LIONHEART
CRITICAL POWER SPECIALISTS

Simplifying NFPA 110 Requirements + Best Practices

For Generators, Automatic Transfer Switches, Paralleling Switchgear and Related Components

As always, you should consult your Authority Having Jurisdiction (AHJ) for all code related matters.
The information provided in this presentation is the interpretation of the code and best practices of the presenter, Monty Hagberg


LIONHEART
CRITICAL POWER SPECIALISTS

LionHeart Critical Power Specialists

Your Solution for Critical Power Needs

- Independent Generator – ATS Service Provider
- Chicago's Largest Generator – ATS Service Company
- Milwaukee Branch
- Indianapolis Branch
- 30 Union Service Technicians
- 24/7/365 Emergency Response (LIVE VOICE)
- Free, Unlimited Customer Training
- Code Experts (Healthcare – NFPA 110)

EGSA 2019 Top USA Technician Award

Rob Plane

Your Presenters

- Cliff Hunter
  - Joined LionHeart in 2010 with a sales background
  - Leads a team of 5 other Account Executives between WI, IL and IN
- Jordan Cazzola
  - Joined LionHeart in 2018 as WI Account Executive
  - Background in diesel engines and sales
  - Works with many WHEA members currently

Agenda

A. Safety Procedures
B. Generator Systems
    A. Generator Equipment Preferences
    B. New Generator Warranty/Service
    C. Diesel vs. Natural Gas
    D. Diesel Fuel Consumption
    E. Benefits of Load Bank Testing
    F. Fluid Analysis
        A. Oil
        B. Coolant
        C. Diesel Fuel
C. Automatic Transfer Switches (ATS)
    A. Safety
D. ATS Operation/Sequence
E. Generator Testing Requirements (code)
    A. Healthcare (WDHS; TJC; CMS)
F. Questions/Discussion

Safety Procedures

- Gloves
- Eye Protection
- Hearing Protection
- Personal Awareness

Safety Procedures

- Never wear loose clothing
- Stay Clear of rotating/ hot items
- Be aware of high voltages
- Qualified/ trained personnel work on generator

PPE

Generators

Caterpillar

Cummins/Onan

Kohler/Spectrum

MTU
Detroit Diesel

Generac

Katolight

Preferred Generator Criteria

- Technical Product Support
- Parts Long-Term Availability
- Parts Accessibility
- New Equipment Investment Cost
- Aftermarket Costs
- Proprietary Software

Preferred Generators

- Caterpillar
- MTU
- Cummins
- Kohler
- Blue Star
- Gillette
- Katolight
- Generac

Diesel vs. Natural Gas

Diesel Fuel

Natural Gas / LP Gas

Diesel vs. Natural Gas

Cost Comparison

Diesel Generator	Natural Gas Generator
• 100 kW = $30K	• 100 kW = $30K
• 200 kW = $48K	• 200 kW = $88K
• 400 kW = $90K	• 400 kW = $200K
• 800 kW = $100K	• 800 kW = $380K

Diesel Fuel Consumption

7 Gallons of Fuel per / 100 kW Output

EXAMPLES

600 kW Generator with 300 kW Load

7-gallons X 3 = 21-gallons per hour

800 kW Generator with 450 kW Load

7-gallons X 4.5 = 31.50-gallons per hour

500 kW – 480V – 752A Generator

Running under 210A load

210A / 752A = 27% capacity load

500 kW X .27 = 135 kW

7 X 1.35 = 9.45-gallons per hour

Recommended Maintenance &Testing

Generator Service & Testing Frequency

PM1 (minor) Inspection
based on load criticality / client guidelines

PM2 (major) Service
Annual

Load Bank Test
Annual

ATS PM2 Service & Testing
Annual

Generator Load Bank Testing

Load Bank Testing when required

- NFPA-110 Requirements for health care facilities (Annually)
- City of Chicago testing
- Property Management requirements
- Corporate requirements

