PROFESSIONAL DEVELOPMENT
SEMINAR SERIES

GPS-140 NATIONAL ELECTRICAL CODE (NEC)

LEARNER'S GUIDE

GENERAC® | INDUSTRIAL POWER

WELCOME

Professional Development Seminar Series

Standby power systems are increasingly in demand. Commercial, industrial, municipal and healthcare facilities are just a few of the markets that require backup power. Understanding the National Electrical Code (NEC) is a crucial part of the process when designing a system.

The ever-changing requirements of the power generation industry, coupled with requests for additional training, has prompted Generac Power Systems to develop this training program.

Titled the Generac Power Systems Professional Development Seminar Series, this program consists of individual training modules that provide both theoretical and practical information. Each module is 90 minutes in length and each incorporate proven learning methodology to ensure a positive experience. These modules are designed to broaden the learner's understanding of topics such as:

- Current Technologies
- Sizing
- Codes & Standards
- Switching Technologies
- Reliable Design Characteristics
- Paralleling
- Engines and Alternators
- Controls
- Emissions

THE MODULE IN PERSPECTIVE

PURPOSE:

This seminar introduces the National Electrical Code (NEC) as it relates to the installation and operation of standby power generators. The initial versions of the *NEC* were not written with generators in mind. Generators were added in various sections of the code over the years. This seminar attempts to examine those various sections and compile the generator relevant information. The information is presented in a question and answer format. Seventeen questions have been identified as being the most commonly asked by the engineering community. We then reference the *NEC* to answer those questions.

TIME:

- 90 minutes of Classroom Instruction
- 30 minutes for Final Assessment

LEARNING OBJECTIVES:

Upon completion of this seminar, participants will become familiar with the National Electrical Code (NEC) relative to the installation and operation of standby generators. Specifically they will be able to:

- Explain the relationship between stated *NEC* codes and the Authority Having Jurisdiction (AHJ)
- Describe the difference between feeder and service cabling as defined by the *NEC*
- List specific generator requirements including sizing, start-up times, load transients, alarms, instrumentation and signage
- Describe specific requirements for disconnects and breakers
- Explain accessibility requirements
- Describe cabling requirements including separation of circuits
- Identify the requirements for overcurrent coordination
- Illustrate grounding and bonding requirements
- Describe requirements for ground fault indication (GFI) and ground fault protection (GFP)
- Describe transfer switch requirements for emergency, legally required standby and healthcare installations
- Summarize generator requirements for fire pump applications including capacity, breaker sizing, overload protection and automatic transfer switches

CONTINUING EDUCATION:

Upon successful completion of this seminar, participants will be awarded a certificate of achievement identifying the seminar title, 2.0 PDHs (Professional Development Hours) and 0.2 CEUs (Continuing Education Units).
Successful completion of a PDSS seminar requires that the participant have:

1. Attended the complete seminar
2. A minimum score of 80% on the Final Assessment

TRAINING AT A GLANCE

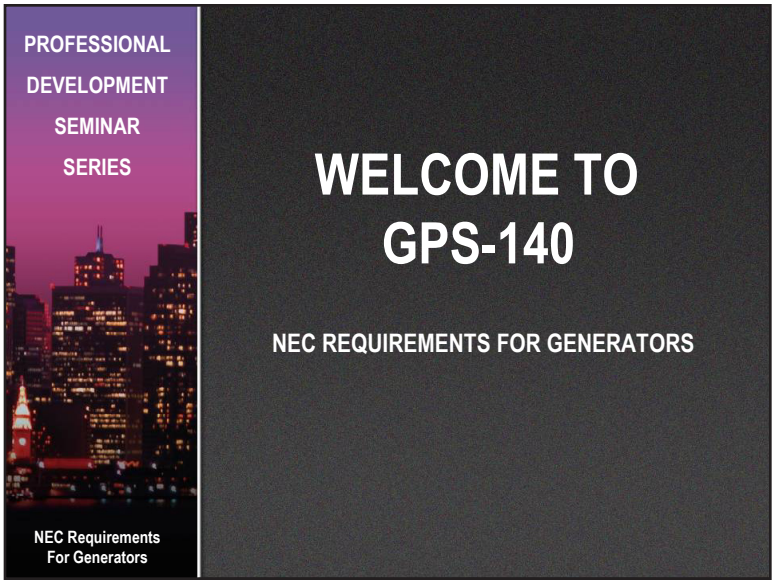
TIME	LESSON	DESCRIPTION
5 minutes	Introductions	Participants and trainer should become briefly acquainted. The trainer welcomes participants and conducts an opening icebreaker activity.
15 minutes	Lesson 1 Key Code References	An introductory summary of the key *NEC* articles associated with generator installation and operation.
15 minutes	Lesson 2 Generator Requirements	A discussion of specific generator requirements including sizing, start-up times, load transients, alarms, instrumentation and signage.
15 minutes	Lesson 3 Disconnect and Generator Breaker	Specific requirements for disconnects and breakers are discussed. Accessibility standards are also described.
5 minutes	Lesson 4 Cabling and Coordination	Cabling requirements, including the separation of circuits and overcurrent coordination are discussed.
15 minutes	Lesson 5 Grounding and Ground Faults	Grounding and bonding requirements will be described along with ground fault indication (GFI) and ground fault protection (GFP) practices.
5 minutes	Lesson 6 Transfer Switch Requirements	A discussion of transfer switch requirements for emergency, legally required standby and healthcare installations.
10 minutes	Lesson 7 Fire Pumps	A description of generator requirements for fire pump applications including capacity, breaker sizing, overload protection and automatic transfer switches.
5 minutes	Conclusion	The trainer will review the objectives of the class and discuss how each objective was accomplished. An evaluation will be given out with which participants can provide feedback about the course. An assessment will also be given to each participant to evaluate the skills and knowledge they received from the course.

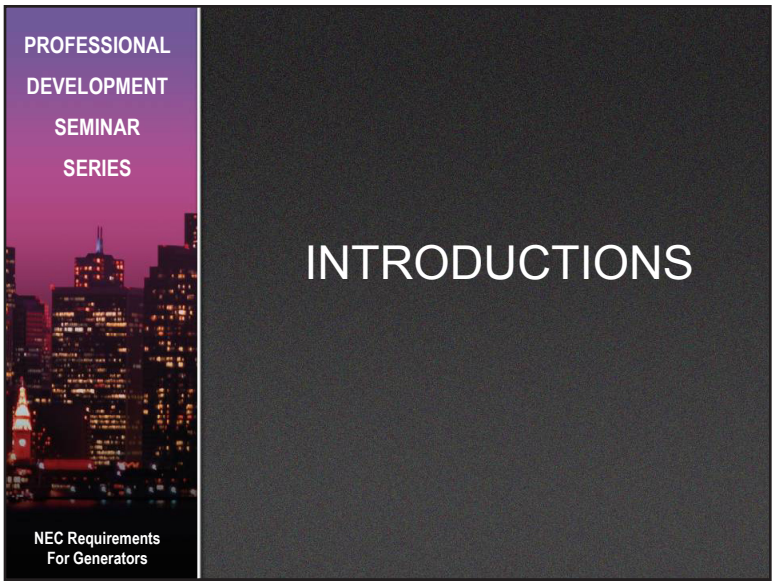
INTRODUCTION

TIME: 5 minutes

OBJECTIVE:

The introduction is an opportunity for the trainer and participants to become familiar with each other. This period will discuss the topics to be covered, capture initial questions and introduce the National Electrical Code.





NOTES

LATERAL THINKING...

A man and his son are in a car accident. Two ambulances arrive. The father is rushed to a hospital five miles north of the accident, but the child is rushed to a hospital five miles south of the accident. When the boy arrives the surgeon says, "I can't operate on this boy, he is my son! " How can this be?

A woman shoots her husband. Then she holds him under water for over five minutes. Finally, she hangs him. But five minutes later they both go out together and enjoy a wonderful dinner together. How can this be?

Why is it better to have round manhole covers than square ones?

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WHAT YOU WILL LEARN

- ***NEC* requirements for on-site power generation.**
  - Recent events have created increased interest in standby power
  - This module organizes *NEC* requirements based on topic
- **Seventeen key generator questions will be asked**
  - Answers to those questions from the *NEC* will be provided

Note: This material is our interpretation of the *NEC* requirements, please coordinate with the AHJ for local interpretations and local requirements.

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INTRODUCTION

WHAT YOU WILL LEARN

Topics Covered	Estimated Time
Introduction	5 min
Key Code References	15 min
Generator Requirements	15 min
Disconnect and Generator Breaker	15 min
Cabling and Coordination	5 min
Grounding and Ground Fault	15 min
Transfer Switch Requirements	5 min
Fire Pumps	10 min
Conclusion	5 min

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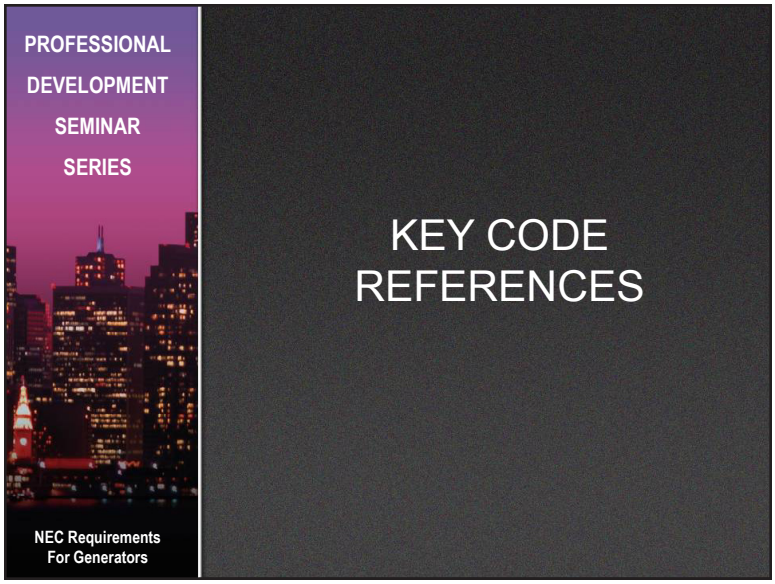
1. Key Code References

TIME: 15 minutes

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

- Describe the differences between "Emergency Systems" and "Legally Required Standby Systems"
- Describe the key functions of the NFPA
- List and describe the seven generator related NFPA standards
- List and describe the four generator related UL standards
- List and describe the ten *NEC* codes associated with generators
- Describe the term "fine print notes" as related to *NEC* documents
- Describe the difference between feeder and service cabling as defined by the *NEC*



NOTES

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

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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

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NOTES

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**

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WHAT ARE THE KEY CODES & STANDARDS FOR GENERATORS?

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

EPA United States Environmental Protection Agency

IEEE Networking the World

UL Underwriters Laboratories Inc.®

IEC

NEMA

NFPA

CSA INTERNATIONAL

c UL US LISTED

ANSI American National Standards Institute

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NOTES

1. Key Code References

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

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WHAT ARE THE KEY CODES & STANDARDS FOR GENERATORS?

- **Underwriters Laboratories (UL)**
  - Develops standards & test procedures
  - Administers the application of the UL mark
  - 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

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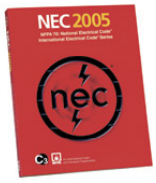
NOTES

1. Key Code References

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



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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

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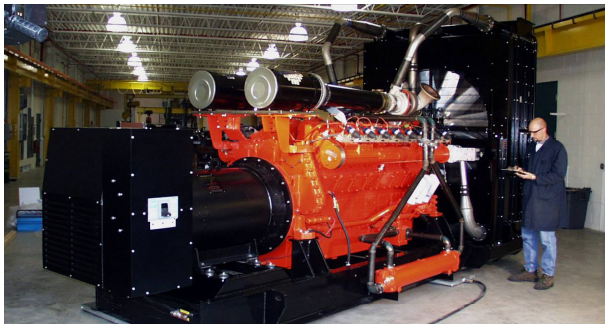
NOTES

WHAT IS A GENERATOR?

Q3) What is a generator?

– Prime mover (engine) & alternator



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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."

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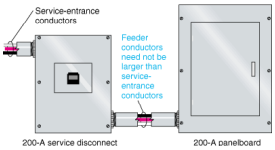
NOTES

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:
"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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NOTES

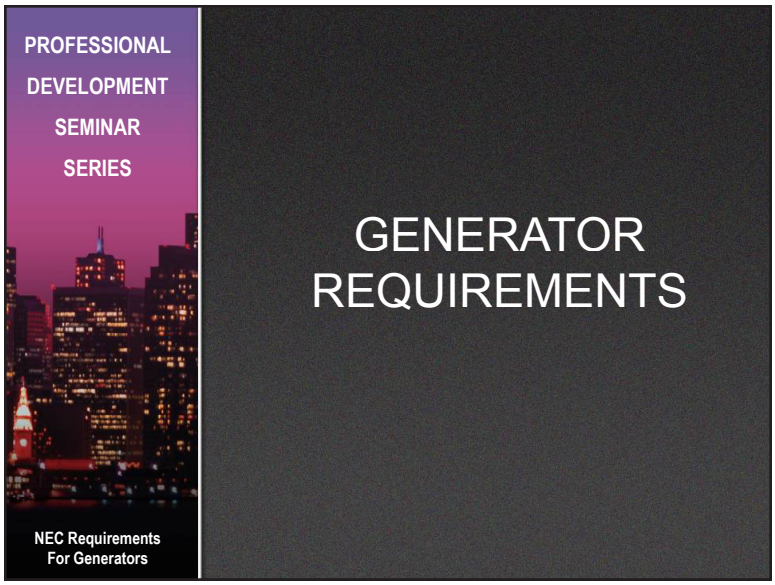
2. Generator Requirements

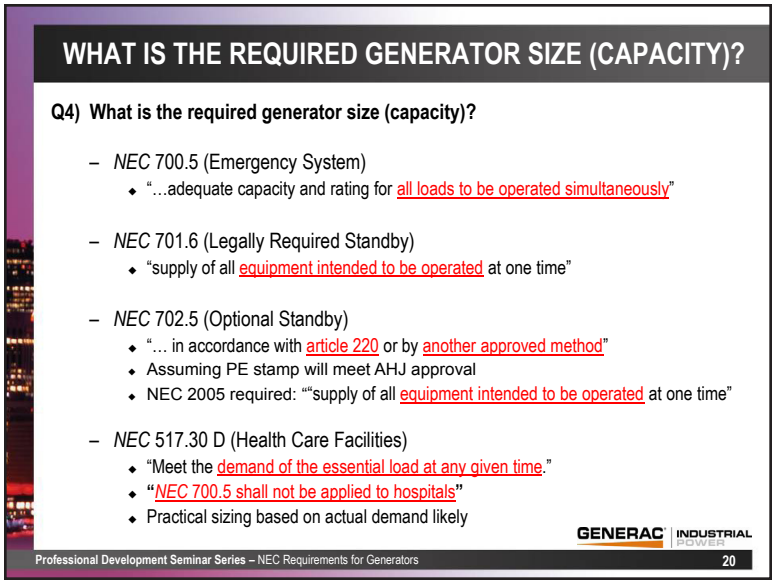
TIME: 15 minutes

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

- Describe *NEC* sizing requirement differences between emergency systems and legally required systems
- Describe start-up times specified by the *NEC* for standby generators
- Identify factors affecting load transients
- Describe the *NEC* alarm and instrumentation requirements for standby generator installations
- Describe the *NEC* signage requirements for generator installations





NOTES

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 3-4.3.1 (Health Care Facilities)
    - Critical & life safety loads
- **60 sec start-up time**
  - *NEC* 701.11 (Legally Required Standby)
- **Variably defined start-up**
  - NFPA 110 4.1 (Emergency & Standby Power Systems)

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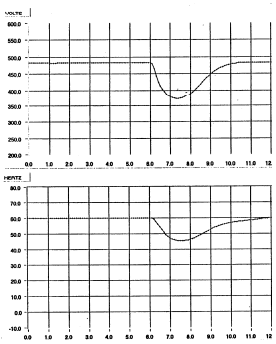
WHAT TRANSIENT LIMITS ARE REQUIRED BY THE NEC?

