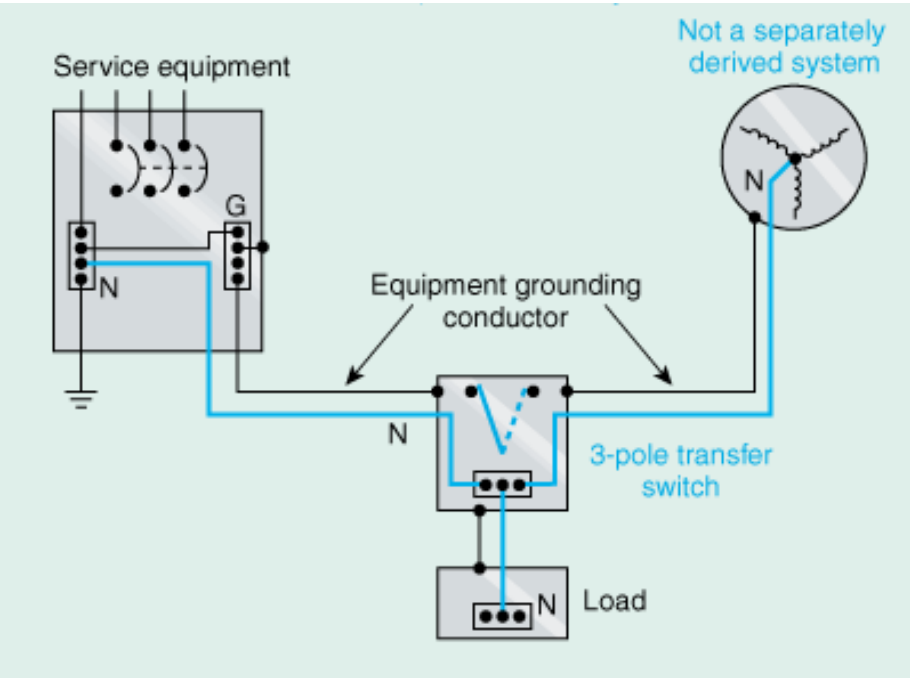
What are the grounding requirements for the generator?

- **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



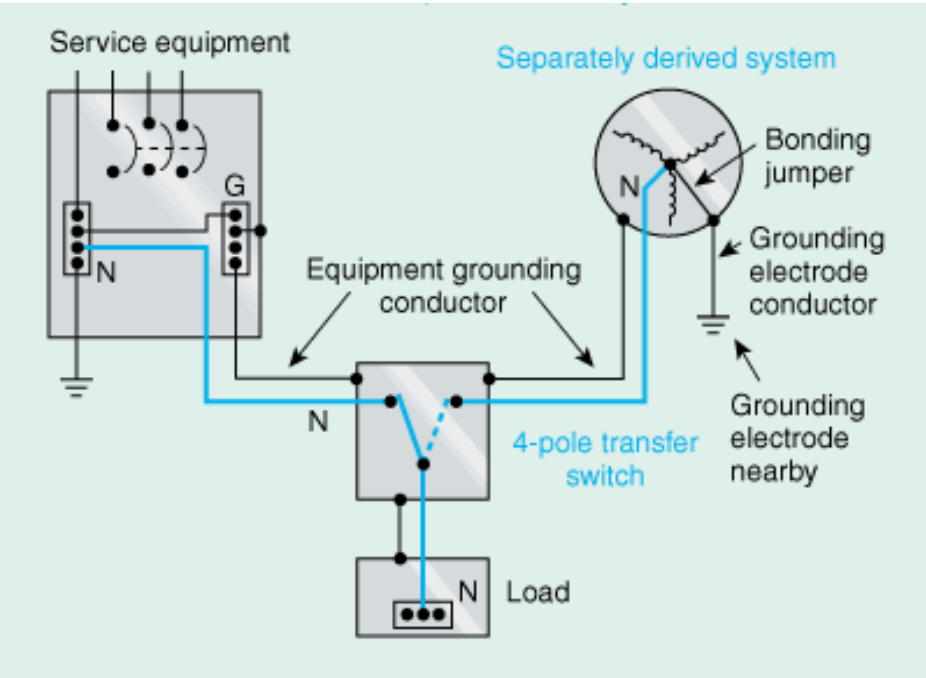
What are the grounding requirements for the generator?

- **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?

Q11) Are generators required to have GFI or GFP?

- Emergency generators (480v, 1000amps) require GFI
- Legally required generators do not require GFI or GFP

Emergency Systems – Ground Fault (NEC 700.7 (D))

"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."

Legally Required Standby -- Ground-Fault Protection of Equipment (NEC 701.17)

"The alternate source for legally required standby systems **shall not be required to have ground-fault protection** of equipment."

Are Generators required to have GFI or GFP?

Q11) Are generators required to have GFI or GFP?

- Optional standby generators typically don't include GFP
- Optional standby (480v, 1000 amps) could be required to include GFP (interpretation)

- ***NEC* 702 (Optional Standby)**
  - No comment on GFP or GFI
  - Feeder Ground-Fault Protection of Equipment (NEC 215.10)
    - "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."

Grounding and Ground Fault Summary

- Generators can be separately or non-separately derived
- Generator neutral should only be bonded at a single point
- Generator requires a grounding conductor
- Ground fault protection is not common on generator feeders

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FIRE PUMPS

(NEC 695 and NFPA 20)

What size is the generator breaker for a fire pump?

Q12) 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 6x running amps
- We feel this is a misinterpretation of *NEC* 695 requirements

- **Code is confusing, resulting in this behavior**
  - Fire Pumps - Overcurrent Device Selection (NEC 695.4(B)(1))

    "**set to indefinitely carry the sum of locked rotor current**"
    - This section only applies to "remote power sources"

What is being confused is the utility versus the generator feeder.

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**
  - Fire Pump - Power Wiring - Overload Protection (NEC 695.6(D))

    "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

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

"Generator Capacity. An on-site generator(s) used to comply with this section shall be of **sufficient capacity to allow normal starting and running** of the motor(s) …. A tap ahead of the on-site generator disconnecting means shall not be required…"

Handbook:

"…alternative source **overcurrent protective device(s)** for the electric-drive fire pump are **not required to be sized for locked-rotor current** of the fire pump motor(s). Rather, the circuit components of the alternative source are **permitted to be sized according to Article 430**…"

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%

- **Fire Pumps – Continuity of Power (NEC 695.4(B))**

  "… Overcurrent protective devices between an on-site standby generator and a fire pump controller shall be **selected and sized** according to **430.62** to **provide short-circuit protection only**."

What size is the generator breaker for a fire pump?

Q13) What are other requirements for fire pumps?

- Voltage dip limited to 15% for normal starting
- ATS must be fire pump rated
- Generator must meet requirements for NFPA 110 Level 1
  - Reliable fuel (AHJ may require on-site fuel)
  - Remote audible alarm
  - NFPA 110 testing, maintenance and recording requirements

Fire Pump Summary

- Locked rotor amp sizing applies to the utility source
- Generator's fire pump breaker needs to be 125 to 250% of pump rating
- Limit voltage dips to 15%

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