Benefits of Load Bank Testing

- Verifies all systems can perform properly at rated load
- Cleans unburned fuel and carbon from the engine
- Dries alternator windings
- Allows testing of your facility - room ventilation, exhaust flow, landscaping hazards

Wet Stacking

Laboratory Analysis of Oil Coolant & Fuel

Laboratory Analysis of Oil

- Detects / tracks abnormal metal wear (cylinders – bearings)
- Detects Contamination (diesel fuel)
- Detects Carbon (lightly loaded – cylinder wear)

Oil Analysis (Tracks Metal Wear)

- Copper
- Oil Cooler Erosion
- Lead / Tin
- Bearing Wear
- Iron
- Liner Wear

Laboratory Analysis of Coolant

- Tracks Inhibitor / Conditioner level (corrosion – poor heat transfer)
- Detects Aeration (air bubbles causing metal erosion)
- Change coolant Indicator (extends life – saves $$)

Laboratory Analysis of Diesel Fuel

- Detects Water (growth of microorganisms or bacteria)
- Detects Microbial growth (sludge)
- Detects Particulates (dirt)

Diesel Fuel Polishing

BATTERIES

They Get their own slide
because they're that important!

Maintainable Batteries

NFPA Requirements

WEEKLY

Inspect **Electrolyte Levels** in all battery cells.

MONTHLY

Complete and document the testing of **Electrolyte Specific Gravity** in all cells

Maintenance Free Batteries

(YES! They are allowed!)

NFPA Requirements

WEEKLY

Inspect battery **Voltage**

MONTHLY

Complete and document a battery **Conductance Test**

Here is a recommended conductance testing from Snap-On. Let us know if you want additional information!!

NOTE: NFPA-110 *recommends* batteries be replaced every 24-30 months (A.5.6.4.5.1)

Starting Batteries

Since the adoption of the 2012 Life Safety Code in 2016, dozens of our clients have requested their starting batteries be replaced with Maintenance Free batteries.

The requests are due to Joint Commission's enforcement of OSHA Instruction STD 01-08-002 which requires eyewash stations in battery charging and maintenance areas.

Battery Chargers

Jacket Water Heaters

Jacket Water Heaters

- Immersion Heater

- External Heaters

Fresh Air Intake & Exhaust

Fresh Air Intake & Exhaust

Control Panels

Control Panels

Remote Annunciators

Generator Alarms - Warnings

High Coolant Temp

- Normal Temperature: 180-190 degrees
- Alarm at approx. 212 degree

Low Coolant Temp

- Normal Temperature (not running): 100-120 degrees
- Alarm at approximately 80 degrees

Low Oil Pressure

- Low on oil, check oil level

Low Fuel Level

- Low fuel in day tank or main tank

Generator Alarms - Shutdowns

Not in Auto	• Engine start switch not in AUTO
Low Batt Voltage	• For a 24 volt system: alarm if under 24
Overcrank	• Unit cranks but will not start after 3 cranking cycles
Overspeed	• Upon start up, engine RPMs exceed 2000 - shutting engine off
High Coolant Temp	• Unit overheated
Low Oil Pressure	• Typically caused by low oil level
Emergency Stop	• Red E-Stop button has been pushed • FIX: Twist button to reset, rest panel

Generator
(Most Common Service Calls)

- No Start Condition
  - Batteries
  - Battery charger
    - Breaker
  - Too cold
- Low Coolant Temperature
  - Jacket water heater
    - Breaker
- High Temperature
  - Radiator
  - Engine thermostat
  - Air flow
    - Intake – exhaust louvers
- Generator Running but Not Connected to Emergency
  - Generator breaker
  - An ATS Issue
- Generator Still Connected to Emergency although Utility is Available
  - An ATS issue

Diesel Fuel Tanks

- Sub-base Tanks
- AST’s (aboveground storage tanks)
- Day Tanks
- UST’s (underground storage tanks)

Automatic Transfer Switches *(ATS)*

Standard Transition ATS

Bypass Isolation ATS

Automatic Transfer & Bypass Isolation Switch

Manual Bypass Switch

(Same Ratings as ATS)