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)
- **Capacity to pick up 100% block load**
  - NFPA 110 7.13.7 (Emergency & Standby Systems)
- **Transients acceptable to the load**
  - NFPA 99 3-4.1.1.8 & NFPA 110 5.6.9.8



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NOTES

WHAT TRANSIENT LIMITS ARE REQUIRED BY THE NEC?

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

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WHAT ALARMS & INSTRUMENTATION ARE REQUIRED?

Q7) What alarms and instrumentation are required?

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

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NOTES

WHAT ALARMS & INSTRUMENTATION ARE REQUIRED?

Table 3-5.5.2(d) Safety Indications and Shutdowns

Indicator Function (at Battery Voltage)	Level 1 C.V.	Level 1 S	Level 1 R.A.	Level 2 C.V.	Level 2 S	Level 2 R.A.
(a) Overcrank	X	X	X	X	X	O
(b) Low water temp. <70°F (21°C)	X		X	X		O
(c) High engine temperature prealarm	X		X	O		
(d) High engine temperature	X	X	X	X	X	O
(e) Low lube oil pressure prealarm	X		X	O		
(f) Low lube oil pressure	X	X	X	X	X	O
(g) Overspeed	X	X	X	X	X	O
(h) Low coolant level	X	O	X	X	O	X
(i) EPS supplying load	X			O		
(j) Control switch not in auto. position	X		X	O		
(k) High battery voltage	X			O		
(l) Low voltage in battery	X			O		
(m) Battery charger ac failure	X			O		
(n) Lamp test	X			X		
(o) Contacts for local and remote common alarm	X		X	X		X
(p) Audible alarm silencing switch			X			O
(q) Low starting air pressure	X			O		
(r) Low starting hydraulic pressure	X			O		
(s) Air shutdown damper when used	X	X	X	X	X	O
(t) Remote emergency stop		X			X	

C.V.: Control panel-mounted visual indication
R.A.: Remote audible
S: Shutdown of EPS
X: Required
O: Optional

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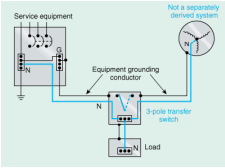
WHAT ARE THE GENERATOR SIGNAGE REQUIREMENTS?

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

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NOTES

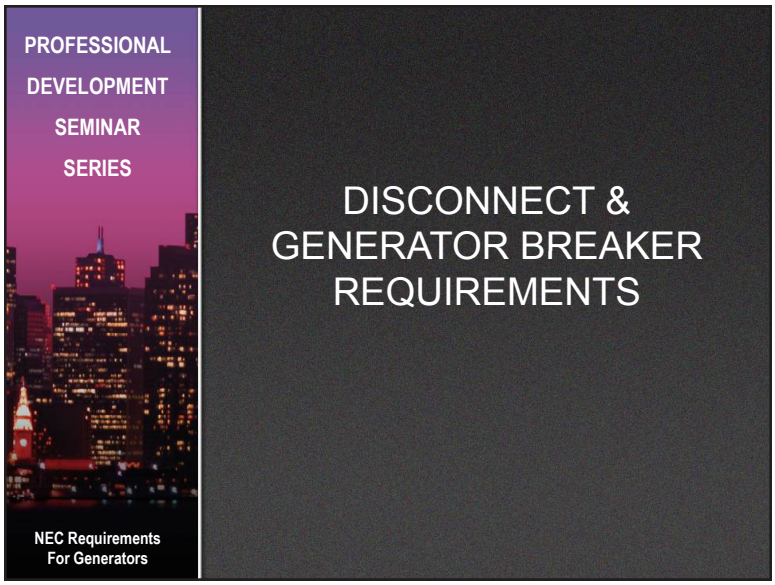
3. Disconnect and Generator Breaker

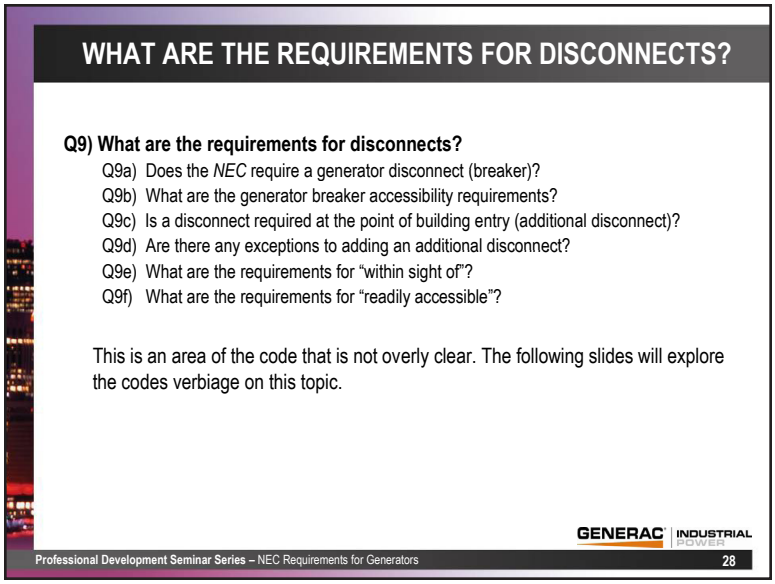
TIME: 15 minutes

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

- Describe the *NEC* requirements for disconnecting means for standby generators
- Describe the *NEC* requirements for breaker accessibility on standby generators
- Describe the *NEC* requirements for disconnects at building point of entry
- Describe the term "readily accessible" as referred to in the *NEC*





NOTES

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 be readily shutdown & not operate in parallel
  - *NEC* seems to have a preference for including a generator breaker
  - Market norm is to utilize a generator breaker
  - UL2200 listing will typically require a disconnect on the generator

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

"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."

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WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

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

- *NEC* 404.8 exception #2 allows the generator breaker to be higher than 6' 7"
  - Generator breakers sometimes get higher due to sub-base fuel tanks

***NEC* 404.8 Accessibility and Grouping**

"**Location.** All switches and circuit breakers used as switches shall be located so that they may be operated from a readily accessible place. They shall be installed so that the center of the grip of the operating handle of the switch or circuit breaker, when in its highest position, is 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 specified in the foregoing and to be accessible by portable means."

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NOTES

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.**

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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* 701.11(B)(5)** Outdoor Generator Sets
***NEC* 702.11** Outdoor Generator Sets

"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?

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NOTES

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."

Local interpretation of accessible may require a break glass shunt trip.

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WHAT ARE THE REQUIREMENTS FOR DISCONNECTS?

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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NOTES

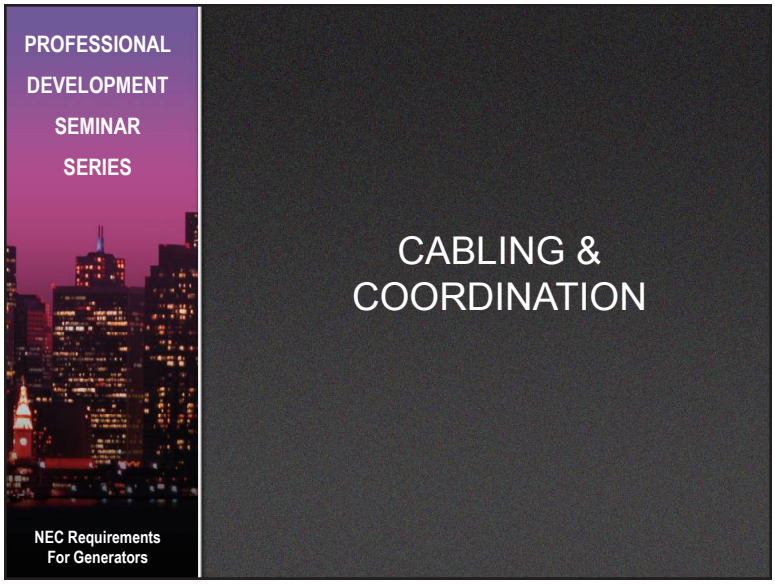
4. Cabling and Coordination

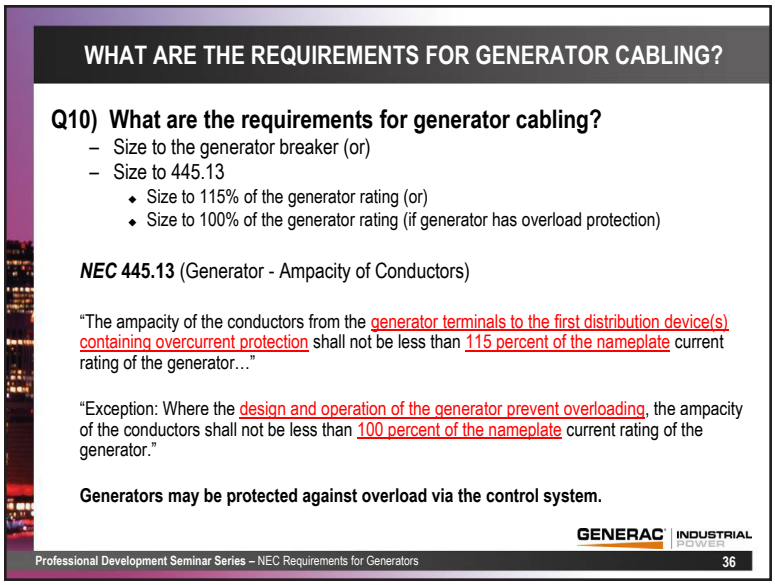
TIME: 5 minutes

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

- Describe the NEC requirements for generator cabling
- Describe the NEC requirements for separation of circuits
- Describe the NEC requirements for overcurrent coordination





NOTES

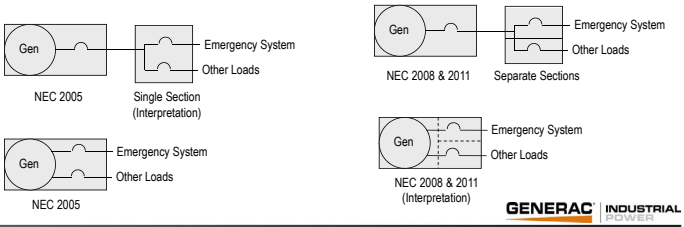
WHAT ARE THE REQUIREMENTS FOR SEPARATION OF CIRCUITS?

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* 700.9 (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"



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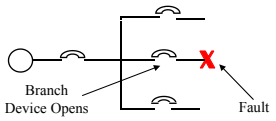
WHAT ARE THE REQUIREMENTS FOR COORDINATION?

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

***NEC* 700.27 (Emergency System – Coordination)**
and
***NEC* 701.18 (Legally Required Standby – Coordination)**

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



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NOTES

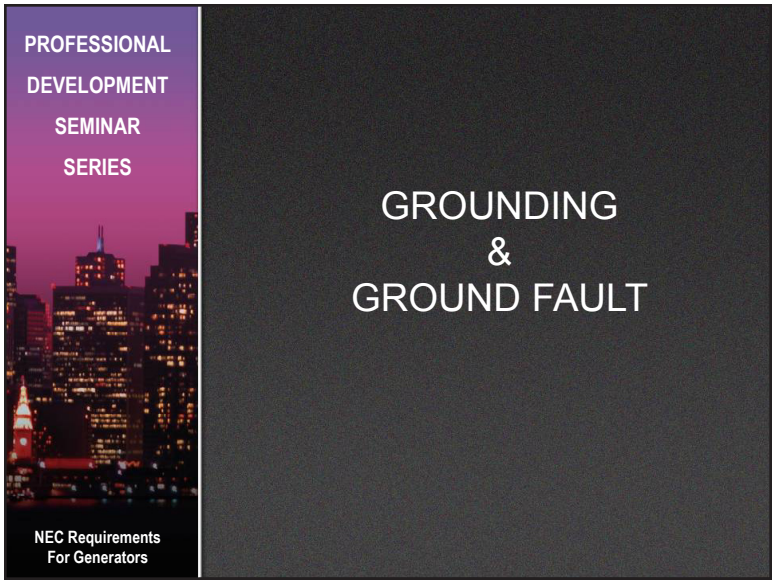
5. Grounding and Ground Faults

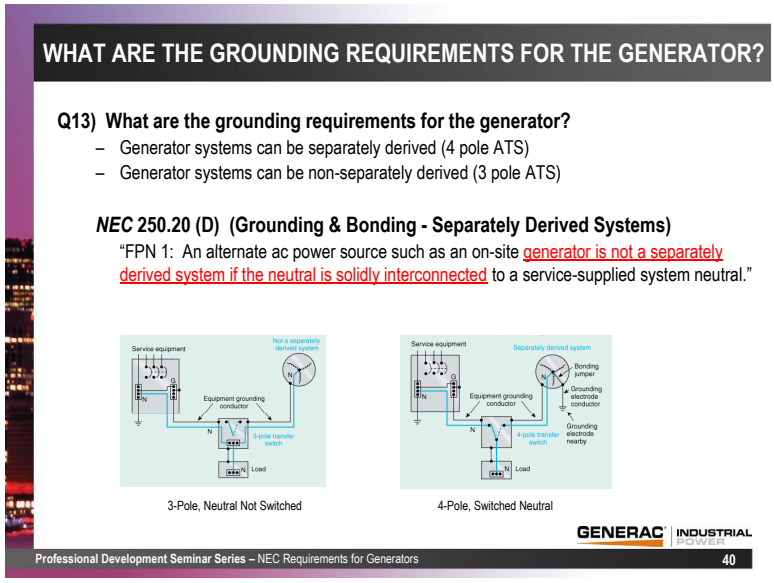
TIME: 15 minutes

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

- Describe the NEC requirements for system grounding for generator installations
- Describe the NEC requirements for system bonding for generator installations
- Describe the NEC requirements for ground fault indication and ground fault protection for generator installations

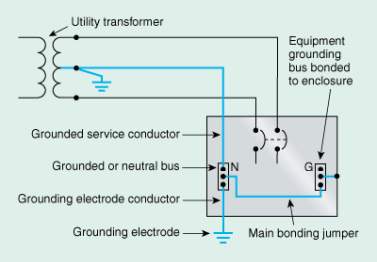




NOTES

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



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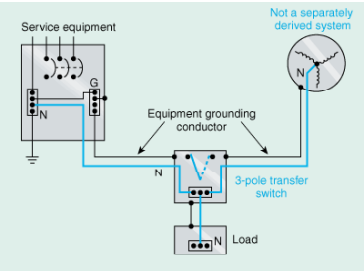
WHAT ARE THE GROUNDING REQUIREMENTS FOR THE GENERATOR?

