NFPA 110 Update:
Paying More Attention to the Business of Emergency Power Reliability

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Introduction

NFPA 110 is undergoing a long-anticipated revision. One of the documents in the 2009 revision cycle along with NFPA 99, NFPA 111 and several others, NFPA 110 has already gone through the first round of public proposals for changes. The NFPA Technical Committee (TC) on Emergency Power Supplies, which is responsible for NFPA 110 and 111, met in early 2008 to review all public proposals and also prepare committee proposals to update this increasingly important document. The NFPA 110 Report on Proposals (ROP) is being released for public comment as of this writing. The NFPA 110 ROP has been reviewed and approved by the 110 TC and the National Electrical Code® Technical Correlating Committee (NEC TCC.) [1]

The purpose of this white paper is not to review all of the proposals. The first part of this paper will discuss some of the existing proposals in the ROP that could have a major effect on the health care community if they survive the second round of public and TC reviews. The second part of this paper will discuss existing provisions in NFPA 110 pertaining to testing and maintenance that are intended to improve the operational reliability of an emergency power supply system (EPSS.)

Readers are urged to obtain a copy of the ROP from the NFPA website (www.nfpa.org) and review all proposed changes, including those that were rejected by the 110 TC. The commentary of the TC members during the balloting stage is also important because there were some differences of opinion within the TC about some of the final ROP wording. Readers are urged to use the opportunity built into the NFPA process for them to comment on the proposals and on the action takes by the TC during the ROP preparation stage. The closing date for receipt of further public comments for the ROP's of all standards in the 2009 revision cycle August 29, 2008.

Major Proposed Changes in NFPA 110 *[Not Final Yet]*

Proposed exclusion of optional standby systems

One of the major results of the disasters and terrorist attacks of the last 15 years has been an increase in the design and installation of optional standby systems. These optional standby

[1] National Electrical Code® and NEC® are both registered trademarks of the National Fire Protection Association

systems are discussed in NEC® Article 702. They include, for example, larger stand-alone EPSS's intended to provide additional emergency power for ventilation and cooling systems that are not required to have emergency power by codes, standards and Authorities Having Jurisdiction (AHJ's.)

The 110 TC decided to clarify the application of 110 to these non-required systems in response to questions from the public. The clarification is the 110 does not apply to the equipment of systems that are not classed (classified, but in NFPA language) as either Level 1 or Level 2 systems. Optional standby systems are not classed as Level 1 or Level 2 systems.

Proposed testing modifications

There have been many questions to the NFPA about the intent of the 110 testing provisions. The 110 TC reworded and reorganized the entire Initial Acceptance Testing section to clarify the TC's intent. There was some toughening of requirements, such as the new requirement to field-verify the engine start function throughout the entire EPSS. There was also the relaxation of some requirements, such as permitting an automatic transfer switch (ATS) test switch to start the acceptance test in existing occupied buildings and facilities rather than requiring a complete normal power outage for the first 2 hours of the Initial Acceptance Test as is presently required in the 2005 edition. Also included in this revision is a reduction from 2 hours to 1 ½ hours for the first portion of the Initial Acceptance Test in order to reduce engine exhaust emissions.

The 110 TC also responded to a number of questions concerning how to switch from the first portion of the Initial Acceptance Test to the second portion of that test in not more than 5 minutes by discussing in the Annex the installation of permanently installed equipment or connection points, such as spare circuit breakers or switches, for load banks and portable generators.

The annual load bank test was shortened from 2 hours from 1 ½ hours, also to reduce engine emissions.

The 3-year 4-hour load test was also rewritten and reorganized to clarify the TC's intent. This rewrite relaxes several requirements, such as permitting the use of ATS test switches rather than requiring that the normal power to the ATS's be dropped. This change was in response to concerns that a generator failure during the 4-hour test would result in a dead ATS unless the normal power source to the ATS stayed alive throughout the test, allowing the ATS to transfer back to normal power automatically. The 110 TC also responded to the joint ASHE/TJC request for a formal interpretation by allowing the 3-year test, one annual load test, and one monthly load test to be a combined test. This change also reduces engine emissions.

Finally, the 110 TC clarified in the Annex that the 110 requirement for weekly EPSS inspections does not require running the generator set weekly. Many facilities run their generator sets unloaded weekly between monthly load tests because they mistakenly believe that 110 requires that. Of course if the engine manufacturer recommends weekly running, or if a local code, standard, or AHJ requires it, those recommendations or requirements might supersede the TC's clarification.

