Ask the Experts:
NFPA 110 for Emergency Power Systems

PowerHour webinar series for consulting engineers
Experts you trust. Excellence you count on.

March 25, 2021 2:00pm Eastern Time / 11:00am Pacific Time
(1 PDH issued by Cummins Inc.)
Welcome!

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- Interact with Cummins experts and gain access to ongoing technical support
- Participate at your convenience, live or on-demand
- Earn Professional Development Hours (PDH)

Technical tips:
- Audio is available through teleconference or Zoom application.
- Attendees are in “listen only” mode throughout the event.
- Use the Zoom Q&A Panel to submit questions, comments, and feedback throughout the event. Time is allotted at the end of the PowerHour to address Q&A.
- If the audio connection is lost, disconnected or experiences intermittent connectivity issues, please check your audio connection through the "Join Audio" or "Audio Connectivity" button at the bottom left of the Zoom application.
- Report technical issues using the Zoom Q&A Panel.
Ask the Experts: NFPA 110 for Emergency Power Systems

NFPA 110, the Standard for Emergency and Standby Power Systems, sets the baseline for emergency power system performance requirements and is critical to installation of nearly every backup power system. This Ask the Experts session will address a number of key topics related to NFPA 110 and will offer an opportunity to connect directly with power system experts at Cummins! Topics addressed during this session will range from fuel and battery testing to Type 10 requirements and complexities arising from paralleled power sources serving life safety loads. Bring your questions and be prepared to engage in open discussion and Q&A with an expert panel.

After completing this course, participants will be able to:

- Identify key topics related to NFPA 110 impacting emergency power supply system design and installation.
- Describe common pitfalls, challenges and misconceptions often encountered when validating power system design.
- Recognize common code requirements mandated by NFPA 110 and their practical application.
Asking a Question:

Q&A Button:
• For technical questions on today’s topic
• Ask at anytime
• Not all questions may get answered but we’ll do our best!

Chat Button:
• For general PowerHour or Zoom questions
Disclaimer

The views and opinions expressed in this course shall not be considered the official position of any regulatory organization and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Participants are encouraged to refer to the entire text of all referenced documents. In addition, when in doubt, reach out to the Authority Having Jurisdiction.
Meet your panelists

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Product Strategy and Sales
Enablement Leader
Cummins Inc.

Earnest Glaser
Senior Sales Application
Engineer
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Donald Sosa
Senior Sales Application
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Cummins Inc.

Trina Casbon
Senior Sales Application
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Cummins Facilitator:

Mark Taylor
Technical Advisor
Cummins Inc.
What are some examples of emergency power system requirements that are derived from NFPA 110?
NFPA 110 Overview

Standard for Emergency and Standby Power Systems

Requirements covering the performance of emergency and standby power systems providing an alternate source of electrical power to loads in buildings and facilities in the event that the primary power source fails.

Covers installation, maintenance, operation, and testing requirements as they pertain to the performance of the emergency power supply system (EPSS).

Intent of standard is to achieve maximum system reliability.
NFPA 110 Overview
Standard for Emergency and Standby Power Systems

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EPS

Emergency Power Source
EPSS
Emergency Power Supply System
What is “Type” and how is it defined and measured?
NFPA 110 Overview

Classification of Emergency Power Supply Systems

4.2 Class. The class defines the minimum time, in hours, for which the EPSS is designed to operate at its rated load without being refueled or recharged.

4.3 Type. The type defines the maximum time, in seconds, that the EPSS will permit the load terminals of the transfer switch to be without acceptable electrical power.

4.4 Level. This standard recognizes two levels for equipment installation, performance and maintenance requirements.

4.4.1 Level 1 systems shall be installed where failure of the equipment to perform could result in loss of human life or serious injuries.

4.4.2 Level 2 systems shall be installed where failure of the EPSS to perform is less critical to human life and safety.

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NFPA 110 Overview

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<tr>
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Why is there a time delay on start? What is the purpose? Is it required?
Utility Outage

Time Delay on Start

6.2.5 Time Delay on Starting of EPS. A time-delay device shall be provided to delay starting of the EPS. The timer shall prevent nuisance starting of the EPS and possible subsequent load transfer in event of harmless momentary power dips and interruptions of the primary source.