- **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



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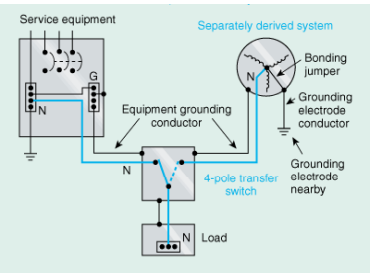
NOTES

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"



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ARE GENERATORS REQUIRED TO HAVE GFI OR GFP?

Q14) Are generators required to have GFI or GFP?
- Emergency generators (480v, 1000amps) require GFI

- ***NEC* 700.7 (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 event of indicated ground fault shall be located at or near the sensor location."

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NOTES

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* 701.17 (Legally Required Standby -- Ground-Fault Protection of Equipment)**
  - "The alternate source for legally required standby systems shall not be required to have ground-fault protection of equipment."

- ***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

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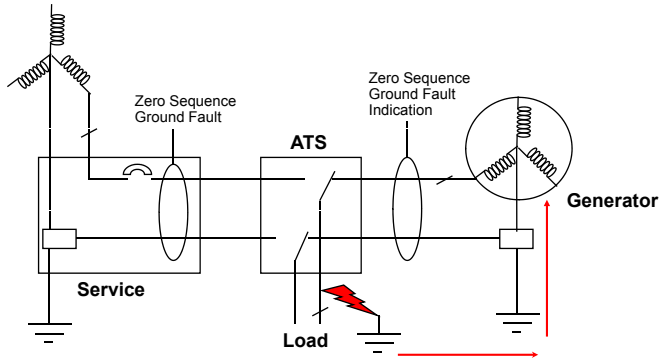
ARE GENERATORS REQUIRED TO HAVE GFI OR GFP?



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NOTES

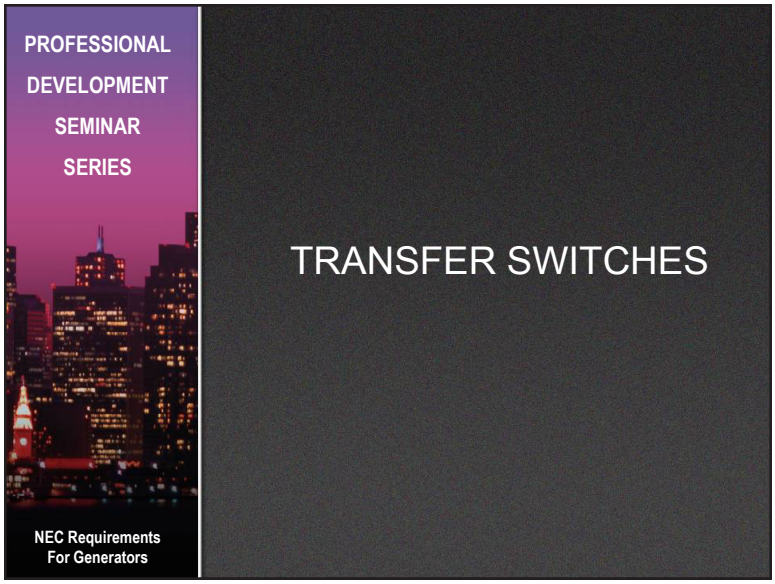
6. Transfer Switch Requirements

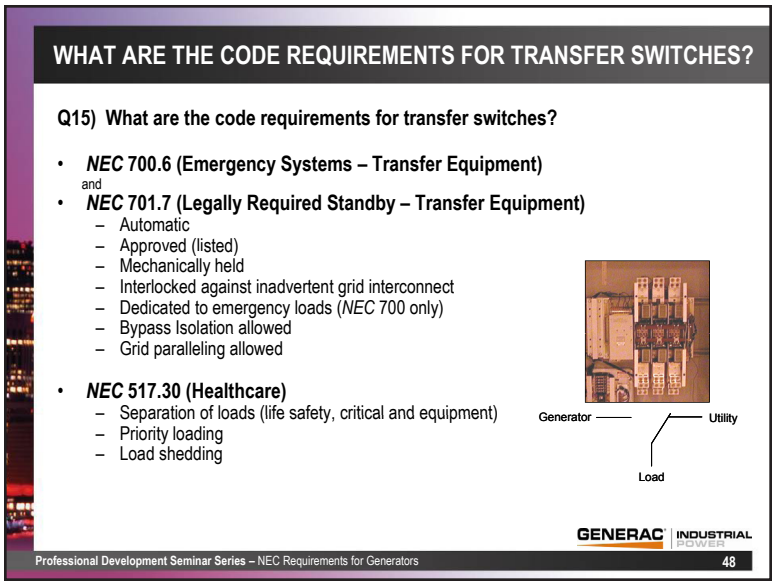
TIME: 5 minutes

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

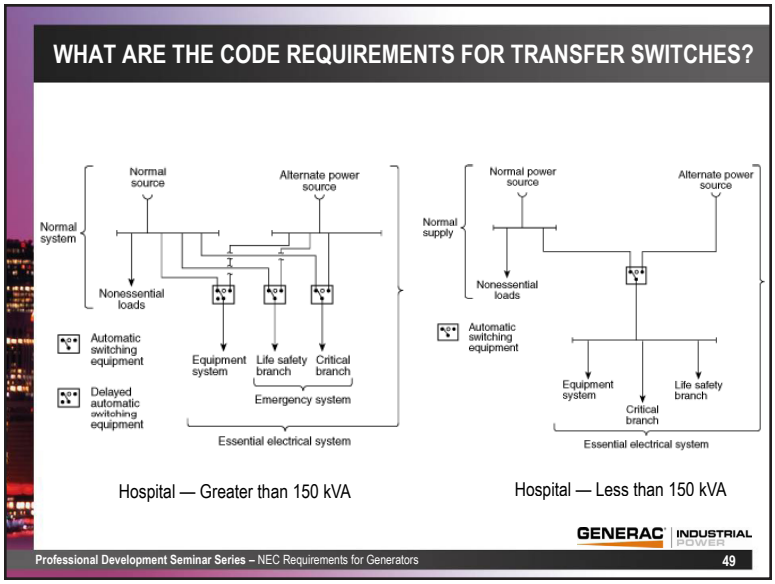
- Describe the NEC requirements for transfer switches as used in emergency, legally required standby and healthcare installations





NOTES

6. Transfer Switch Requirements



NOTES

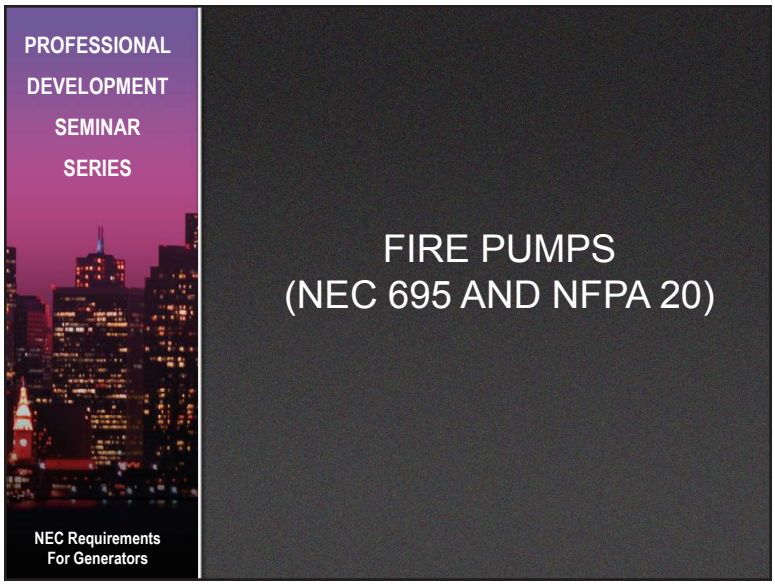
7. Fire Pumps

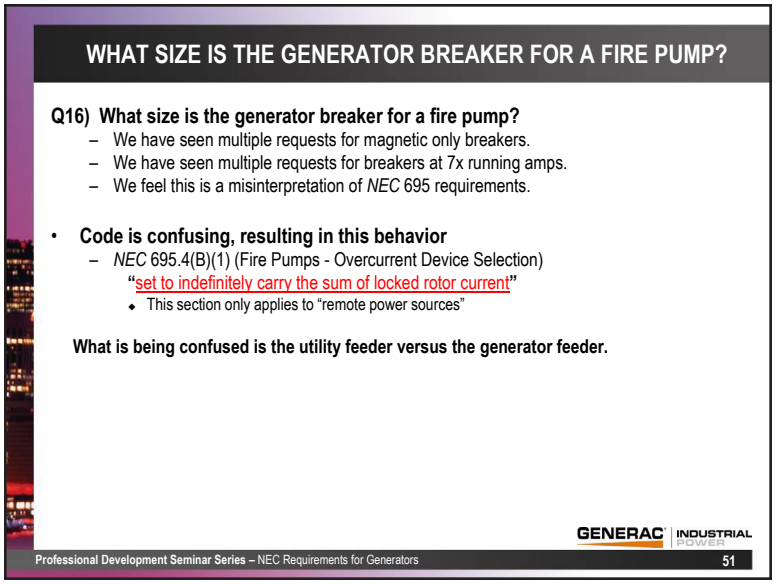
TIME: 10 minutes

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

- Describe the *NEC* requirements for generator breaker size for fire pumps
- Describe the *NEC* requirements for overload protection
- Describe the *NEC* requirements for generator capacity for fire pump applications
- Describe the *NEC* requirements for automatic transfer switches for fire pumps





NOTES

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(D)** (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."

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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(B)(1) **(Fire Pumps – Generator Capacity)**
"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) driving the fire pump(s) while supplying all other simultaneously operated load. Automatic shedding of one or more optional standby loads in order to comply with this capacity requirement shall be permitted. **A tap ahead of the on-site generator disconnecting means shall not be required**…"

Handbook:
"Where the alternative source of power is an on-site generator, the alternative source disconnecting means and the 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**, provided they are "selected or set to allow instantaneous pickup and running of the fire pump load."

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NOTES

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) (Fire Pumps – Continuity of Power)**

  "… 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**."
- ***NEC* 695.6(D) (Fire Pumps – Overload Protection)**

  "Exception No. 2: For on-site standby generator(s) that produce continuous currents 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 695.6(B) or protected in accordance with 430.52"

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WHAT ARE OTHER REQUIREMENTS FOR FIRE PUMPS?

Q17) 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)
  - Annunciator panel
  - NFPA 110 testing, maintenance and recording requirements

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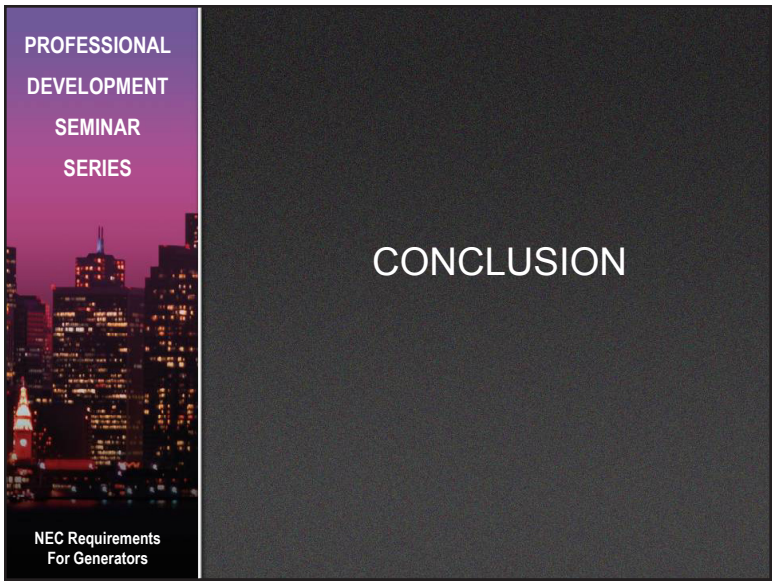
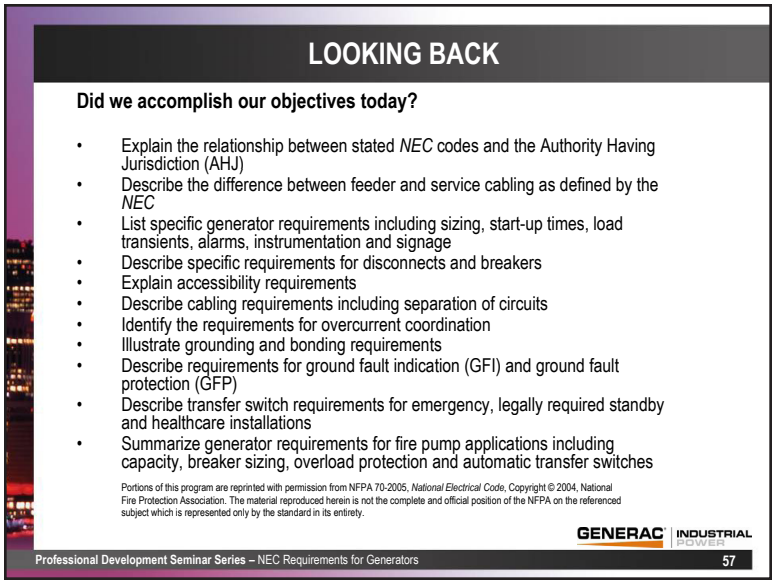
NOTES