Automatic Transfer Switch

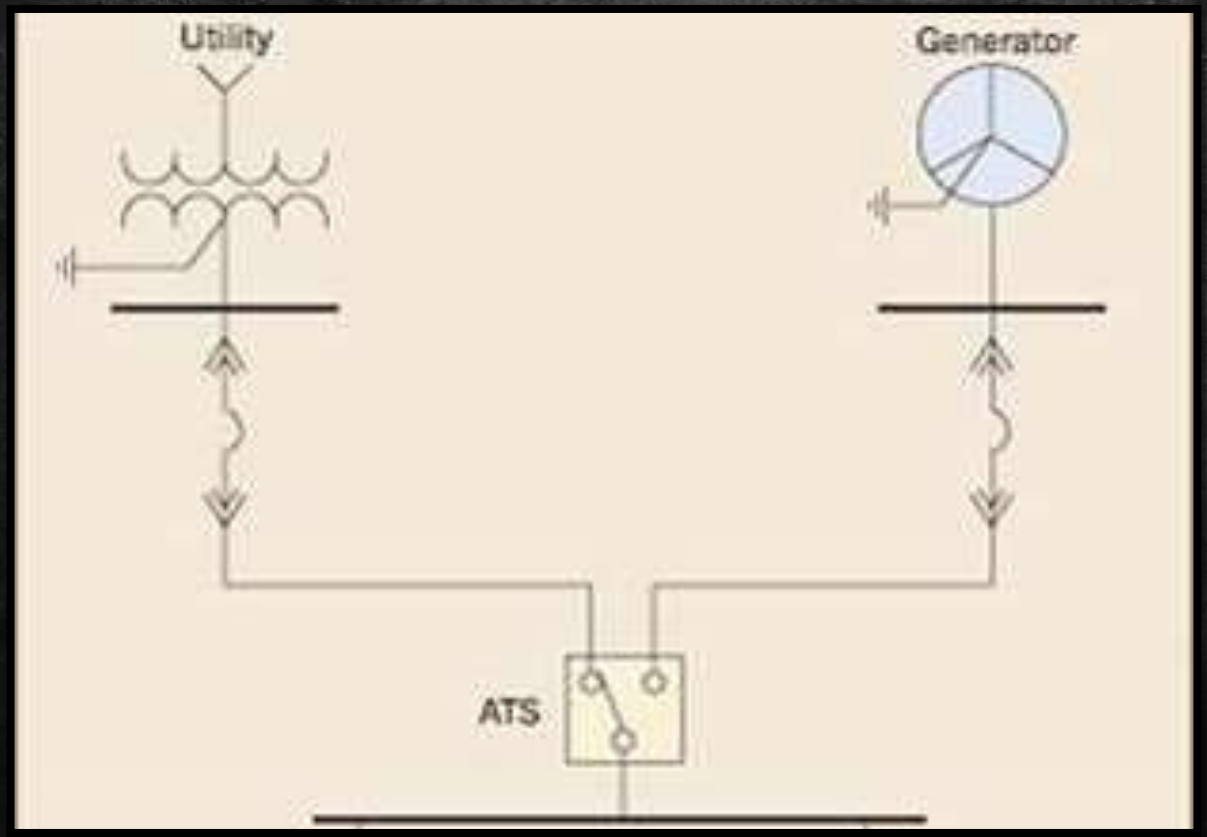
NFPA 110
NFPA 99
NEC 700-5 700-6

" The Bypass Isolation Switch shall have a continuous current rating current rating compatible with that of the associated transfer switch"