A.6.2.5 For most applications, a nominal delay of 1 second is adequate. The time delay should be short enough so that the generator can start and be on line within the time specified for the type classification.
Utility Outage

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When we talk about or specify Class of the EPS, how does that differ from the recommended or requested onsite fuel storage?
4.2 Class. The class defines the minimum time, in hours, for which the EPSS is designed to operate at its rated load without being refueled or recharged.

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4.4.1 Level 1 systems shall be installed where failure of the equipment to perform could result in loss of human life or serious injuries.

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NFPA 110 Overview

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<table>
<thead>
<tr>
<th>Class</th>
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</thead>
<tbody>
<tr>
<td>Class 0.083</td>
<td>0.083 hr (5 min)</td>
</tr>
<tr>
<td>Class 0.25</td>
<td>0.25 hr (15 min)</td>
</tr>
<tr>
<td>Class 2</td>
<td>2 hr</td>
</tr>
<tr>
<td>Class 6</td>
<td>6 hr</td>
</tr>
<tr>
<td>Class 48</td>
<td>48 hr</td>
</tr>
<tr>
<td>Class X</td>
<td>Other time, in hours, as required by the application, code, or user</td>
</tr>
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Is regular testing of diesel fuel required and if so, how frequently should it be conducted?
7.9.1.2 Fuel system design shall provide for a supply of clean fuel to the prime mover.

7.9.1.3 Tanks shall be sized so that the fuel is consumed within the storage life, or provisions shall be made to remediate fuel that is stale or contaminated or to replace stale or contaminated fuel with clean fuel.

8.3.7 A fuel quality test shall be performed at least annually using appropriate ASTM standards or the manufacturer’s recommendations.
NFPA 110 – Generator Set Subsystems

Engine Fuel System

7.9.1.2 Fuel system design shall provide for a supply of clean fuel to the prime mover.

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8.3.7 A fuel quality test shall be performed at least annually using appropriate ASTM standards or the manufacturer’s recommendations.

Spec Note Require vendors to provide service and maintenance contracts that include fuel testing at least annually.
How and when should I be testing the emergency power supply system?
EPS Testing with Load

8.4.2 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 standby nameplate kW rating

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 than 75 percent of the EPS nameplate kW rating for 1 continuous hour for a total test duration of not less than 1.5 continuous hours.

**Recommendation** Test emergency generator sets at least monthly for at least 30 minutes with a load bank at no less than 30% of the generator set rating.
Transfer Switch Operational Testing

8.4.6 Transfer switches shall be operated monthly.

8.4.6.1 The monthly test of a transfer switch shall consist of electrically operating the transfer switch from the primary position to the alternate position and then a return to the primary position.

**Spec Note** Employ transfer switch functionality that enables seamless transition from normal to emergency source and back with minimal interruption to loads (active sync in-phase transition).

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

8.4.9.1 Level 1 EPSS shall be tested continuously for the duration of its assigned class.

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.

8.4.9.4 A power interruption to non-EPSS loads shall not be required.
NFPA 110 36 Month Testing

8.4.9.5 The minimum load for this test shall be as specified in 8.4.9.5.1, 8.4.9.5.2, or 8.4.9.5.3.

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.

Spec Note Specify a permanent load bank to the system to allow for proper loading during weekly testing.
8.4.9.6 The test required in 8.4.9 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 portion of the test shall be at not less than the minimum loading required by 8.4.9.5, the last hour shall be at not less than 75 percent of the nameplate kW rating of the EPS, and the duration of the test shall be in accordance with 8.4.9.1 and 8.4.9.2.
Can natural gas generator sets be used in Level 1 / Life Safety applications?
Compliance to Codes and Standards

Myths and Misconceptions

**MYTH:** “Gaseous generator sets are not allowed for emergency or life safety applications.”

- Generator set manufacturers may be able to offer gaseous-fueled products that meet a wide range of applications.
- Natural gas may be acceptable to local authority having jurisdiction for life safety applications.
- Gaseous products may provide advantages over diesel products in applications due to fuel quality and logistics.
Compliance to Codes and Standards
Fuel Source for Emergency Systems

