PROFESSIONAL DEVELOPMENT
SEMINAR SERIES

GPS-110 GENERATOR SWITCHING

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. Reliability is a crucial component for these systems.

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:

The purpose of this course is to provide you with a basic overview of automatic transfer switches. Beginning with a review of the various types of transfer switches, you'll learn how each is constructed and operates. You will be shown different topologies along with animated sequence of operation visuals of each type. In the second lesson we'll explore application considerations. We'll discuss in-phase vs. delay-in-neutral transfers and fault current ratings. We'll also cover automatic transfer switch construction considerations and separately derived vs. non-separately derived operation.

TIME:

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

LEARNING OBJECTIVES:

Upon completion of this seminar, participants should be able to:

- Describe the operation of an Open Transition transfer switch
- Describe the function of a Bypass Isolation transfer switch
- Describe the function of a Service Entrance rated transfer switch
- Describe the operation of a Closed Transition transfer switch
- Select the appropriate type of switch for a particular application
- Explain the terms "Soft-Load", "Base-Loading" and "Peak-Shaving"
- List two ways that open transition switches transfer between two live sources
- Explain the "Delay-in-Neutral" transfer operation
- Explain the "In-Phase" transfer operation
- Explain the differences between Contactor, Molded Case and Insulated Case & Power Breaker switching devices
- Describe the 4-Pole method of neutral switching
- Describe the Overlapping method of neutral switching
- Specify proper fault current ratings for particular transfer switches
- Explain the terms "Separately Derived" and "Non-Separately Derived"

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

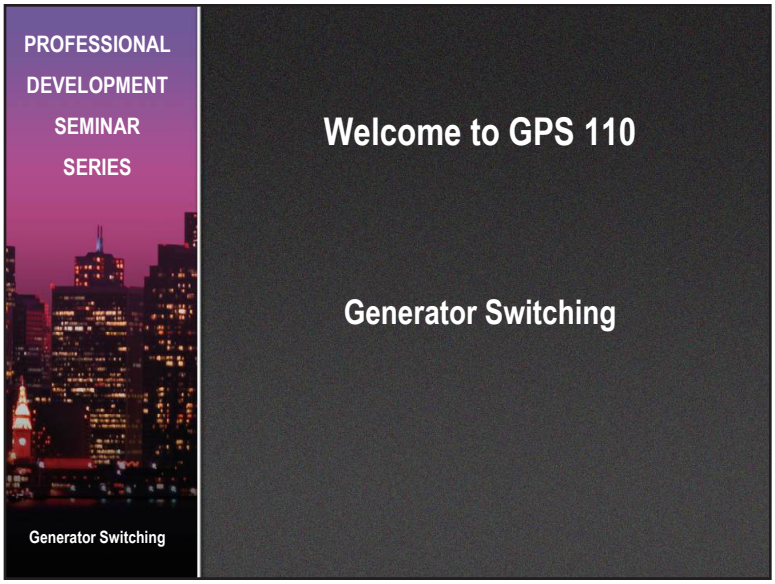
TIME	LESSON	DESCRIPTION
5 minutes	Introductions	Get to know other participants and the trainer. The trainer welcomes participants and conducts an opening activity.
40 minutes	Lesson 1 Types of Generator Switching	This lesson provides an overview of the operation and selection criteria for various types of automatic transfer switches. The goal of this lesson is to be able to select the type of switching technology that best matches the application.
40 minutes	Lesson 2 Application Considerations	This lesson provides information on special operational and application considerations. The goal of this lesson is to explore problems in ATS applications and provide real world recommendations.
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.

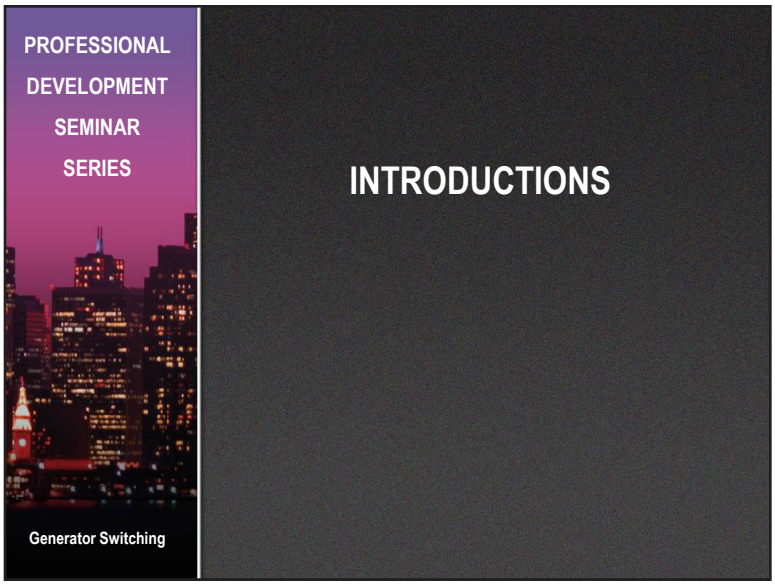
INTRODUCTION

TIME: 5 minutes

OBJECTIVE:

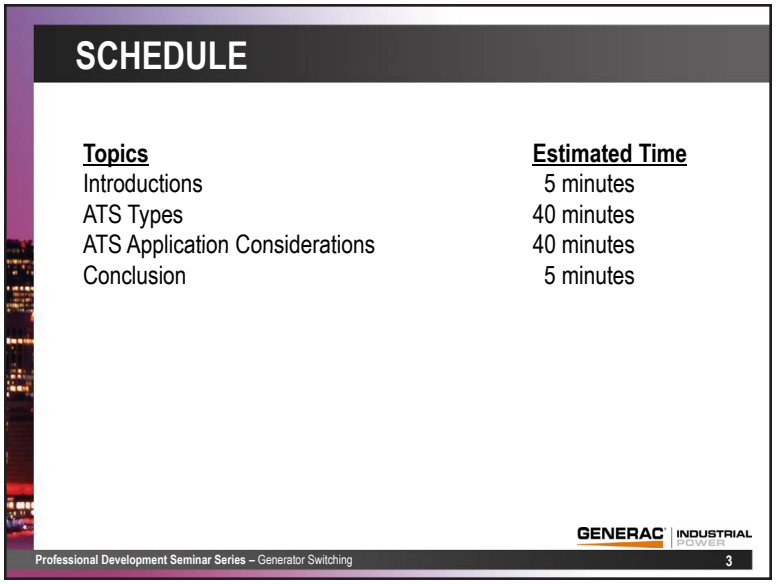
The introduction is an opportunity for the trainer and participants to become familiar with each other. This period will discuss the topics to be covered, capture initial questions, introduce transfer switches and review ATS sizing.

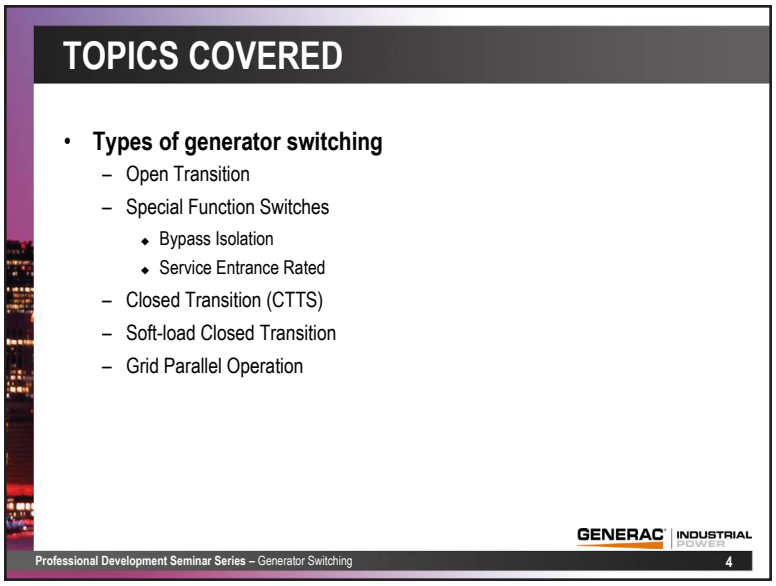




NOTES

INTRODUCTION





NOTES

TOPICS COVERED

- **Application considerations**
  - In-phase vs. Delay-in-Neutral Transfers
  - ATS construction considerations
    - Controllers
    - Switching device type
    - Four-pole vs. Overlapping Neutral Switches
  - Fault Current Ratings
  - Separately Derived vs. Non-separately Derived

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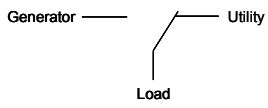
AUTOMATIC TRANSFER SWITCHES (ATS)

- **An Automatic Transfer Switch transfers the connected load from one source of power to another.**
- **Generally, the two power sources are:**
  - Utility
  - Generator



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NOTES

WHAT DOES AN ATS LOOK LIKE?

- **ATS Enclosures**
  - Indoor (NEMA 1 & 12)
  - Outdoor (NEMA 3R)
  - Non-corrosive (NEMA 4x)

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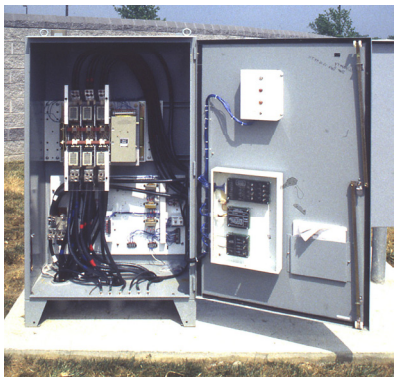
WHAT DOES AN ATS LOOK LIKE?

- **Controller**
- **Indicating lights**
- **Test switch**
- **Transformers**
- **Contactor**
- **UL 1008 Sticker**



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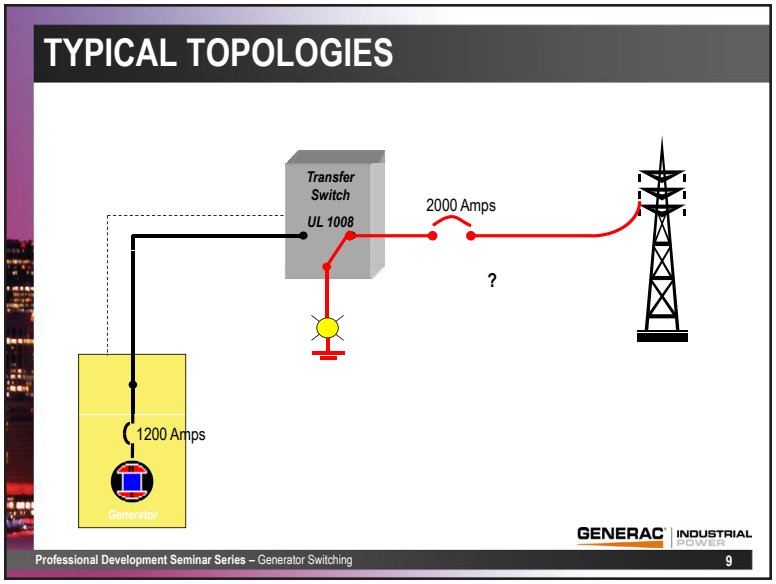
TYPICAL TOPOLOGIES
Transfer Switch
UL 1008
2000 Amps
?
1200 Amps
Generator
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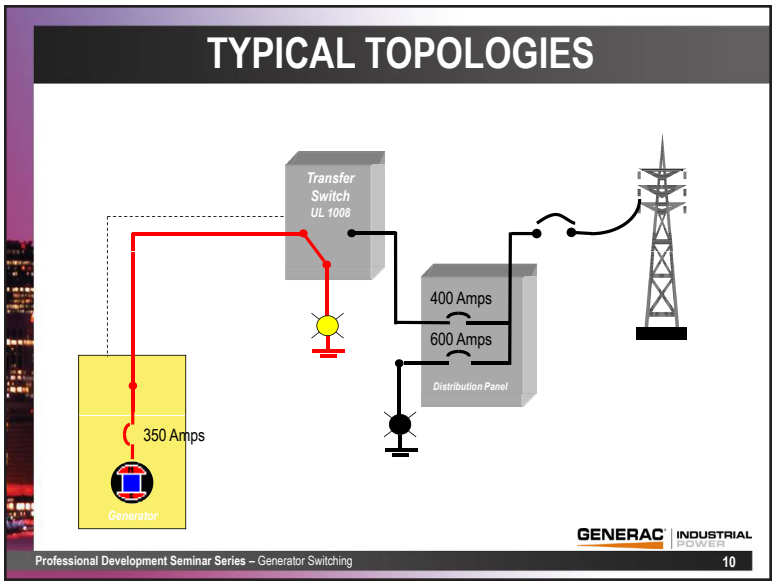
TYPICAL TOPOLOGIES
Transfer Switch
UL 1008
400 Amps
600 Amps
Distribution Panel
350 Amps
Generator
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NOTES

1. TYPES OF GENERATOR SWITCHING

TIME: 40 minutes

OBJECTIVES:

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

- Describe the operation of an Open Transition transfer switch
- Describe the function of a Bypass Isolation transfer switch
- Describe the function of a Service Entrance rated transfer switch
- Describe the operation of a Closed Transition transfer switch
- Select the appropriate type of switch for a particular application
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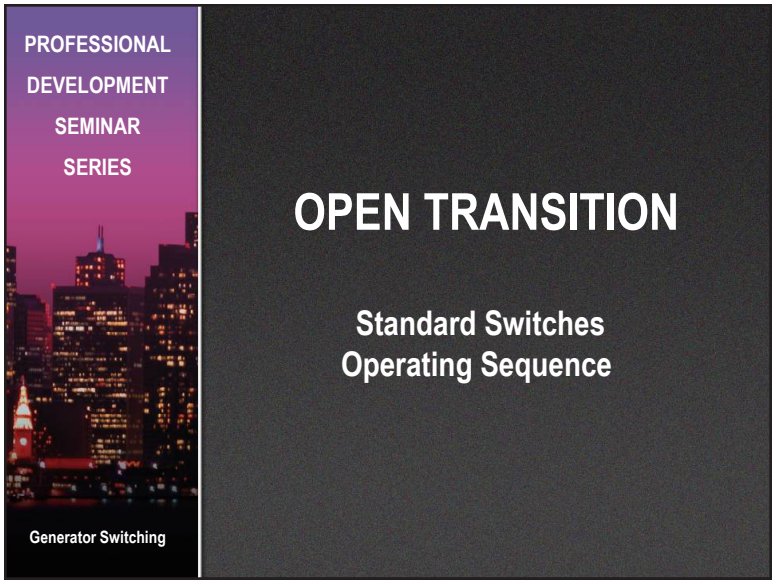
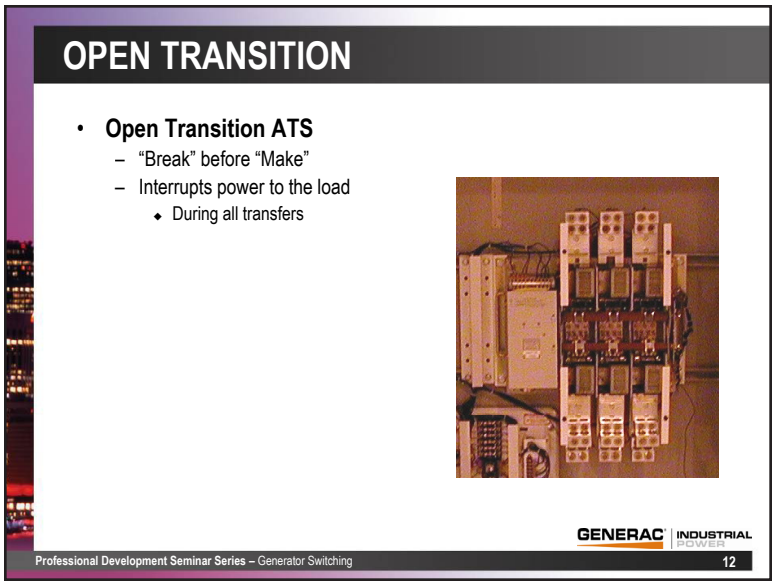


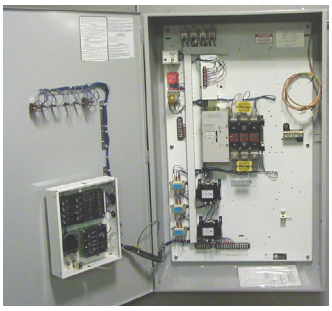


NOTES

1. TYPES OF GENERATOR SWITCHING

OPEN TRANSITION

- **Open Transition Switches**
  - Cost-effective
  - Most commonly used
  - Momentary outage on retransfer
  - Outage to maintain switch contacts