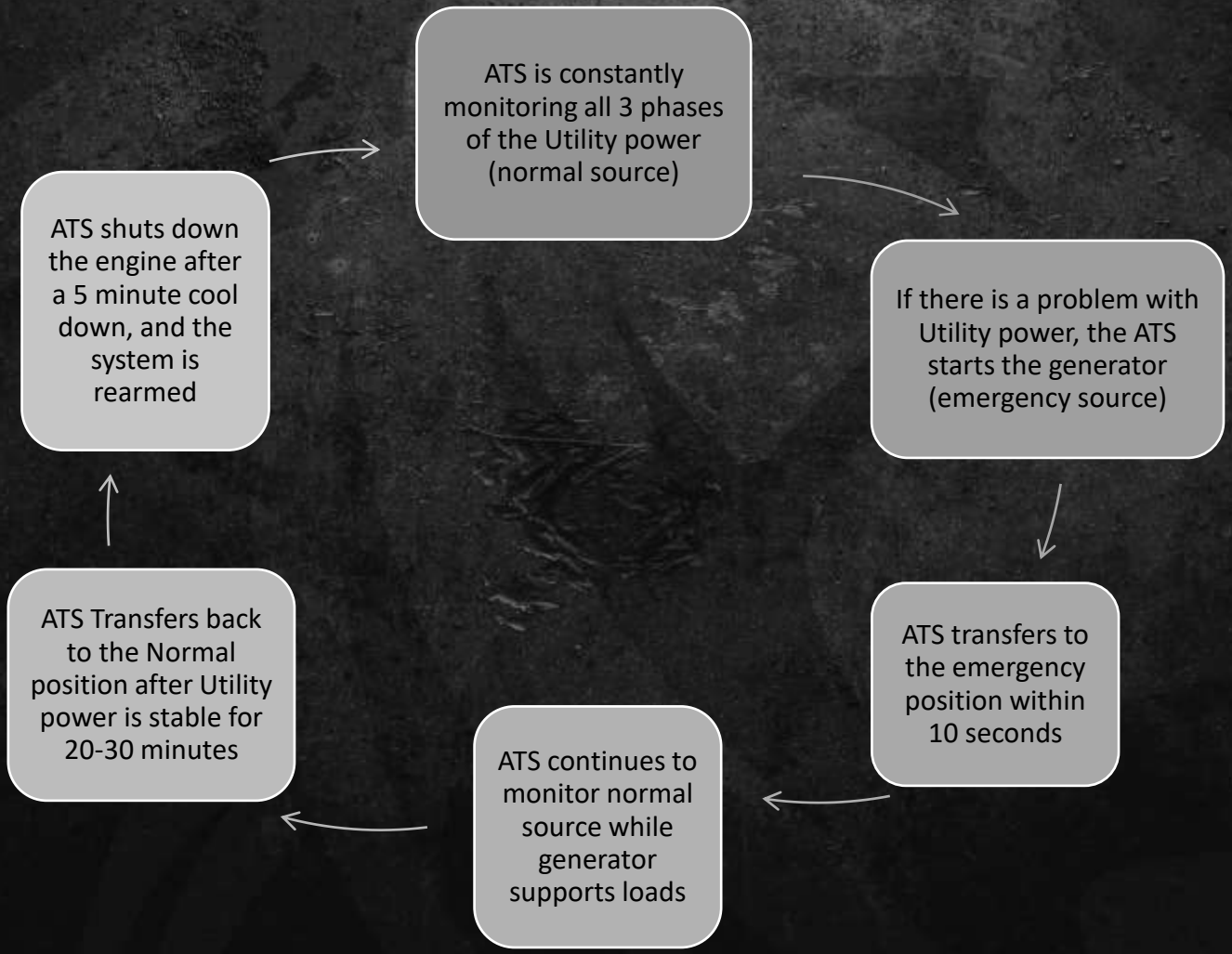
ASC Power Technologies

EMERSON Network Power

One-line Diagram



ATS Operation Details



NFPA 110

So…..What's New?

But we want you to be comfortable with THESE changes!!

