Emergency Power Supply Systems

Codes, Standards, and Compliance Issues

Jim Taufer
Square D Company
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Introductions

Jim Taufer
Power Management Specialist
Schneider Electric

- BSEE, University of Florida, 1986
- 19 years experience with power equipment, distribution systems, automation & motor control, communications, & networking
- Expert in power monitoring & controls
- Home: Orlando, FL
- Territory = Florida, S. GA, Nashville
Square D – Power Management Overview

- **Global Leader in Power Monitoring & Control Systems (PMCS)**
- **HQ in LaVergne, TN**
- **Providing complete system solutions – hardware, software, networking, application engineering, custom solutions, installation & commissioning, training, and support services**
- **Major Markets:**
  - Industrial
  - Commercial
  - Government
  - Utility
- **Power Monitoring Lines:**
  
  *PowerLogic & Power Measurements (ION)*
Presentation Outline

- **Emergency Power Supply Systems (EPSS)**
  - Applications
  - Applicable Codes & Standards
  - EPSS Components

- **EPSS Testing & Reporting**
  - Why the EPSS Needs to be Tested
  - Testing Procedures
  - Documentation/Reports

- **How to Improve EPSS Testing & Reporting**
  - Training
  - EPSS Monitoring Systems
  - EPSS Automated Testing & Reporting
Critical Power Applications

Where are Emergency & Standby Power Systems Used?

- Hospitals
- Data Centers
- Telecom / Internet

- Government
- Water/Waste Water
- Banking & Financial
- Universities
- Military Bases
- Industry
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Codes & Standards - Organizations

- National Fire Protection Association (NFPA)
  - International codes & standards organization
  - Influences every building, process, service, design, and installation in the U.S.
  - 300 Codes & Standards
  - When an NFPA Standard refers to another document or portion, that referenced document is considered to be part of the requirements
  - Not an enforcer of code compliance
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Codes & Standards - Organizations

**Joint Commission on Accreditation of Healthcare Organizations (JCAHO)**

- Evaluates and accredits over 15,000 healthcare organizations and programs in the U.S.
- Provides standards that focus on patient safety and quality of care
- Accreditation process evaluates compliance with these and other standards
The Authority Having Jurisdiction (AHJ) is the organization or individual responsible for enforcing the requirements of the codes and standards

- Local
- State
- Federal
EPSS – Applicable NFPA Codes & Standards

- **NFPA 70 - National Electric Code**
- **NFPA70E - Standard for Electrical Safety in the Workplace**
- **NFPA 99 - Standard for Healthcare Facilities**
- **NFPA 101 - Life Safety Code**
- **NFPA 110 - Standard for Emergency and Standby Power Systems**
- **NFPA 111 - Standards for Stored Energy Power Systems**
JCAHO EC 7.40

Emergency Electrical Power System inspection, maintenance, and testing

- Incorporates NFPA 110-2005 requirements
- New 2006 additions to the standard that address testing and maintenance
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NFPA 99 – Standard for Healthcare Facilities

Electrical Systems for Hospitals

[Diagram showing electrical systems for hospitals, including normal and alternate power sources, nonessential loads, automatic and delayed automatic switching equipment, equipment, life safety, and critical branches, with essential electrical system highlighted.]

FPN Figure 517.30, No. 1 Hospital — Minimum Requirement for Transfer Switch Arrangement.
NFPA 99 – Standard for Healthcare Facilities

Essential Electrical System (EES) – Required system of alternate power sources and all distribution systems designed to provide continuity of electrical power to designated areas and functions of a healthcare facility

- **Emergency System** – Circuits and equipment used to supply alternate power to loads vital to the protection of life and safety
  - Critical Branch Circuits
  - Life Safety Branch Circuits

- **Equipment System** - Circuits used to supply specific equipment
NFPA 99 – Standard for Healthcare Facilities

