



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN
OFFICE OF NUCLEAR REACTOR REGULATION

SECTION 9.5.7 EMERGENCY DIESEL ENGINE LUBRICATION SYSTEM

REVIEW RESPONSIBILITIES

Primary - Power Systems Branch (PSB)

Secondary - None

I. AREAS OF REVIEW

The emergency diesel engine lubrication system (EDELS) provides essential lubrication to the components of the emergency diesel engines. The PSB reviews the EDELS and associated auxiliary systems to assure conformance with the requirements of GDC 2, 4, 5, and 17. The review includes system piping, pumps, components, and associated auxiliary equipment essential for system operation up to the engine interface.¹

1. The PSB reviews the characteristics of the EDELS and system components with respect to the effect on functional performance of adverse environmental occurrences, abnormal operational requirements, and accident conditions.
2. The PSB determines that a malfunction or failure of a component, or the loss of a cooling source does not reduce the safety-related functional performance capabilities of the emergency powered systems. Further, the PSB review assures that:
 - a. System components and piping have sufficient physical separation or barriers to protect the system from internally and externally generated missiles.
 - b. The system is protected from the effects of pipe cracks or breaks in high- and moderate-energy piping.
 - c. System components are designed in accordance with the design codes required by the assigned quality group and seismic category classifications.

¹As defined by the engine manufacturer.

Rev. 2

USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

- d. The system is housed in structures designed to seismic Category I requirements.
 - e. Failure of nonseismic Category I structures or components will not affect the safety-related functions of the system.
3. The PSB will also review the design of the EDELS with respect to the following:
- a. Functional capability during abnormally high site water levels (probable maximum flood).
 - b. Capability for detection and control of system leakage.
 - c. Measures to assure the quality of the lubricating oil.
 - d. Capability for isolating portions of the system in the event of excessive leakage or component malfunction.
 - e. Instrumentation and control features provided to permit operational testing of the system and to assure that normal protective interlocks do not preclude engine operation during emergency conditions.
 - f. Measures are provided for cooling the system and removing system heat load.
4. The PSB will determine the adequacy of the design, installation, inspection, and testing of all electrical components (sensing, control, and power) required for proper operation of the system, including interlocks.

In the review of the diesel engine lubrication system, the PSB will coordinate the evaluations of other branches that interface with the overall review of the system as follows: The Structural Engineering Branch (SEB) determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as the safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5. The Mechanical Engineering Branch (MEB) determines that the components, piping, and structures are designed in accordance with applicable codes and standards as part of its primary review responsibility for SRP Sections 3.9.1 through 3.9.3. The MEB also determines the acceptability of the seismic and quality group classifications for system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. The Auxiliary Systems Branch (ASB) determines that the EDELS is in accordance with Branch Technical Position ASB 3-1 and MEB 3-1 for breaks in high-energy and cracks in moderate-energy piping systems outside containment as part of its primary review responsibility for SRP Section 3.6.1. The Materials Engineering Branch (MTEB) verifies, upon request, the compatibility of the materials of construction with service conditions. The Procedures and Test Review Branch determines the acceptability of the preoperational and startup tests as part of its primary review responsibility for SRP Section 14.0.

The reviews for fire protection, technical specifications, and quality assurance are coordinated and performed by the Chemical Engineering Branch, Licensing

Guidance Branch, and Quality Assurance Branch as part of their primary review responsibility for SRP Sections 9.5.1, 16.0, and 17.0, respectively.

those areas of review identified above as being part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

Acceptability of the emergency diesel engine lubrication system, as described in the applicant's safety analysis report (SAR), is based on specific general design criteria and regulatory guides. The reviewer will also utilize information obtained from other sources such as other Federal agencies, published reports, industry standards, military specifications, and technical literature on commercially available products. An additional basis for the acceptability of the system will be the degree of similarity with systems in previously reviewed plants with satisfactory operating experience.