Several public proposals were rejected by the TC for a wide variety of reasons. They are not discussed in this white paper, but are available for public review, and rebuttal, in the ROP.

Reliability Requires Smart Testing and Maintenance

Emergency power supply system (EPSS) failures have occurred in large part because of the lack of smart maintenance and testing at various levels. Some facilities fall down on the regular testing and maintenance and then simply replace infrastructure equipment when its condition deteriorates too much. NFPA 110 recognizes this and includes testing and maintenance requirements in the body of the standard and recommendations 5n the Annex. Consider this:

> "Reliability and facility infrastructure health are not guaranteed simply by investing in and installing new equipment. Unexpected failures can compromise even the most robust facility infrastructure if appropriate testing, maintenance and due diligence techniques are not employed." [2]

When a power system vulnerability analysis is undertaken, perhaps in response to The Joint Commission's Sentinel Event Alert Issue 37, one of the commonly-found areas of increased vulnerability is related to inadequate testing and maintenance. [3]

One example of this type of vulnerability is inadequate ATS maintenance because many existing ATS's are not of the bypass-isolation type and the facility is unwilling to turn off the ATS loads during the maintenance period. A second example is when some facilities fail to operate selected ATS's every month because they view switching the ATS loads from normal to emergency power and back again as problematic. Yet another example is when circuit breakers have not been maintained since they were first installed, despite industry data to the effect that the failure rate of circuit breakers increases remarkably when they go for 5 consecutive years without maintenance. [4] [5]

Although The Joint Commission allows the 3-year load test to be a load bank test with a load not less than 30% of the generator set nameplate rating,[6] this is not necessarily the best approach if the EPSS peak demand load is greater than the 30% TJC load bank test requirement. Why wouldn't due diligence demand that the test load be not less than the documented EPSS peak demand loading? It just makes sense if the purpose of the test is to verify the continued performance of the EPSS to perform its intended function. The best tests are those that simulate, as closely as practical, the real operating conditions expected during a normal power outage.

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[2] Reprinted from the "BITS Guide to Business-Critical Power" with permission, published September 2006 by the BITS Financial Service Roundtable, Washington, DC. www.bitsinfo.org.

[3] Sentinel Event Alert Issue 37: "Preventing adverse events caused by emergency electrical power system failures." September 6, 2006, The Joint Commission. Also refer to the SEA-37 discussion in the September 2007 issue of Environment of Care News, The Joint Commission.

[4] Callanan, Michael, Neitzel, Dennis, and Neeser, Dan, Preventative Maintenance and Reliability of Low Voltage Overcurrent Protective Devices.

[5] Smith, Jack, Out With the Old - Planning helps manage electrical system upgrade, Plant Engineering, www.plantengineering.com/article/CA6271634.html, October 1, 2005.

[6] The Joint Commission, CAMH, EC.7.40

The present maintenance requirements in NFPA 110 are of a preventive maintenance (PM) nature; they are calendar based. There are also other possible approaches, such as predictive maintenance (PdM) and reliability-centered maintenance (RCM). The last alternative that is NOT recommended is the reactive maintenance approach, also called “run-to-failure maintenance” or “breakdown maintenance.”

NFPA 110 has basic testing and maintenance requirements and recommendations for the generator set itself, its batteries, its fuel oil; the EPSS transfer switches and paralleling switchgear, and circuit breakers. Readers are urged to review manufacturers’ recommendations, NFPA 70B and other industry guidance to determine what proactive maintenance program will be invoked for their own facilities.

NFPA Disclaimer:

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Session Outline:

- Get Ready for Anticipated Changes in 2009 Revision
- Impact of Testing & Maintenance on EP Reliability
- Assess Existing Programs Against NFPA 110

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NFPA 110 Revision Cycle

- Proposal Closing Date: (33 Proposals) 11/26/2007
  - Report on Proposals (ROP) available at www.nfpa.org
- Report on Proposals Mailing Date: 6/20/2008
- **Comment Closing Date: 8/29/2008**
- Report on Comments Mailing Date: 2/20/2009
- Notice of Intent to Make a Motion Closing Date: 4/3/2009
- Posting of Certified NITMAM: 5/1/2009
- Revised Edition Date: 2010