NFPA 110-2019

5.1.1 The following energy sources shall be permitted to be used for the emergency power supply (EPS):

1. Liquid petroleum products…
2. Liquified petroleum gas…
3. Natural or synthetic gas
Compliance to Codes and Standards

Fuel Source for Emergency Systems

NFPA 110-2019

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(3) Natural or synthetic gas

Exception: For Level 1 installations in locations where the probability of interruption of off-site fuel supplies is high, on-site storage of an alternate energy source sufficient to allow full output of the EPSS to be delivered for the class specified shall be required, with the provision for automatic transfer from the primary energy source to the alternate energy source.
Compliance to Codes and Standards
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Natural Gas Council
Natural gas is a secure, reliable and resilient choice for customers

- Operational reliability
  - 2017 survey of 51 interstate pipelines – 99.97% of contractual commitments
  - Geographic dispersion of production reduces vulnerability to local weather
  - Transportation network interconnected, offering multiple pathways for rerouting

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Compliance to Codes and Standards

Fuel Source for Emergency Systems

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<tr>
<td>708 “COPS”</td>
<td>✓</td>
<td>✓</td>
<td>X**</td>
</tr>
<tr>
<td>700 “Life Safety”</td>
<td>✓</td>
<td>✓</td>
<td>✓*</td>
</tr>
<tr>
<td>701 “Legally Req’d”</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>702 “Optional”</td>
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* Follow exemption process w/ AHJ per NFPA 110 Level 1 Systems

** NEC Article 708: Prime movers shall not be solely dependent on a public utility gas system for their fuel supply… Where internal combustion engines are used as the prime mover, an on-site fuel supply shall be provided…
## Compliance to Codes and Standards

### Fuel Source for Emergency Systems

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**Related Content**

Specifying Gaseous Sources

[PowerHour](#)
Can you talk about product testing and prototype testing?
Product Testing Overview

Why is standby power system testing important?

- There is no single performance test standard for standby power systems.
- Existing test standards may be incomplete or may not address all potential failure modes adequately.
- Testing throughout the life of a product ensures adequate product performance at all stages of assembly and installation.
- Equipment testing is critical to the reliability of the product and the power system.
Prototype Testing Overview

Prototype testing…

- Validates a complete product’s operating characteristics and limitations, as well as its ability to withstand “normally occurring abnormal events”.
- Will include potentially destructive testing you wouldn’t want to do on your customer’s new generator (short circuits, bolted faults, endurance, harsh environments, seismic, etc.)
- Defines installation design parameters.
- Provides a realistic baseline for performance expectations.
- Is one part of product lifecycle testing critical to component and power system reliability.
NFPA 110 requires that a generator set manufacturer certify compliance to the prototype testing requirements of that standard. Each manufacturer is free to decide what testing is necessary for their product. Actual testing practices vary dramatically between suppliers. Designer is expected to understand what is required and evaluate the ability of a specific supplier to meet objectives of NFPA 110.
Prototype Test Documentation

- NFPA 110 requires that a generator set manufacturer certify compliance to the prototype testing requirements of that standard.
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- Actual testing practices vary dramatically between suppliers.
- Designer is expected to understand what is required and evaluate the ability of a specific supplier to meet objectives of NFPA 110.
What is "Level" and how is it defined and measured?
NFPA 110 Overview

Classification of Emergency Power Supply Systems

4.4 Level: This standard recognizes two levels for equipment installation performance and maintenance requirements.

4.4.1 Level 1 systems shall be installed where failure of the equipment to perform could result in loss of human life or serious injuries (Equates to NEC Article 700).

4.4.2 Level 2 systems shall be installed where failure of the EPSS to perform is less critical to human life and safety (Equates to NEC Article 701).
What are the considerations for Type 10 EPSS when we parallel gensets?
Paralleled Generator Set EPSS

FIGURE B.1(b) Typical Multiple-Unit Emergency Power Supply System.

