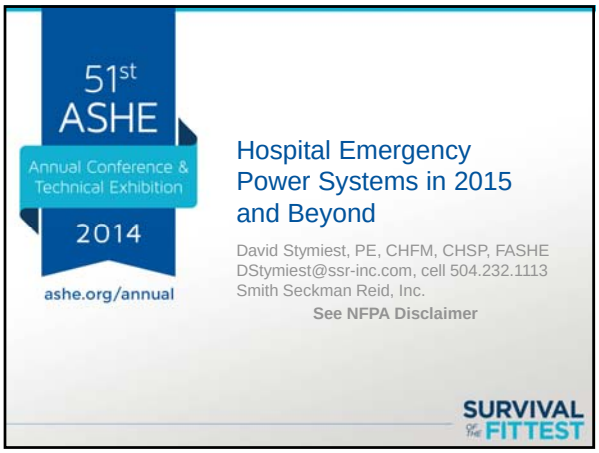

Hospital Emergency Power Systems in 2015 and Beyond

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NFPA Disclaimer

- Although the speaker is Chairman of the NFPA Technical Committee on Emergency Power Supplies, which is responsible for NFPA 110 and 111, the views and opinions expressed in this presentation are purely those of the speaker and shall not be considered the official position of NFPA or any of its Technical Committees and shall not be considered to be, nor be relied upon as, a Formal Interpretation. Readers are encouraged to refer to the entire texts of all referenced documents.
- NFPA members can obtain staff interpretations of NFPA standards at nfpa.org.

Learning Objectives

- Describe major changes in the 2014 edition of the ASHE monograph "Managing Hospital Emergency Power Systems – Testing, Operation, Maintenance, Vulnerability Mitigation, and Power Failure Planning"
- List major challenges and benefits of using different approaches to inspection, testing, operations, and maintenance
- Describe processes for finding hidden EP system vulnerabilities
- Discuss solutions for mitigating typical EP system vulnerabilities
- List major compliance challenges and EP system management solutions

Changes related to newer standards

- NFPA 110-2013
- NFPA 99-2012
- NFPA 70-2014 (NEC®)
- NFPA 70E-2012 (Electrical Safety)
- NFPA 70B-2011 (Maintenance)
- ANSI/NETA ATS-2013 (Acceptance testing)
- ANSI/NETA MTS-2011 (Maintenance)

New sections

- Commissioning EP systems
- Finding and Mitigating EP vulnerabilities
- Weekly EPSS inspections
- Best Practice Means and Methods for Mitigating EP System Vulnerabilities

Expanded existing discussions

- Installation Acceptance Testing Updates
- 36 Month 4-Hour Test Changes
- Vulnerability Analyses
- Risk Assessments
- EP Test Procedures – rotate starting ATS
- Gen & ATS Maintenance
- Maintenance & Testing of Other EP System Components

Commissioning

- Importance of EP system commissioning
- Types of vulnerabilities found by commissioning
- Functional performance testing

Weekly inspections

- NFPA 110 requirement – entire EPSS
- Inspecting an electrical room
  - Additional questions to ask
- Optional weekly generator runs or not?

Main Sections

- Testing
- Operation
- Finding & Mitigating Vulnerabilities
- Planning for Power Failures
- Maintenance

Frequently used nomenclature

<table>
<tr><th colspan="3">NFPA 70-2014 & NFPA 99-2012</th><th colspan="2">NFPA 110-2013</th><th>Commonly Used Components [2]</th></tr>
<tr><td rowspan="10">Legally-Required Standby System, Art. 701</td><td rowspan="10">Essential Electrical System, Art. 700</td><td rowspan="10"></td><td rowspan="2">Alternate Power Source</td><td rowspan="10">Emergency Power Supply System (EPSS)</td><td rowspan="2">Emergency Power Supply (EPS)</td><td>Generator and energy source (Fuel)</td></tr>
<tr><td>Generator accessories (batteries, cooling & exhaust systems, fuel supply system, controls, local & remote alarms etc.), unit-mounted generator breaker</td></tr>
<tr><td rowspan="8"></td><td rowspan="8"></td><td>Wiring from generator to remote generator breaker [4]</td></tr>
<tr><td>Generator breaker</td></tr>
<tr><td>Generator breaker output wiring</td></tr>
<tr><td>Generator transformer [2]</td></tr>
<tr><td>Generator distribution panel or paralleling switchgear [6]</td></tr>
<tr><td>Wiring between generator distribution equipment and transfer switches</td></tr>
<tr><td>Transfer switches down to load terminals (See specific branches below)</td></tr>
<tr><td>Life Safety Branch</td><td rowspan="3"></td><td>Life Safety Branch transfer switches, feeders and branch circuit wiring, panels and transformers [See acceptable load list in 99 & 70.]</td></tr>
<tr><td>Critical Branch</td><td>Critical Branch transfer switches, feeders and branch circuit wiring, panels and transformers [See acceptable load list in 99 & 70.]</td></tr>
<tr><td>Equipment system</td><td>Equipment System transfer switches, feeders and branch circuit wiring, panels and transformers [See acceptable load list in 99 & 70.]</td></tr>
<tr><td>Optional Standby System, Art. 702</td><td></td><td>Optional Loads</td><td></td><td colspan="2"></td><td>Other load equipment transfer switches, feeders and branch circuit wiring, panels, transformers [4]</td></tr>
</table>

NOTES and LEGEND: [#] Where Applicable
* For simplicity, this monograph uses the term "emergency power system" (EP system) generically to describe all of the subsystems listed in Table 1
NFPA 110-2013, Standard for Emergency and Standby Power Systems
NFPA 99-2012, Health Care Facilities Code and NFPA 70-2014, National Electrical Code®
NEC® and National Electrical Code® are registered trademarks of the National Fire Protection Association.