NFPA 2009 Annual Revision Cycle Report on Proposals

- NFPA TC on Emergency Power Supplies
  - NFPA 110
  - NFPA 111
- NFPA NEC Technical Correlating Committee
  - NFPA 110/111 TC reports through NEC TCC
- ***Public comments due August 29, 2008***

NEC Art. 702 Optional Standby Systems excluded from NFPA 110 scope

1.1.3 This standard does not cover the following:
(1) Application of the EPSS
(2) Emergency lighting unit equipment
(3) Distribution wiring
(4) Utility service, when such service is permitted as the EPSS
(5) Parameters for stored energy devices

(6) The equipment of systems that are not classed as Level 1 or Level 2 systems in accordance with Chapter 4 of this standard.

Substantiation: *The scope of this document does not apply to the equipment of systems, such as optional standby systems covered by Article 702 of NFPA 70. This revision clarifies that point.*

Chapter 8 Routine Maintenance and Operational Testing

- Clarified that Chapter 8 applies to both new and existing systems
- No real change in intent but this keeps the code people happy

Recommended diesel fuel

Annex A.5.1.1(1), new 2nd sentence:

Diesel fuel should be either 1D, 2D, or a blend and have a minimum cetane rating of forty.

Substantiation: High speed diesel engines use either 1D or 2D fuels, important characteristics of diesel fuels are its viscosity, pour point, and cetane number. The primary differences between 1D and 2D fuel are the pour point and the viscosity. Pour point is the lowest temperature at which a liquid will flow. Viscosity is the resistance of a liquid to flow. A 1D fuel is designed for cold weather operation; thus, it is less viscous and has a lower pour point. A 2D fuel is used in warmer weather because it has a higher viscosity and pour point. The higher viscosity provides better lubrication qualities for the moving parts of the fuel injection system. The cetane number is a measure of the ease with which the fuel is ignited in the engine. It is most significant in relation to low temperature startability, warm-up and smooth, even combustion. Most engine manufacturers recommend diesel fuels with a cetane number of at least 40. Diesel fuels sold by reputable marketers meet or exceed this requirement.

Installation acceptance test

- CP3: Major re-write, reorganized to clarify intent
- Some relaxation, some toughening: *Read it!*
- Deletes NP outage in existing occupied buildings
- *Cold Start* defined in Annex
- Annex discusses permanently installed equipment or connection points (spare breakers or switches) for load banks and portable generators.

Installation acceptance test

- Different requirements in occupied vs. unoccupied buildings to address potential hazards of opening NP circuit breakers and switches in occupied buildings.
- Eliminate unnecessary record keeping that is not critical to verification of proper operation.
- 1st portion reduced from 2 hours to 1½ hours to reduce emissions.
- 2nd 2-hour portion uses step loading rather than 100% block loading to mitigate potential EPS damage.
- Require verification of engine start function throughout entire EPSS

Annual load bank test

- Change from 2 hours to 1½ hours
  - Proposed 50% for 30 minutes, then 75% for 60 minutes
  - Sufficient to do the job
  - Reduces EPS emissions

Testing spark-ignited gensets

- Test monthly for 30 minutes or long enough to stabilize water temperature and oil pressure
  - Wet stacking is not an issue with gas engines

3 year / 4 hour load test

- CP4: Major rewrite to clarify requirements
- Allows use of ATS test switches
- 4 hours maximum (incorporates FI-05.1)
- Can combine 3 year test with 1 monthly load test and 1 annual load bank test. (settles ASHE/TJC FI request on 8.4.2.3 and 8.4.9.)
- Minimum loading as in monthly tests to mitigate wet-stacking and potential engine damage.

Level 1 systems

- Specifically refers to NFPA 20, NFPA 99, and NFPA 101 as examples of standards that require Level 1 systems.