Here are a few key differences between the previous edition (1999) and the 2010 edition:

- Differentiation between Diesel and Natural Gas generators
- Annual Load Bank Testing duration is reduced and testing levels are relaxed
- 4-hour Load Testing is required for all generators every 36 months
- Fuel Quality Test is required annually
- Transfer Switch Maintenance and Testing Program is required
- Paralleling Switchgear Maintenance and Testing Program is required
- Breaker exercising and testing is required
- Maintenance-free batteries are allowed
- A monthly-style test is required after repairs that "impact" operational reliability

NFPA 110

Key Terms

Level 1 vs. Level 2 Systems

Level 1 systems refer to systems that are essential for safety to human life. For the sake of this discussion, were going to be talking about Level 1 systems.

Percentages

When NFPA provides required percentages that must be met during testing, it is referring to the percentage of the rated kW percentage for the generator.

Spark-ignited

For this presentation, I will address spark-ignited as NATURAL GAS fueled engines

EPSS = Emergency Power Supply System

This term encompasses the generator(s), transfer switches, and related components

Let's cruise...

through the daily, weekly & monthly requirements

Weekly

GENERATOR

NFPA Requirements

- Visual Inspection and Documentation
- Specifically calls-out inspecting electrolyte levels (or battery voltage for maintenance free batteries)

Best Practices

- Run the generator for 10 minutes to ensure proper start, no leaks, and the absence of alarms or warnings

TRANSFER SWITCH

NFPA Requirements

- Inspected weekly

Best Practices

- Visual Inspection of the exterior, lamps, and control panel

Monthly

GENERATOR

NFPA Requirements

Diesel Generator Testing

- Operate the generator under building load for a minimum of 30 min.
- To be exempt from annual load bank testing, load the generator to 30% or more
- (or maintain the minimum exhaust gas temperature recommended by the OEM - but this info is not available in most cases)

Natural Gas Generator Testing

- Operate the generator with the EPSS load for 30 minutes or until the water temperature and oil pressure have stabilized

Best Practices

- Natural Gas generators should ran a FULL 30 minutes for the monthly test (just like diesel generators)

TRANSFER SWITCH

NFPA Requirements

- Operate all connected transfer switches once per month

Best Practices

- Rotate the ATS used to *initiate* each monthly test (to confirm the operation of each ATS's start signal)

Annually

GENERATOR

NFPA Requirements

Natural Gas

Engine and Generator Maintenance

- "Manufacturer's recommended Maintenance" to include inspection, testing all the main systems:
  - **Starting/Electrical**
  - **Fuel**
  - **Cooling**
  - **Lube Oil**
  - **Air Intake/Exhaust**
  - **Controls and Safeties**

Load Bank Testing - No longer required for natural gas generators

Best Practices

- Natural Gas generators should be load bank tested annually
  We identify more problems with the stability of natural gas engines than with diesel engines
- Laboratory analysis of oil and coolant samples

Diesel

Engine and Generator Maintenance

- "Manufacturer's recommended Maintenance" to include inspection, testing all the main systems:
  - **Starting/Electrical**
  - **Fuel**
  - **Cooling**
  - **Lube Oil**
  - **Air Intake/Exhaust**
  - **Controls and Safeties**

Load Bank Testing - If the monthly testing documentation does not meet the required load levels or exhaust temperatures, an annual Load Test is required. This test is typically performed with a load bank so the testing level can be 75% or greater for the last hour.

Load bank testing duration has been reduced from 2 hours to 1.5 hours

Load levels have been "relaxed"

Fuel Testing - Required

TRANSFER SWITCH

NFPA Requirements

- Transfer switches shall be subjected to a maintenance and testing program to include:
  - **checking connections**
  - **inspection for overheating**
  - **checking for excessive contact erosion**
  - **removal of dust and dirt**
  - **replacement of contacts, if necessary**

Best Practices

- In addition to NFPA Requirements, we recommend adding the following to annual switch maintenance:
  - Infrared scans or thermography of all cable connection points and the contactor assembly
  - Operation and testing of the bypass module if the ATS is a Bypass/Isolation switch
  - Confirm all time delays and pick-up / drop out settings

Annually

GENERATOR

NFPA Requirements

For Diesel Generators: A fuel quality test must be performed annually using testing approved by ASTM standards.
But which ATSM standards? Please share what you know.

