

Operating Experience Smart Sample (OpESS) FY 2008-01
“Negative Trend and Recurring Events Involving Emergency Diesel Generators”

Highlighted documents have an active [hyperlink](#).

OBJECTIVE:

To support NRC inspector’s review of emergency diesel generators (EDGs) problems by giving performance insights and related operating experience (OpE) references. This OpESS provides follow-up for [NRC IN 2007-27, “Recurring Events Involving Emergency Diesel Generator Operability”](#) and [NRC Information Notice 2007-36: Emergency Diesel Generator Voltage Regulator Problems](#). This OpESS is a voluntary inspection activity performed under the baseline program.

BACKGROUND:

Based on the recent negative trend information and several EDG issues and concerns, the OpE clearinghouse and NRR management directed development of this Operating Experience Smart Sample (OpESS) to focus inspector attention in this area.

NRR staff review of recent operating experience related to EDG failures identified several recurring events and general negative trends, [see [NRC Information Notice, IN 2007-18 “Recurring Events Involving Emergency Diesel Generator Operability”](#) issued on August 6, 2007, and the NRC Information Notice 2007-36: [“Emergency Diesel Generator Voltage Regulator Problems”](#) issued on November 15, 2007]. The staff noted that since the beginning of 2004, eight of the 27 “greater than Green” inspection findings within the mitigating systems cornerstone have been EDG-related, (one Yellow and seven White findings). These EDG related findings generally involved either the failure to take prompt corrective action, the failure to perform adequate post-maintenance testing, or the failure to follow procedures.

One recurrent issue that continues to stand out involves the vibration-induced failure of EDG piping and tubing. In many cases, piping/tubing failures occurred after minor leaks were already identified and not immediately or properly repaired by the licensee. One licensee recently noted that (1) the training for their employees did not cover common tubing failure mechanisms and (2) their managers and supervisors were not aware of industry operating experience relating to these types of failures.

To prevent these types of failures, it is important that EDG piping and tubing be properly routed, supported and maintained. This topic was previously addressed in 1989 by [NRC IN 89-07, “Failures of Small-Diameter Tubing in Control Air, Fuel Oil, and Lube Oil Systems Which Render Emergency Diesel Generators Inoperable,”](#) dated January 25, 1989.

One means of measuring EDG reliability is the NRC Mitigating System Performance Index (MSPI). The MSPI Performance Indicator for Emergency AC Power Systems measures the sum of the unavailability of the emergency AC power plus the unreliability for the emergency AC power system during the previous twelve quarters.

NRR OpE staff noted that seven units were listed as “WHITE” in the 2nd Quarter 2007 for this Emergency AC power system performance indicator. The seven units were: Brunswick 1 & 2,

Cooper, Kewaunee and the Oconee site, a three unit site which is unique as it relies on hydro units for its emergency AC power source.

The reliability of EDGs can be one of the key factors affecting the risk of core damage (due to station blackout event potential). Assuring the high reliability and availability of EDGs at nuclear power plants contributes greatly to reducing the probability of a station blackout event and improving overall nuclear plant safety.

As stated in [Regulatory Guide 1.155 "Station Blackout."](#) section 1.2, Reliability Programs: The reliable operation of onsite emergency AC power sources should be ensured by a reliability program designed to maintain and monitor the reliability level of each power source over time for assurance that the selected reliability levels are being achieved. An EDG reliability program would typically be composed of the following elements or activities (or their equivalent):

1. Individual EDG reliability target levels consistent with the plant category and coping duration selected from Table 2 [of Regulatory Guide 1.155]
2. Surveillance testing and reliability monitoring programs designed to track EDG performance and to support maintenance activities
3. A maintenance program that ensures that the target EDG reliability is being achieved and that provides a capability for failure analysis and root-cause investigations
4. An information and data collection system that services the elements of the reliability program and that monitors achieved EDG reliability levels against target values
5. Identified responsibilities for the major program elements and a management oversight program for reviewing reliability levels being achieved and ensuring that the program is functioning properly.

The testing of EDGs to ensure operability is discussed extensively in [NRC Regulatory Guide 1.9, "Application and Testing of Safety-Related Diesel Generators in Nuclear Power Plants"](#) was revised in March 2007, (Revision 4). As stated in the RG 1.9 Section (D); "Implementation: Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with specified portions of the NRC's regulations, the methods described in this guide will be used in evaluating (1) submittals in connection with applications for construction permits, standard plant design certifications, operating licenses, early site permits, and combined licenses; and (2) submittals from operating reactor licensees who voluntarily propose to initiate system modifications involving diesel generators used as onsite emergency electric power systems."