Weekly EPS inspections

Add a new first sentence to annex A.8.4.1 to read:

A.8.4.1 **Weekly inspection does not require running of the EPS. Running unloaded generators as part of this weekly inspection can result in long term problems such as wet-stacking.**

Substantiation: *Running of unloaded generators as part of the weekly inspection can have deleterious effects including wet-stacking as well as environmental concerns.*

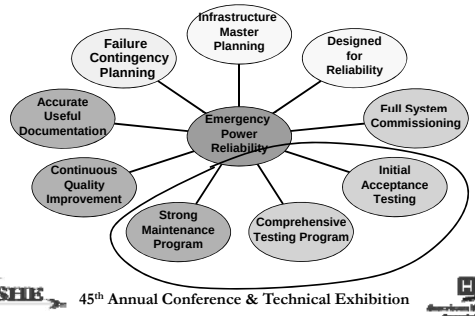
Rejected proposals

- Bypass-isolation ATSs **are recommended**
  - Conflicts with NFPA manual of style
  - "… shall be permitted" wording to remain
- Outdoor EPS separation of 10' to wall; 20' to NP service equipment
- Relaxation of prohibition of EPSS & high energy NP service in same room

Rejected proposals

- Require surge protective devices [COPS]
- Require use of non-sparking tools
- Move outdoor remote stop to remote annunciator location
- Others ….

Rx for emergency power reliability



Reliability requires smart O&M

- **"Reliability and facility infrastructure health are not guaranteed simply by investing in and installing new equipment. Unexpected failures can compromise even the most robust facility infrastructure if appropriate testing, maintenance and due diligence techniques are not employed."**
  - Reprinted from the "BITS Guide to Business-Critical Power" with permission, published September 2006 by the BITS Financial Service Roundtable, Washington, DC. www.bitsinfo.org.

EPSS failures – # 1 cause

- Lack of maintenance and testing of:
  - Batteries
  - Battery cables
  - Other starting system components

Other causes of EPSS failures

- Installation error + lack of acceptance testing
  - Generator auxiliaries on NP (fans, fuel oil pumps)
- Lack of maintenance
- Load shed not working – multiple generators fail

EP system vulnerabilities

- ATS's not bypass-isolation type
- ATS's not maintained regularly
- ATS's not transferred every month
- Branch maintenance (Life Safety, Critical Branch, Equipment System)

TJC Sentinel Event Alert 37

- Fully test the entire EPSS per NFPA 110.
- Review monthly test results for more than just generator set data
  - *ASHE 2006 Management Monograph [2008 update being reviewed]*

EP System testing program

- Initial acceptance testing
- Monthly EP System load & transfer tests
- Monthly review & analysis of test results
- Trend analysis of results and problems
- Investigate & resolve training, systemic issues
- Extended run load test every 36 months

TJC 36-month extended load test

- **TJC EC.7.40, EP-5**
  - Minimum 4 hours
  - Requires only 30% nameplate loading
  - Dynamic or static load permitted
  - First such test due before 7/1/2007; could use prior operation since 7/1/2004, >30% loaded for >4 hours
  - If actual facility loads are used, and monthly load test requirements are also satisfied, can take the place of one of the EP-1 monthly load tests.
  - Any problems identified during the test must be resolved promptly.
  - Fuel supply should be replenished after the test.

36-month test might not show

- Generator set auxiliary equipment on NP (fuel oil transfer pump, remote radiator fan)
- Restricted generator set cooling airflow path that is a problem only near full rated load or on high ambient design days
- Other critical equipment that is not on EP but perhaps should be on it.
- NFPA 110 Acceptance Test will show these if NP is turned off.

Caution, re: static load test option

- The purpose of this test is to verify the system's continued viability and minimize the chances of missing any developing reliability problems.
- Better test is with actual EP System loads (NFPA 110), particularly with EP Systems that are loaded > 30%.
- Although the NFPA 110 initial acceptance test permits each generator in a multi-unit installation to be 100% load-tested tested individually, that approach is not particularly wise for the 36-month 30% load test.
- Any interactions between generators would not be caught by a test that only tests one generator at a time.
- Where is the due diligence?

Other recent TJC changes

- **EP-1** (monthly load test requirement)
  - Modified to require compliance with NFPA 110-2005 testing and maintenance requirements when the monthly load tests do not meet the 30% criterion.
- If an EPSS test required by EC.7.40 fails
  - **EP-6** requires interim measures until necessary repairs or corrections are completed
  - **EP-7** requires a retest after completion of the necessary repairs or corrections.