Annually

Your Paralleling Switchgear needs some love too!

PARALLELING SWITCHGEAR

NFPA Requirements

- Paralleling switchgear shall be subjected to a maintenance and testing program to include:
  - checking connections
  - inspection for overheating
  - checking for excessive contact erosion
  - removal of dust and dirt
  - replacement of contacts, if necessary

Best Practices

Full function test to include all paralleling operations!

Annually

Yep! There's More! Let's Talk Breakers….

BREAKERS

NFPA Requirements

- **Circuit breakers including main and feed breakers between the generator and the transfer switch shall be exercised.**
- **If circuit breaker is in excess of 600v - it shall be exercised every 6 months and tested under overload conditions every 2 years.**

Best Practices

Annual generator maintenance includes exercising the output breaker on the generator, HOWEVER --- ***we suggest discussing this requirement with your electrician or the vendor who performs breaker maintenance on your utility switchgear.***

Triennially

(36 months)

GENERATOR

NFPA Requirements

Natural Gas

- 4-hour Load Test. Can be performed with building load (ATSs in EM position for 4 continuous hours).

Diesel

- 4-hour Load Test. Must be performed at equal to or greater than 30% for 4 continuous hours
- If combined with an annual 1.5 hour test, the last hour must be equal to or greater than 75%
- If combined with a monthly 30-minute test, the test must be initiated with an ATS and all connected ATSs must be transferred during the test.

Best Practices

- Natural Gas generators should be tested with a load bank to ensure proper operation at heavy load.

TRANSFER SWITCH

NFPA Requirements

- None

Best Practices

- No special recommendations for every 36 months, however we recommend powering-down each ATS every 5 years to torque lugs and cable connections

WARNING!!!!!

12 Slides of NFPA 110 code details are coming!

Hang in there...we’re in the final stretch...

(This is a good time to jot down questions :-)

NFPA-110, 2010 edition

Chapter 8 Routine Maintenance and Operational Testing

*8.1** General

8.1.1 The routine maintenance and operational testing program shall be based on all of the following:
(1) Manufacturer’s recommendations
(2) Instruction manuals
(3) Minimum requirements of this chapter
(4) The authority having jurisdiction

8.1.2 Consideration shall be given to temporarily providing a portable or alternate source whenever the emergency generator is out of service.

*8.2** Manuals, Special Tools, and Spare Parts.

8.2.1 At least two sets of instruction manuals for all major components of the EPSS shall be supplied by the manufacturer(s) of the EPSS and shall contain…..

8.2.3 Special tools and testing devices necessary for routine maintenance shall be available for use when needed.

8.2.4 Replacement for parts identified by experience as high mortality items shall be maintained in a secure location(s) on the premises.

8.2.4.1 Consideration shall be given to stocking spare parts as recommended by the manufacturer.

(TESTING FOLLOWING REPAIRS)

8.3 **Maintenance and Operational Testing**

8.3.2 A routine maintenance and operational testing program shall be initiated immediately after the EPSS has passed acceptance tests or after completion of repairs that impact the operational reliability of the system.

8.3.2.1 The operational test shall be initiated at an ATS and shall include testing of each EPSS component on which maintenance or repair has been performed, including the transfer of each automatic and manual transfer switch to the alternate power source, for a period of not less than 30 minutes under operating temperature.

(ATS MAINTENANCE REQUIREMENT)

8.3.5* **Transfer switches shall be subjected to a maintenance and testing program** that includes all of the following operations:

(1) Checking of connections
(2) Inspection or testing for evidence of overheating and excessive contact erosion
(3) Removal of dust and dirt
(4) Replacement of contacts when required

(PARALLELING GEAR MAINTENANCE REQUIREMENT)

8.3.6 **Paralleling gear shall be subject to an inspection, testing, and maintenance program** that includes all of the following operations:

(1) Checking of connections
(2) Inspection or testing for evidence of overheating and excessive contact erosion
(3) Removal of dust and dirt
(4) Replacement of contacts when required

(BATTERY REQUIREMENTS)

*8.3.7** Storage batteries, including electrolyte levels or battery voltage, used in connection with systems shall be inspected weekly and maintained in full compliance with manufacturer's specifications.