SOURCE DOCUMENTS:

1) NRC Information Notices (4):

[NRC IN 2007-27, "Recurring Events Involving Emergency Diesel Generator Operability"](#)
(Available in ADAMS ML071760544)

[NRC Information Notice 2007-36: Emergency Diesel Generator Voltage Regulator Problems.](#)
(Available in ADAMS ML072780394)

[NRC IN 98-43: "Leaks in the Emergency Diesel Generator Lubricating Oil and Jacket Water Piping"](#)
(Available in ADAMS ML031040540)

[NRC IN 89-07, "Failures of Small-Diameter Tubing in Control Air, Fuel Oil, and Lube Oil Systems Which Render Emergency Diesel Generators Inoperable."](#) (Available in ADAMS ML031180501)

3) [NRC REGULATORY GUIDE 1.9, APPLICATION AND TESTING OF SAFETY-RELATED DIESEL GENERATORS IN NUCLEAR POWER PLANTS](#) , revised March 2007, (Revision 4).

4) Baseline inspection procedures are to be used for performing this OpESS and can include inspection procedures used for performing EDG system alignment inspection, EDG surveillance testing, post maintenance testing or PI&R corrective action follow-up inspections related to EDG issues. Links to these baseline procedures are provided in the inspection guidance section.

CORNERSTONES: Mitigating Systems (100%)

APPLICABILITY: All licensed operating commercial nuclear reactors with EDGs. Applicable portions of this guidance may also be useful for inspecting sites using station blackout (SBO) or safe shut down facility diesel generators or for diesel-driven pumps.

INSPECTION GUIDANCE:

- [IP-71111.04, "Equipment Alignment"](#)
- [IP-71111.15 "Operability Evaluations"](#)
- [IP-71111.19 "Post Maintenance Testing"](#)
- [IP-71111.22 "Surveillance Testing"](#)
- [IP-71152 "Problem Identification and Resolution"](#)

The above procedures provide baseline inspection program attachments that are used to support various EDG inspections and follow-up on EDG issues. Review, as applicable – (ideally during a complete walkdown per IP-71111.04, "Equipment Alignment," for the site specific EDGs, using the additional EDG inspection guidance described below and in this OpESS Attachment):

1) Review the Background and Source Document Sections of this OpESS and the related documents as needed to obtain a general understanding of some of the various EDG concerns (i.e., vibration-induced failures of EDG piping and tubing and failure to take prompt corrective action, especially related to repair of EDG fluid leaks or inadequate EDG post-maintenance testing, etc.).

2) During equipment alignment walkdowns, surveillance testing or post maintenance testing look for signs of excessive tubing / piping vibration and for any signs of leaks and click to view a previous [NRC Information Notice 98-43: Leaks in the EDG Lubricating Oil and Jacket Cooling Water Piping](#)).

Ensure the licensee has entered these vibration and leak type issues into their CAP, work request programs, etc. and addresses them in a timely manner, as appropriate. Note: The common underlying cause of these failures often is the inadequate design or installation of the supports for the small-diameter tubing in a high vibration environment. Inspect the related tubing supports and any grommets (rubber vibration dampeners) to verify they are properly installed.

3) Closely review any EDG voltage regulator issues and related licensee related corrective actions. Ensure EDG voltage regulator is restored to the position specified in the associated surveillance procedure following testing. [Refer to NRC IN 2007-36, "Emergency Diesel Generator Voltage Regulator Problems."](#)

Note: This completes the OpESS, however, other EDG inspection guidance and an inspection tool for consideration by inspectors is provided in the "**ATTACHMENT**" to OpESS FY2008-01 Negative trend and Recurring Events Involving Emergency Diesel Generators."

REPORTING INSPECTION RESULTS / TIME CHARGES / ADDITIONAL ISSUES:

Document any inspection result findings, as applicable, in an integrated inspection report (i.e., quarterly inspection report/ PI&R or CDBI report) and reference the title/ OpESS number (example: "**Review of Operating Experience Smart Sample: OpESS FY2008-01, "Negative trend and Recurring Events Involving Emergency Diesel Generators."** If no findings are identified document completion of the OpESS using the "OpESS number/ title" under the applicable inspection attachment (i.e., 1R04,) stating that no findings of significance were identified.

Inspection time for this OpESS is to be charged to the normal baseline procedure under which it is being documented (along with any routine preparation and documentation charge times).