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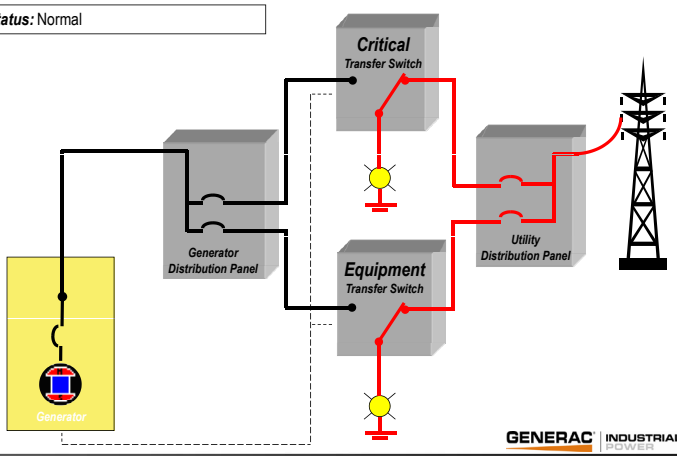
SEQUENCE OF OPERATION

Status: Normal



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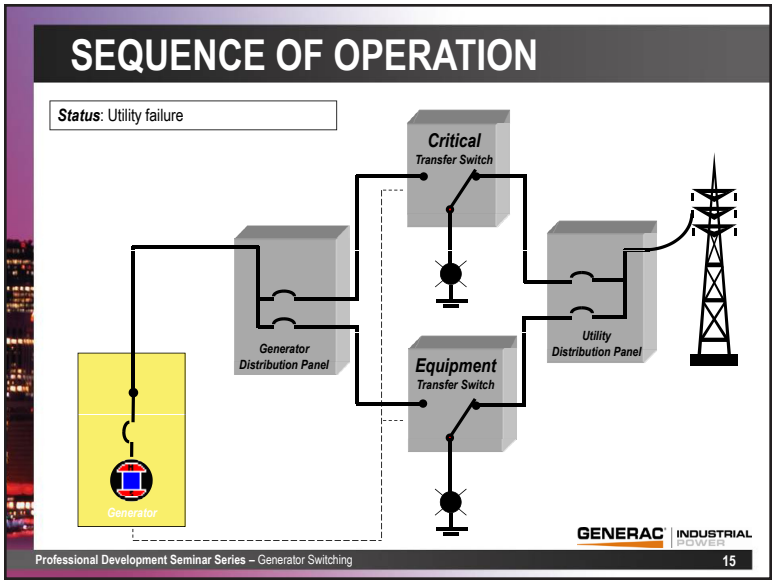
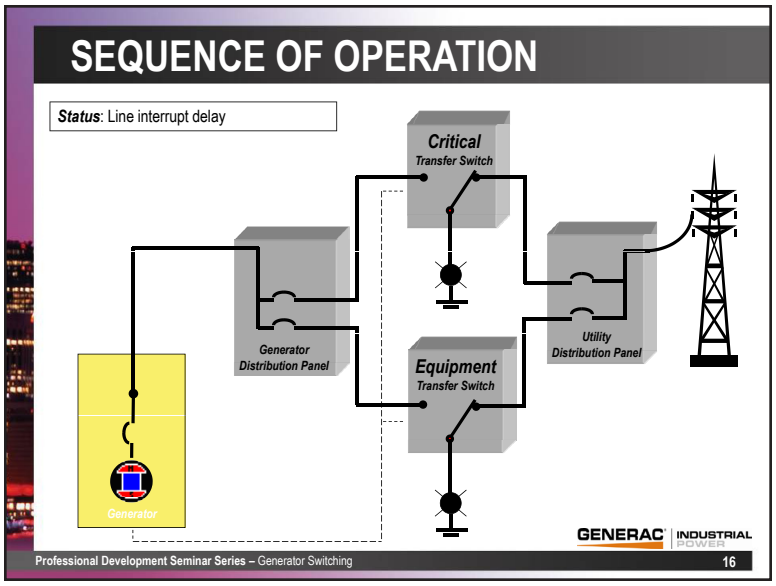
NOTES

1. TYPES OF GENERATOR SWITCHING





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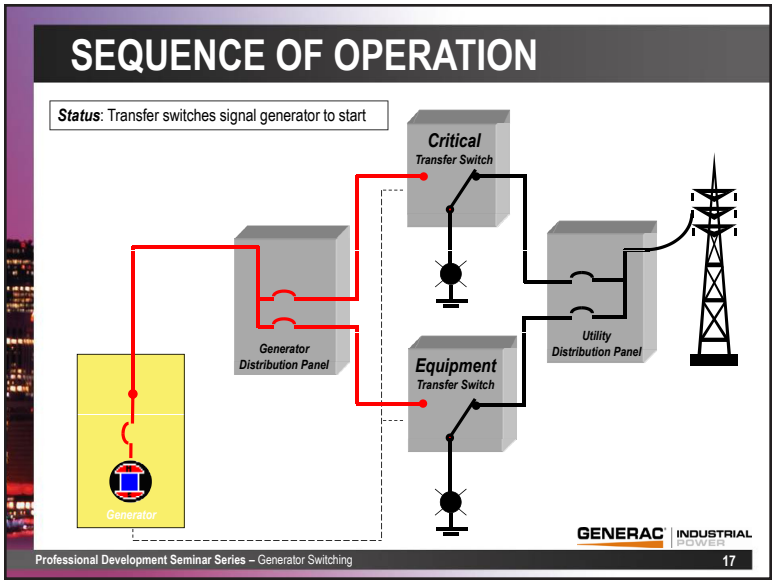

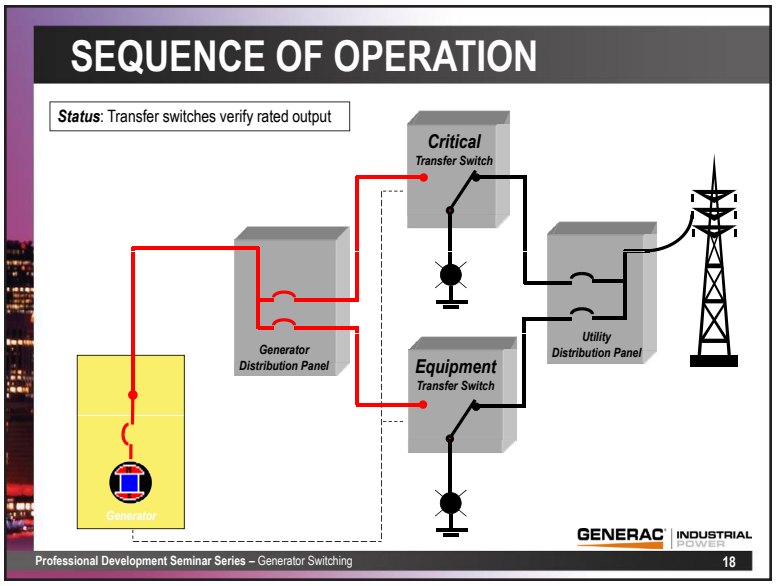

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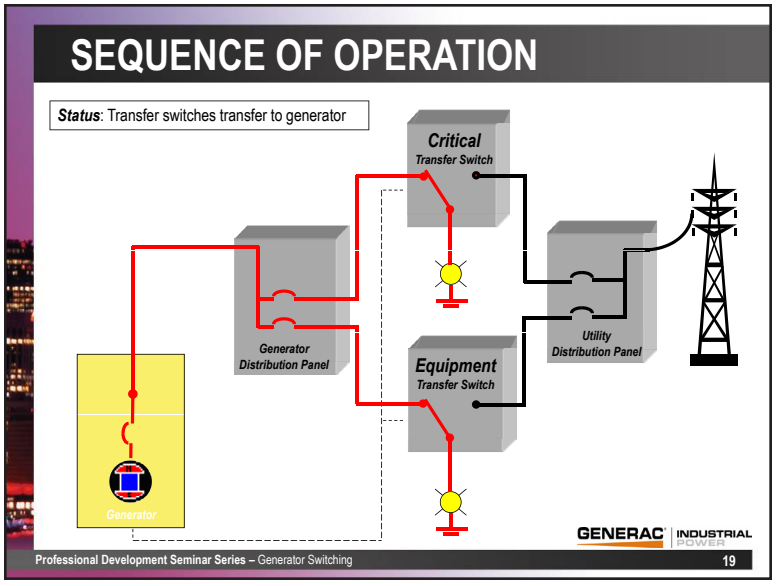

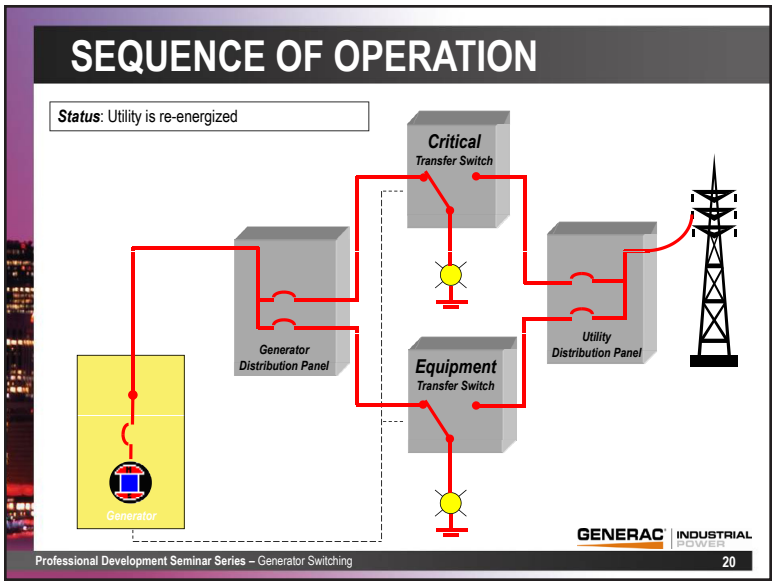

NOTES

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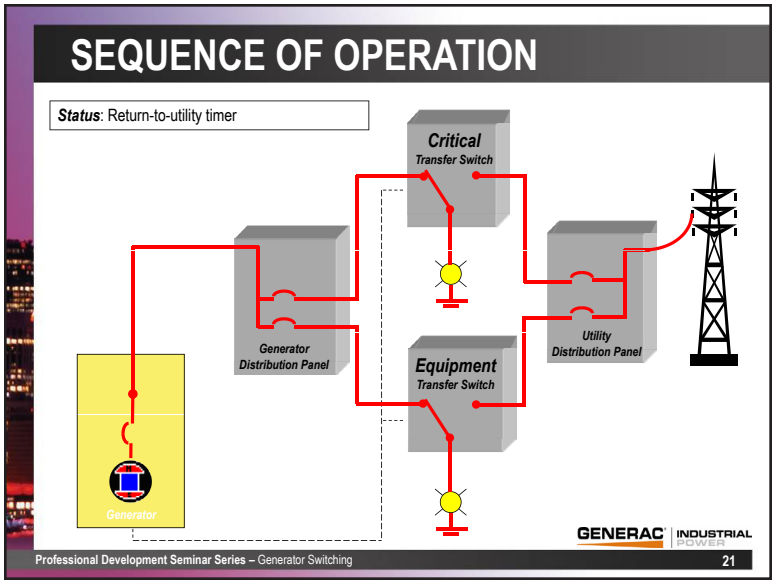

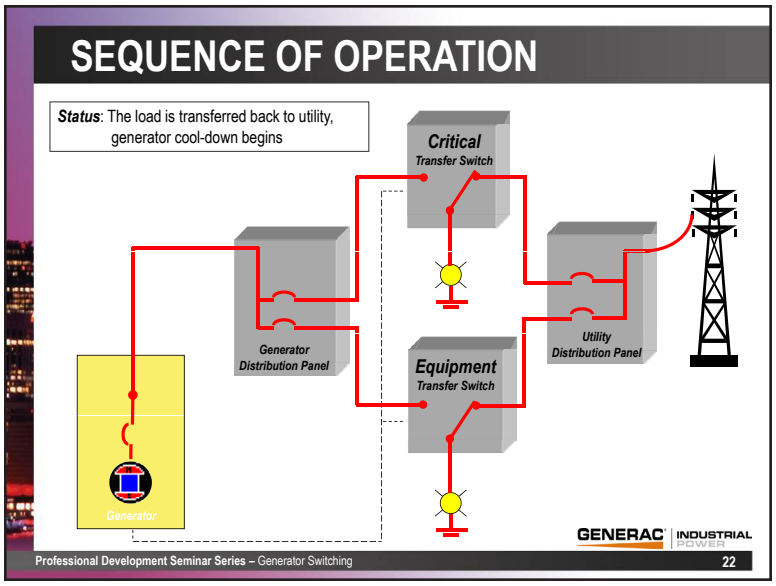

NOTES

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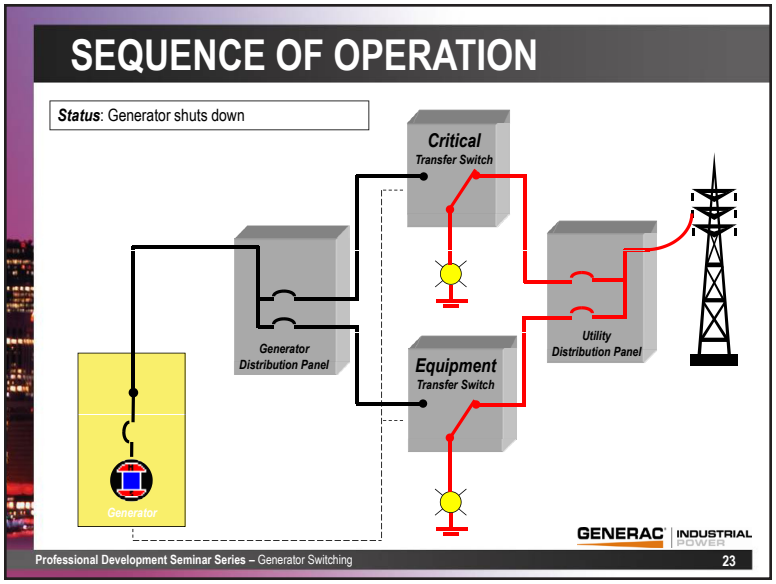

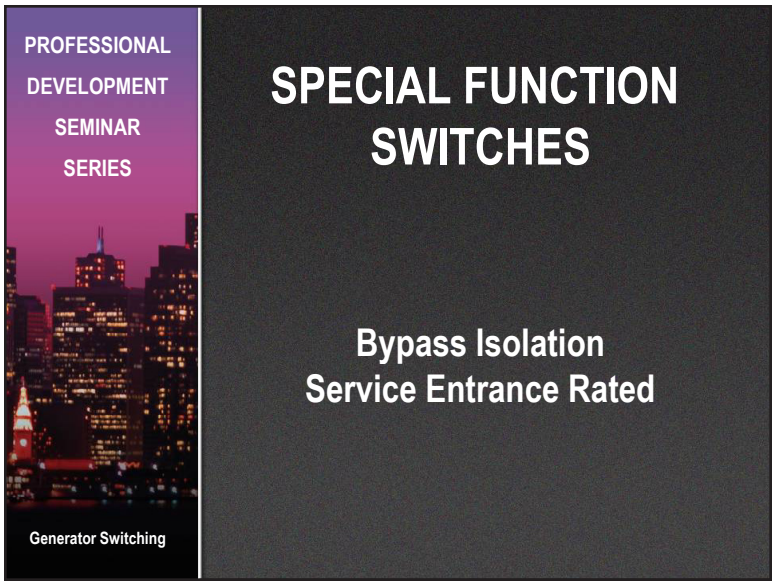

NOTES

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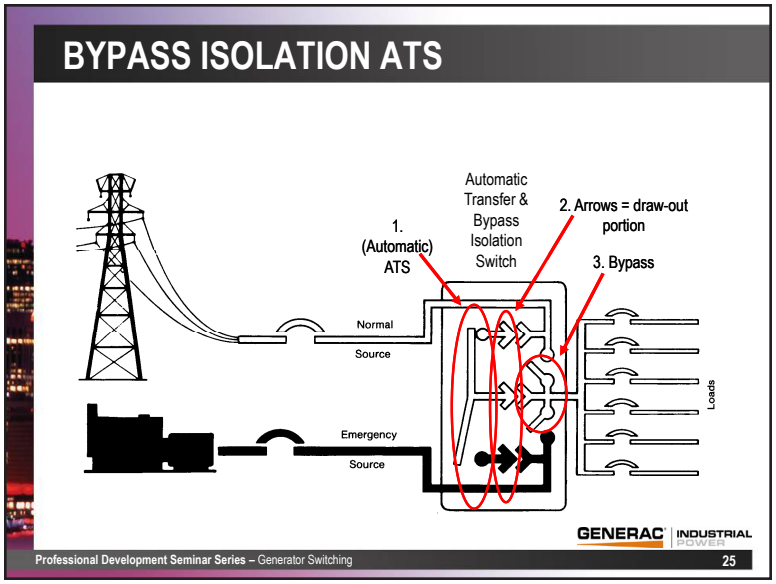