Testing

- Value of Testing & Transferring Power
- Testing Program Goals
- Description of EP Testing Program
- Installation Acceptance Testing
- Commissioning
- Weekly Inspections
- Choosing a Monthly Test Time - Pros & Cons
- EP System Test Procedures
- Effects of Monthly Testing
- Exhaust Emissions
- Avoiding Elevator Entrapments Due to Testing
- Analyzing Monthly Test Results
- Using dBs to Discover Hidden Trends
- Analyzing Equipment Failures
- Other Examples of Findings from Trend Analysis
- Other Quality Improvement Considerations
- Containing the Direct and Indirect Costs of Emergency Power Testing
- Special EPSS Extended Run Load Test
- Establish Test Procedures
- Table – Sample steps for 36 month load test using dynamic loads
- Table – Sample steps for 36 month load test using only static loads

Operation

- Determining the Actual EP Demand Load
- Table 4 – How to Measure Typical ATS Loads and ATS Load Profiles
- Time of Use Load Profiles
- Test Loading vs. Real Time Emergency Loading
- Utility Management Considerations

Finding & Mitigating Vulnerabilities

- EP Gap Analyses
- Power System Vulnerability Analyses and Risk Assessments
- EP Risk Assessments
- EM Tracer-Type Questions for Power Failures
- Best Practice Means and Methods for mitigating EP vulnerabilities

Planning for Power Failures

- Power System Failure Contingency Planning
- Utility Management Documents for Training Clinical and Support Staff
- Emergency Management for EP Systems
- Disasters and Lessons Learned
- Additional Backup Power Needs
- Keeping a Handle on Growing EP System Demand

Maintenance

- EP System Maintenance Programs
- Infrared Thermography
- Generator maintenance
- Generator Set Fuel Oil Stability
- Maintenance & Testing of Other EP System Components

Figures & Tables

- Sample Hospital ATS Load Profiles using 15 Minute Demands
- Sample Hospital EPSS Load Profile using 15 Minute Demands
- Sample 2-Day Load Profile for Mechanical Equipment System ATS using 1-Minute Demands
- Sample Plot of Elevator Loading During an EP Test
- Sample Radiology Load Profiles
- Sample Plot of ATS Current During EP Test
- Impact of Fire Alarm Condition on LS ATS Load Profile
- Sample Keywords for EP Testing Databases
- Sample Issues Found During EP Testing

Finding Vulnerabilities

- Recognize that things break.
- Inspect what you expect. Ask critical questions. Without information you have only opinions. Sweat the small stuff. Pay attention to the details
- Analyze "what if" scenarios
- Importance of rigorous ITM protocols
- Your personnel are the eyes and ears of the organization
- Review UF incidents for commonalities
- Common-mode failures
- You can't control what you can't control, so plan for it

Managing Vulnerabilities

- Finding
- Prioritizing
- Assessing
- Reporting
- Mitigating
- Verifying

Simplified hospital power system

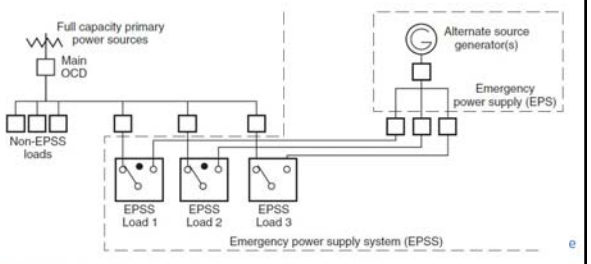

FIGURE B.1(a) Typical Rotating Emergency Power Supply System.

Common-mode failures

- Failures of two or more components or systems due to a single event or cause
- A *safety engineering concept*: once a failure mode is identified, it usually can be mitigated by adding extra or redundant equipment to the system
- *The existence of an uncorrected common mode failure potentially removes the advantage of other redundancies.*
- You cannot correct what you have not yet identified.

Other types of common-mode failures

- Normal and emergency power equipment on same level
- Fuel oil storage tank subject to flooding
- Common fuel oil transfer pumps, controls, power circuits
- Feeders for elevated equipment located in flooded levels
  - Other types of damage also
- Contaminated fuel oil system

Causes of fuel oil contamination

- Natural fuel degradation from aging
- Day tank corrosion
- Excessive fuel oil filter replacement interval
- Workmanship during FO system renovation
- Fuel oil truck operator error
- Day tank microorganism contamination
- Inconsistent fuel oil quality from the supplier
- Incorrect biocide usage
- Inadequate sampling techniques
- Clogged or fouled fuel oil filter

Common locations

Paralleled generator sets can mitigate the impact of a generator failure, but also can be subject to common mode failures due to shared location, shared fuel or shared cooling systems.

Other types of common-mode failures

- Co-located equipment and systems
- One sump pump
- Multiple sump pumps on same branch
- Paralleling switchgear
- Transfer switch failure

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Holistic – "relating to or concerned with complete systems rather than with individual parts"

– (Merriam-Webster 2014)

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