8.3.7.1 Maintenance of lead-acid batteries shall include the monthly testing and recording of electrolyte specific gravity. Battery conductance testing shall be permitted in lieu of the testing of specific gravity when applicable or warranted.

8.3.7.2 Defective batteries shall be replaced immediately upon discovery of defects.

(BREAKER EXERCISE & TESTING REQUIREMENT)

8.4.7 EPSS circuit breakers for Level 1 system usage, including main and feed breakers between the EPS and the transfer switch load terminals, shall be exercised annually with the EPS in the “off” position.

8.4.7.1 Circuit breakers rated in excess of 600 volts for Level 1 system usage shall be exercised every 6 months and shall be tested under simulated overload conditions every 2 years.

(MONTHLY INSPECTIONS & TESTING)

8.4 Operational Inspection and Testing

*8.4.1** EPSSs, including all appurtenant components, shall be inspected weekly and exercised under load at least monthly

*8.4.2** Diesel generator sets in service shall be exercised at least once monthly, for a minimum of 30 minutes, using one of the following methods:
(1) Loading that maintains the minimum exhaust gas temperatures as recommended by the manufacturer
(2) Under operating temperature conditions and at not less than 30 percent of the EPS nameplate kW rating

(ANNUAL 1.5-HOUR LOAD TESTING FOR DIESEL GENERATORS)

8.4.2.3 Diesel-powered EPS installations that do not meet the requirements of 8.4.2 shall be exercised monthly with the available EPSS load and shall be exercised annually with supplemental loads at not less than 50 percent of the EPS nameplate kW rating for 30 continuous minutes and at not less than75 percent of the EPS nameplate kW rating for 1 continuous hour for a total test duration of not less than 1.5 continuous hours.

8.4.2.4 Spark-ignited generator sets shall be exercised at least once a month with the available EPSS load for 30 minutes or until the water temperature and the oil pressure have stabilized.

8.4.3 The EPS test shall be initiated by simulating a power outage using the test switch(es) on the ATSs or by opening a normal breaker. Opening a normal breaker shall not be required.

(36-MONTH, 4-HOUR LOAD TESTING)

*8.4.9** Level 1 EPSS shall be tested at least once within every 36 months.

8.4.9.2 Where the assigned class is greater than 4 hours, it shall be permitted to terminate the test after 4 continuous hours.

8.4.9.3 The test shall be initiated by operating at least one transfer switch test function and then by operating the test function of all remaining ATSs, or initiated by opening all switches or breakers supplying normal power to all ATSs that are part of the EPSS being tested ******

(36-MONTH, 4-HOUR LOAD TESTING)

8.4.9.5.1 For a diesel-powered EPS, loading shall be not less than 30 percent of the nameplate kW rating of the EPS. A supplemental load bank shall be permitted to be used to meet or exceed the 30 percent requirement.

8.4.9.5.2 For a diesel-powered EPS, loading shall be that which maintains the minimum exhaust gas temperatures as recommended by the manufacturer

8.4.9.5.3 For spark-ignited EPSs, loading shall be the available EPSS load.

(36-MONTH, 4-HOUR LOAD TESTING)

8.4.9.6 **The test required in 8.4.9 [36-month test] shall be permitted to be combined with one of the monthly tests required by 8.4.2 and one of the annual tests required by 8.4.2.3 as a single test.**

8.4.9.7 **Where the test required in 8.4.9 is combined with the annual load bank test, the first 3 hours shall be at not less than [30%] the minimum loading required by 8.4.9.5 and the remaining hour shall be at not less than 75 percent of the nameplate kW rating of the EPS.**

End

Questions & Discussion

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