Notes:
1. One alternate source generator unit of the paralleling system to have sufficient capacity to carry all required Level 1 loads.
2. The EPSS distribution center can be installed in additional cubicles as part of the paralleling board setup.
### Utility Outage with Single Generator Set System – Sequence of Events

1. **ATS control detects failure of normal source**
2. **ATS programmed time before next step**
3. **ATS control sends start signal to generator set control**
4. **Generator set control initiates engine start sequence**
5. **Generator set engine starts**
6. **Generator set reaches “Ready to Load”**
7. **ATS transitions from normal to neutral position**
8. **ATS transfer time delay**
9. **ATS transitions from neutral to emergency position**

**Time Frames**

- **0 – 1 Seconds** based on application
- **4 – 8.5 Seconds** based on generator set configuration
- **0.5 – 1.5 Seconds** based on transfer switch and application
Utility Outage with Multiple Generator Set System – Sequence of Events

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2) ATS programmed time before next step
3) ATS control sends start signal to generator set control
4) Generator set control initiates engine start sequence
5) Generator set engine starts
6) Generator set reaches “Ready to Load”
7) Generator set paralleling controls begin “first start arbitration”
   1) Generator set that “wins” first start arbitration proceeds to next step
   2) All other generator sets must synchronize before proceeding to the next step
8) Generator set paralleling circuit breaker closes
9) ATS transitions from normal to neutral position
10) ATS transfer time delay
11) ATS transitions from neutral to emergency position

0 – 1 Seconds based on application
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4 – 8.5 Seconds based on generator set configuration
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4 – 8.5 Seconds based on generator set configuration
0.5 – 1 Second for first generator set
0.5 – 1 Second for each additional generator set
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- 0 – 1 Seconds based on application
- 4 – 8.5 Seconds based on generator set configuration
- 0.5 – 1 Second for first generator set
- 0.5 – 1 Second for each additional generator set
- 0.5 – 1.5 Seconds based on transfer switch and application
Utility Outage with Multiple Generator Set System – Sequence of Events

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2) ATS programmed time before next step
3) ATS control sends start signal to generator set control
4) Generator set control initiates engine start sequence
5) Generator set engine starts
6) Generator set reaches “Ready to Load”
7) Generator set paralleling controls begin “first start arbitration”
   1) Generator set that “wins” first start arbitration proceeds to next step
   2) All other generator sets must synchronize before proceeding to the next step
8) Generator set paralleling circuit breaker closes
9) ATS transitions from normal to neutral position
10) ATS transfer time delay
11) ATS transitions from neutral to emergency position

Spec Note The smallest generator set on the generator set paralleling bus shall have sufficient capacity to support all emergency loads.
Utility Outage with Multiple Generator Set System – Sequence of Events

1) ATS control detects failure of normal source
2) ATS programmed time before next step
3) ATS control sends start signal to generator set control
4) Generator set control initiates engine start sequence
5) Generator set engine starts
6) Generator set reaches “Ready to Load”
7) Generator set paralleling controls begin “first start arbitration”
   1) Generator set that “wins” first start arbitration proceeds to next step
   2) All other generator sets must synchronize before proceeding to the next step
8) Generator set paralleling circuit breaker closes
9) ATS transitions from normal to neutral position
10) ATS transfer time delay
11) ATS transitions from neutral to emergency position

Spec Note: The smallest generator set on the generator set paralleling bus shall have sufficient capacity to support all emergency loads.

NFPA 110 Time to Readiness
PowerHour
White Paper

10 Seconds
What are some of the commonly misinterpreted or misapplied portions of NFPA 110?
NFPA 110 – Generator Set Subsystems

Temperature Maintenance

5.3.1 The EPS shall be heated as necessary to maintain the water jacket and battery temperature determined by the EPS manufacturer for cold start and load acceptance for the type of EPSS.
NFPA 110 – Generator Set Subsystems

Temperature Maintenance

5.3.1 The EPS shall be heated as necessary to maintain the water jacket and battery temperature determined by the EPS manufacturer for cold start and load acceptance for the type of EPSS.