- **Emergency System Circuits**
  - *Life Safety Branch Circuits* – Egress illumination, exit signs per NFPA 101, Fire alarms, and Hospital communications systems
  - *Critical Branch Circuits* – Task illumination, fixed equipment, and selected circuits serving areas and functions related to patient care

- **Equipment System Circuits**
  - *Nondelayed Circuits* – Generator Accessories
  - *Delayed Circuits* – Specific medical systems, elevators, heating equipment, and ventilation.
Types of Essential Electrical Systems (EES)

- **Type 1 – Applies to Hospitals & Healthcare Facilities where Life Support Equipment is Required**
  - Onsite Generator(s) required to provide standby power if the normal source is interrupted
  - Generator classified as NFPA Type 10, Class X, Level 1

- **Type 2 – Applies to Nursing Homes** (per Sec. 17.3.4.2)
  - Onsite Generator(s) required to provide standby power if the normal source is interrupted
  - Generator classified as NFPA Type 10, Class X, Level 1

- **Type 3 – Limited Care Facilities**
  - Alternate power source required and may be a generator, battery system, or battery integral to the equipment.
Uses for the Essential Electrical System (EES)

- The EES generating equipment shall be normally reserved exclusively for emergency standby operation or...

- The EES generating equipment may be used for other normal purposes such as peak demand control, load relief, cogeneration, etc. provided that...
  - Two or more generator sets are installed
  - The maximum demand of the emergency system + other required equipment loads be met with the largest generator out-of-service

- Other loads may be added to the EES provided that they can be shed if the system is overloaded
Standard for Emergency & Standby Power Systems

**NFPA 110**

- **Standard covers performance requirements of emergency power supply systems (EPSS) for loads in the event that the normal power source fails. This includes:**
  - System Installation
  - System Maintenance
  - System Operation
  - System Testing Requirements

- **The standard does not specify where an EPSS is required** – see NFPA99

- **The standard is applicable for healthcare facilities, but is often used by other industries as well**
NFPA 110 – Standard for Emergency Power Systems

EPSS Classifications:

➾ EPSS Type – Determines the maximum time (seconds) that essential ATS load terminals can be without power
  ✴ - Type 10: Ten seconds to restore power
  - Type 60: Sixty seconds to restore power

➾ EPSS Class – Determines the minimum time (typically in hours) that the EPSS can operate without being refueled
  - Class 6: 6 Hours operation
  - Class 48: 48 Hours operation
  ✴ - Class X: X = Hours as required by application, code, or user

➾ EPSS Level – Defines the loads powered and the risk to human life and safety
  ✴ - Level 1: Failure of equipment could result in loss of life or serious injury
  - Level 2: Failure of equipment less likely to result in loss of life or serious injury
Emergency Power Supply Systems

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Full capacity primary power sources

Main OCD

Non-EPSS loads

Manual standard or emergency bypass switch

Level 1 EPSS load
Level 1 EPSS load
Level 1 or 2 EPSS load

Emergency power supply system (EPSS)

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.

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

- **Emergency Power Supply (EPS)**
  - Typically a diesel or gas powered generator set
  - Sized to carry the essential electrical system
  - Dedicated fuel source
  - Electrical starter system
  - Prime mover cooling system
  - Remote starting & alarm indication
  - Operator controls

- **Transfer Switches**
  - Automatic transfer
  - Delayed transfer

- **Protection**
  - Circuit Breakers
EPSS Administration

- Maintenance shall be performed in accordance with NFPA110, Chapter 8 & JCAHO 7.40
- Testing conducted 12 times annually every 20-40 days
- 4 hour testing required every 36 months (per NFPA110-2005 & JCAHO 7.40 2006)
- Simulated cold start test conditions
- Testing conducted by competent personnel
- A written record of EPSS inspection, performance, testing, and repairs shall be maintained and available for AHJ(s).
EPSS Testing & Documentation