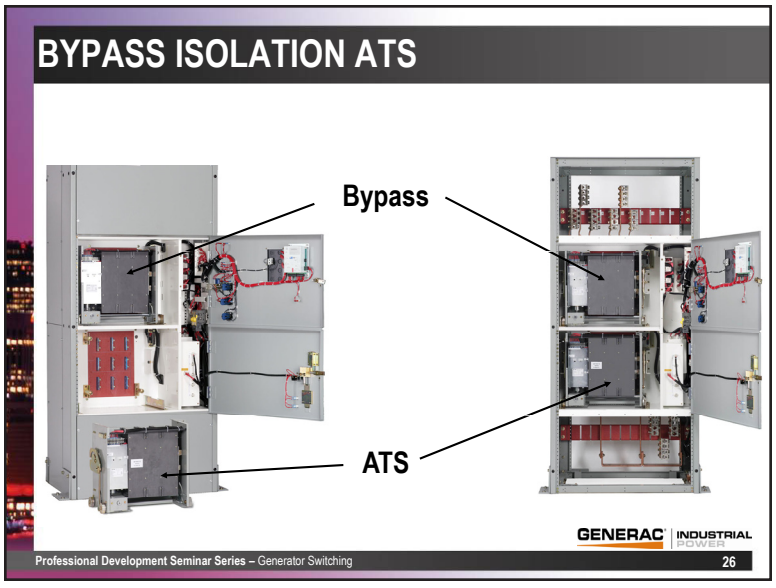

NOTES

1. TYPES OF GENERATOR SWITCHING

BYPASS ISOLATION ATS

- **Why Bypass Isolation?**
  - Primary markets — Healthcare and data centers
  - Service ATS w/o power outage
  - Local and application code requirements
- **Why not Bypass Isolation?**
  - Costs about 3 times normal ATS
  - Standard transfer switches are proven, reliable devices

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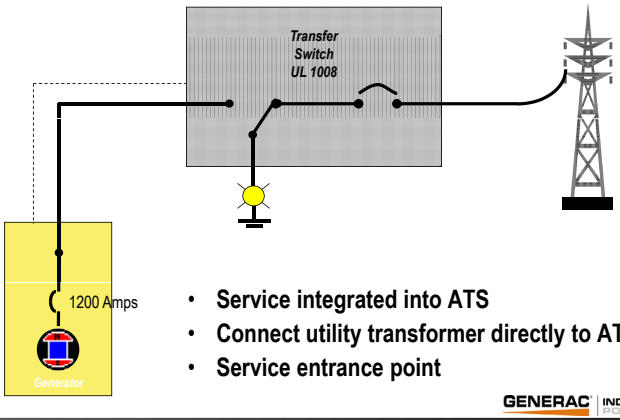
SERVICE ENTRANCE RATED



- **Service integrated into ATS**
- **Connect utility transformer directly to ATS**
- **Service entrance point**

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NOTES

SERVICE ENTRANCE RATED

- **Two implementations**
  - Package a breaker with ATS
    - Contactor type with a breaker
  - Utilize breaker style ATS
    - Molded case type
    - Isolated case "Power Breaker" type

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SERVICE ENTRANCE RATED

- **Applications**
  - Retrofit whole building applications (outside installation)
  - Old distribution equipment
    - Local requirements to "bring up to code"
- ***Factors to Consider***
  - Comfort level of facility's personnel
  - Lock-out methods implemented

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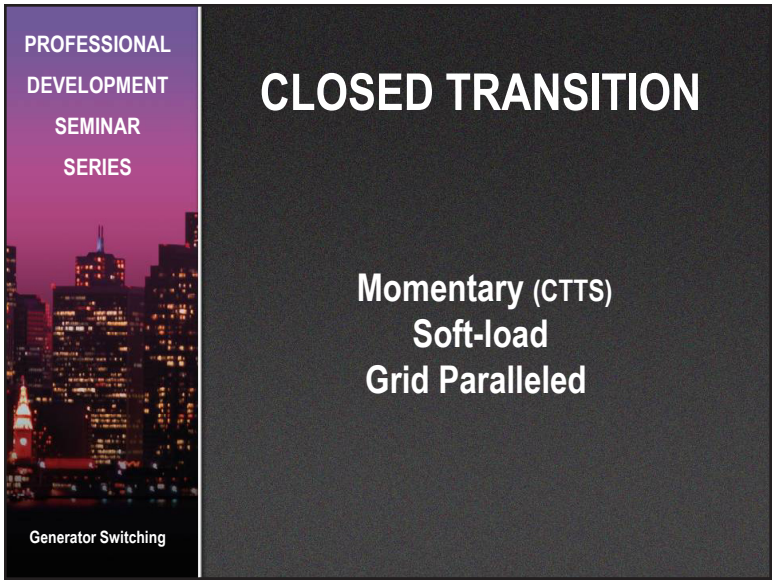
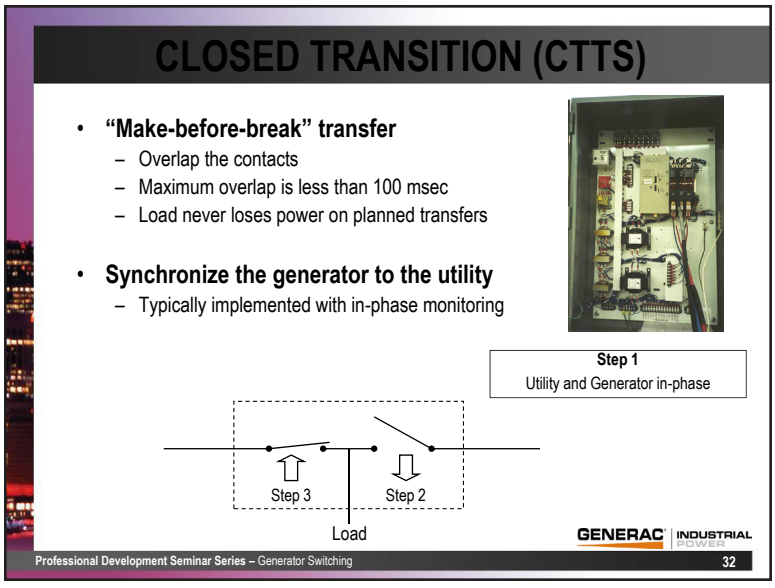
NOTES

1. TYPES OF GENERATOR SWITCHING





NOTES

CLOSED TRANSITION (CTTS)

- **Protective considerations**
  - Check utility requirements
    - Most utilities allow 100 msec CTTS operation
    - Most utilities require a protective timer (monitors connection duration)
    - Some utilities have additional requirements
  - Protective timer (ensure grid separation during CTTS failure)
    - Common feature in most CTTSs
    - Connect timer contacts to generator's shunt trip breaker

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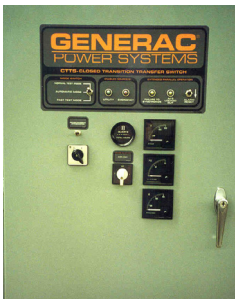
CLOSED TRANSITION (CTTS)

- **Benefits**
  - Exercise with load (more reliable generator)
  - Other benefits
    - Interruptible power rate customers
    - Storm mitigation (airport philosophy)
    - Reduces power outages (retransfer)
    - Retransfer with heavily inductive loads



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NOTES

CLOSED TRANSITION (Soft-load)

- **Synchronize the generator to the utility**
  - Active synchronization
- **Use the "make-before-break" transfer method**
  - Load never loses power on planned transfers
  - Load is ramped between sources
  - No transient on the generator
- **Open utility connection within 15 seconds**
  - Utility protective relay required

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CLOSED TRANSITION (Soft-load)

- **Examples of protective relaying that may be required**
  - Device 67 – Phase Directional Over-Current Protection
  - Device 32 – Reverse Power
  - Device 46 – Negative Sequence Over-Current
  - Device 47 – Negative Sequence Voltage
  - Device 81 – Under/Over-Frequency
  - Device 27/29 – Under/Over-Voltage
  - Device 86 – Lockout Relay
- **Increased requirements for connections longer than 100 msec**
  - Fault study may also be required

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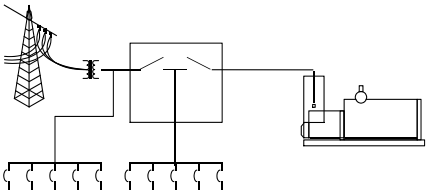
NOTES

1. TYPES OF GENERATOR SWITCHING

CLOSED TRANSITION (Grid Connected)

- **Electrically connected to the utility grid**
- **Allows for "soft" power transfers**
- **Energy management** (base loading & peak shaving)
  - Emissions (natural gas engines)
  - Spark Spread (cost feasibility)
  - Utility barriers (standby charges, ratchets, grid interconnect)



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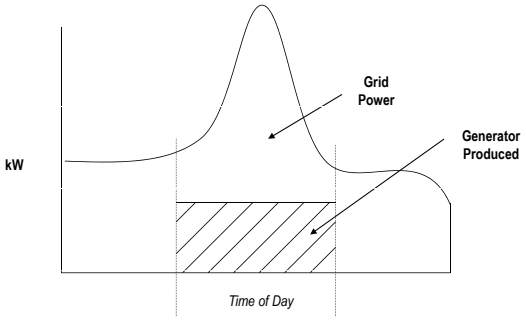
CLOSED TRANSITION (Base Loading)



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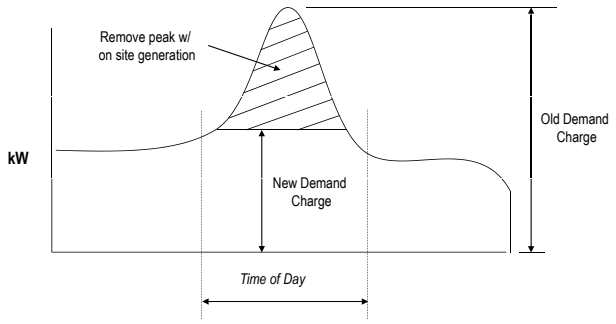
NOTES

CLOSED TRANSITION (Peak Shaving)



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ENERGY MANAGEMENT?

- **Base loading and peak shaving**
  - Typically, not cost feasible
- **Interruptible , curtailable, and demand response programs**
  - Grid paralleled operation not required
  - Transferring grid load to on-site generation resources
  - Emission constraints for operation over 15 hours / year
  - Emission regulations in flux (coordinate with your state air quality board)
  - Emission regulations will typically require non-emergency configuration
    - Diesels will require tier 4 capability
    - Natural gas units require low output catalytic converter configurations

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NOTES

2. APPLICATION CONSIDERATIONS

TIME: 40 minutes

OBJECTIVES:

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

- List two ways that open transition switches transfer between two live sources
- Explain the "Delay-in-Neutral" transfer operation
- Explain the "In-Phase" transfer operation
- Explain the differences between Contactor, Molded Case and Insulated Case & Power Breaker switching devices
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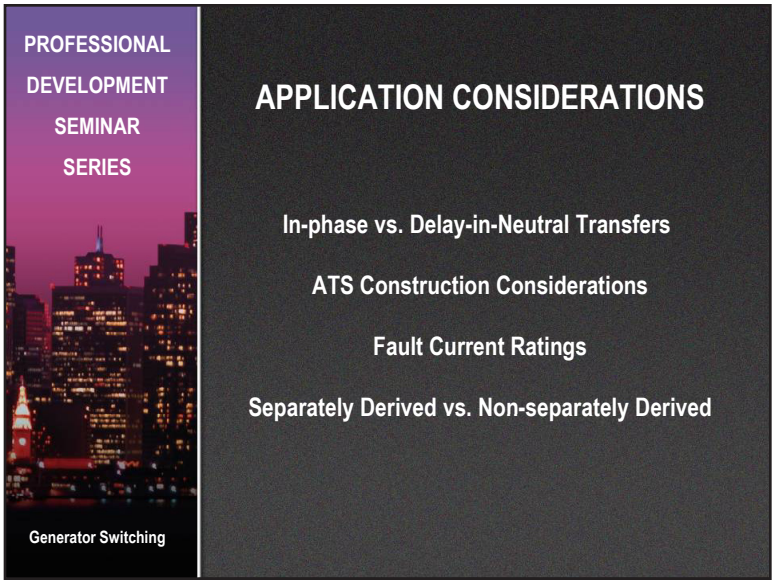

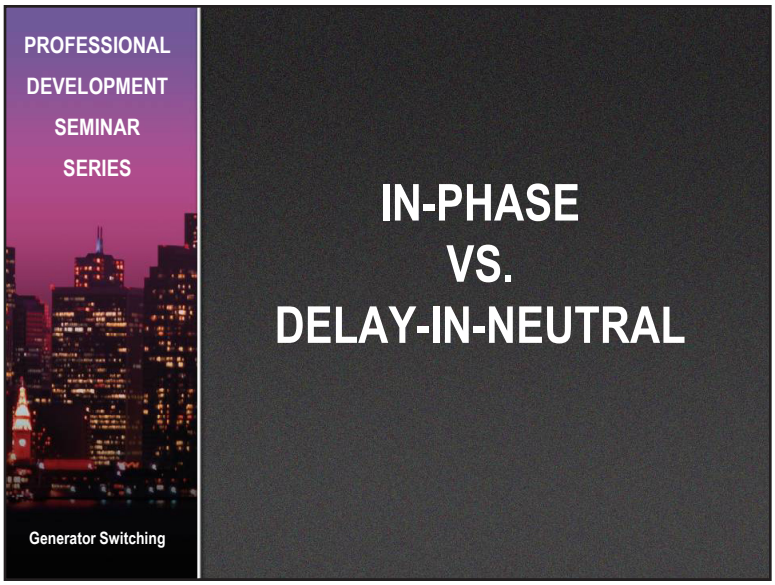

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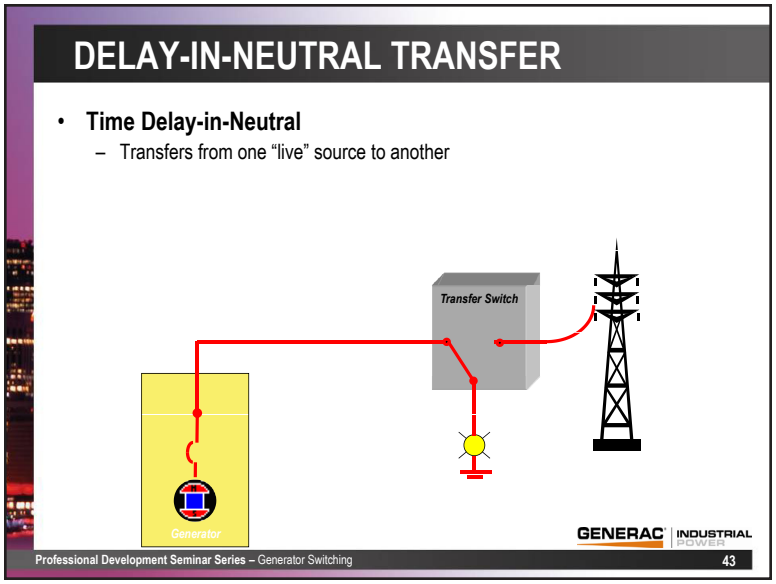
DELAY-IN-NEUTRAL TRANSFER
• Time Delay-in-Neutral
– Transfers from one "live" source to another
Transfer Switch
Generator
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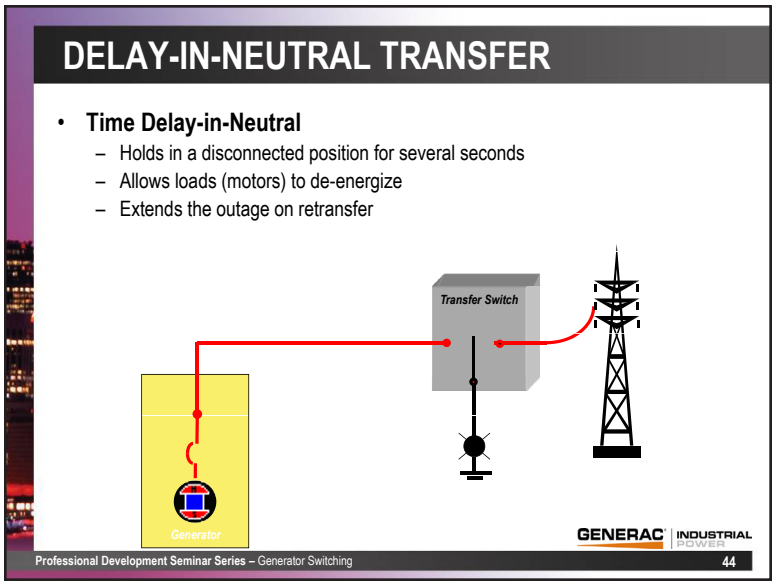
DELAY-IN-NEUTRAL TRANSFER
• Time Delay-in-Neutral
– Holds in a disconnected position for several seconds
– Allows loads (motors) to de-energize
– Extends the outage on retransfer
Transfer Switch
Generator
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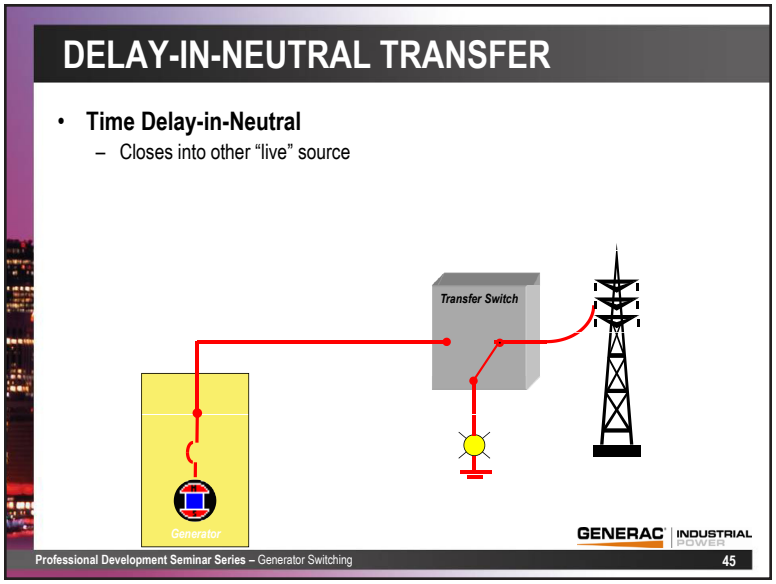
NOTES


DELAY-IN-NEUTRAL TRANSFER
• Time Delay-in-Neutral
– Closes into other "live" source
Transfer Switch
Generator
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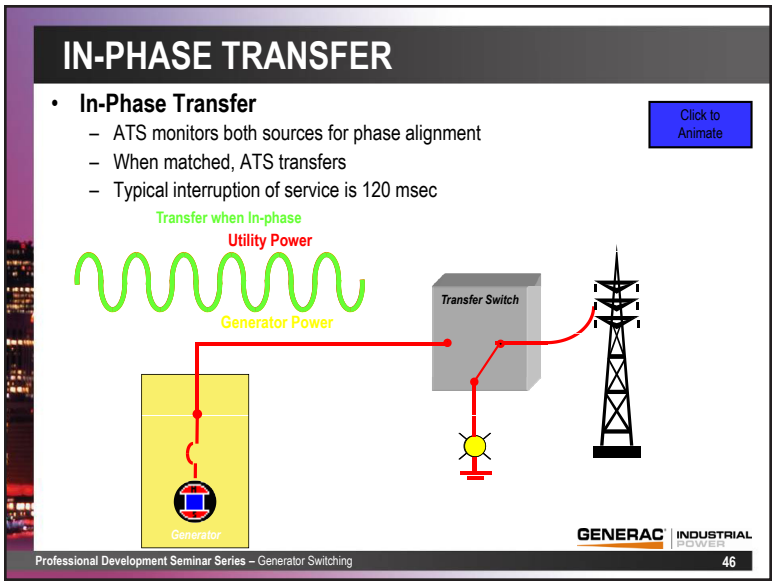
IN-PHASE TRANSFER
• In-Phase Transfer
– ATS monitors both sources for phase alignment
– When matched, ATS transfers
– Typical interruption of service is 120 msec
Click to Animate
Transfer when In-phase
Utility Power
Generator Power
Transfer Switch
Generator
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NOTES

IN-PHASE vs. DELAY-IN-NEUTRAL

- **In-Phase**
  - Typical means of transfer for general applications
- **Time Delay-in-Neutral**
  - UPS with filtering capacitors
  - Applications with heavy motor loads
- **Why are motors a concern?**

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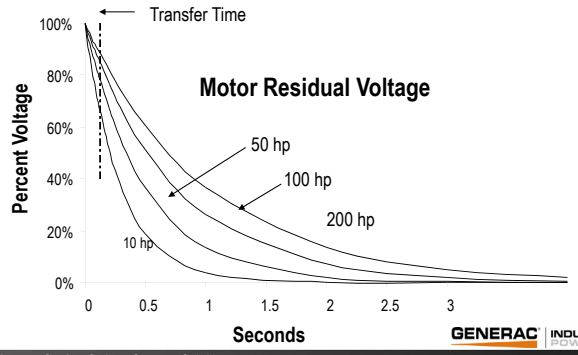
IN-PHASE vs. DELAY-IN-NEUTRAL

- **Why are motors a concern?**
  - Regenerative motor voltage
  - Motor slows down and pulls out of phase



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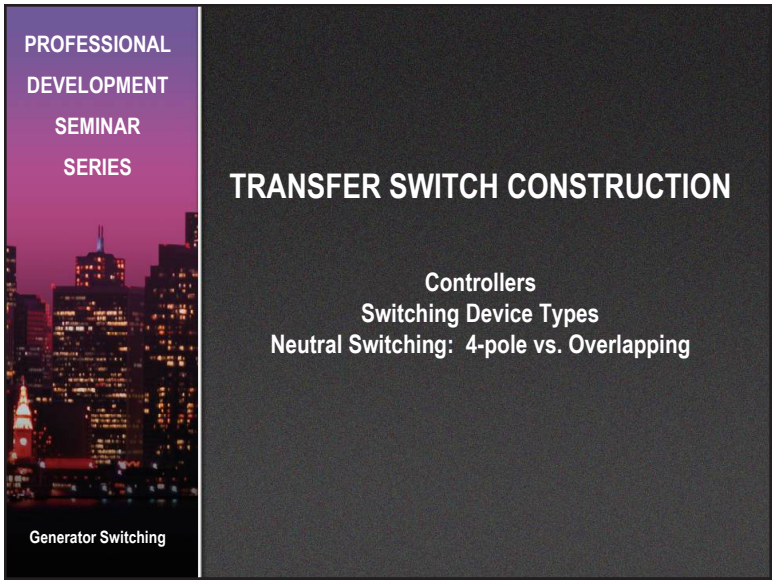
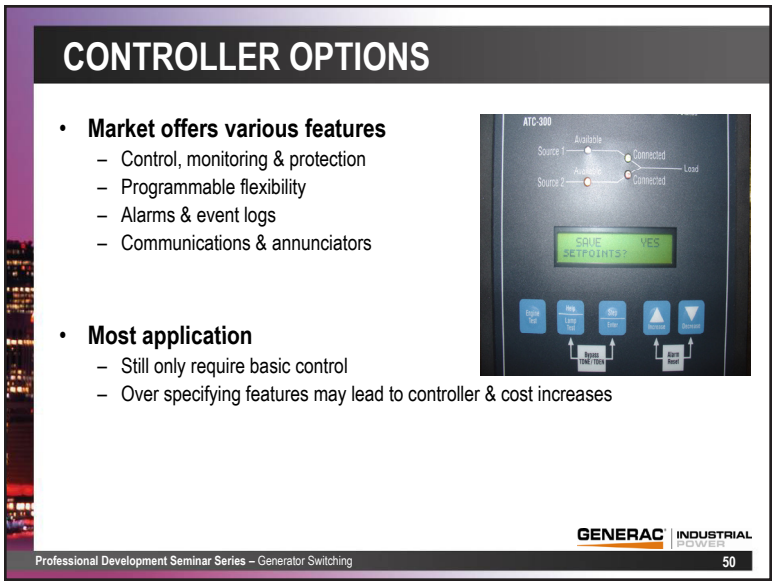
NOTES

2. APPLICATION CONSIDERATIONS





NOTES

SWITCHING DEVICE

- **Contactors**
  - Best cyclic mechanical operation
  - Lower fault current ratings
  - Good cost point

- **Molded Case**
  - Good fault ratings (65 kA) & service capable
  - Slower operation (Delay-in-Neutral operation)

- **Insulated Case & Power Breakers**
  - Highest fault ratings (100 kA capable)
  - Fast operation (in-phase & closed transition)
  - Costly at smaller ratings

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4-POLE vs. OVERLAPPING NEUTRAL

- **Two ways to switch the neutral**
  - 4-pole switch (switched neutral)
    - All four poles switched concurrently (including the neutral)
    - Neutral is disconnected during transfer
  - Overlapping neutral
    - Three poles are open transition switched
    - Neutral pole is overlapped (like Closed Transition)
    - Overlapping maintains grounded neutral during transfer

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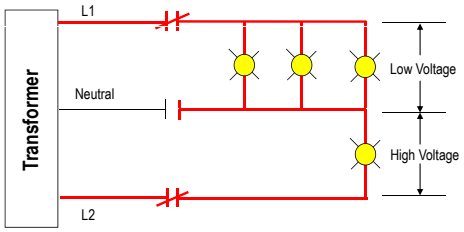
NOTES

4-POLE vs. OVERLAPPING NEUTRAL

- **Overlapping neutral**
  - Understanding the position for this approach



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4-POLE vs. OVERLAPPING NEUTRAL

- **Responding to the overlapping neutral approach**
  - There are thousands of 4-Pole ATS in-field.
  - There is no known problem with 4-Pole applications.
  - Most systems are relatively balanced (within 25%).
  - A fully rated, 4-pole switch offers the most reliable transfer.
  - The 4-pole mechanisms are simpler than overlapping neutrals.
  - It is not necessary to coordinate GFI & GFP times.

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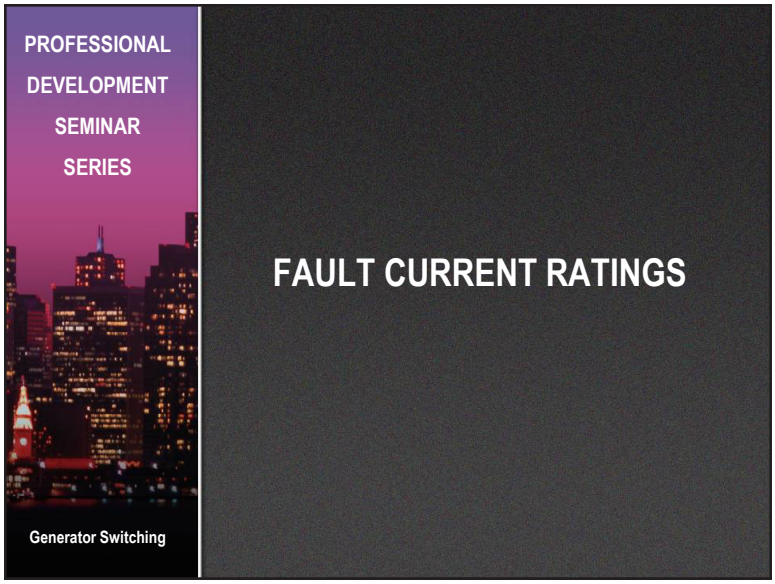
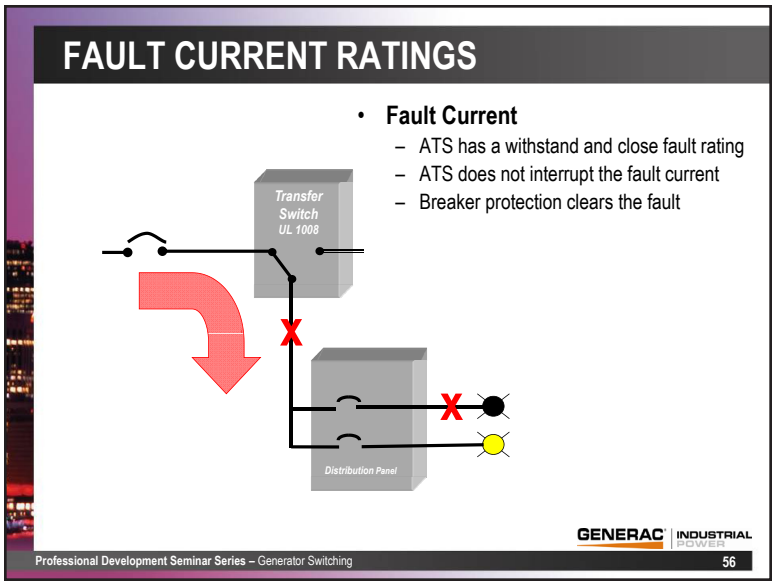
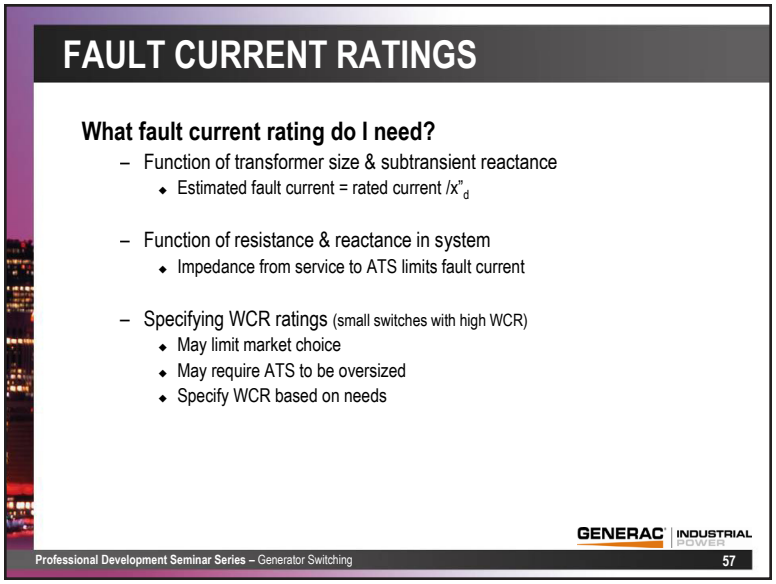
NOTES

2. APPLICATION CONSIDERATIONS





NOTES


FAULT CURRENT RATINGS
What fault current rating do I need?
– Function of transformer size & subtransient reactance
◆ Estimated fault current = rated current /x"d
– Function of resistance & reactance in system
◆ Impedance from service to ATS limits fault current
– Specifying WCR ratings (small switches with high WCR)
◆ May limit market choice
◆ May require ATS to be oversized
◆ Specify WCR based on needs
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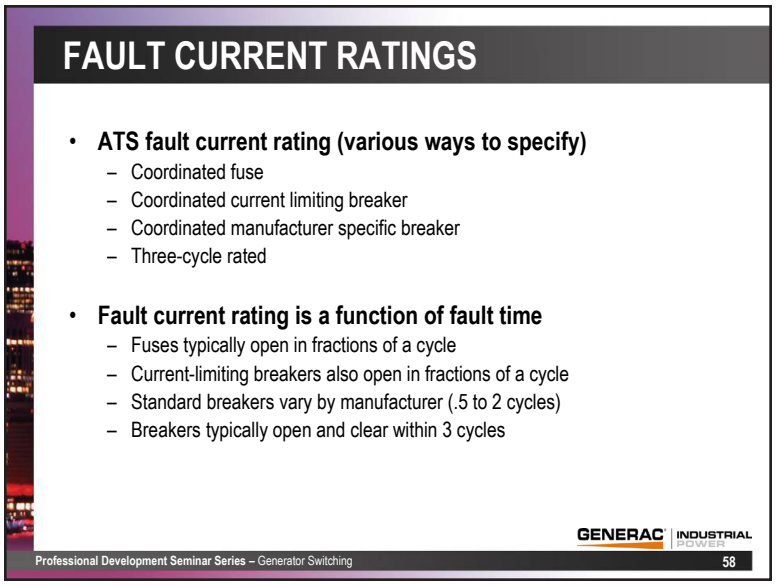
FAULT CURRENT RATINGS
• ATS fault current rating (various ways to specify)
– Coordinated fuse
– Coordinated current limiting breaker
– Coordinated manufacturer specific breaker
– Three-cycle rated
• Fault current rating is a function of fault time
– Fuses typically open in fractions of a cycle
– Current-limiting breakers also open in fractions of a cycle
– Standard breakers vary by manufacturer (.5 to 2 cycles)
– Breakers typically open and clear within 3 cycles
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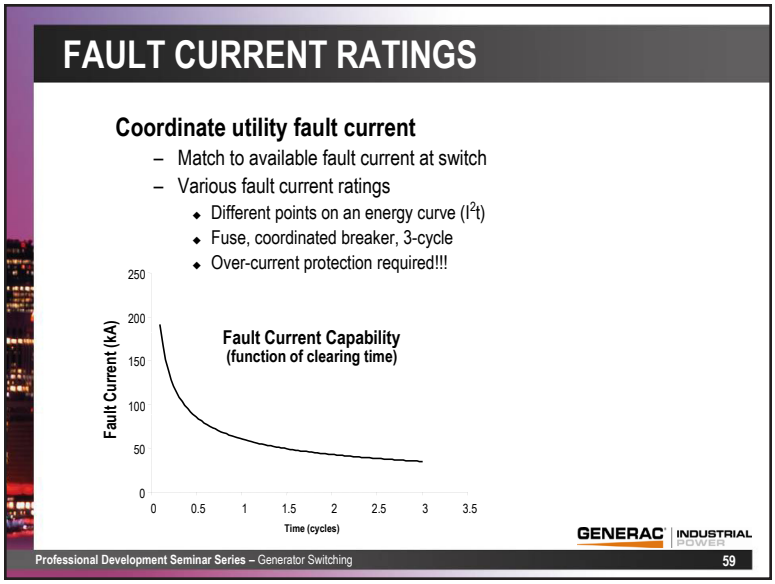
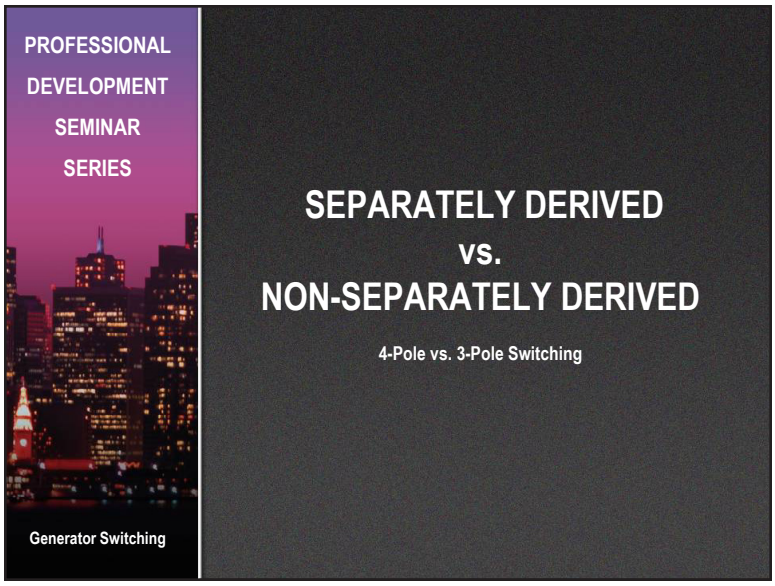
NOTES

2. APPLICATION CONSIDERATIONS





NOTES

GROUNDING

- **Grounding conductor**
  - The equipment ground (green wire)
- **Grounded "bonded" conductor**
  - The neutral conductor that is bonded to the system ground
  - The neutral conductor should be bonded at only one point
- **Generator Neutral Bonding**
  - To building ground plane (non-separately derived)
    - 3-pole ATS
  - To generator ground plane (separately derived)
    - 4-pole ATS

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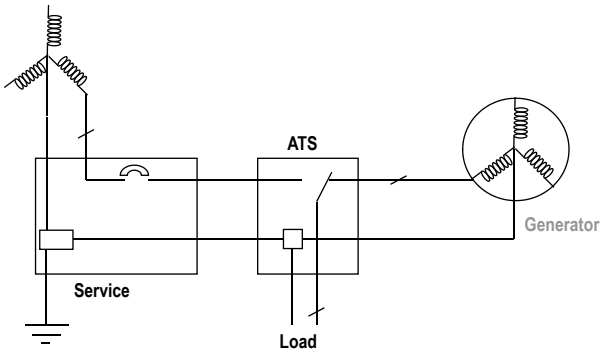
3-POLE SWITCHING



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NOTES

3-POLE SWITCHING

- **Three-pole transfer switches (first choice)**
  - Neutral is not switched
  - Neutral is typically bonded at the building service
  - It's known as a **non-separately derived system**
- **Advantages of 3-pole switches:**
  - Better neutral bonding (not switching the neutral)
  - No ground plane required at the generator
  - Simpler system
  - Lower cost

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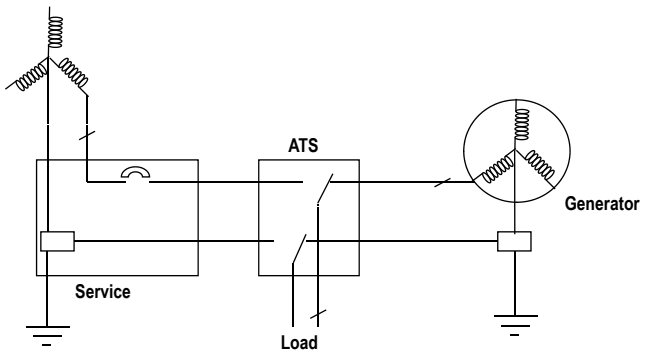
4-POLE SWITCHING



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NOTES

4-POLE SWITCHING

- **Four-pole transfer switches**
  - Neutral is switched
  - Neutral is bonded at the building service and the generator (switched)
  - Referred to as a **separately derived system**
- **A 4-pole switch must be used when…**
  (separately derived system, switched neutral)
  - Multiple ATS application & GFP are on the utility sources
  - There is good sensitivity GFI on the generator
  - There are two buildings (separate ground planes) and one generator

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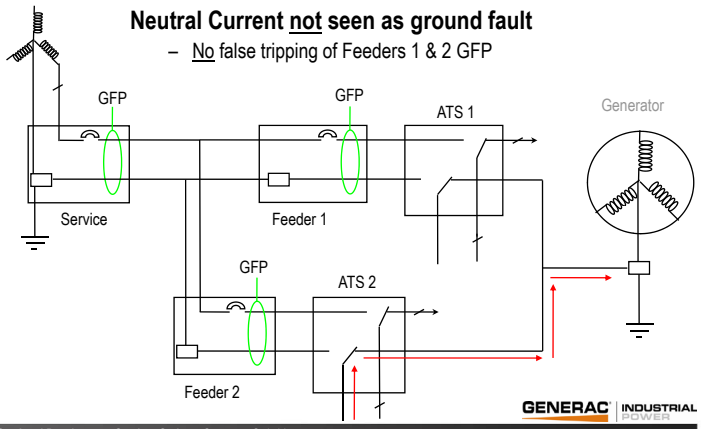
MULTIPLE ATSs & GFP

Neutral Current not seen as ground fault

– No false tripping of Feeders 1 & 2 GFP



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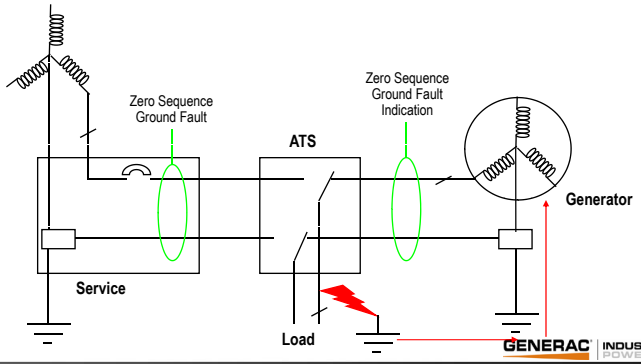
NOTES

GOOD SENSITIVITY GFI

Generator GFI (zero sequence) works

- More sensitive than vectorial



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EXERCISES

What ATS would you recommend for these applications?

- Waste water treatment plant?
- Office building?
- Data center?
- Airport?
- Hospital critical loads?
- Retrofit, whole facility application (electrical room full)?
- Base load and peak shave apply?

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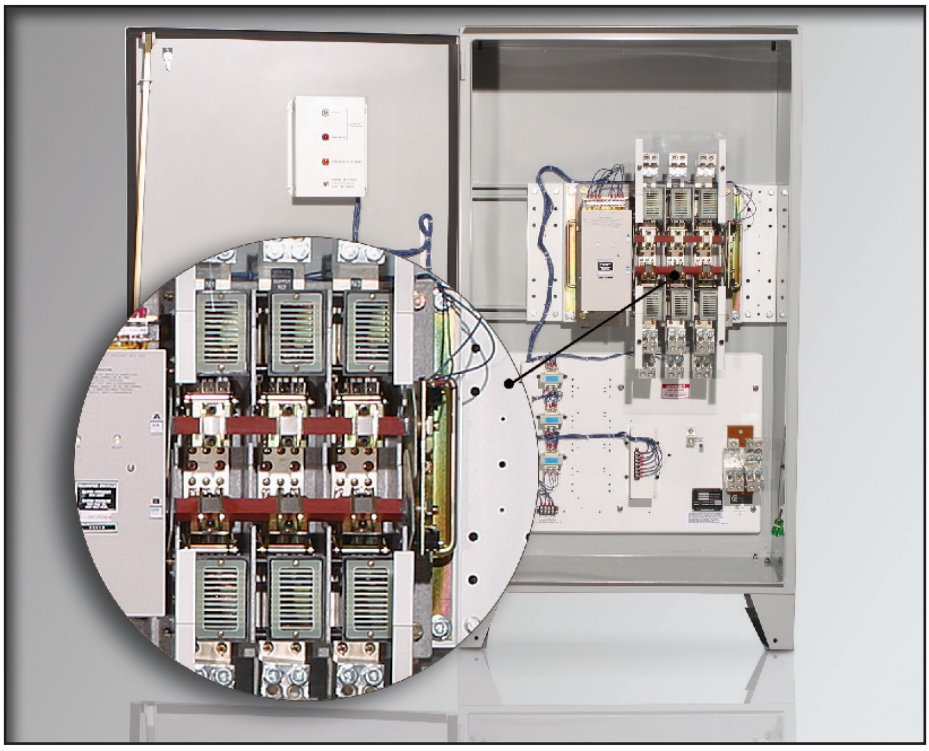
NOTES

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.

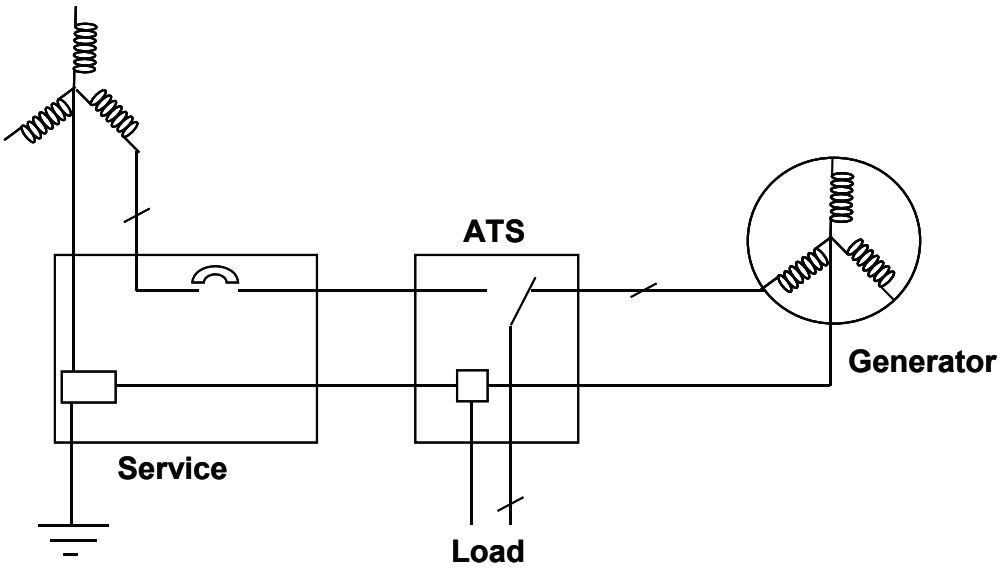


Figure 1

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.

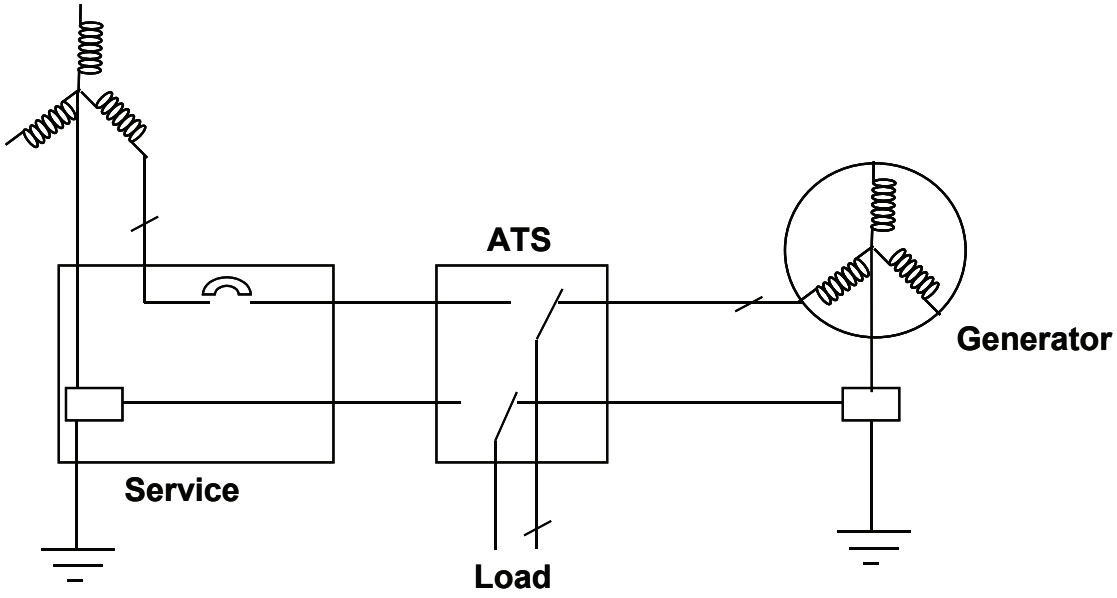


Figure 2

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.

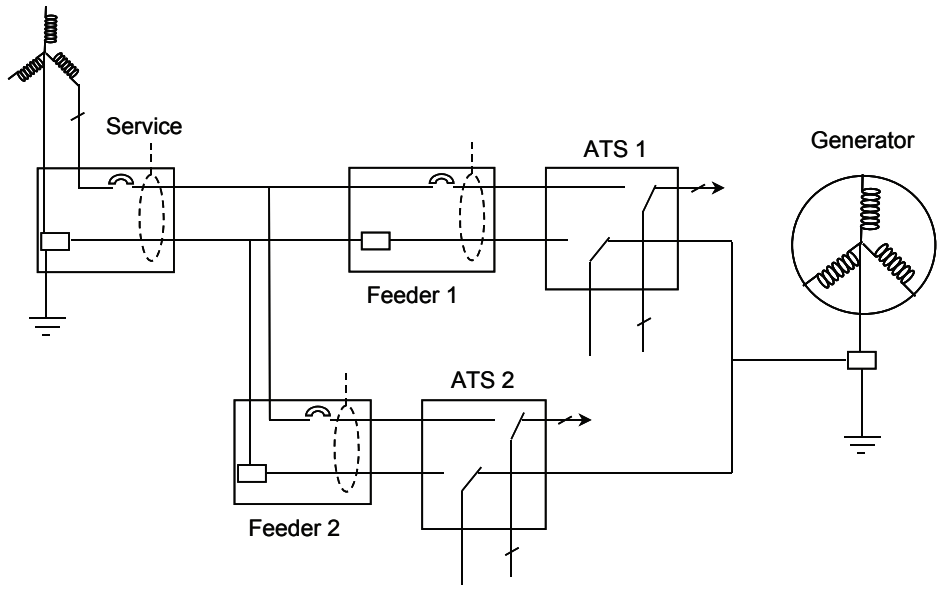


Figure 3

• 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.

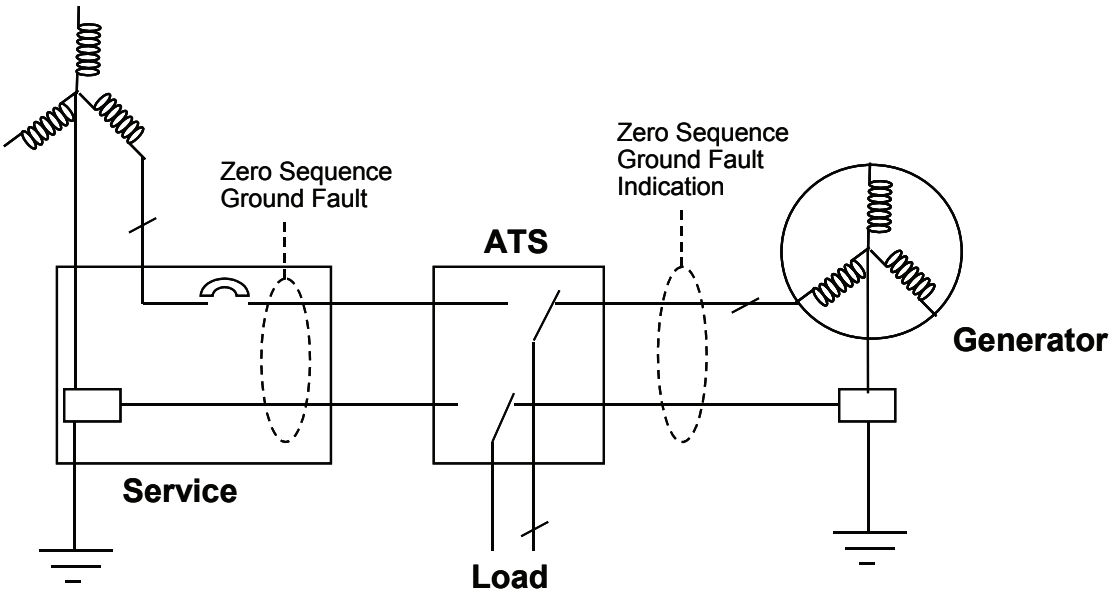


Figure 4

• 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.

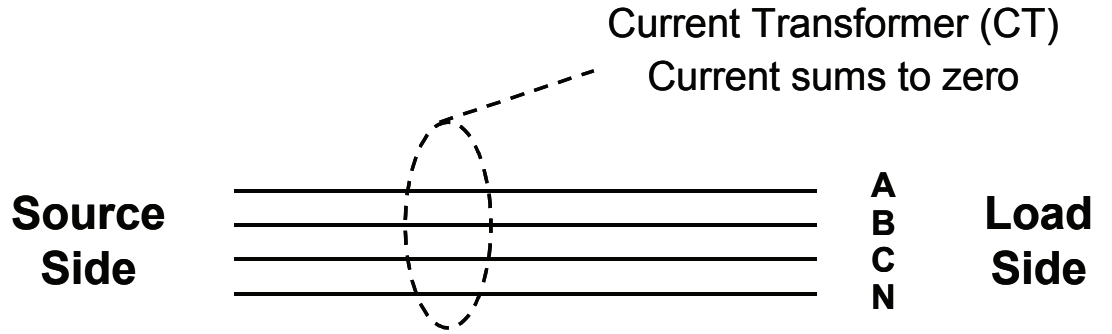


Figure 5

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.

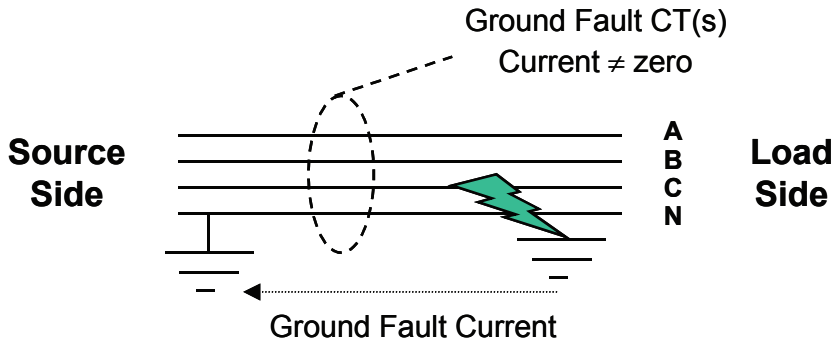


Figure 6

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.

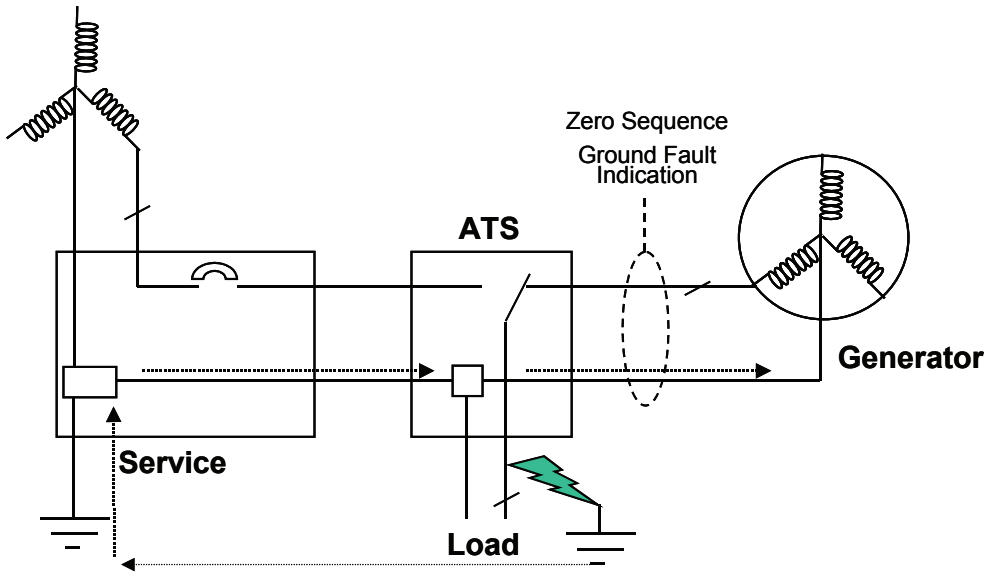


Figure 7

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.

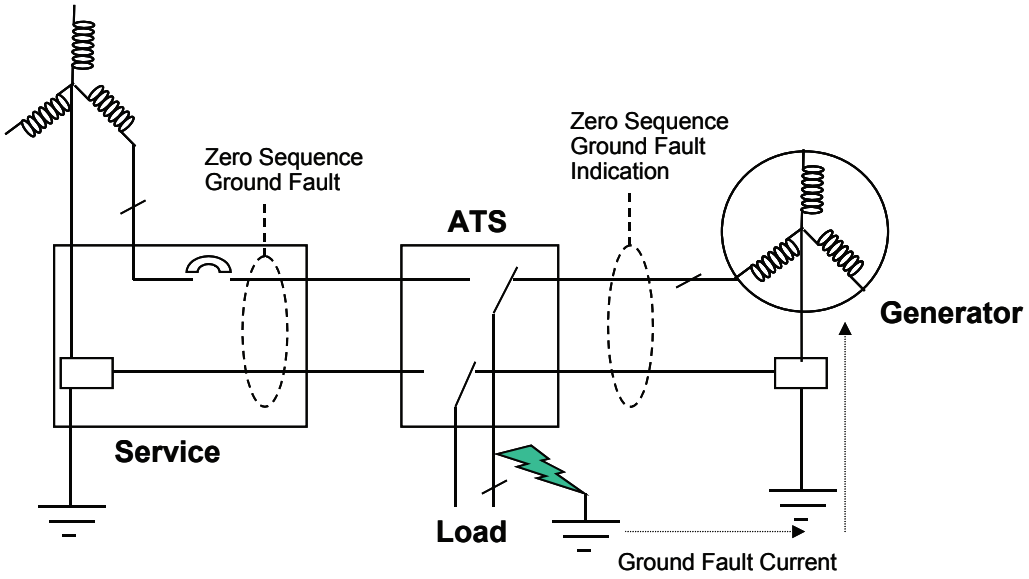


Figure 8

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.

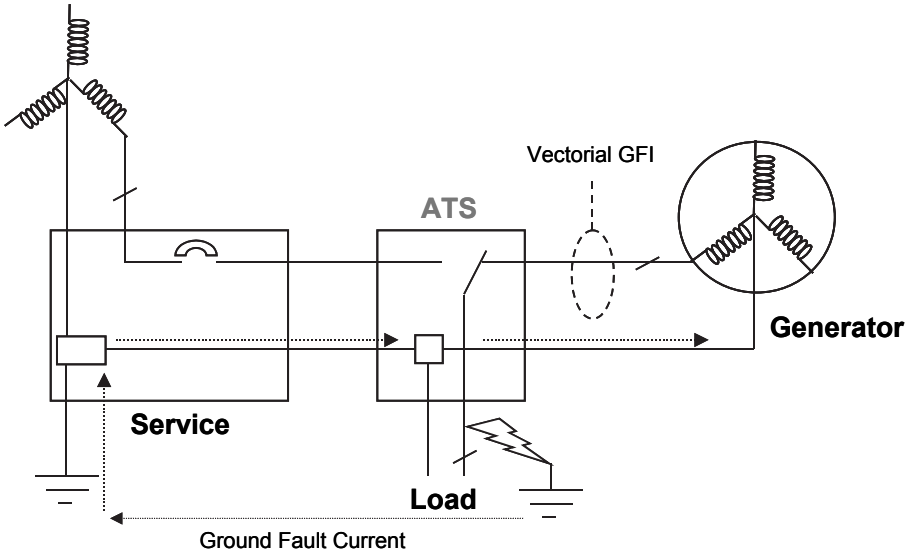


Figure 9

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).

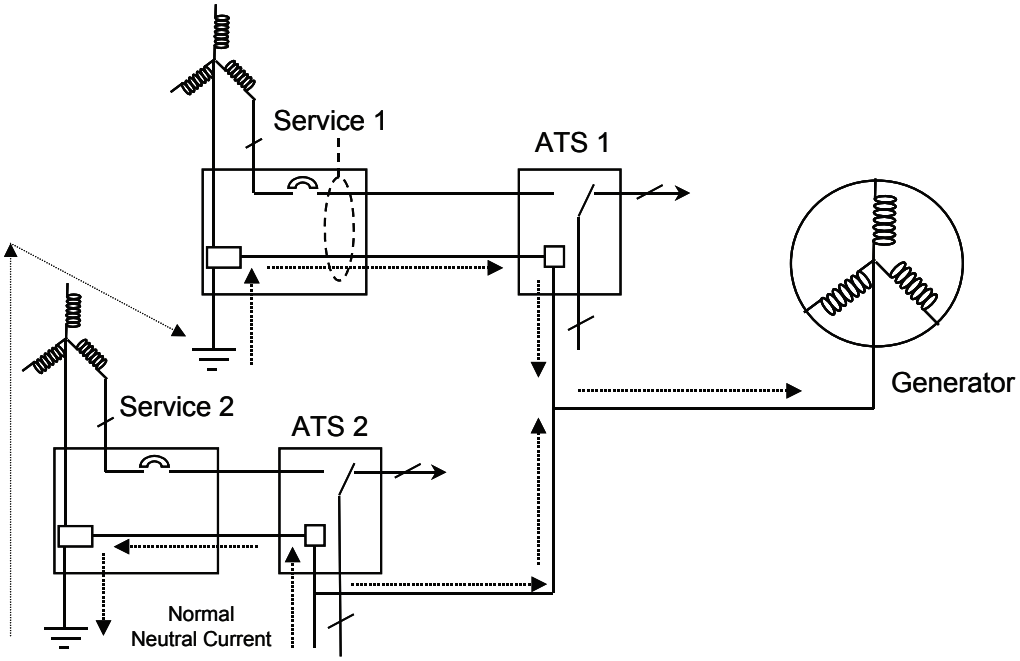


Figure 10

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.

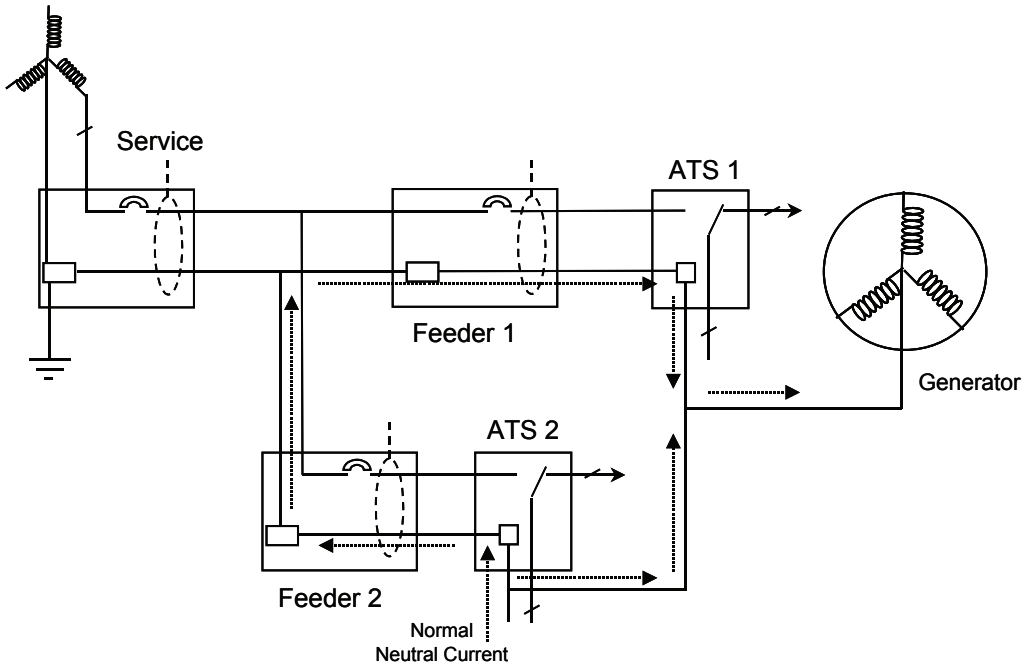


Figure 11

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

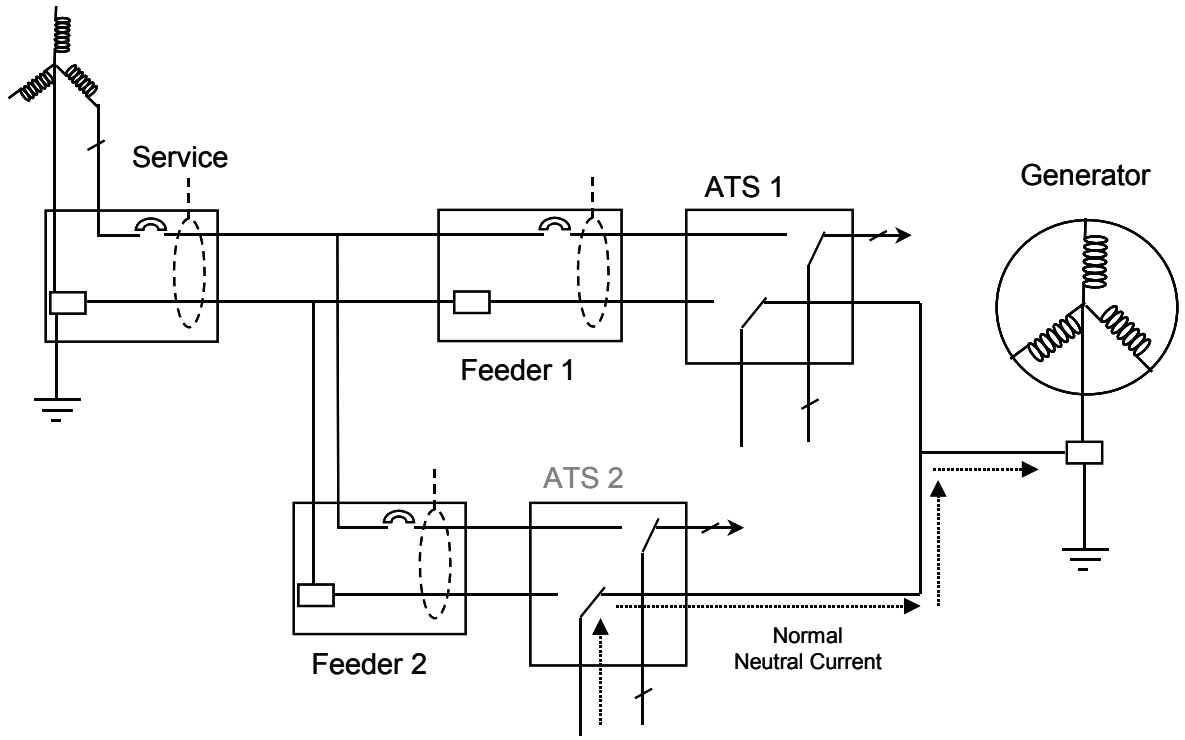


Figure 12

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
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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"*

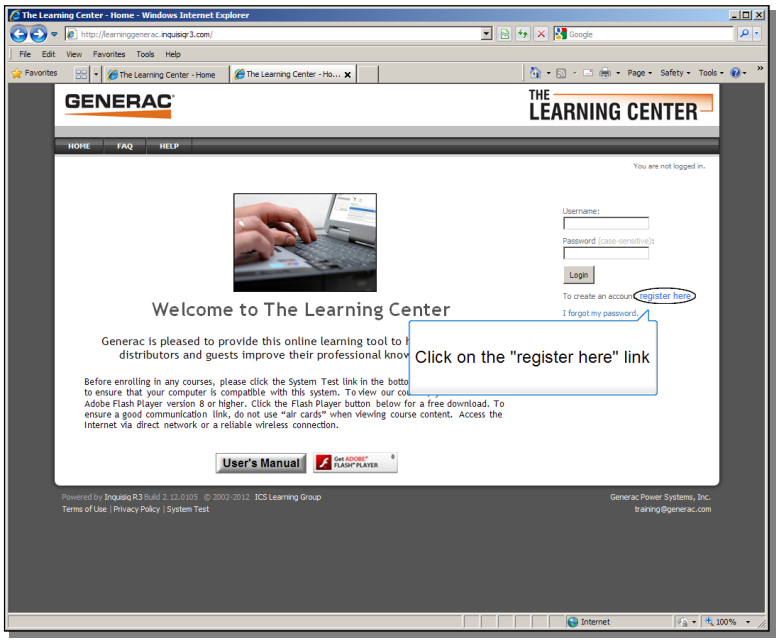
To gain access to *"The Learning Center*", you are required to register and set up a user account. During your account setup you will create a *Username* and *Password*. Your username and password can then be used to log in on subsequent visits.

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

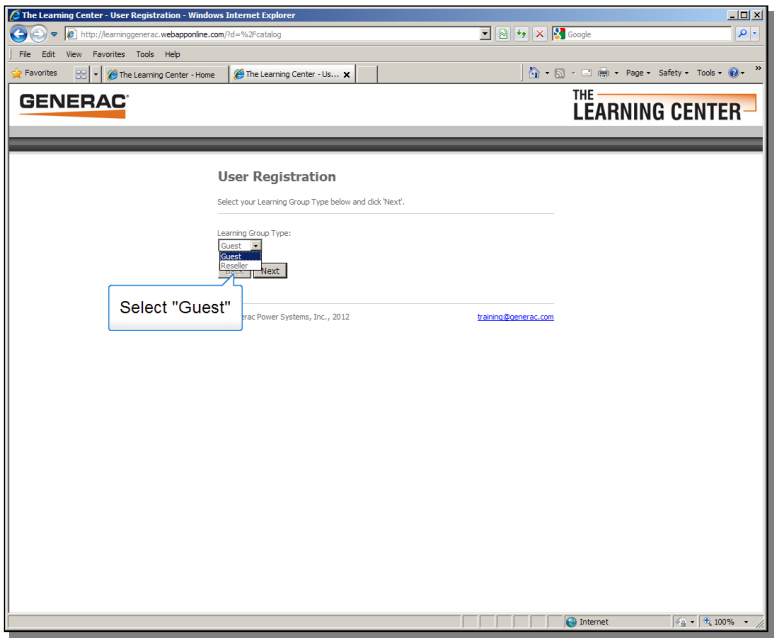
To begin the registration process, open your computer's browser and enter http:// learning.generac.com. This should take you to *"The Learning Center"* home page. This page is displayed at the top of the next page. From this point you can follow illustrated steps.

ONLINE FINAL ASSESSMENT AND CERTIFICATE REGISTRATION AND LOGIN PROCEDURE

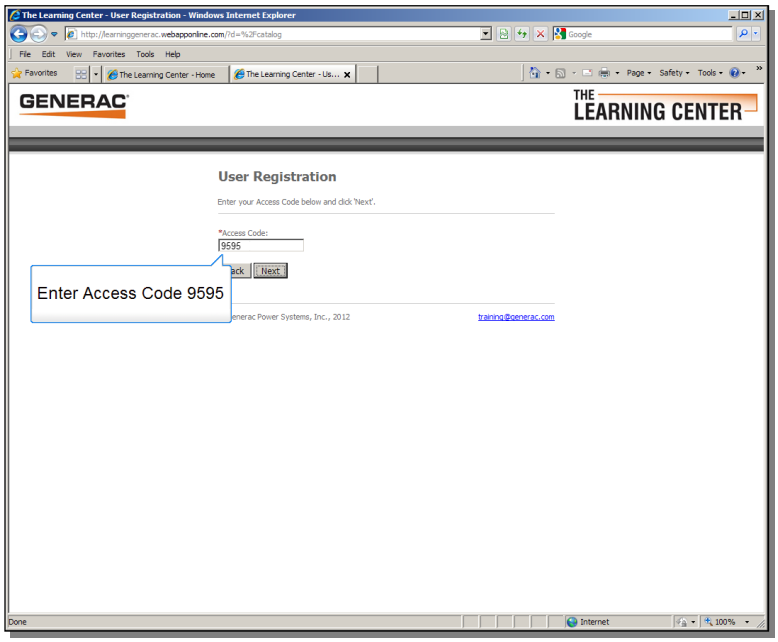
Begin by entering http://learning.generac.com in your computer's browser. The screen below will be displayed. Click on the "register here" link to begin the registration process.



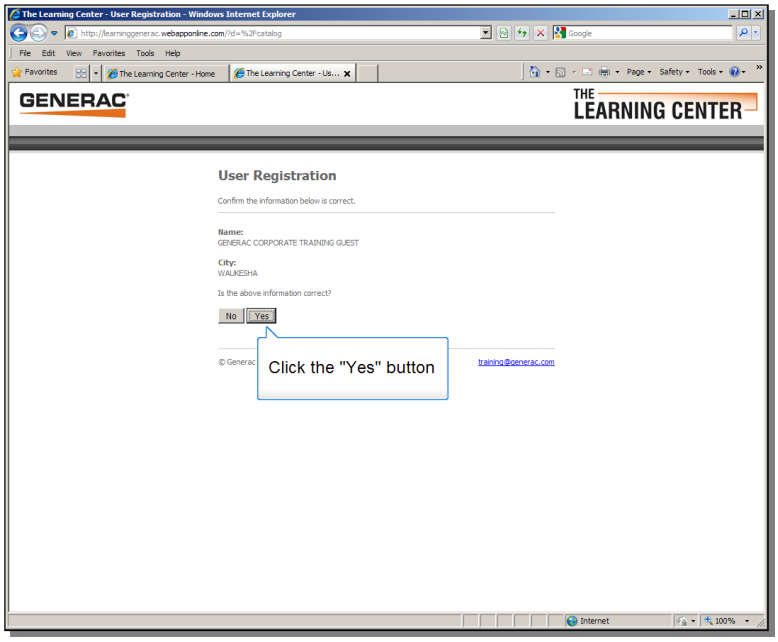
On this screen you will select "Guest" from the drop down box and click the "Next" button.



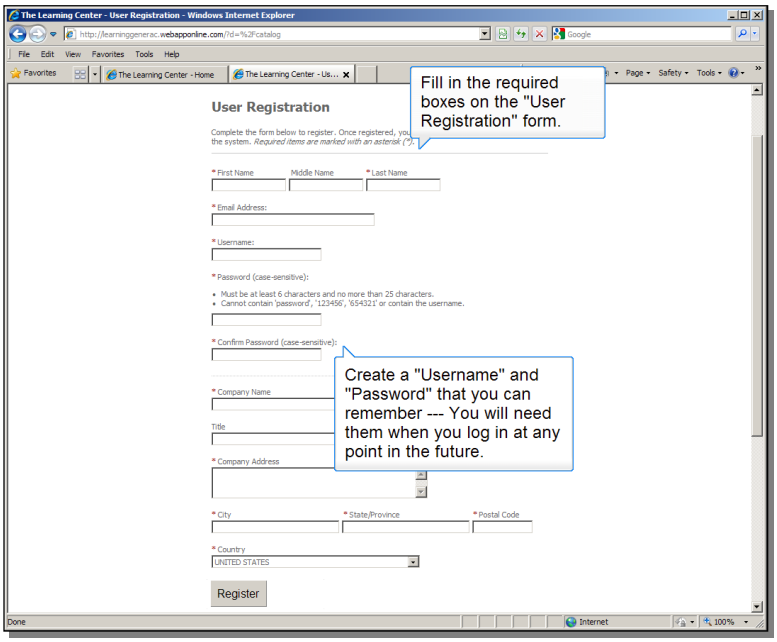
In this next screen enter **Access Code 9595** and click the “Next” button. Please keep this code private.



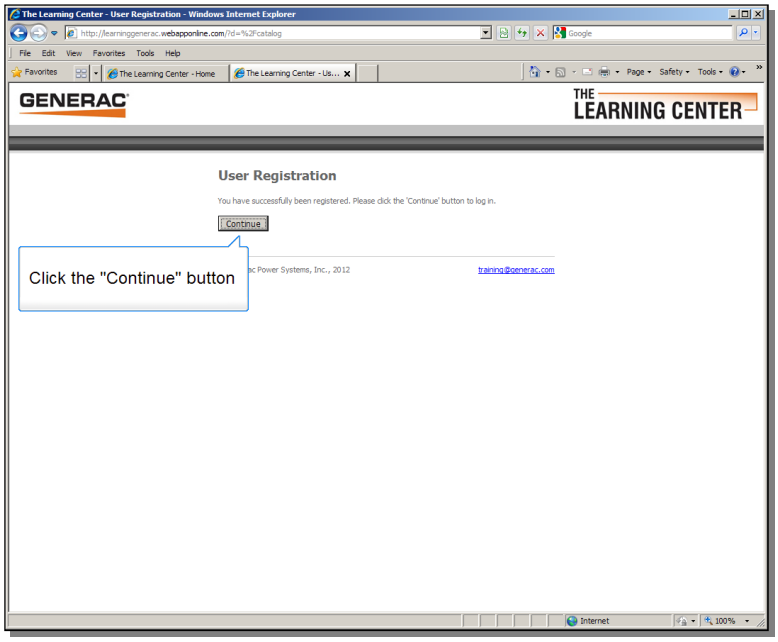
This screen confirms the correct access code entry. Click the “Yes” button to proceed.



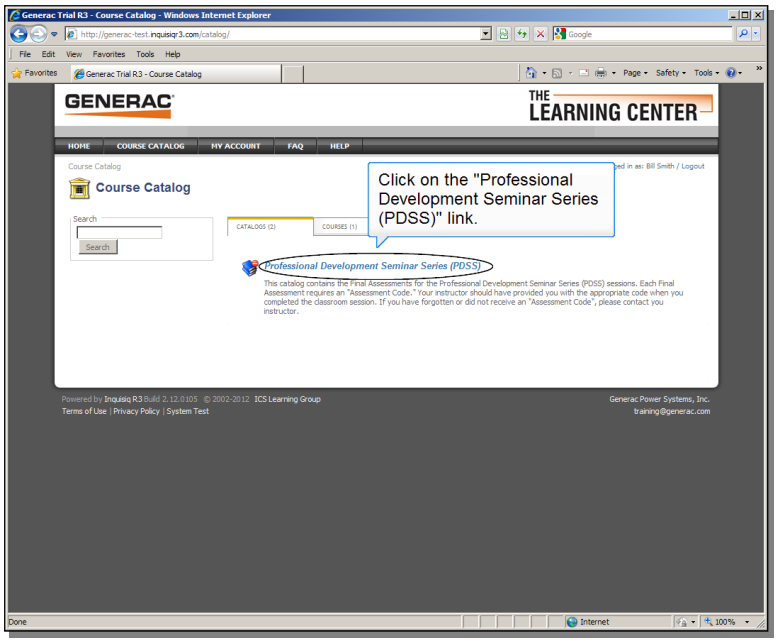
The next screen contains the “User Registration” form. Fill in the required boxes, and then click the “Register” button.



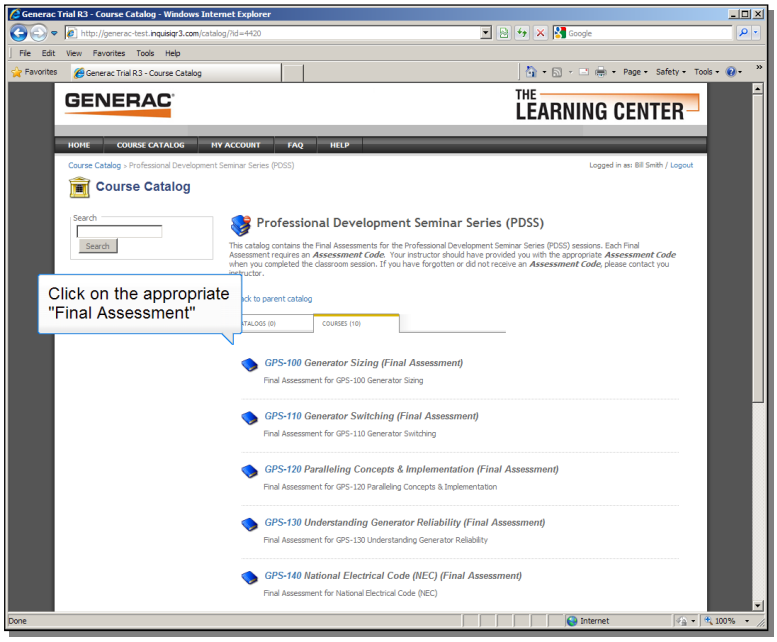
The next screen confirms your registration. Click the “Continue” button to proceed.



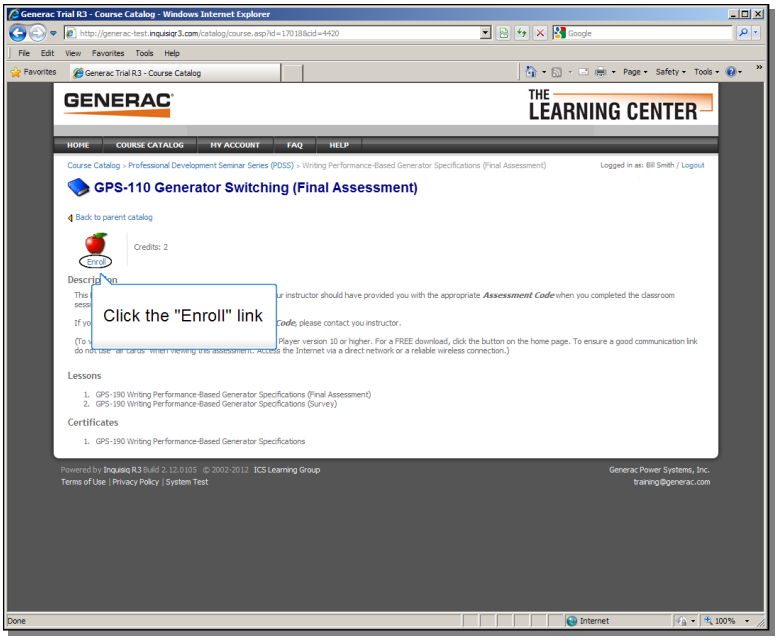
The next screen displays the “Course Catalog.” Click on the “Professional Development Seminar Series” link.



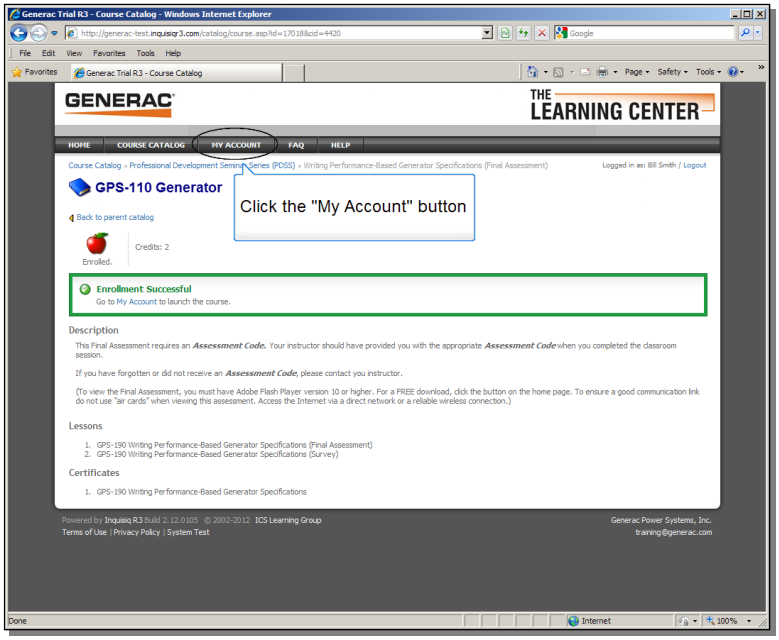
This next screen lists all currently available Final Assessments. Click on the Final Assessment that is tied to the course name and number you completed.