CONCLUSION



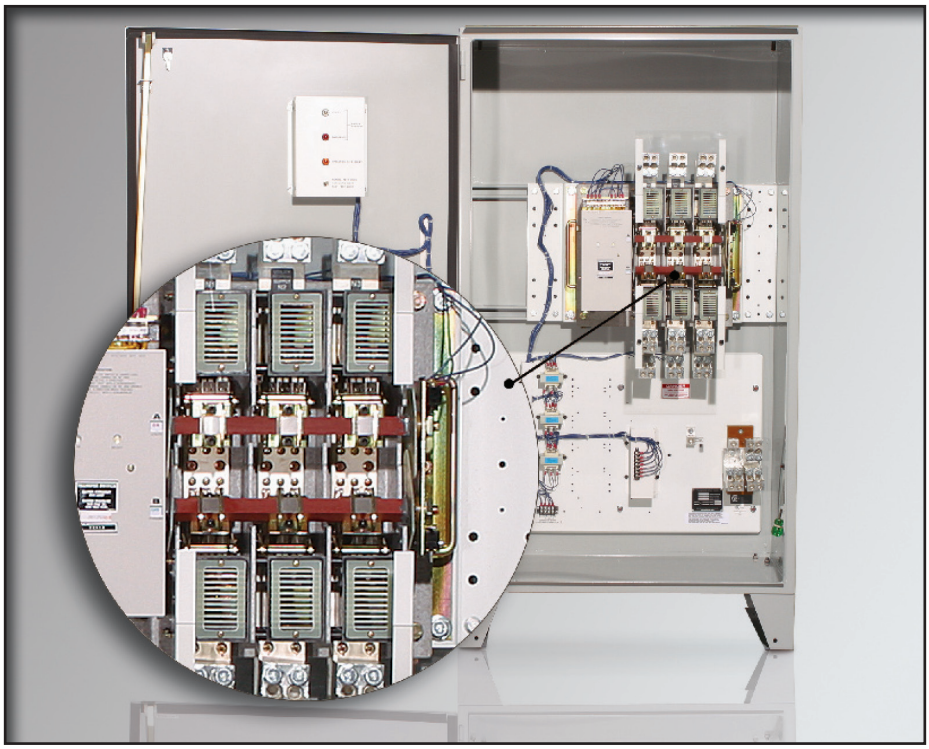


NOTES

Generator Switching

Separately Derived Versus Non–Separately Derived (3–pole, 4–pole and Overlapping Neutral)

WHITE PAPER



3–pole transfer switch

INTRODUCTION

A question often asked by engineers and electrical contractors is when to use a 4–pole automatic transfer switch (ATS) instead of a 3–pole switch. The numerous advantages of 3–pole switches make them the primary choice unless their use will result in a ground fault related system problem. This paper will identify specific conditions that require the use of 4–pole switches and explain the ground fault issues.

The National Electrical Code (NEC) references two types of grounding methods when using multiple power sources — separately and non–separately derived.

Non–Separately Derived System

A non–separately derived system utilizes the existing facility neutral bonding by solidly connecting the generator neutral to the facility's neutral conductor (Figure 1 on following page). This is done at the transfer switch. This type of system utilizes a 3–pole ATS, which does not switch the load's neutral conductor. When operating on the generator, the load's neutral is solidly bonded to ground at the facility service.

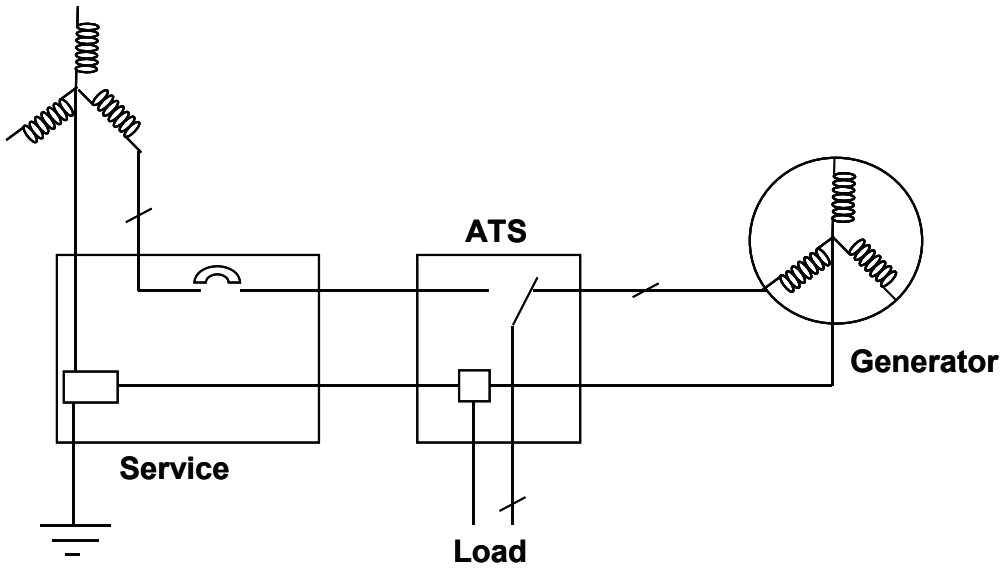


Figure 1

Separately Derived System

A separately derived system establishes a separate neutral bonding for the generator. (Figure 2). The generator's neutral conductor is not connected to the facility's existing bonded neutral. Instead, this type of system uses a 4–pole ATS that transfers the neutral conductor of the load from the facility's service bonded neutral to the generator's separately bonded neutral. When operating on the generator, the load's neutral conductor is bonded to ground at the generator.

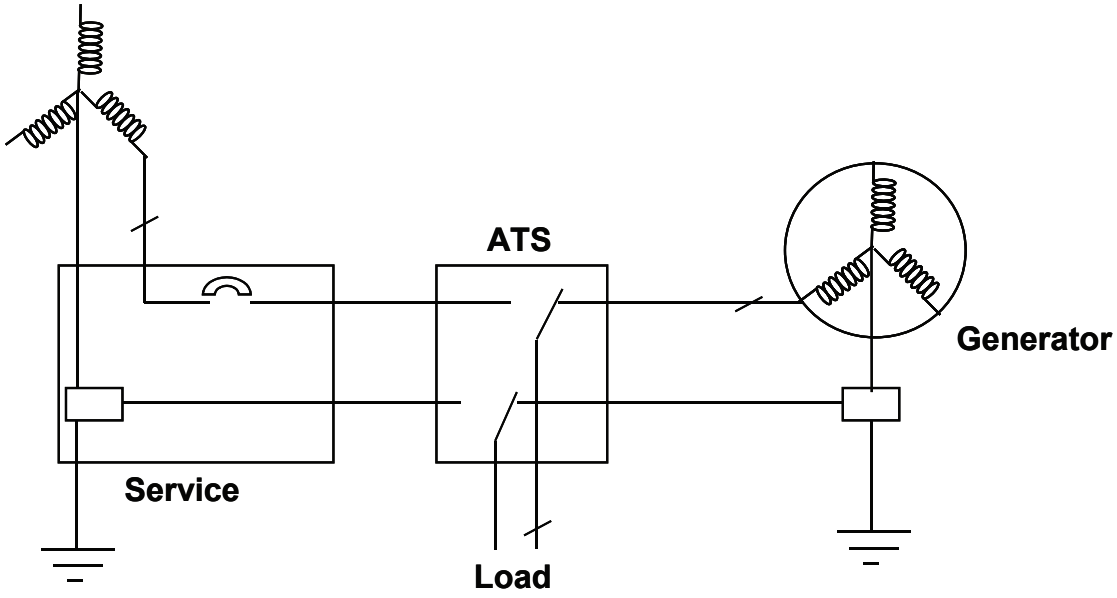


Figure 2

Generator Conductors — Service or Feeders?

The conductors from the generator are often misinterpreted as a service instead of a feeder. This misinterpretation would require the generator to always be a separately derived system. However, NEC 100 clearly states that a service only applies to the serving utility. It also clearly defines the conductors from "a source of a separately derived system" or "other power supply source" (non–separately derived generator) as a feeder — not a service. In other words, NEC leaves it to the system designer to determine the generator grounding method.

NEC Terminology – Grounded Versus Grounding Conductor

The NEC does not use the term "neutral conductor". The neutral conductor is referred to as the "grounded conductor" in a grounded 4–wire system. Their reasoning is that the neutral's function is not grounding — the conductor just happens to be grounded. The grounding conductor is the typical equipment "green wire" earth-bonding conductor whose purpose is grounding. Understanding NEC's terminology should help in understanding the code's requirements and grounding options.

Advantages of 3–Pole Switches (Non–Separately Derived)

There are several reasons that 3–pole automatic transfer switches are the most popular option for most applications.

- Simplicity.
  - In most cases, the added complexity of a 4–pole switch it is not needed.
  - The generator uses the highly reliable ground plane and bonding of the normal utility source.
- Reliability
  - The load's neutral remains solidly bonded during transfer switch operation.
  - The neutral's connectivity is improved through solid lugging versus a switch contact.
- Cost
  - Three–pole switches are typically about 25% less expensive than 4–pole switches.

Applications Requiring 4–Pole Switches (Separately Derived)

Four–pole switches are sometimes, but not always, required for applications involving ground fault protection (GFP) and ground fault indication (GFI). Determining when 4–pole switching is necessary requires a thorough examination of ground fault operation and ground fault paths. Following are examples of applications in which 4–pole (separately derived) solutions are recommended.

- **Multiple ATS Applications**

  Four–pole switches are required when multiple automatic transfer switches are fed from the same generator and GFP is on the utility sources (Figure 3). The ground fault protected utility sources may be multiple services or multiple feeders, but the determining factor is the combination of multiple ATS circuits with GFP enabled utility sources.

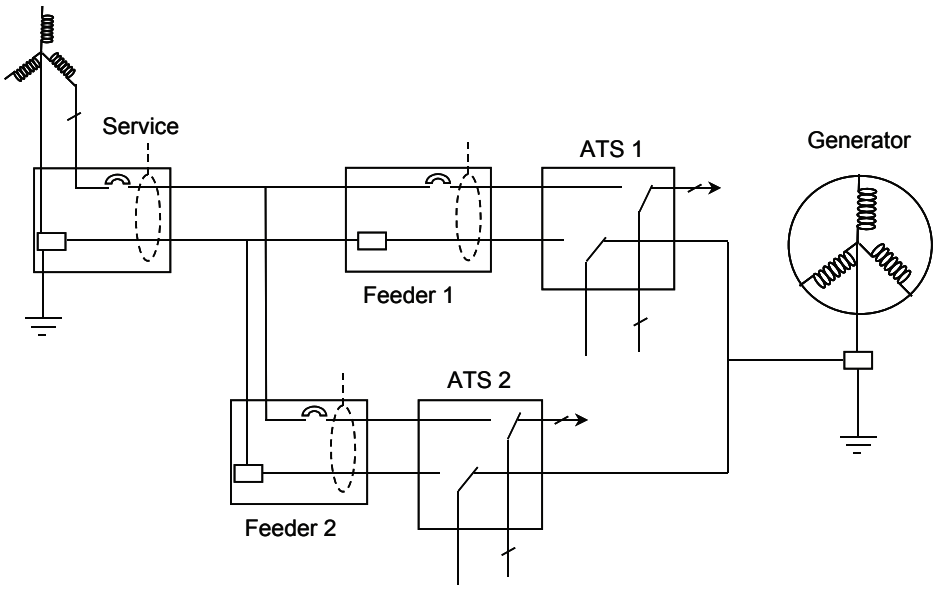


Figure 3

• **When Highly Sensitive Generator GFI is Desired**

A separately derived system is necessary when highly sensitive generator ground fault indication (GFI) is desired. When generators are feeding 480 volt, 1000 amp emergency systems (NEC 700.6D), generator ground fault indication is required (Figure 4). Whenever highly sensitive ground fault indication is desired, 4–pole switching is recommended. It should be noted however, that NEC permits low sensitivity by allowing a maximum ground fault setting of 1200 amps.

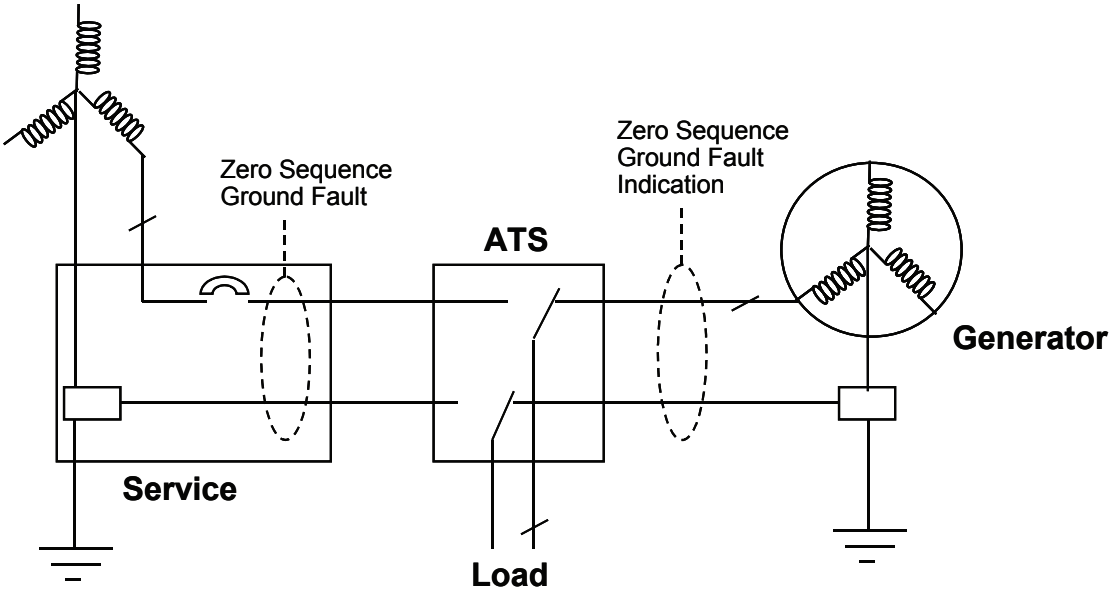


Figure 4

• **When Powering Multiple Buildings**

When the same generator powers multiple buildings, 4–pole switching is recommended in order to isolate each building's ground plane. With 3–pole switches, the various building ground planes would be interconnected through the generator's neutral circuit. Although the negative effects of using 3–pole switching in this application are minimal, good system design attempts to avoid any possibility of potential ground loop paths.