**EPSS Maintenance & Testing (NFPA 110 & JCAHO 7.40)**

- The operational testing shall include **all EPSS components**:
  - (EPS) Generators
    - Weekly inspection
    - Monthly exercised under 30% nameplate loading or at required exhaust temperature for 30 minutes
    - Exception available if monthly EPS load is less than 30%
      - Additional annual EPSS exercise with 25% for 30 min, 50% for 30 min, 75% for 60 min for a total of 2 continuous hours
  - Automatic Transfer Switches
    - Complete operation monthly
  - Circuit Breaker
    - Main and feeder breakers between the EPS and ATS shall be exercised annually
    - MV breakers shall be exercised every 6 months
EPSS Testing & Documentation

**EPSS Maintenance & Testing**

- The test is initiated from an ATS test switch or opening a branch circuit breakers
- All ATS switches supplying power to the EPSS shall be included in the test
- The test shall be for a period of not less than 30 minutes while at operating temperature
- Standby or peak shaving duty may be substituted for scheduled operations and testing if all requirements and documentation are satisfied
- Failed Tests require interim measures until repairs and retesting after repairs are completed (JCAHO 7.40 2006)
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Critical Power Systems

Why all the attention on emergency power systems???
The Emergency Power System reliability must be better than the normal power source!

2003 Major Power Blackout
2004 Four Major Hurricanes Hit Florida
Why Proper EPSS Testing is Necessary

- Exercising a generator below 30% can actually reduce the Emergency Power Supply reliability

- ATS switches and circuit breakers need to be exercised to assure correct mechanical lubrication

- Proper testing and monitoring identifies EPSS problems during testing rather than experiencing failures under emergency situations

- Joint Commission and the AHJs require testing, maintenance, and documentation per NFPA110
### Suggested Operation and Testing Procedures

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Perform maintenance per Figure A.8.3.1(a).</td>
</tr>
<tr>
<td>2.</td>
<td>Record running time meter reading at start and end of test.</td>
</tr>
<tr>
<td>3.</td>
<td>Simulate normal power failure from a “cold start” by use of the test switch in automatic transfer switch or by opening normal power supply to EPSS.</td>
</tr>
<tr>
<td>4.</td>
<td>Observe and record time delay on start.</td>
</tr>
<tr>
<td>5.</td>
<td>Record cranking time (terminates when engine starts).</td>
</tr>
<tr>
<td>6.</td>
<td>Transfer load to EPS. <em>(See 8.4.1 and 8.4.2.)</em></td>
</tr>
<tr>
<td>7.</td>
<td>Record ac voltage, frequency, amperage.</td>
</tr>
<tr>
<td>8.</td>
<td>Record initial oil pressure and battery-charging rate.</td>
</tr>
<tr>
<td>9.</td>
<td>Record oil pressure, battery-charging rate, and water or air temperature after 15 minutes running time.</td>
</tr>
<tr>
<td>10.</td>
<td>Return test switch to normal or reestablish normal power supply at such time to cause a minimum running time of 30 minutes under load.</td>
</tr>
<tr>
<td>11.</td>
<td>Record prime mover and ac instruments just prior to transfer.</td>
</tr>
<tr>
<td>12.</td>
<td>Record time delay on retransfer.</td>
</tr>
<tr>
<td>13.</td>
<td>Record time delay on shutdown for units so equipped.</td>
</tr>
<tr>
<td>14.</td>
<td>Place unit in automatic operation mode.</td>
</tr>
</tbody>
</table>

*FIGURE A.8.4.1(b)  Operation and Testing Procedures Suggested for Level 1 and Level 2 Rotating Equipment.*
Typical EPSS Reports Information:

- Operator name
- Test time/date
- Gen crank time
- Transfer time
- Generator Electrical Measurements
  - AC Voltage
  - Frequency
  - Amperage
  - Power
- Engine Parameters
  - Oil Pressure
  - DC Amperage
  - Water Temperature
  - Exhaust Temperature
- Gen run time
- Cool down time
- End of test time
Manual Recording Issues