Proactive EP System testing

- Functional test of generation & distribution equipment – make it real
- Dealing with power transfers
  - Train maintenance personnel
  - Train clinical personnel
  - Mechanical system responses
  - Other building system responses
- **EP-2**: Must test (operate) ATS's monthly
  - Transfer those loads – prove it works
- Avoid compromising patient treatment and patient safety

Written test procedures

- FM control of test process, equipment variations
- Require testing personnel to take responsibility for performing all required tasks
- Reduce chances of incorrect actions by testing personnel
- Documentation of actions taken during the test in case something goes wrong
- Mechanism for potential trends to be explored
- Source documentation for later trend analyses

EPSS failures during testing

- Why? Because equipment is operating.
  - That is when MEP failures occur.
- Benefits of testing failures
  - Controlled conditions, already paying close attention
  - Heightened awareness throughout hospital
  - The failures would have occurred anyway during the next unanticipated NP outage.
  - Normal power is still available
  - Valuable learning experiences, consider if generic
- These are not "problems" – this is why we test.
- If result is EP System test failure: EP-6 and EP-7

Discovering hidden trends

- Database or spreadsheet – management tool
- Second order consequences
- Interactions between EPSS and loads
- Identify training / systemic issues requiring further investigation
- Use keywords for trend analysis
- Ref: ASHE Management Monograph

Tools for EP System CQI

- Cross-train testing personnel
- Supervisors review all events
  - Mechanical systems, elevators, surprises
  - Not just engine parameters
- Lessons learned from EP System testing
  - Ongoing competency training for maintainers and users

Generator service contractor's observations from Ivan and Katrina

- Monthly testing "work-arounds" came back to haunt some hospitals
- Many loads THOUGHT to be on EP were not
- Only full NP outage shows reality of EP

EP system maintenance

- Why should you maintain your EP system?
- Why should you change the oil in your car?
- In both cases the answer is the same – so that the equipment will continue to operate reliably as it was designed to operate.
- Find and correct incipient failures before they occur.

Maintenance approaches

- Preventive Maintenance (PM) *now in 110*
- Predictive Maintenance (PdM)
- Reliability-Centered Maintenance (RCM)
  - Uses system analyses, logic, statistical input, and criticality of the equipment to be maintained
  - Has been called the optimum mix of reactive, time-interval-based, condition-based, and proactive maintenance practices
- Reactive maintenance, also called "run-to-failure" or "breakdown" maintenance

Maintenance and operational testing

- ***A.8.1 The continuing reliability and integrity of the EPSS are dependent on an established program of routine maintenance and operational testing.***

8.3 Maintenance and Operational Testing.

8.3.1* The EPSS shall be maintained to ensure to a reasonable degree that the system is capable of supplying service within the time specified for the type and for the time duration specified for the class.

- ***A.8.3.1 The suggested maintenance procedure and frequency should follow those recommended by the manufacturer. In the absence of such recommendations, Figure A.8.3.1(a) and Figure A.8.3.1(b) indicate alternate suggested procedures.***

Routine 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 automatic transfer switch 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.

Transfer switch maintenance

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

A.8.3.5 *… Maintenance should be performed according to manufacturer's recommendations. In the absence of such recommendations, the list given in 8.3.5 suggests minimal procedures. Transfer switches should be subjected to an annual maintenance program including (one) major maintenance and (three) quarterly inspections.*

Paralleling switchgear maintenance

8.3.6 Paralleling gear shall be subject to 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 maintenance

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.

- *A.8.3.7 A battery load test should be performed quarterly.*

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.

Fuel oil stability

- Ref: NFPA 110-2005 Annex; ASHE 2006 Monograph
- Contamination can include algae, bacteria, yeast, acids, sludge, oxidation, sediment, suspended solids emulsification, and even foreign objects.
- Water and impurities in fuel oil due to system condition, maintenance error, fuel stagnation, day tank corrosion, clogged or fouled fuel oil filter, excessive fuel oil filter replacement interval, workmanship during fuel oil system renovation, fuel oil truck operator error, day tank micro-organism contamination, inconsistent fuel oil quality from the supplier, incorrect biocide usage, and even inadequate sampling techniques.

Fuel oil testing

8.3.8 A fuel quality test shall be performed at least annually using tests approved by ASTM standards.

- *Comment: The current edition of NFPA 110 does not cite a specific standard to be used for the fuel quality test, therefore the authority having jurisdiction is responsible for acceptance of the fuel quality standard and means of assessment to be used. There are ASTM standards on diesel fuel quality that can be used for establishing an ongoing fuel quality program.*
- *Refer to ASHE 2006 Management Monograph for more information.*

Circuit breaker maintenance

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.

- *A.8.4.7 Circuit breakers should be tested under simulated overload conditions every 2 years.*

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.

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