Understanding Ground Fault Monitoring

The basic concept utilized in monitoring ground fault current is that the outward current should equal the returning current. Ground fault monitoring is typically accomplished with a "summation of currents" process using one or more current transformers (CT). Under normal operation, inbound currents should be equal to all outbound currents and cancel each other when measured at the transformer(s). If current flows through the grounding conductor and/or the facility ground plane, the inbound and outbound currents no longer cancel through the ground fault current transformer(s) and a ground fault is detected. Figure 5 illustrates this configuration.

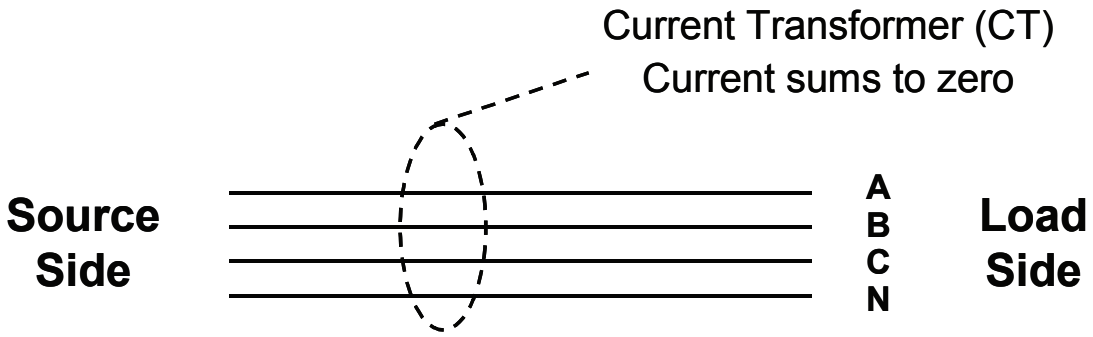


Figure 5

Zero Sequence Ground Fault Monitoring

The configuration in figure 5 is called zero sequence ground fault monitoring. In this configuration, the neutral (grounded) conductor is included in the current summation. By including normal single–phase neutral currents, the ground fault monitor process can be more sensitive than methods that exclude the neutral currents. Although zero sequence monitoring offers increased sensitivity, it requires that the neutral be bonded to ground on the source side of the ground fault current transformer(s). Figure 6 shows the correct bonding for zero sequence GFP & GFI.

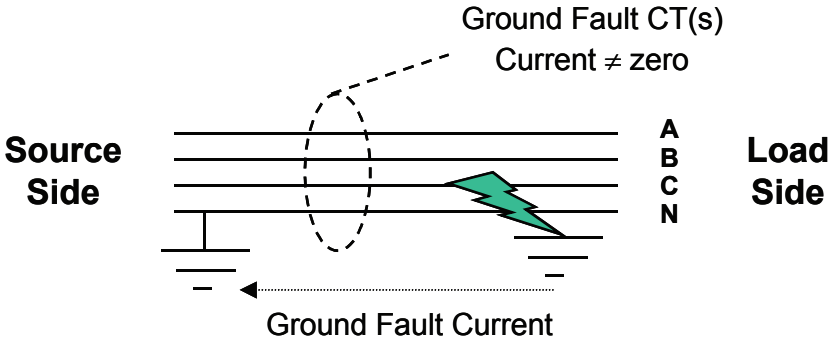


Figure 6

Zero Sequence Ground Fault Monitoring (Incorrectly Grounded)

If the neutral is bonded on the load side, the ground fault current will not return to the source around the ground fault indication CT and no ground fault will be sensed. This point is often overlooked when implementing GFI on an emergency generator system. Figure 7 is an illustration of zero sequence ground fault indication that is incorrectly implemented. This configuration will never indicate a ground fault because all the current leaving the generator will return to the source through the GFI CT.

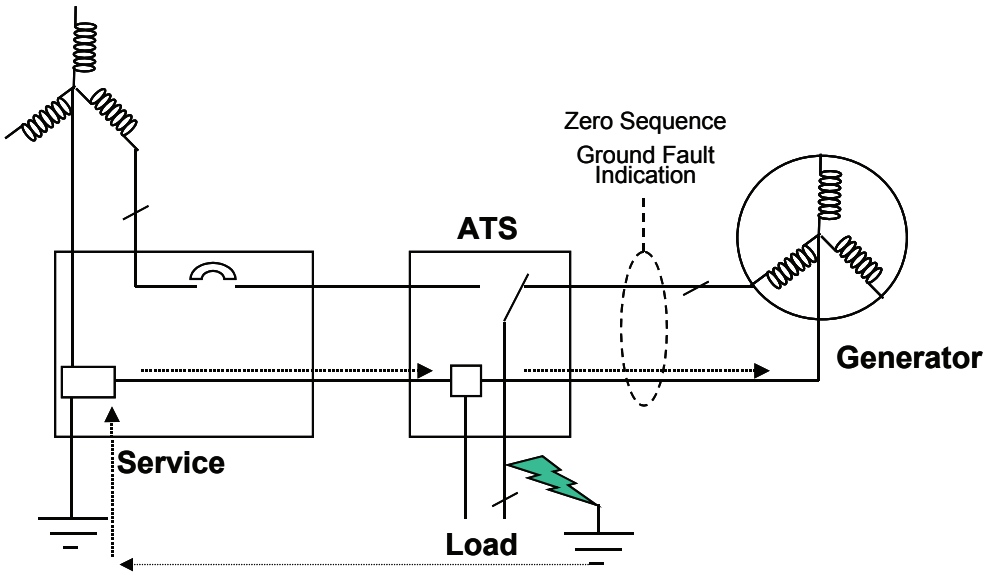


Figure 7

Zero Sequence Ground Fault Monitoring (Correctly Grounded)

There are two ways to correct the situation presented in figure 7. One solution is to utilize a 4–pole transfer switch. With a 4–pole (separately derived) system, the neutral (grounded) conductor will be correctly bonded on the source side of the ground fault indication CT. Figure 8 is an illustration of this correct implementation. Notice that the ground fault current is returning around the CT and proper GFI will occur.

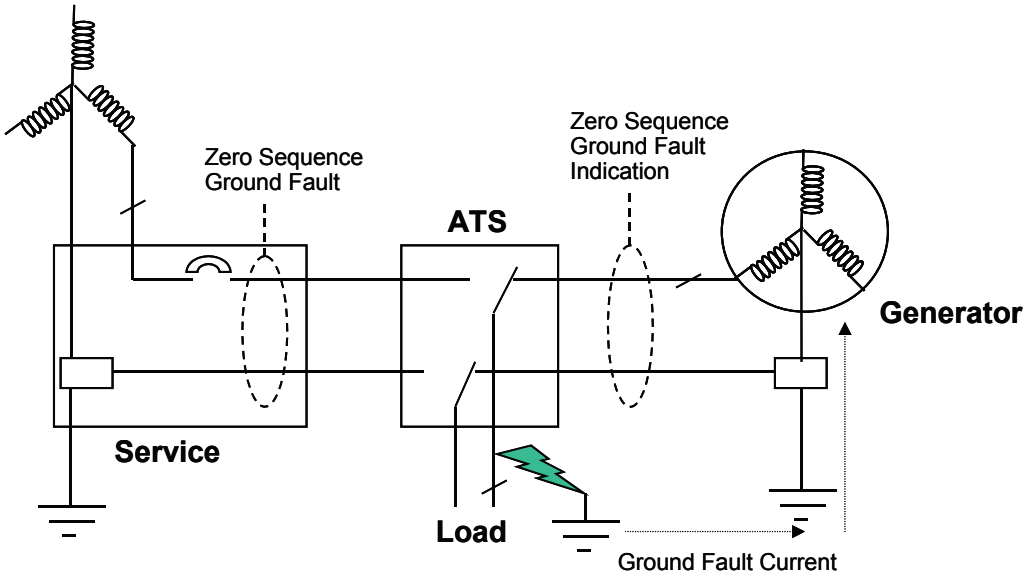


Figure 8

The second solution is called vectorial ground fault monitoring (Figure 9). When this method is used, the neutral (grounded) conductor is not included in the current summation. By not including single–phase neutral currents, the ground fault monitor process must be set at a trip point above the normal system neutral currents. The advantage of this approach is that 3–pole (non–separately derived) systems can be configured to provide GFI on the generator. As long as the normal neutral currents are less than 1200 amps, this solution complies with NEC 700.6(D). The disadvantage of the 3–pole vectorial method is that the GFI will not be as sensitive as a separately derived, 4–pole solution.

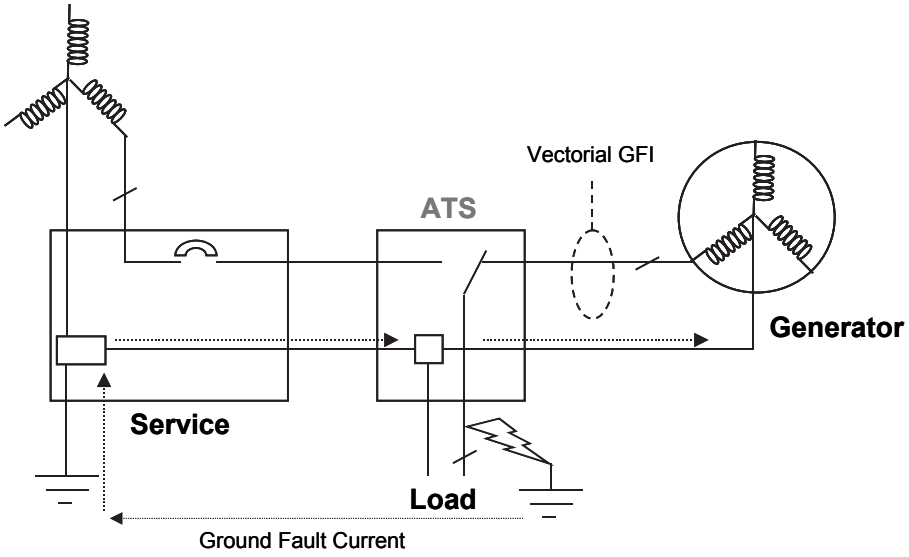


Figure 9

Single ATS Applications With GFP

Sometimes system designers incorrectly assume that if the service has GFP then the system will need to be separately derived to prevent false GF tripping of the service. Figure 9 shows a 3–pole system with an active ground fault condition. If the service had GFP, it would trip in response to a system ground fault when utility power was restored. In this case, that's desirable because it will prevent the ATS from transferring back to the utility source, only to have the utility source trip open on ground fault. When there is no active ground fault condition, there is no path for normal neutral currents to negatively affect service operation.

Multiple ATS Applications Requiring 4–pole Switches

When multiple transfer switches are utilized, multiple current paths are inadvertently created for neutral currents returning to the generator source. These inadvertent paths may take normal system neutral currents through utility side GFP, creating the potential for false ground fault operation of a building service or feeder circuit. Figure 10 illustrates this condition when multiple services are connected to the same generator source(s).

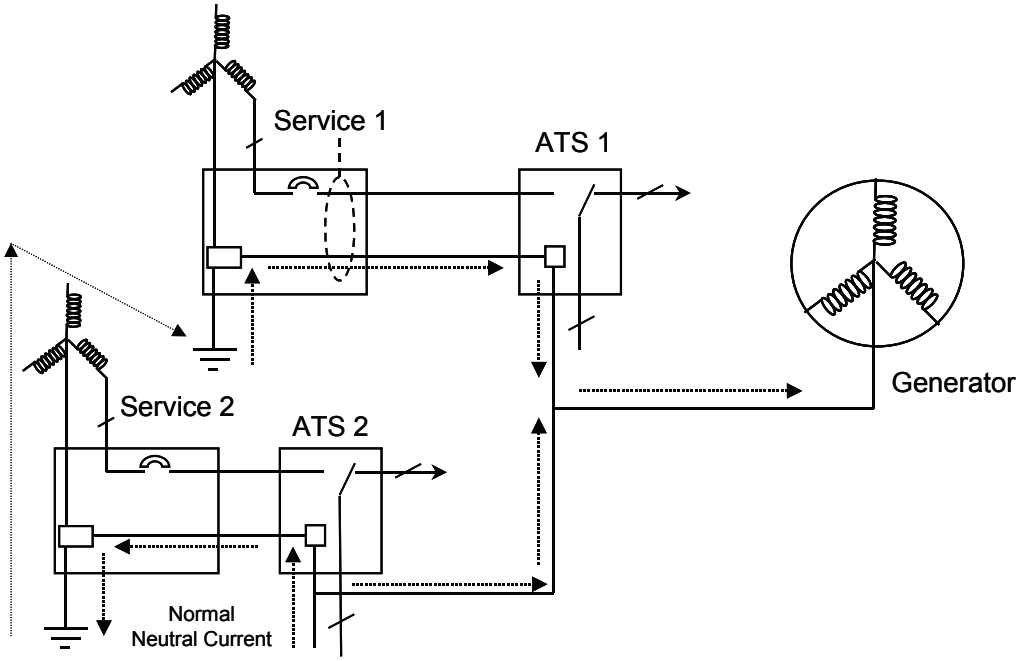


Figure 10

Figure 11 illustrates a typical healthcare application with required GFP on the feeders. The applications depicted in both figures 10 and 11 should utilize 4–pole transfer switches to prevent false ground fault tripping.

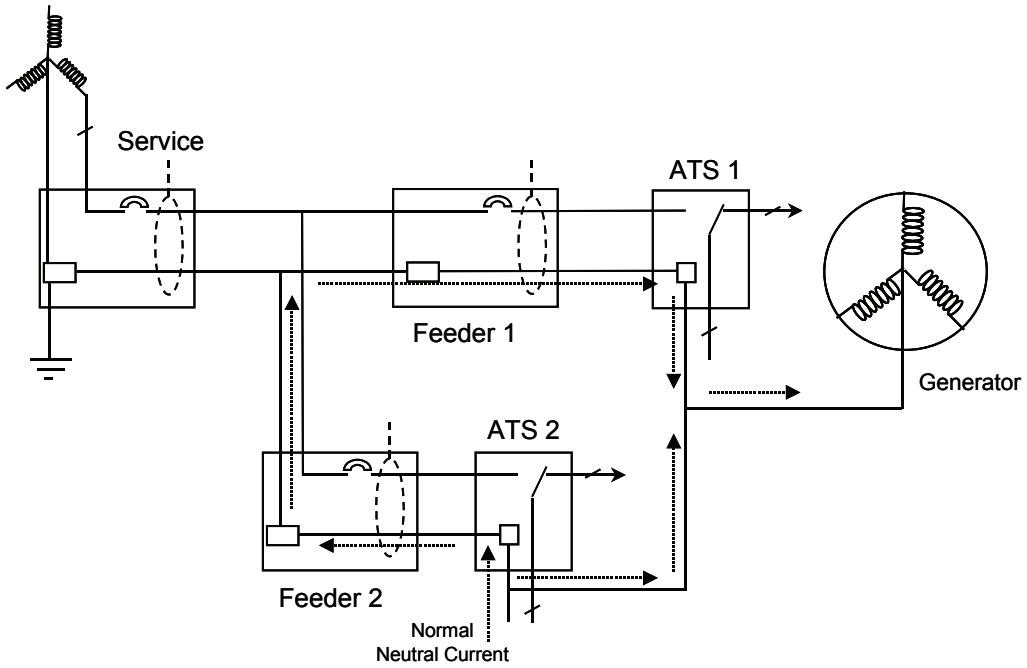


Figure 11

Figure 12 shows how a 4–pole ATS scheme corrects the problems illustrated in figures 10 and 11.