- Manpower removed from normal duties to conduct test
- Difficult to manually monitor EPSS load levels during entire test
- Not able to manually record precise timing of transfer switches
- Actual generator operating temperatures ignored. Could result in possible development of “wet-stacking” condition
- Additional trending and analysis requires data to be transferred manually to a PC
- Reduced EES loading during testing (typically)
- Limited value for profiling EPSS loads
How to Improve EPSS Testing & Documentation

- Personnel Training
- Incorporate a Power Monitoring System
- Automate the EPSS Testing & Reporting
EPSS Maintenance Certification

**Personnel Training**

Emergency Power Supply Systems

- **Weekly Maintenance & Monthly Testing Procedures**
  - includes cooling, lubrication, fuel, and battery & charging subsystems

- **Ensuring Personnel Safety During the Testing**

- **Self Paced, Independent Course Study**
EPSS Monitoring Systems

Key Monitoring Points
- Generator Main Breakers
- ATS Switch Load Connections
- Engine Controller

Other Considerations:
- Normal Service Mains
- Critical Loads – MRI, X-Ray, Data
- Cost Allocation – MOBs, etc.
Incorporating a Power Monitoring Systems

**Power Monitoring Systems** provide continuous real-time monitoring & logging of EPSS data

- **EPS Generators**
  - Circuit Monitors (CM) installed on Main Breakers
  - CM I/O to Circuit Monitor the Gen Run status
  - Interface to Gen Controller

- **Automatic Transfer Switches**
  - Power Meters (PM) installed on ATS load terminals
  - Power Meter I/O to monitor ATS position, test & source available contacts & optional remote test command

- **Gen Engine Controllers**
  - Gen Vendors Engine Controllers with remote communications capabilities – EMCP3, PCC, D550, etc.
Power Monitoring Systems

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Meters can be provided in new equipment or retrofit into the existing EPSS equipment. Other existing vendors equipment can be integrated if only basic monitoring is needed.
Power Monitoring Systems

Typical System Layout

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Prepared by Jim Tauber, Powerlogic Business Development
PMCS Software – Real-Time Information

### Meters with Alarm Banding

<table>
<thead>
<tr>
<th>Device</th>
<th>MCC Panel CM2</th>
<th>Time Stamp: 08/21/2003 10:04:01 AM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Current A</th>
<th>1800</th>
<th>Current B</th>
<th>1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>1200</td>
<td>800</td>
<td>1200</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current C</th>
<th>1800</th>
<th>Current D</th>
<th>1800</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>1200</td>
<td>800</td>
<td>1200</td>
</tr>
</tbody>
</table>

**Legend:**
- Green: Normal
- Yellow: Warning
- Red: Alarm

**Sample Rate:** 1 Minute

**Power**
- 3-Phase 4-Wire
- 3-Phase 3-Wire

**System:**
- PMCS
- PMCS Software
- Real-Time Information
- Real-time Tables
- Real-time Trending
- Meters with Alarm Banding
PMCS Software – System Information

Embedded O&M Manuals, As-Built Drawings, Floor Plans, Web Links, etc.
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PMCS Software – Asset Management

Circuit Utilization (Historical)
PMCS Software – Event Capture

Question - How could you address this PQ event without power monitoring?

Event Waveform Capture & Analysis
Disturbance in the System:
- Circuit Monitors Detect the Disturbance
- Waveforms Captured
- Direction Identified
- Event Documented

PMCS Software - Disturbance Analysis
Harmonic Histogram Report

System: Data Center
Report Start Time: 4/1/02 2:20 PM
Report Generated on: 4/13/02 6:47 PM

Database Server: 16UH2KASMSJUW, History DSN: SMS-1000 History SQL, System DSN: SMS-ADN System N21

Harmonic Histogram

Number of Samples

Percent Total Harmonic Distortion

Cumulative Percentage

Harmonic Spectral Plot

Harmonic Histogram
PMCS Software - Power Quality Analysis

PQ Index Summary
Shows the Trend
(better or worse) over time
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PMCS Software – Emergency Power System Status