Spec Note Require the generator set vendor to provide an engine jacket water heater sized appropriately for the engine.
5.6.4.1 Starting Systems. Starting shall be accomplished using either an electric or a stored energy starting system.

5.6.4.3 Number of Batteries. Each prime mover shall be provided with both of the following:

(1) Storage battery units as specified in Table 5.6.4.2

5.6.4.4 Size of Batteries. The battery unit shall have the capacity to maintain the cranking speed recommended by the prime mover manufacturer through two complete periods of cranking limiter time-outs as specified in Table 5.6.4.2, item (d).

<table>
<thead>
<tr>
<th>Table 5.6.4.2 Starting Equipment Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starting Equipment Requirements</td>
</tr>
<tr>
<td>(a) Battery unit</td>
</tr>
<tr>
<td>(b) Battery certification</td>
</tr>
<tr>
<td>(c) Cycle cranking</td>
</tr>
<tr>
<td>(d) Cranking limiter time-outs</td>
</tr>
<tr>
<td>Cycle crank (3 cycles)</td>
</tr>
<tr>
<td>Continuous crank</td>
</tr>
<tr>
<td>(e) Float-type battery charger</td>
</tr>
<tr>
<td>dc ammeter</td>
</tr>
<tr>
<td>dc voltmeter</td>
</tr>
<tr>
<td>(f) Recharge time</td>
</tr>
<tr>
<td>(g) Low battery voltage alarm contacts</td>
</tr>
</tbody>
</table>

X: Required. O: Optional. NA: Not applicable.
5.6.4.1 Starting Systems. Starting shall be accomplished using either an electric or a stored energy starting system.

5.6.4.3 Number of Batteries. Each prime mover shall be provided with both of the following:

(1) Storage battery units as specified in Table 5.6.4.2

5.6.4.4 Size of Batteries. The battery unit shall have the capacity to maintain the cranking speed recommended by the prime mover manufacturer through two complete periods of cranking limiter time-outs as specified in Table 5.6.4.2, item (d).

Spec Note: Require vendors to provide starting batteries sized appropriately for use with the generator set configuration.
One of the most important maintenance items that deserves some extra attention is about batteries. Can you tell us more about the key role of batteries and how we can ensure utmost reliability?
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

Spec Note Require equipment vendors to provide electronic or hard-copies of owner/operator manuals which include anticipated service intervals.
8.2.4 Replacement for parts identified by experience as high mortality items shall be maintained in a secure location(s) on the premises.

8.3.2 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.

**Spec Note** Require equipment vendors to maintain an inventory of replacement parts and employ manufacturer trained service engineers capable of servicing the emergency equipment.
Starting Battery Maintenance

8.3.6 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.

8.3.6.1 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.

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

Spec Note Use starting batteries and battery chargers sized appropriately for use with the generator set configuration as recommended by the equipment manufacturer.
Ask the Experts: NFPA 110 for Emergency Power Systems

NFPA 110, the Standard for Emergency and Standby Power Systems, sets the baseline for emergency power system performance requirements and is critical to installation of nearly every backup power system. This Ask the Experts session will address a number of key topics related to NFPA 110 and will offer an opportunity to connect directly with power system experts at Cummins! Topics addressed during this session will range from fuel and battery testing to Type 10 requirements and complexities arising from paralleled power sources serving life safety loads. Bring your questions and be prepared to engage in open discussion and Q&A with an expert panel.

After completing this course, participants will be able to:

• Identify key topics related to NFPA 110 impacting emergency power supply system design and installation.

• Describe common pitfalls, challenges and misconceptions often encountered when validating power system design.

• Recognize common code requirements mandated by NFPA 110 and their practical application.
Additional Resources

Cummins White Papers

Maintenance is one key to diesel generator set reliability
Rated power factor tests and installation acceptance of emergency and standby power systems
The 10-second start: NFPA 110 Type 10 starting requirements for generator set applications
Design for safety and reliability-appropriate connection provisions for generator sets

Cummins PowerHour (Live and On-Demand Webinars)

Specifying Generator Set Testing for Reliable Power Systems
NFPA 110 Type 10 Requirements for Emergency Power Systems
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Closing

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