ATTACHMENT
(OpESS FY2008-01 “Negative trend and Recurring Events Involving Emergency Diesel Generators” - (additional inspection guidance for consideration))

- 1) Inspector sites should consider establishing a site specific EDG inspection notebook that retains important reference information and guidance for use related to their site specific EDG inspections, operability issue reviews, etc. This handbook can be used during new resident training and during turnover at the site. The below information provides some general EDG supplemental inspection guidance for consideration in this EDG notebook development.
- 2) Review licensee testing and procedures to ensure they conform with [NRC Regulatory Guide 1.9](#), that states: “conformance with the guidelines in IEEE Std 387-1995 (Ref. 3) constitutes an acceptable method for satisfying the Commission’s regulations with respect to the design, qualification, and periodic testing of diesel generators used as onsite electric power systems for nuclear power plants,” [note: subject to the exceptions, as discussed in NRC Regulatory Guide 1.9].
- 3) Prior to performing baseline inspections on the EDGs, inspectors should consider reviewing the licensee CAP documents (perform a search of the licensee CAP for EDG system related issues) to look for negative EDG trends or specific CAP issues that should be examined further. Review Maintenance Rule documentation (any “a1” status corrective actions status, etc). Look for incomplete actions, inadequate or untimely corrective actions related to EDG issues.
- 4) Prior to performing baseline inspections on the EDGs, inspectors should consider reviewing outstanding (open) work orders, work history / maintenance records, equipment deficiencies, and any temporary system modifications existing on the EDGs. Review these to ensure they have been appropriately entered into the licensee’s CAP or other appropriate program and have been resolved or are being resolved in a timely manner, appropriate to their level of safety significance.
- 5) Review typical operational parameters based on the licensee procedures/vendor guidance/ EDG design basis and Technical Specification surveillance requirements for the applicable site EDG to ensure that it is operable. Review current or past EDG operating data recorded during testing including applicable system engineer EDG trend analysis data, as necessary.

To ensure EDG readiness for operation, inspect during routine plant status walkdowns, or during other baseline inspections related to the EDG the following items, as necessary. Some of these may need to be verified by actual observation during licensee operator rounds, or licensee conducted operational testing or surveillance test runs. These EDG operability type items typically include, but are not limited to, the following types of operational parameters (which may include minimum/maximum values):

Parameter(s) - (minimum /maximum values, as applicable, etc.)

- a.) Starting Air Pressure _____
- b.) Fuel Oil tank levels:
EDG Day tank level _____
Main EDG Fuel Oil Storage tank level _____
- c.) Lubricating oil - proper level _____

Parameter(s) - (minimum /maximum values, as applicable, etc.)

- d.) Cooling (i.e., jacket) water level _____
- e.) Cooling water / keep-warm temperatures _____
- f.) EDG Governor settings proper _____
- g.) Overspeed trip level (in the correct run position) _____
- h.) Fuel racks -no paint/ obstructions, and free of binding when licensee moves them by hand _____
- i.) System valve alignment (using licensee procedures, locked valve control procedures, etc. / using IP-71111.04, Equipment Alignment guidance, develop a site specific alignment checklist (note: consider periodically checking starting air and fuel transfer valve alignments even during routine plant status walkdowns) _____
- j.) Barring of the engine (performed prior to operation - to check for water/ fuel/ oil leaks into the cylinders with the cylinder test valves open and fuel racks in the no fuel position, normally prior to licensee surveillance testing _____ [Note: observe during NRC IP-71111.21 Surveillance Testing baseline sample, however, this item is not applicable for EDG "fast start" surveillance testing]
- k.) Engine/ generator reaches rated speed (rpm) and voltage and frequency per Tech Specs _____
- l.) Review additional "operating parameters" and trends to be in accordance with licensee procedure/ vendor recommendations during loaded runs (such as trends of jacket water temps, cylinder exhaust temperatures and differentials, lube oil temperatures, lube oil pressure, fuel oil pressure and EDG crankcase pressure). Especially consider any need for filter or strainer element cleaning / replacement that may be indicated by these types of parameters/ trends. _____
- m.) Check for unusual noises (that may indicate signs of mechanical trouble) and ensure they are investigated and documented by the licensee _____
- n.) Check for unusual smells that may indicate coolant or fuel leaks, over-heating, and for any smoke or burned discolored paint, etc. that may indicate problems; _____
- o.) Review the EDG room for proper transient combustible and fire ignition control (hot work) _____
- p.) Check the EDG for fluid/air/ exhaust system leaks (cooling system, fuel oil system, lube oil system, exhaust system, air system and ensure the licensee is aware / captures these in the appropriate response program (CAP or work order/equipment deficiency programs) _____
- q.) Verify the EDG shuts down properly in accordance with licensee procedure (observing for abnormal conditions, such as voltage regulator swings or excessive frequency variations, etc.) _____
- r.) Review operator logs and procedures during and following surveillance testing (to ensure they are followed and that the loading; speed and voltage (power factors, etc) are properly conducted and the necessary operating data is correct. Pay particular attention to any notes of comments recorded in the

procedure(s) by operators that may indicate abnormal conditions exist (verify necessary actions such as work orders/ corrective action documents were generated). _____

s.) Discuss concerns of EDG performance with the appropriate personnel to gain their insights into potential EDG issues, consider including:

Operator(s) _____

Maintenance personnel _____

System engineer(s) _____

t.) Review trending reports and/ or compare operating logs over extended time that may indicate an impending or slowly developing issue. _____

u.) Review battery / EDG related electrical system information and surveillances _____

v.) Review periodically the six month EDG fast load surveillance testing _____

w.) For periodic refueling outage EDG testing, as applicable, review the EDG testing response for:

Fast Start _____

Loss of Off-site Power (LOOP) _____

Safety Injection Actuation System (SIAS) _____

Combined SIAS and LOOP _____

Largest load rejection _____

Design load rejection _____

Endurance (i.e., 24 hour run, or 8 hour run) and load margin _____

Hot restart _____

Synchronizing _____

Protective trip bypass _____

Test mode override _____

[Note: Refer to licensee's TS, FSAR, EDG licensing basis documents, surveillance testing procedures and [NRC Regulatory Guide 1.9](#) , as applicable for additional information guidance related to the above EDG surveillance test requirements].

x.) Review Ten-Year Testing, when applicable, (Independence testing) _____

This testing involves demonstrating that the trains of standby electric power are independent at a frequency of once every 10 years (during a plant shutdown) or after any modifications that could affect emergency diesel generator independence (whichever is shorter) by starting all redundant units simultaneously to identify certain common-failure modes undetected in single diesel generator unit tests.

y.) Review EDG control panel switch lineup following testing periodically and during routine plant walk downs to ensure they are restored properly and the EDG remains operable and ready to start (verify ready to start light indication, as applicable) _____

6) Review chemistry test results and analysis for EDG fuel / lube oil samples to ensure that it meets TS/ ASTM standards (free of water, etc. per licensee TS and procedures, especially after new deliveries).

7) During maintenance activities review foreign material exclusion (FME) controls to ensure licensee is maintaining system cleanliness. Click to view EDG/FME related [Information Notice No. 90-80: Sand Intrusion Resulting in Two Diesel Generators Becoming Inoperable](#).

8) Periodically observe and/or review, as applicable, EDG related In-Service Testing (IST) vibration data results and discuss this EDG vibration trend analysis with the appropriate engineer(s).

9) Consider for review any EDG related permanent plant modifications (using IP-71111.17) or any EDG related temporary modifications (using IP-71111.23), and temporary scaffolding.

10) Review, as necessary, any EDG troubleshooting activities to ensure licensee properly identifies the root cause under the corrective action process. Diagnostic aids and reference materials that may assist the inspectors in this review may include such items as: Piping and Instrumentation diagrams (P&IDs), equipment drawings, system descriptions, maintenance/work history records, previous operating logs, CAP data base, vendor diagrams/ drawings, manufacturer maintenance manuals including; troubleshooting charts, parts lists, and operating experience data including INPO EPIX data, vendor owner's group alert lists, etc. Also observe /conduct discussions between and with the system engineer(s), maintenance engineer(s), vendor service representatives and various troubleshooting team members and supervisors, as necessary.

11) Periodically review any EDG engine analysis reports, EDG system health reports, on-line computer monitoring programs, or other unique diagnostic tools licensees use for EDG systems for any diagnostic or performance trending insights they may provide in following up on EDG related issues.

12) During and following painting in the EDG room verify painting activities do not adversely impact the EDGs operability, such as fuel racks locked up due to paint preventing the diesel from reaching rated speed. Click to view an IN that describes this type of concern: [Information Notice 91-46: Degradation of Emergency Diesel Generator Fuel Oil Delivery Systems](#) .

13) Periodically review various EDG support systems and their capability to support EDG operability (i.e., EDG ventilation (heating ventilation and air conditioning), service water or other cooling systems, EDG room sumps and drains/ flood control, fire suppression systems, and various electrical power supplies to EDG controls and protections.

14) Periodically review specific electrical components and circuits that affect the EDG operation - (i.e., the specific testing of load sequence logic controls and relay testing, SI start initiator relays, load shed logic controls and relay testing, exciter and regulator, generator output breaker testing). During surveillance testing of the relays, and other specific components that impact EDG operation periodically select these surveillances for review (under IP-71111.22 Surveillance Testing).

15) Inspectors should considering developing and retaining other EDG checklists and guidance information, as necessary, for inspecting their site specific EDGs. Inspector developed additional

Inspector Additional Notes / Remarks:
