

## Where Will You Find Generators

### Q1) Where Will You Find Generators?

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



11 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

11

## 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



12 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

12

## 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
- Cellular & Communications
  - 911 function battery backed
  - Up-time marketability
- Food storage & processing
  - Spoilage of product
  - Inability to ship
- Distribution centers
  - Operation
- Retail industry
  - Home supplies
  - Groceries
- Gaming industry
  - Revenue

13 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

13

## Where Will You Find Generators

### Optional Standby (NEC 702)

- Process industries
  - Clean up costs
- Restaurants
  - Lost revenue
  - Customer experience
- Lodging industry
  - Security & guest services
- Banks / Financial inst.
  - Mission critical
  - Online banking
  - Security
- Schools
  - No parents at home
  - May also be an emergency shelter

14 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

14

## Where Will You Find Generators

- **Grid Support & Interconnection (NEC 705)**
  - Paralleling gear & controls
  - Protection (separate when grid fails)
  - Fault current (both sources)
  - Micro-grid
  
- **Comply with Utility Interconnect Requirements**
  - Typically monitor grid frequency (separation protection)
  - Utility grade protective relaying
    - IEEE 1547 *Interconnecting Distributed Resources with Electric Power Systems*

15 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

15

## Where Will You Find Generators

- **Critical Operation Power Systems (NEC 708)**
  - Section was requested by the federal government after Katrina
  - Design criteria for enhanced reliability (defending in place)
  - Not utilized often (customer requested)
  - Greater attention to items already in NFPA 110 (ex flooding, commission, etc)
  - Requires a risk assessment (identify hazards & mitigation strategies)
  - Fuel on-site (72 hours)
    - Plan for maintaining the fuel
  - Bypass isolation transfer switch
  - Selective coordination

16 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

16

# What Are The Key Codes & Standards For Generators?

## Q2) What are the Key Codes and Standards for Generators?

- Installations standards (NFPA, IBC, CSA)
- Listing standards (UL2200, UL1008, ...)
- Manufacturer consensus standards (NEMA, ANSI, IEEE)



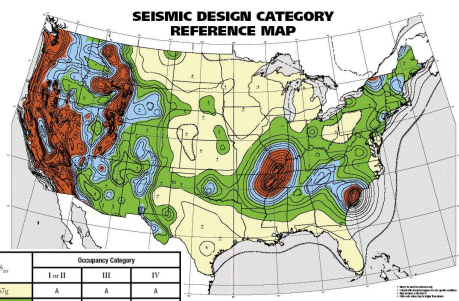
17 Professional Development Seminar Series – NEC (Part 1)

17

# 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



Value of $S_{DS}$	Occupancy Category			
	I or II	III	IV	
$S_{DS} < 0.167g$	A	A	A	
$0.167g < S_{DS} < 0.33g$	B	B	C	
$0.33g < S_{DS} < 0.66g$	C	C	D	
$S_{DS} > 0.66g$	D	D	D	

## • International Building Code (IBC)

- Integrated into state statutes
- Common generator elements
  - IBC Seismic certification (seismic level, occupancy, emergency systems)
  - IBC Wind certification (wind level, exposure category, emergency systems)

18 Professional Development Seminar Series – NEC (Part 1)



18

## What Are The Key Codes & Standards For Generators?

- **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
- 101 Life Safety Code
- 110 Standard for Emergency & Standby Power Systems



19 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

19

## What Are The Key Codes & Standards For Generators?

- **Underwriters Laboratories (UL) & Intertek (ETL)**

- Develops standards & test procedures
- Administers the application of the UL & ETL marks
- Focused on product safety and usability
- UL & ETL do not “approve”
- AHJ often use UL ETL listing as “approved for use”



- **Power Generation Related Standards**

- 2200 Stationary Engine Generators
- 1008 Automatic Transfer Switches
- 891 Dead Front Panel Board
- 142 Liquid Storage Tanks



20 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

20



## What Are The Key Codes & Standards For Generators

- **Generator Related NEC Articles**

- NEC 100 Definitions
- NEC 215 & 225 Feeders
- NEC 220 Service & Feeder Load Calcs
- 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



21 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

21

## 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



22 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

22

## What Is A Generator

### Q3) What is a Generator?

- Prime mover (engine) & alternator
- NEC sections
  - Service vs. Feeder



23 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

23

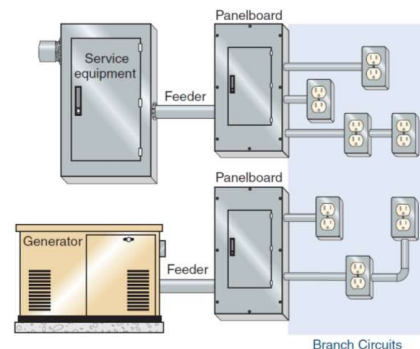
## What Is A Generator?

### • 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.”



24 Professional Development Seminar Series – NEC (Part 1)

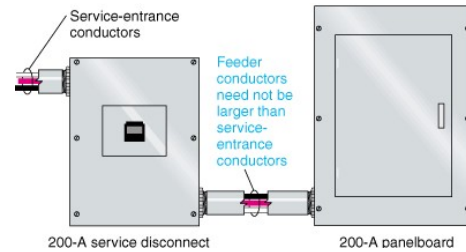
**GENERAC** INDUSTRIAL POWER

24

## 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 connection the servicing utility to the wiring system of the premises served."

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 servicing utility, the supplied conductors and equipment are considered feeders, not a service.

# Generator Requirements

Professional Development Seminar Series – NEC

**PROFESSIONAL DEVELOPMENT SEMINAR SERIES**



## What Is Required Generator Size (Capacity)?

### Q4) What is the Required Generator Size (Capacity)?

- NEC 700.4 (Emergency System)
  - NEC 701.4 (Legally Required Standby)
  - NEC 702.4 (Optional Standby)
  - NEC 517.31 D (Health Care Facilities)
- **Overtime the requirements for these load types have evolved**
    - Historically
      - All loads to operate simultaneously
      - All loads intended to operate
    - Currently
      - Article 220 sizing or “other approved methods”

27 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

27

## NEC Sizing

- **Emergency Power Systems (NEC 2017)\***
  - NEC 700.4(A) (Emergency System - Capacity)
    - “...adequate capacity and rating for **all loads to be operated simultaneously**”
- **Emergency Power Systems (NEC 2020)\***
  - NEC 700.4 (Emergency System - Capacity)
    - “...adequate capacity in accordance with **article 220 or by another approved method.**”
  - NEC 517.31 D (Health Care Facilities)
    - “... to meet the maximum **actual demand likely to be produced...**”
    - **“NEC 700.4 & NEC 701.4 shall not be applied to hospitals”**
    - Practical sizing based on historical, demand factors, calculations

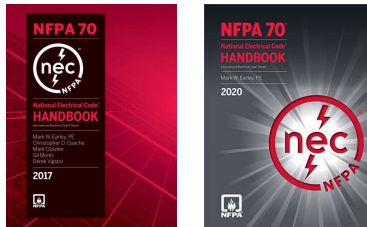
28 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

28

# NEC Sizing

- **Standby Power Systems (NEC 2017)\***
  - NEC 701.4 (Legally Required System - Capacity)
    - "...adequate capacity and rating for **all loads intended to be operated at one time**"
- **Standby Power Systems (NEC 2020)\***
  - NEC 701.4 & 702.4(B)(2) (Legally Required & Optional - Capacity)
    - "...adequate capacity in accordance with **article 220 or by another approved method.**



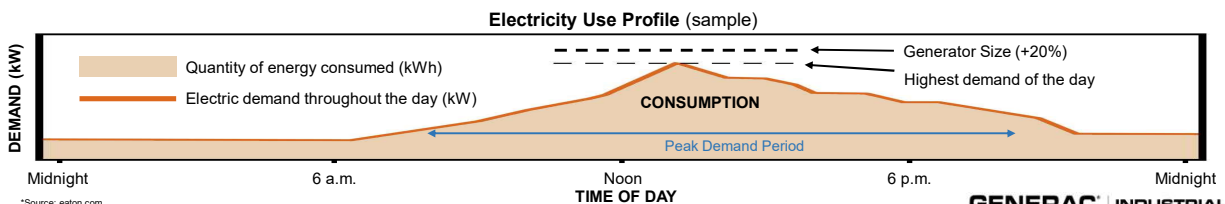
29 Professional Development Seminar Series – NEC (Part 1)



29

# NEC Sizing

- **Article 220 (Feeder & Service load Calculations)**
  - Part III
    - Sum of the loads on the branch circuits
    - Applicable code allowed demand factors
    - Non-coincidental load allowance
  - Part IV
    - Existing installations can use actual maximum demand
      - Utility peak demand info across one year
      - Measurement data: 30 days
    - Generator sized for 80% loading (demand x 1.25)



30 Professional Development Seminar Series – NEC (Part 1)



30

## Measurement Data

- Existing Facilities Should Utilize Historical & Measurement Data

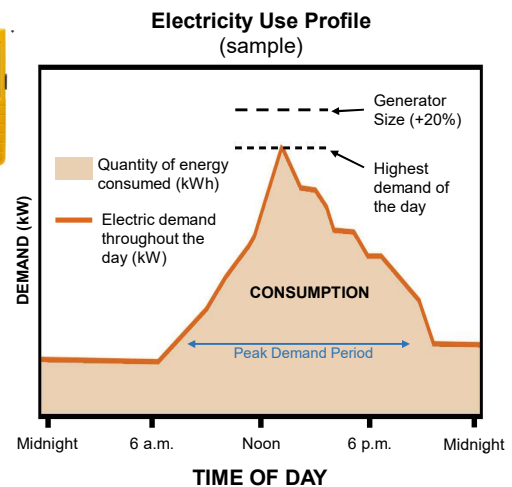
- Billing History**

- Demand charges (capture peak kW)
  - Captures seasonality & business cycles
  - Peak power over 15 minute average
    - Does not include motor start transients



- Power Analyzer**

- Snapshot / short history (measures transient spikes)
- NEC wants 30 days (15 min averages)
- Capture power quality
  - Harmonic content
  - Power factor



\*Source: FLUKE Corporation

31 Professional Development Seminar Series – NEC (Part 1)

GENERAC INDUSTRIAL POWER

31

## Other Approved Methods

- “Other Approved Methods”**

- Open to AHJ interpretation
- AHJ & plan review have to be comfortable with the sizing process
- Engineering judgement & PE stamp carry weight
  - New construction circuit loading may be under defined
  - Historical design rules for needed (kW/ft<sup>3</sup>)
  - Factors for uncertainty & load growth



\*Source: Computerhistory.org

32 Professional Development Seminar Series – NEC (Part 1)

GENERAC INDUSTRIAL POWER

32

## 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 (Health Care Facilities)
    - Critical & life safety loads
- **60 Sec Start-up Time**
  - NEC 701.12 (Legally Required Standby)
- **Variably Defined Start-up**
  - NFPA 110 4.1 (Emergency & Standby Power Systems)



33 Professional Development Seminar Series – NEC (Part 1)

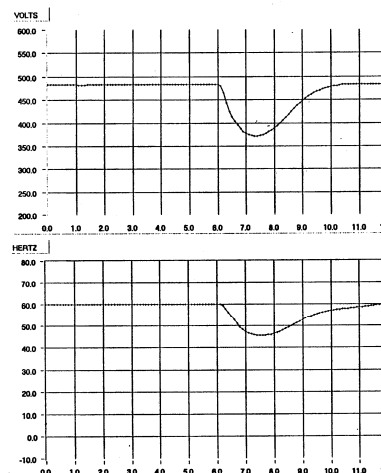
**GENERAC** INDUSTRIAL  
POWER

33

## What Transient Limits Are Required By The NEC?

### Q6) What Transient (Voltage & Frequency) Limits Are Required by the NEC?

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



34 Professional Development Seminar Series – NEC (Part 1)

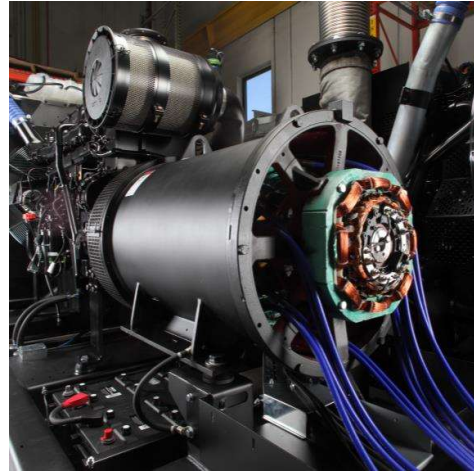
**GENERAC** INDUSTRIAL  
POWER

34

## What Transient Limits Are Required By The NEC?

- **What Items Affect Load Transients?**

- Size of load and its characteristics
- Motor starting codes and starting methods
- Engine size & fuel type (frequency dips)
- Alternator size (voltage dips)



35 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

35

## 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 (Control Functions)**
  - Alarms & instrumentation



36 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

36



# What Alarms & Instrumentation Are Required

- **Derangement**
  - Common alarm (typically any alarm condition)
  - NEC does clarify shutdown vs. pre-alarms (warnings)
- **Carrying load**
  - ATS position (typically wired back to the generator)
  - Displayed on generator controls & remote annunciators
- **Battery charge fail**
  - Loss of AC power
  - Low generator battery voltage



37 Professional Development Seminar Series – NEC (Part 1)



37

# What Alarms & Instrumentation Are Required?

- **NEC & NFPA 110**
  - Remote audio alarm
- **NFPA 99 (healthcare)**
  - Remote visual alarming



Table 5.6.5.2 Safety Indications and Shutdowns

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

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

38 Professional Development Seminar Series – NEC (Part 1)



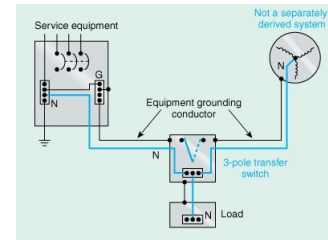
38

## 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



39 Professional Development Seminar Series – NEC (Part 1)

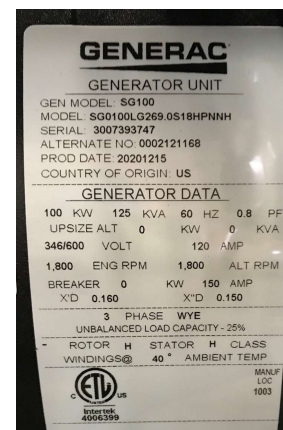
**GENERAC** INDUSTRIAL POWER

39

## What Are The Generator Signage Requirements?

- **NEC 445 (updated manufacturer marking & instruction requirements)**

- Clarifies nameplate & instruction requirements
- Alternator reactance information
- Alternator neutral bonding (internal or external)
  - Protecting against floating or two points of bond
  - Label inside the connection box
  - Most alternators are not factory bonded



40 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

40

## What Are The Generator ESD Requirements?

### Q9) What are the Requirements for Emergency Shutdown (ESD)?

- **NEC 445.18(B) (Emergency Shutdown of the Prime Mover)**
  - Installed as part of the generator control panel (inside the enclosure)
  - If the ESD is considered lockable
    - Replaces need for a disconnect (breaker)
    - Replaces the need for a lock on the generator breaker
    - If ESD is inside a lockable genset enclosure is it considered lockable?
  
- **NEC 445.18(C) (Remote Emergency Shutdowns)**
  - Required for all generators over 15 kW
  - ESD are typically installed inside the generator but NEC also requires remotely accessible
  - Location
    - Required outside of the equipment room (or)
    - Required outside the generator enclosure



[www.safetycents.com](http://www.safetycents.com)

41 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

41

## What Are The Generator Breaker Requirements?

### Q10) What are the Requirements for the Generator Breaker

- Separating the need for building feeder disconnect
- The need and location of feeder disconnect is explored in GPS 345 (NEC Part 2)
  
- **NEC 445.18 requires a lockable disconnect**
  - Unless you supply a lockable ESD
  - Most generators utilize a generator breaker
    - Generator breakers aren't typically individually lockable (typically an option)
    - Most AHJ interpret the lockable genset enclosure as adequate



42 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL POWER

42

## What Are The Generator Breaker Requirements?

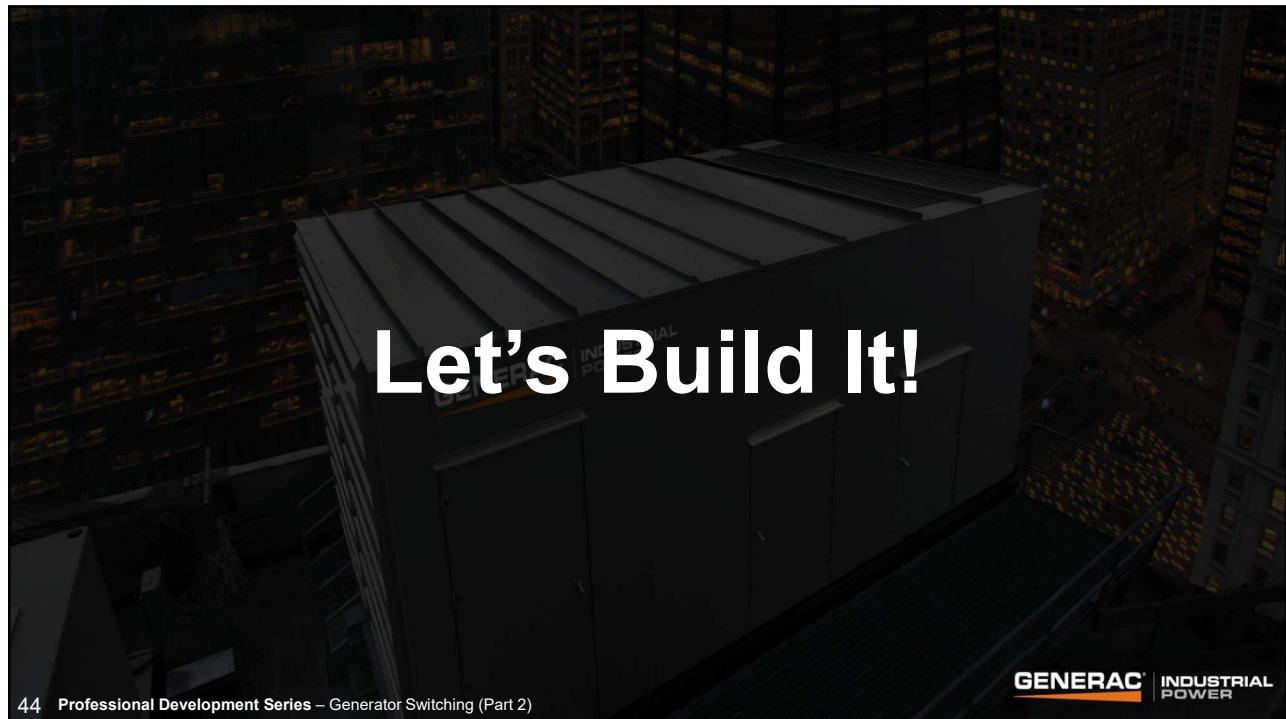
### Q10) What are the Requirements for the Generator Breaker

- **Ground Fault**
  - Discussed in detail in GPS 345 (NEC Part 2)
  - Typically implemented as a genset controller function when code required
    - Can be indication or trip
  
- **NEC 240.87 (Arc Energy Reduction)**
  - Code required when breaker reaches 1200 amps
  - Can be implement within an LSI breaker (maintenance input switch – reduces trip setting)
    - More expensive implementation and not an integrated generator solution
  - Preferred implementation is within the genset controller feeding a shunt trip breaker
    - Integrates genset shutdown and alarm indication
    - Current trip point must be less than arcing current
    - Typically 2 x rated amps (208V generators) & 3 x rated amps (480V generators)

43 Professional Development Seminar Series – NEC (Part 1)

**GENERAC** INDUSTRIAL  
POWER

43



44 Professional Development Series – Generator Switching (Part 2)

**GENERAC** INDUSTRIAL  
POWER

44