ATS Transfer Waveforms
Power Monitoring Systems – Safety Benefits

- Capture and analyze power events using permanently installed monitors
- Eliminate the need to open energized gear to take measurements and troubleshoot problems
- Provide the worker PPE requirements at equipment as monitoring system pages
- Improve overall facility safety by reducing the risk of electrical accidents

WARNING
Arc Flash and Shock Hazard
Appropriate PPE Required
EPSS Reporting Module

- U verify EPSS monthly tests or standby operation and generates a summary report
- Reports are printed out, viewed as web pages, and e-mailed to all effected parties for review and action.
- Uses information that is captured from the power monitoring system meters and stored in the software database.
- Compares EPS loading with nameplate to assure that kVA load remains above 30% for 30 minutes (minimum)
- Verify EPSS restoration time (10 seconds)
- Wizard driven user report interface to enter nameplate ratings, manually read data, & test observations – Monthly EPSS Testing Report is Published!
EPSS Reporting Module – Typical Report

Report Title Page

Technician Name
Test Time/Date
EPSS Equipment Involved
### EPSS Reporting Module – Typical Report

#### EPSS Reporting Module – Typical Report

**Emergency Power Supply System**

**Automatic Transfer Switches Summary**

<table>
<thead>
<tr>
<th>Transfer Switch</th>
<th>In Emergency</th>
<th>Time in Emergency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATS 1</td>
<td>7</td>
<td>0:01:29</td>
</tr>
<tr>
<td>ATS 2</td>
<td>3</td>
<td>0:01:13</td>
</tr>
<tr>
<td>ATS 3</td>
<td>3</td>
<td>0:01:29</td>
</tr>
<tr>
<td>ATS 4</td>
<td>7</td>
<td>0:01:29</td>
</tr>
<tr>
<td>ATS 5</td>
<td>3</td>
<td>0:01:19</td>
</tr>
</tbody>
</table>

**Event Log:**

<table>
<thead>
<tr>
<th>TIME</th>
<th>MS</th>
<th>DEVICE NAME</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/01/2014 14:16:13PM</td>
<td>453</td>
<td>CMN</td>
<td>Normal</td>
</tr>
<tr>
<td>11/01/2014 14:16:13PM</td>
<td>400</td>
<td>ATS 1</td>
<td>Emergency</td>
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<td>11/02/2014 14:16:13PM</td>
<td>730</td>
<td>ATS 2</td>
<td>Emergency</td>
</tr>
<tr>
<td>11/02/2014 14:16:13PM</td>
<td>120</td>
<td>ATS 3</td>
<td>Emergency</td>
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<tr>
<td>11/02/2014 14:16:13PM</td>
<td>120</td>
<td>ATS 4</td>
<td>Normal</td>
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<tr>
<td>11/02/2014 14:16:13PM</td>
<td>120</td>
<td>ATS 5</td>
<td>Normal</td>
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<tr>
<td>11/02/2014 14:16:13PM</td>
<td>120</td>
<td>ATS 6</td>
<td>Stop</td>
</tr>
<tr>
<td>11/02/2014 14:16:13PM</td>
<td>120</td>
<td>ATS 7</td>
<td>Normal</td>
</tr>
<tr>
<td>11/02/2014 14:16:13PM</td>
<td>120</td>
<td>ATS 8</td>
<td>Stop</td>
</tr>
<tr>
<td>11/02/2014 14:16:13PM</td>
<td>120</td>
<td>ATS 9</td>
<td>Normal</td>
</tr>
</tbody>
</table>

**ATS Information**
- Transfer Time
- Time in Emergency

**EPSS Device Status Changes**
- Time/Date Stamped

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PREPARED BY JIM TAUFER, POWERLOGIC BUSINESS DEVELOPMENT
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EPSS Reporting Module – Typical Report