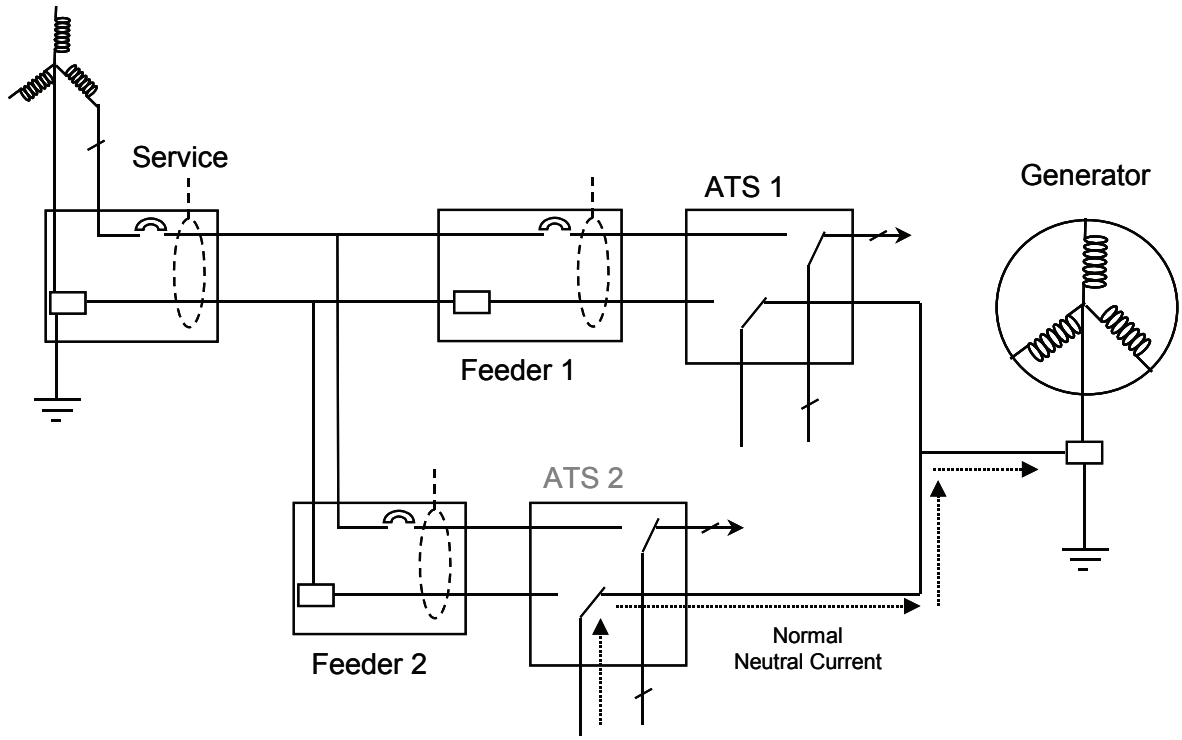


Figure 12

4–pole Switches vs. Overlapping Neutral

Most applications requiring a separately derived system utilize an industry standard 4-pole transfer switch. There are tens of thousands of 4-pole switches installed and operating without issue. However, due to market competition, a limited number of manufacturers have chosen to differentiate their 4-pole switches by overlapping the neutral contact during transfer. This is marketed as a solution to a proposed theoretical problem with implementing industry standard 4-pole automatic transfer switches (ATSs).

> The proposed theoretical problem is that during transfer, the neutral will disconnect prior to the line conductors. The higher current on the line conductors results in greater arching than the neutral connection. The arching will then maintain line connections longer than the neutral connection. With the neutral disconnected and the line connections still energized, a potential voltage divider condition exists. The single-phase loads in the system are now in series between line-to-line voltages. If the loads are unbalanced, a voltage difference may develop on each phase. It is proposed that this is an equipment damaging voltage spike.

As a theoretical argument this sounds, reasonable, but the reality is that the "theoretical" problem doesn't seem to present itself in practice as illustrated by thousands of 4-pole transfer switch applications. Furthermore, given the number of 4-pole ATSs in the market, suppliers of overlapping neutral ATSs should not have any problem documenting the "proposed" problem with strip chart equipment. This data does not seem to exist or, if it does, it hasn't been used in typical marketing materials. Some of the possible reasons that this proposed issue is not proven in practice are listed below:

- Most three-phase applications are dominated by three-phase load. As a result, the potential load imbalance caused by single-phase loads is minimal.
- Applications with significant single-phase loading tend to be relatively balanced between the available line conductors. This is a natural function of distribution panel layout and period checks of system balance.
- The natural inductance in the system tends to oppose switching transients.

On the surface, it would appear that there is no disadvantage with utilizing overlapping neutral ATS equipment – so why not require it just to be "safe"? The reality is that an overlapping neutral ATS does offer some significant disadvantages:

- 4-pole ATSs utilize a single switching mechanism that reliably drives all 4-poles. With an overlapping neutral ATS, the switching of the ATS neutral is significantly different than the phase conductors. This requires a more complex switching mechanism that increases the possible failure modes for the ATS.
- During transfer, overlapping neutral ATSs create two points of ground (generator and service) during the transfer. This could cause normal neutral currents in the system to have multiple paths back to the power source(s). The resulting unintended neutral current paths can cause nuisance ground fault protection (GFP) operations. This may require the ground fault protection to be set at a higher trip point or have a time delay added, resulting in a decrease in ground fault protection.
- This next point is based on human error. Since most applications use 3-pole ATSs, we have encountered numerous systems where the installing contractor didn't understand the functionality of the less common overlapping neutral ATS. They did not always recognize the overlapping neutral ATS as a separately derived system device requiring a ground plane to be established at the generator. They were aware that 4-pole switches required and additional ground plane, but less certain about overlapping neutral technology. The resulting mistake can leave the facility ungrounded during generator operation.
- The final point is based in cost. Overlapping neutral ATSs are only offered by a limited number of manufacturers in an effort to differentiate their product offering. Once specified, the less competitive nature of this product results in significantly higher ATS capital cost.

In conclusion, 4-pole transfer switches are market proven, highly reliable, simpler in concept and operation, cost effective and avoid potential GFP issues. Though overlapping neutral ATSs do solve a "theoretical" problem, this problem seems to be self-solved in practice.

System designers always face multiple, and sometimes confusing, choices when designing power distribution systems. It is the intent of Generac Power Systems to provide designers with accurate information that will help to facilitate informed decisions. Although separately derived systems are preferable or necessary in some situations, it is our opinion that non–separately derived systems provide numerous advantages in the majority of applications. If you have specific questions or would like additional information regarding this topic, please feel free to contact your local Generac dealer or Generac Power Systems.

Generac Power Systems
www.Generac.com
1–888–Generac

Online Final Assessment

Final assessments are available for each PDSS session. These assessments are Web-based and can be accessed using Generac's online learning system *"The Learning Center"* (http:// learning.generac.com). PDSS participants are required to obtain a score of at least 80% to pass an assessment. Each online assessment also contains a training survey. The survey provides each participant an opportunity to rate various components of the learning experience along with information relative to business development. Instructions for how to register and log in to this system, take the final assessment and print a certificate, are described in the Registering in *"The Learning Center"* section below.

Continuing Education

Upon successful completion of a seminar, participants will be awarded 2.0 PDHs (Professional Development Hours) and 0.2 CEUs (Continuing Education Units). Successful completion of a seminar requires that the participant have:

- Attended the complete seminar
- Received a minimum score of 80% on the Final Assessment

Certificate of Accomplishment

Participants who successfully complete the seminar and receive a passing score on the online final assessment are entitled to a "Certificate of Accomplishment." Certificates are available for printing directly from the participant's account screen on Generac's online training system *"The Learning Center".* Instructions for how to register and log in to this system, take the final assessment and print a certificate, are described beginning in the following section.

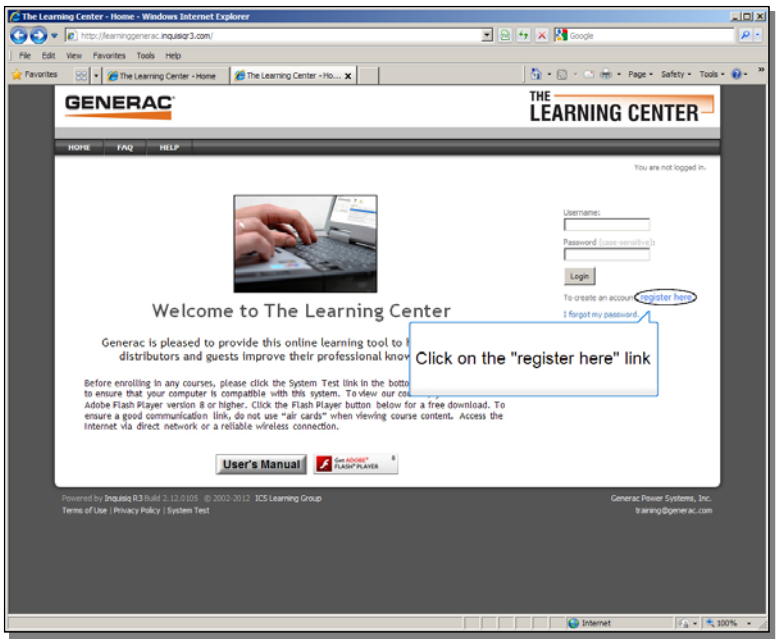
Registering in *"The Learning Center"*

To gain access to *"The Learning Center*", you are required to register and set up a user account. During your account setup you will create a *Username* and *Password*. Your username and password can then be used to log in on subsequent visits.

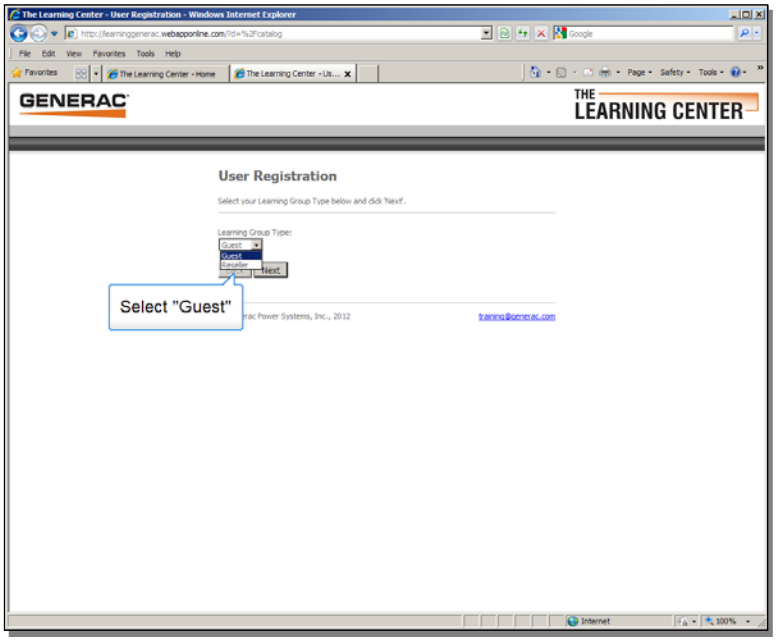
The following pages will aid you in the registration process along with the Final Assessment, Survey and Certificate procedures.

To begin the registration process, open your computer's browser and enter http:// learning.generac.com. This should take you to *"The Learning Center"* home page. This page is displayed at the top of the next page. From this point you can follow illustrated steps.

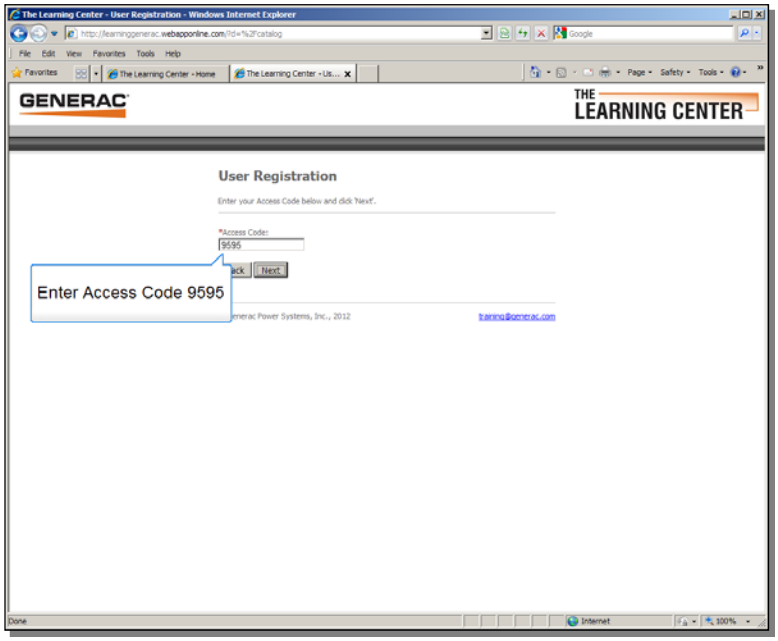
Begin by entering http://learning.generac.com in your computer's browser. The screen below will be displayed. Click on the "register here" link to begin the registration process.



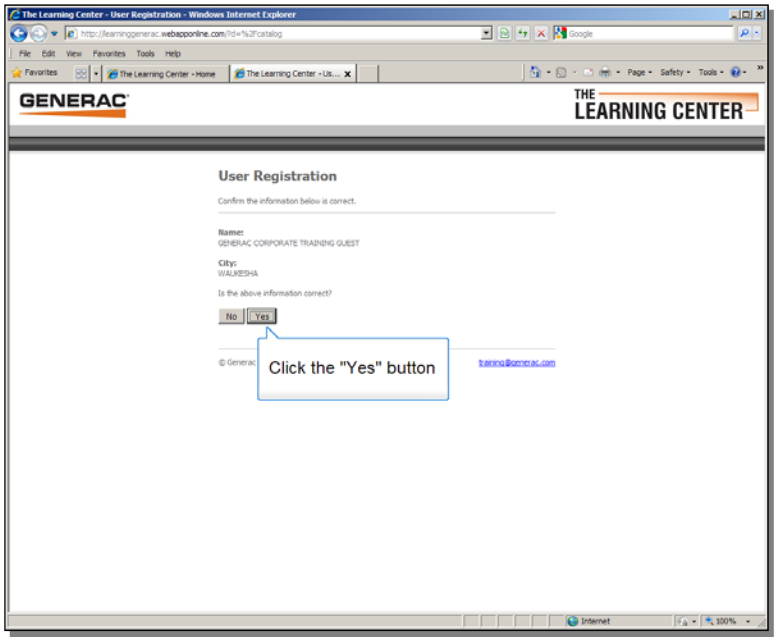
On this screen you will select "Guest" from the drop down box and click the "Next" button.



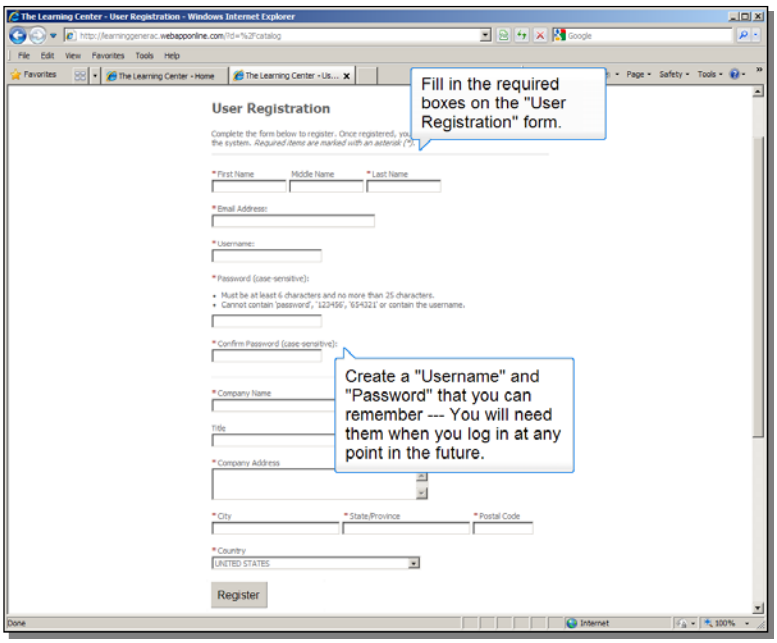
In this next screen enter **Access Code 9595** and click the “Next” button. Please keep this code private.



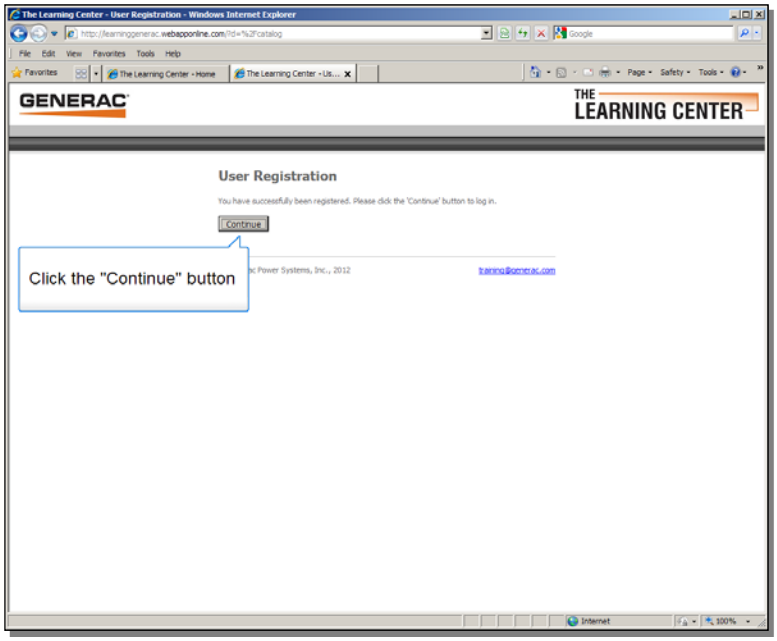
This screen confirms the correct access code entry. Click the “Yes” button to proceed.



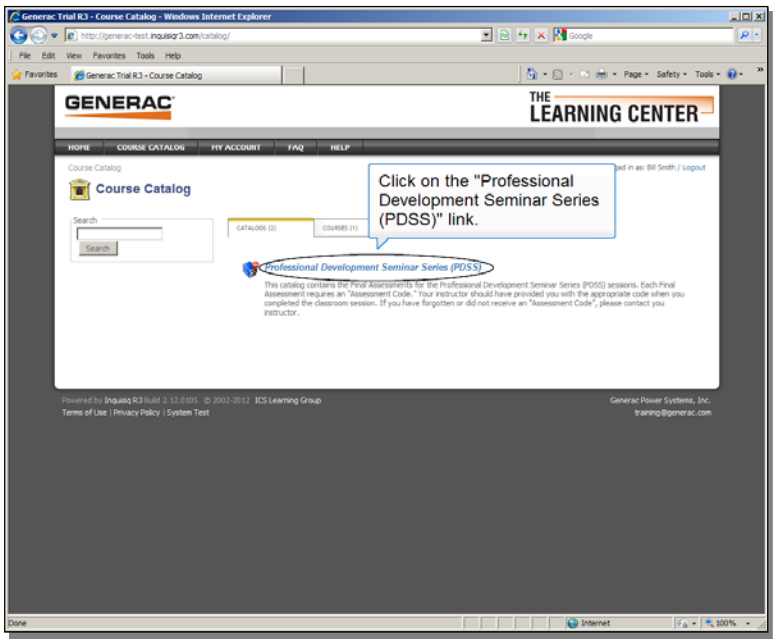
The next screen contains the “User Registration” form. Fill in the required boxes, and then click the “Register” button.



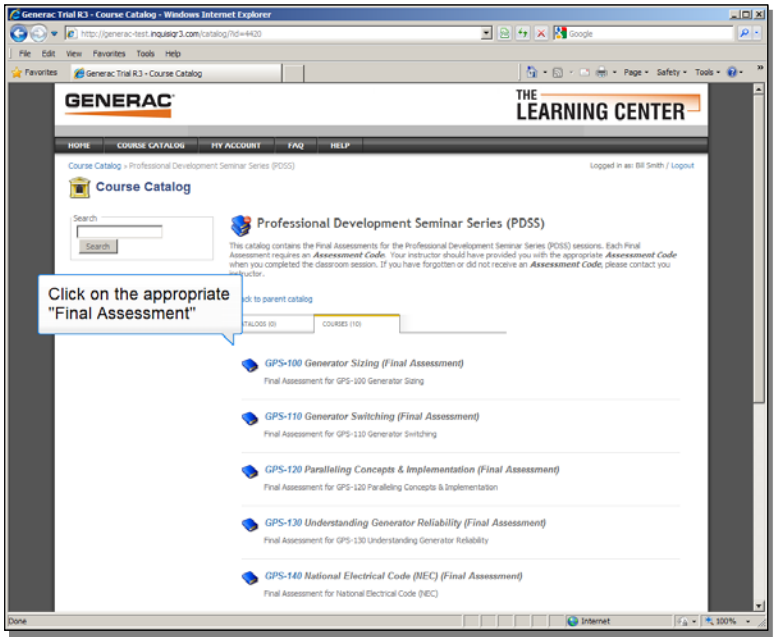
The next screen confirms your registration. Click the “Continue” button to proceed.



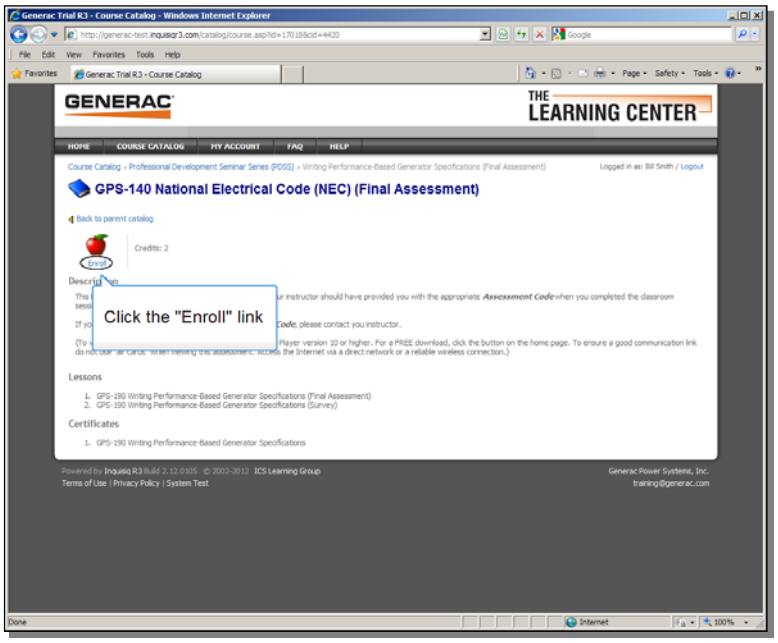
The next screen displays the “Course Catalog.” Click on the “Professional Development Seminar Series” link.



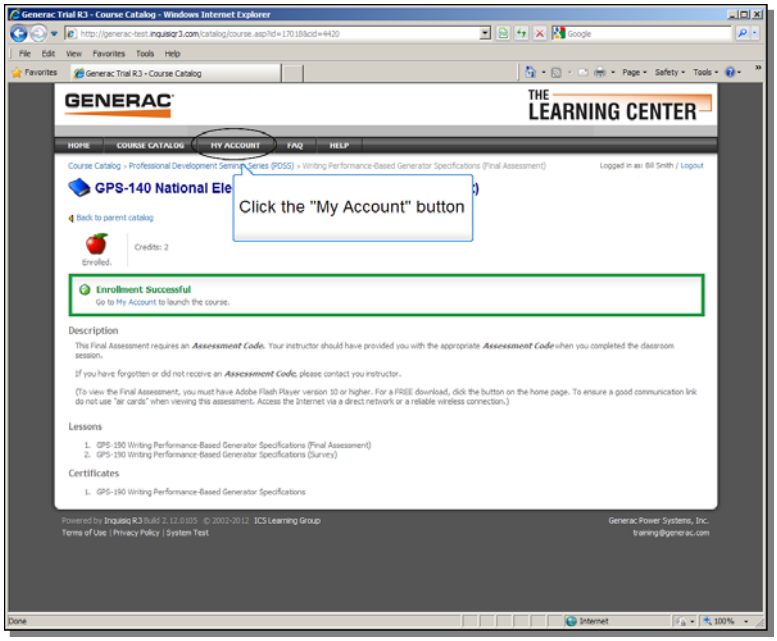
This next screen lists all currently available Final Assessments. Click on the Final Assessment that is tied to the course name and number you completed.



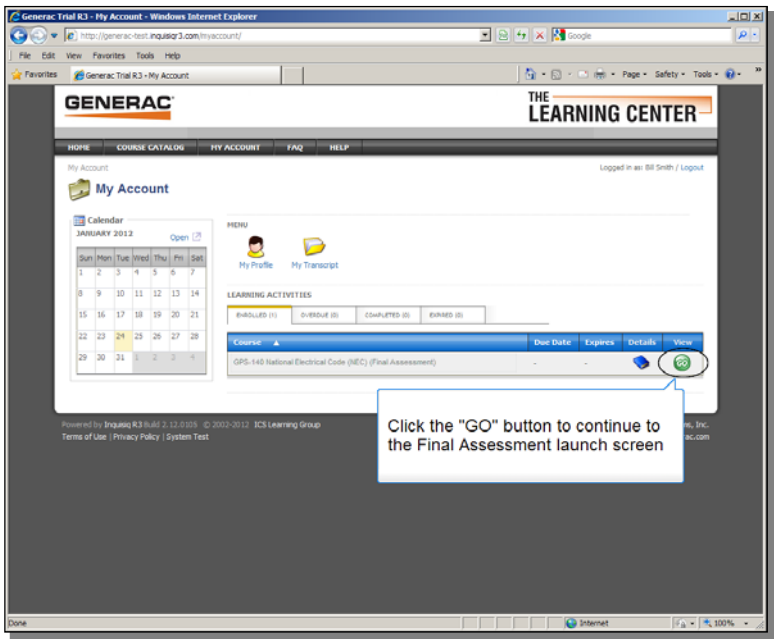
The next screen is the “Enrollment” screen for the Final Assessment that you selected. Click the “Enroll” link to proceed.



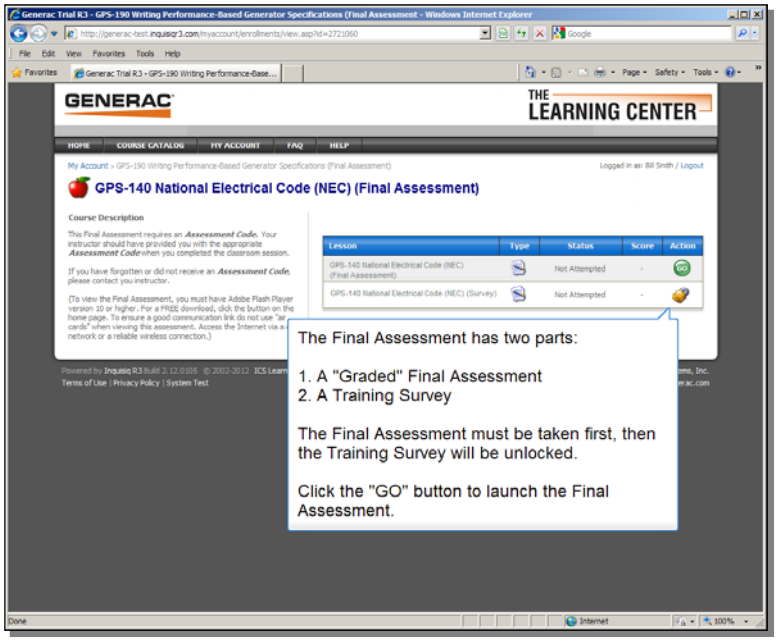
This screen confirms your enrollment. Click the “My Account” button to proceed.



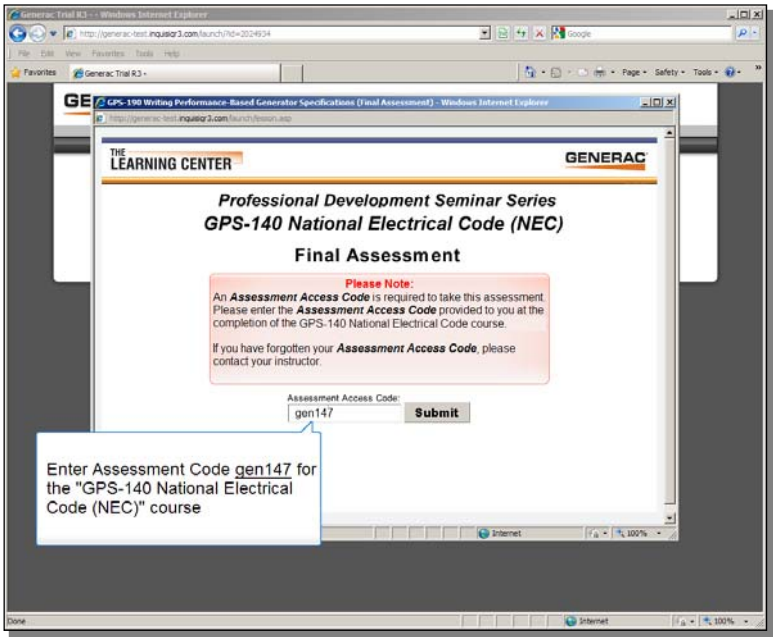
This is your “My Account” screen. Note that the Final Assessment you selected is displayed under the “Enrollment” tab. Click the “GO” button to proceed.



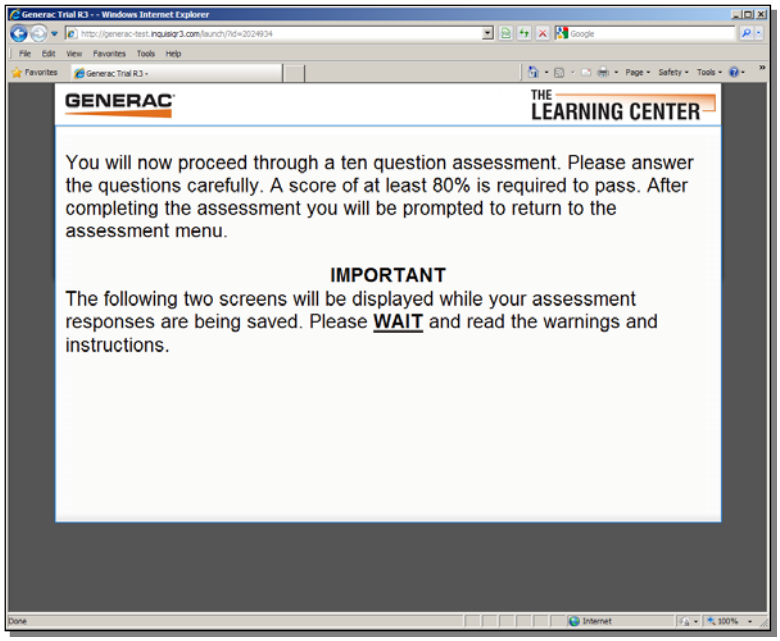
This screen lists the two parts to the Final Assessment. You must take the “Graded” Assessment first, then the Training Survey.



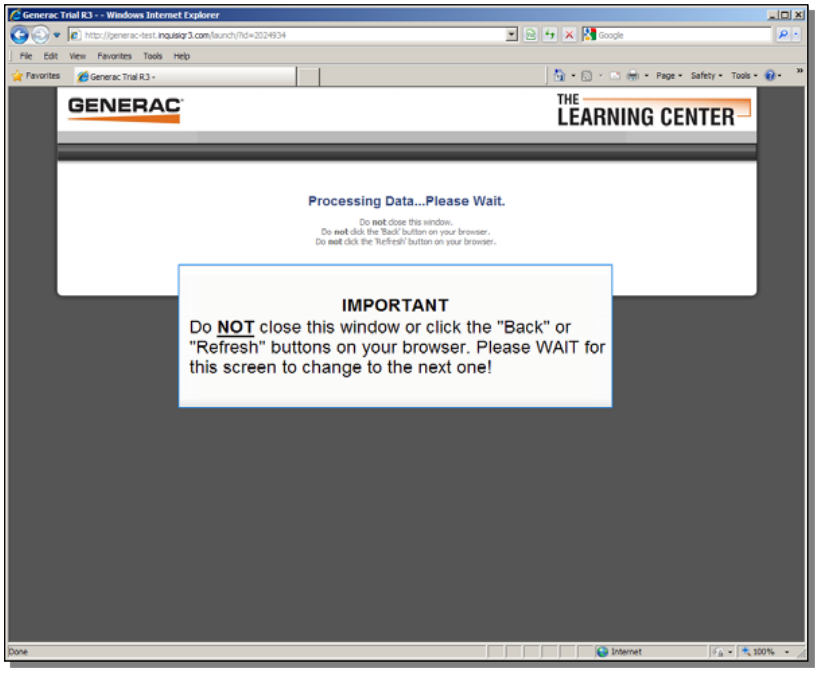
In the next screen an “Assessment Code” is required before you can continue. The code for GPS-140 National Electrical Code (NEC) is **gen147**. Enter the code in the box and click the “Submit” button to continue.



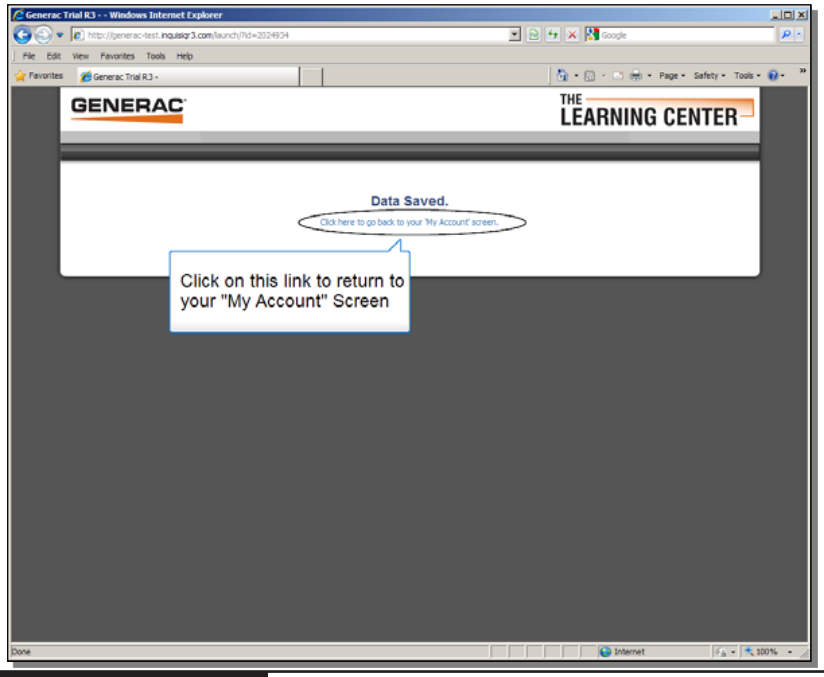
You will now proceed through a ten question assessment. Please read the warnings below.



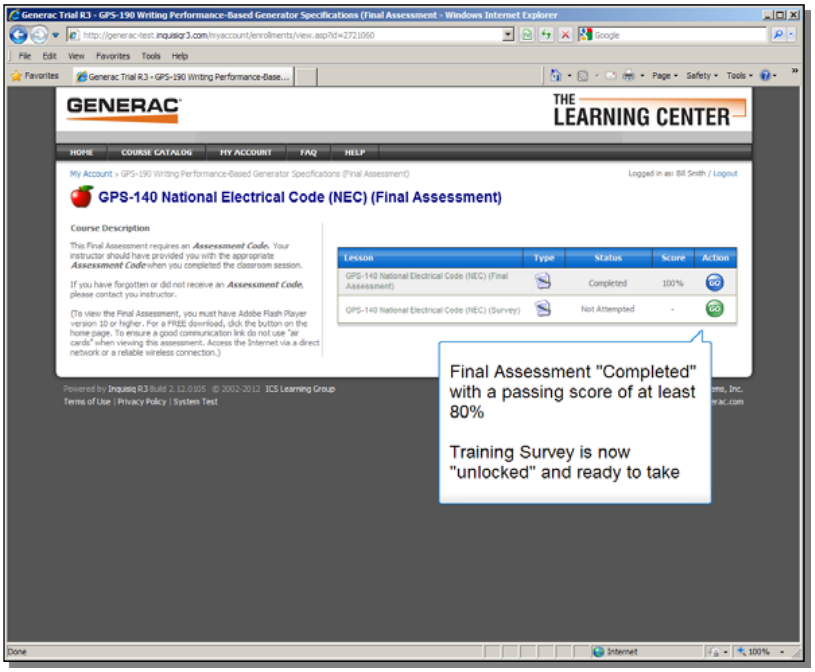
Please follow the instructions on this screen. You must wait for your assessment data to be saved. Do not close this window or click the 'Back' of 'Refresh' buttons on your browser.



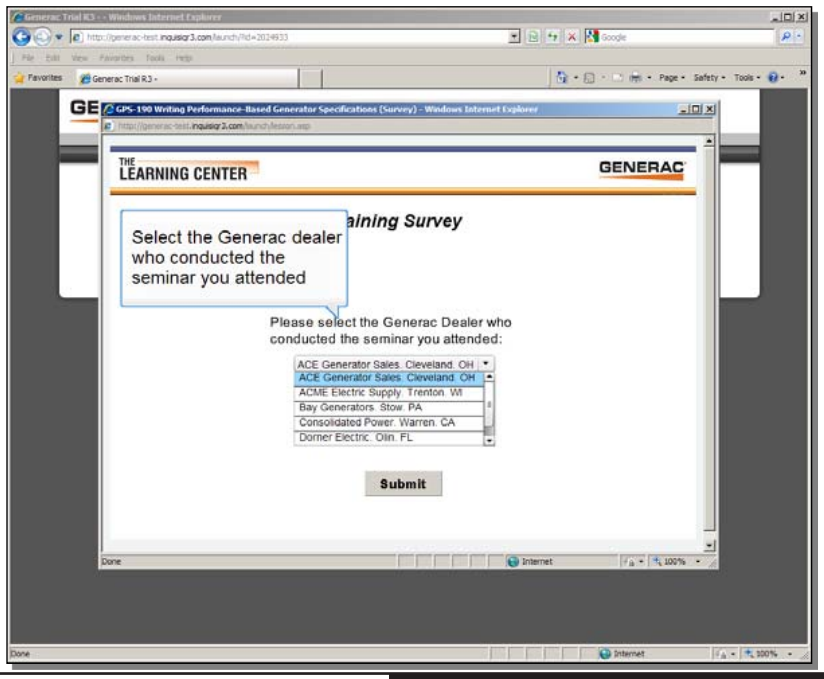
This screen confirms that your data was saved. Click on the link shown here to proceed.



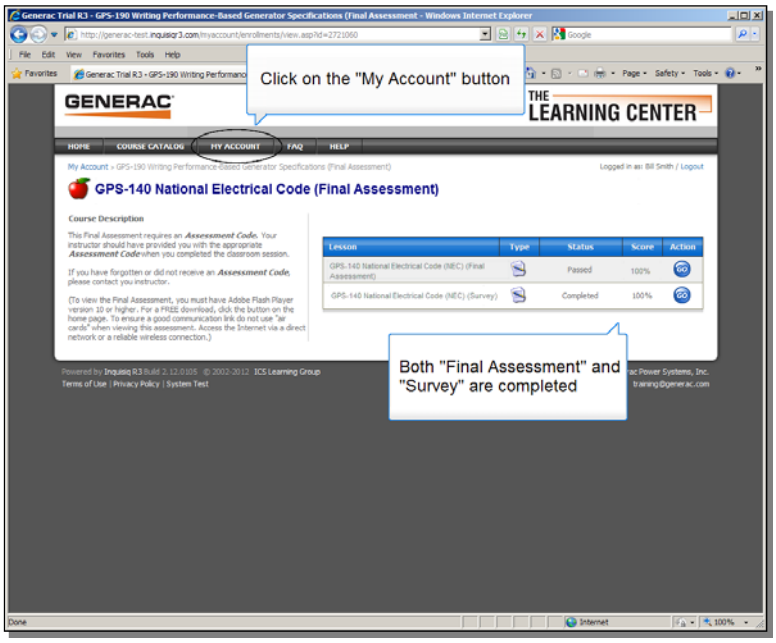
This screen will be displayed after your assessment data is saved. Note that in this example the assessment was passed with a score of 100% and the Survey is unlocked and ready to launch.



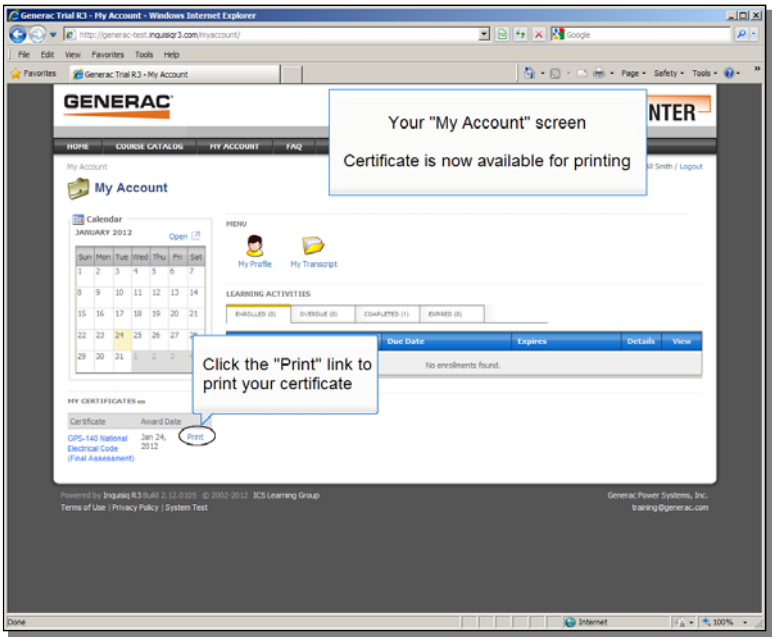
Upon launching the Survey, this screen will be displayed. Select the Generac dealer who conducted the seminar you attended.



After completing the survey you will be prompted to return to the assessment menu. Your response data will be saved as before, and you will see the screen below. Click the "My Account" button to continue.



Your "My Account" screen will look similar to the one shown here. Click the "Print" link to print your certificate.



NOTES

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