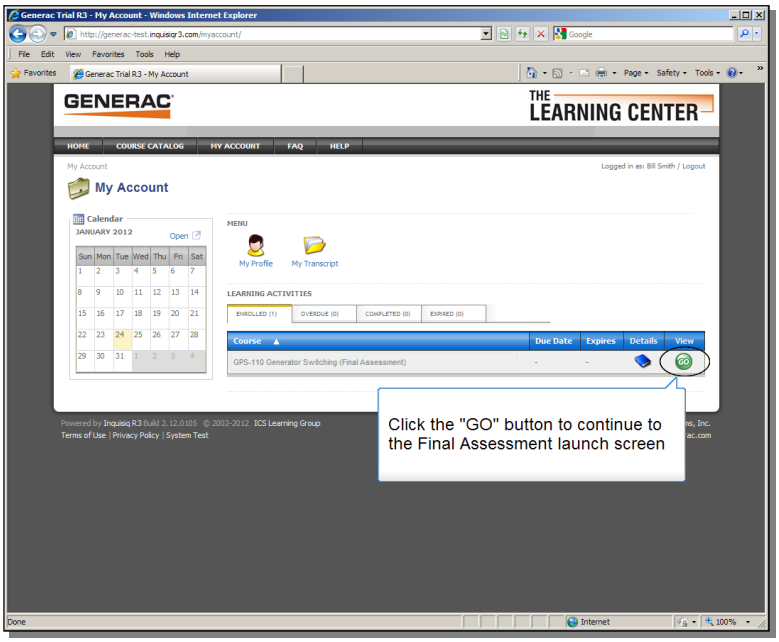
The next screen is the “Enrollment” screen for the Final Assessment that you selected. Click the “Enroll” link to proceed.



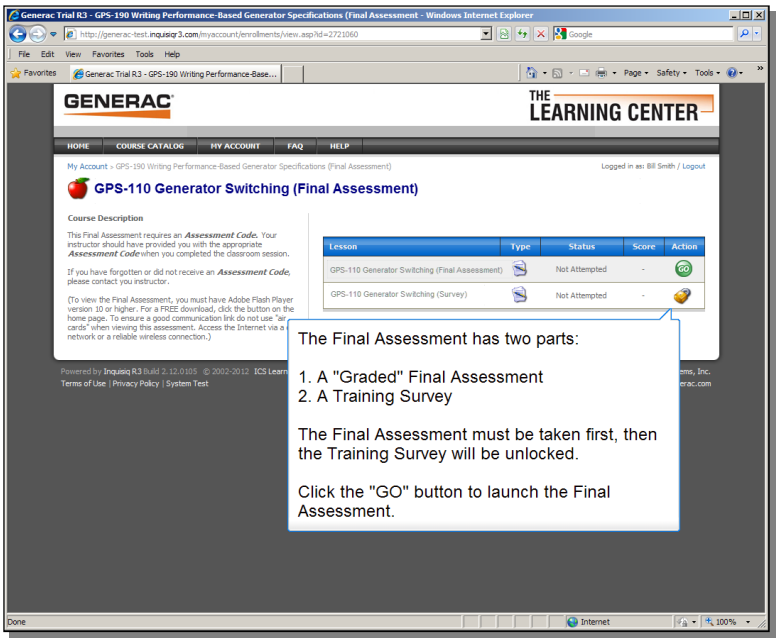
This screen confirms your enrollment. Click the “My Account” button to proceed.



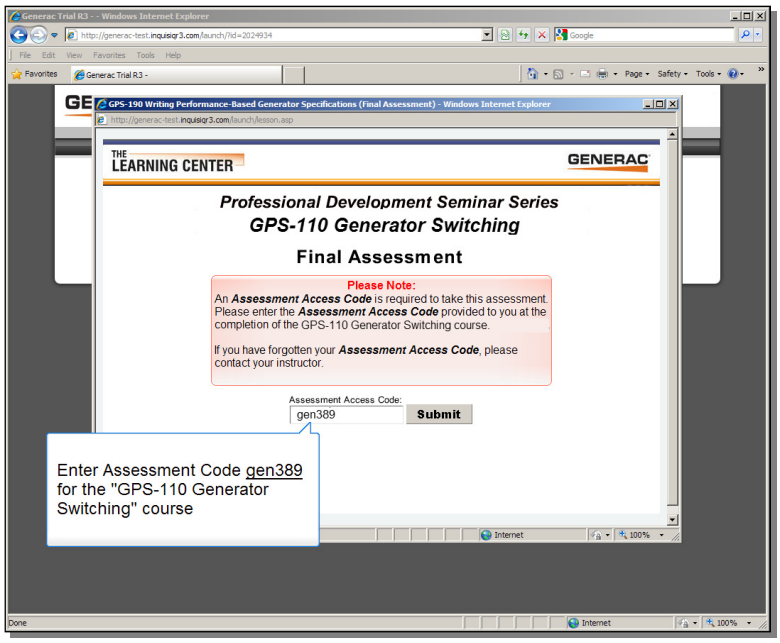
This is your “My Account” screen. Note that the Final Assessment you selected is displayed under the “Enrollment” tab. Click the “GO” button to proceed.



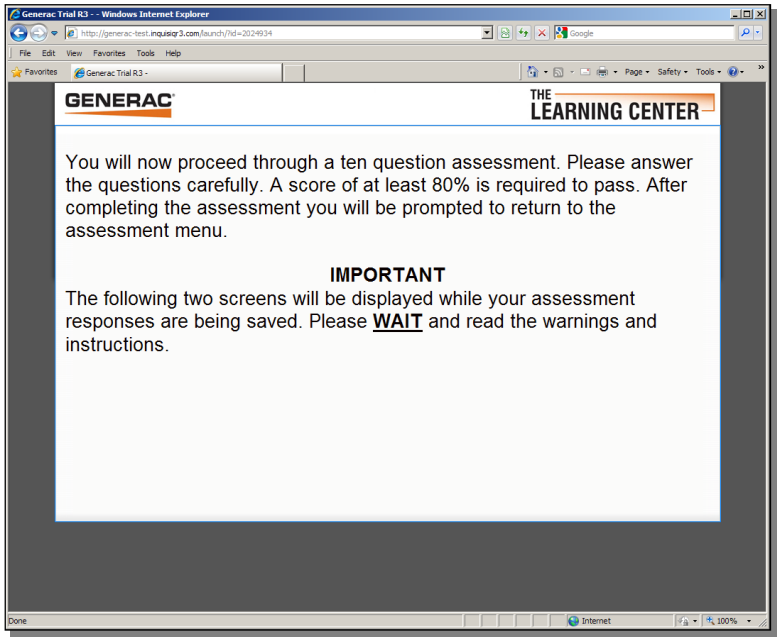
This screen lists the two parts to the Final Assessment. You must take the “Graded” Assessment first, then the Training Survey.



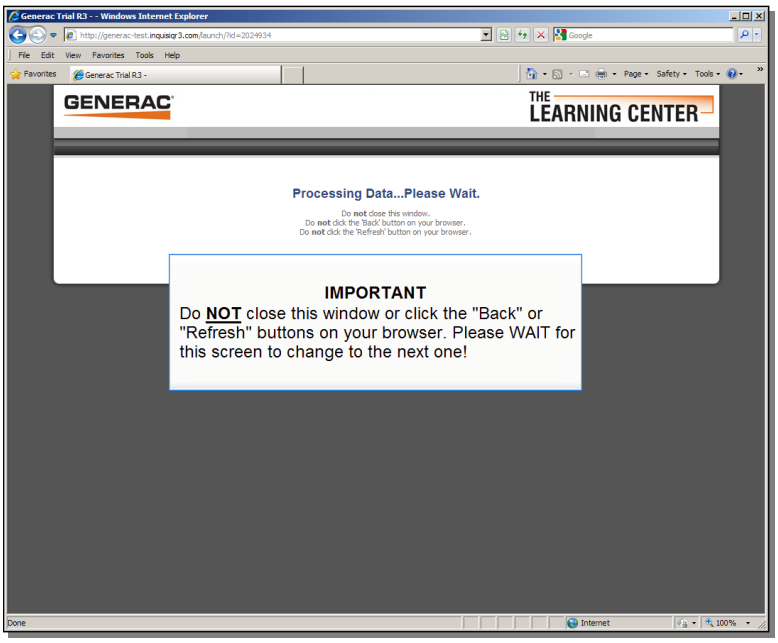
In the next screen an “Assessment Code” is required before you can continue. The code for GPS-110 Generator Switching is **gen389**. Enter the code in the box and click the “Submit” button to continue.



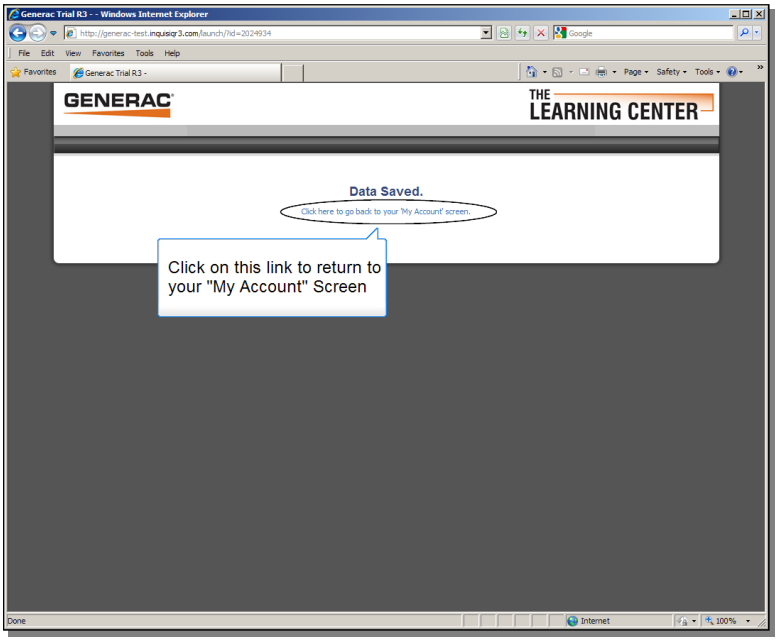
You will now proceed through a ten question assessment. Please read the warnings below.



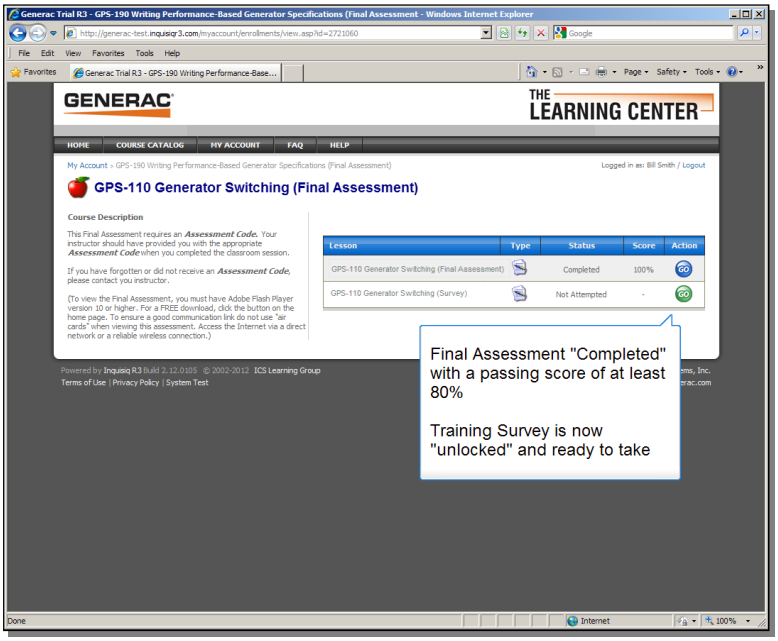
Please follow the instructions on this screen. You must wait for your assessment data to be saved. Do not close this window or click the 'Back' of 'Refresh' buttons on your browser.



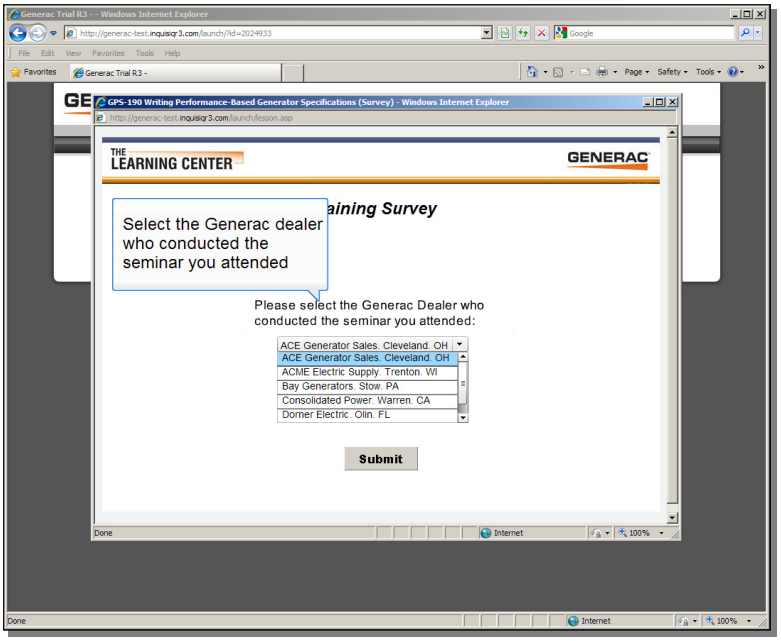
This screen confirms that your data was saved. Click on the link shown here to proceed.



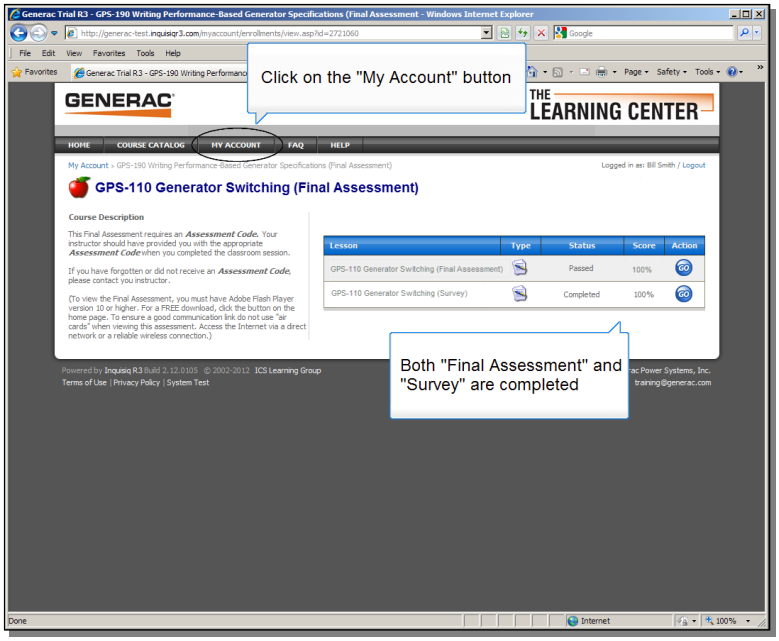
This screen will be displayed after your assessment data is saved. Note that in this example the assessment was passed with a score of 100% and the Survey is unlocked and ready to launch.



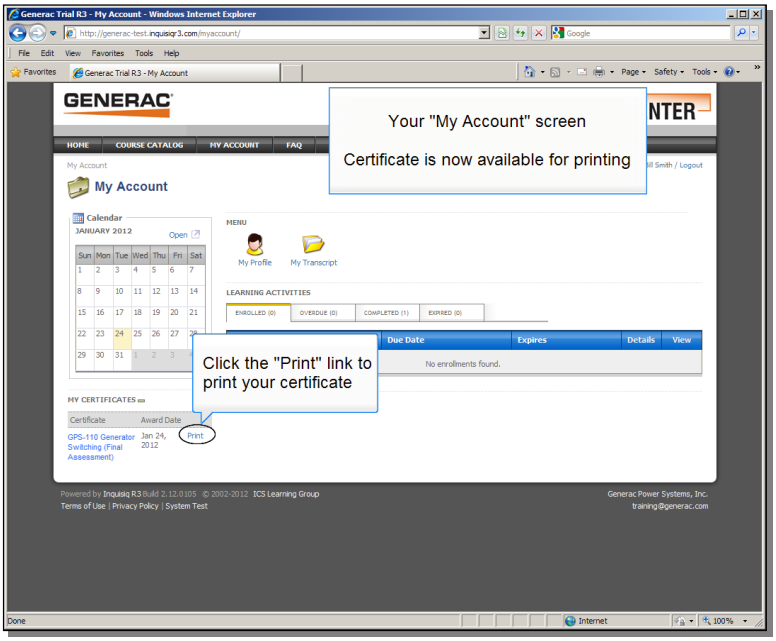
Upon launching the Survey, this screen will be displayed. Select the Generac dealer who conducted the seminar you attended.



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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