- Gen Nameplate Rating
- Trend of Generator KVA & KW vs 30% Nameplate
- Min/Max/Ave Voltage & Current Readings During Test
- Generator Trend/Profile

Test Verification (Pass/Fail)
Engine Readings are Recorded Automatically from the Engine Controller or Manually by the Operator

**Engine Test Information**

**EPSS Reporting Module – Typical Report**

- **Gen RTM Readings**
- **Oil Pressure Readings**
- **Water Temperature**
- **Battery Charge Data**

**Engine Data**

<table>
<thead>
<tr>
<th>Engine Type</th>
<th>Engine Test Information</th>
<th>Sample Time</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine Test</td>
<td>Engine Test Information</td>
<td>Sample Time</td>
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<tr>
<td>Engine Test</td>
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**Oil Pressure Readings**

<table>
<thead>
<tr>
<th>Engine Type</th>
<th>Engine Test Information</th>
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**Water Temperature Readings**

<table>
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<td>Engine Test Information</td>
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**Battery Charge Data**

<table>
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<tr>
<th>Engine Type</th>
<th>Engine Test Information</th>
<th>Sample Time</th>
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<td>Engine Test</td>
<td>Engine Test Information</td>
<td>Sample Time</td>
<td>Sample</td>
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</tbody>
</table>
**EPSS Reporting Module – Typical Report**

**Emergency Power Supply System Generator Summary Report**

Logged Data for: GEN 1  
Nameplate Rating: 1256 KVA  
1600 KW

<table>
<thead>
<tr>
<th>Time</th>
<th>KW</th>
<th>KVA</th>
<th>GDR Load</th>
<th>Gen Limit</th>
<th>PF</th>
<th>HPES</th>
<th>VOLTS</th>
<th>FREQ</th>
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**Logged Gen Data**

- Generator(s) Data Logged at 1 Minute Intervals by Circuit Monitors
- Logged Parameters Can Include: KW, KVA, Amps, Volts, PF, Frequency, Demand, THD
- Provides the % Rated KVA Comparison for Each Sample
EPSS Reporting Module – Typical Report

Emergency Power Supply System
Generator Summary Report

Comments:

GEN 1
Test Initiated at ATS-1 via TEST switch.
All Panel Lamps tested – OK
No Malfunctions
All Switches Returned to AUTO
Test completed

GEN 2
Test Initiated at ATS-2 via TEST switch.
All Panel Lamps tested – OK
No Malfunctions
All Switches Returned to AUTO
Test completed

Test observations, the ATS or breaker where the test was initiated, any repairs made, action items, etc. are...

Documented Here

Operator’s Comments
EPSS Reporting

Good
Power Monitoring System

Better
Power Monitoring System + EPSS Reporting

Best
Power Monitoring System + EPSS Reporting + Automated Testing
EPSS Automated Testing

- Incorporates a industrial PLC to supervise and control EPSS testing
- Includes interactive graphic screens to allow operators to remotely monitor and control the EPSS test
- Testing can be initiated at ATS (test switch) or via remotely from the power monitoring PC
- EPS load monitored and test time extended (if necessary) to assure compliance with NFPA110
- Interfaces with Gen control & alarms via I/O or communications interface
- Does not effect the EPS start contacts, paralleling controls, load-shedding, etc
EPSS Automated Testing

Essential Power - Status Screen
Building a New Electric World

EPSS Automated Testing

EPS Test Initiated Remotely via ATS
EPSS Automated Testing

Generators Started and Essential Load Transferred
# EPSS Automated Testing

## Testing Monitored and Information Recorded System
Upon Test Completion System Returns to the “Normal” Source and Generators Cool Down
System Considerations

Emergency Power Monitoring Solutions

System Criteria:
- Provide JCAHO / AHJ test documentation
- Factory Installed or Retrofit into existing SWGR
- Separate Enclosed Equipment Available
- Integration to multiple Vendors (ATS, GENs)
- Real-Time + Historical Trending + Alarming
- Web Based Interfaces
Summary
Questions ?