The design of the EDELS is acceptable if the integrated design of the system is in accordance with the following criteria:

1. General Design Criterion 2, as related to structures housing the system and the system itself being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3 of the SAR. Acceptance is based on meeting Position 13 of the appendix to Regulatory Guide 1.117, as related to the protection of structures, systems, and components important to safety from the effects of tornado missiles.
2. General Design Criterion 4, with respect to structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks. Acceptance is based on meeting Position C.1 of Regulatory Guide 1.115 as related to the protection of structures, systems, and components important to safety from the effects of turbine missiles.
3. General Design Criterion 5, as related to shared systems and components important to safety being capable of performing required safety functions.
4. General Design Criterion 17, as related to the capability of the diesel engine lubrication system to meet independence and redundancy criteria. Acceptance is based on meeting the following specific criteria:
 - a. Regulatory Guide 1.9, as related to the design of the diesel engine systems.
 - b. Branch Technical Position ICSB-17 (PSB), as related to diesel engine lubrication systems' protective interlocks during accident conditions.
 - c. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

- d. IEEE Standard 387, as related to the design of the diesel engine lubrication system.
- e. Diesel Engine Manufacturers Association (DEMA) Standard, as related to the design of the diesel lubrication system.
- f. The operating pressure, temperature differentials, flow rate, and heat removal rate of the system external to the engine are in accordance with recommendations of the engine manufacturer.
- g. The system has been provided with sufficient protective measures to maintain the required quality of the oil during engine operation.
- h. Protective measures (such as relief ports) have been taken to prevent unacceptable crankcase explosions and to mitigate the consequences of such an event.
- i. The temperature of the lubricating oil is automatically maintained above a minimum value by means of an independent recirculation loop including its own pump and heater, to enhance the "first-try" starting reliability of the engine in the standby condition.
- j. The diesel engine is provided with a dedicated lube oil system design which includes measures to provide lubrication to the diesel engine wearing parts during standby conditions and/or normal and emergency starts.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to determine that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II of this SRP section. For the review of operating license (OL) applications, the procedures are utilized to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report.

The OL review includes a determination that the content and intent of the technical specifications prepared by the applicant are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the LGB review, as indicated in subsection I of this SRP section.

The primary reviewer will coordinate this review with the other branches' areas of review as stated in subsection I of this SRP section. The primary reviewer obtains and uses such input as required to assure that this review procedure is complete.

The reviewer will select and emphasize material from this SRP section as may be appropriate for a particular case.

- 1. The SAR is reviewed to establish that the EDELS is a dedicated system and that the description and related diagrams clearly delineate system operation, including the means provided for indicating and monitoring oil levels, temperatures, and pressures required for continuous operation of the system. The reviewer verifies the following:

- a. The SEB reviews the seismic design bases and the MEB reviews the quality and seismic classification as indicated in subsection I of this SRP section. The PSB assures that essential portions of the EDELS including the isolation valves separating essential and nonessential portions are classified Quality Group C and seismic Category I. Components and system descriptions in the SAR that identify mechanical and performance characteristics are reviewed to verify that the above seismic and quality classifications have been included and that the P&IDs indicate any points of change at the systems and/or systems components interfaces.
- b. Failure of a piping interconnection, as shown on the system piping and instrumentation diagrams (P&IDs) between subsystems will not cause total degradation of the lube oil system function. The results of failure modes and effects analyses will be used in this determination.
- c. The system layout drawings are examined to ascertain that sufficient space has been provided to permit inspection of components.
- d. The system has been designed to preclude the entry of deleterious material into the system due to operator error or extreme natural phenomena during recharging or normal operation. The system is acceptable if it is shown in the SAR that the system is locked closed, or if entry is administratively controlled.
- e. The design contains an independent circulation loop to maintain the temperature of the crankcase oil above a minimum value during the standby mode.
- f. The system P&IDs indicate the temperature, pressure, and level sensors which alert the operator when these parameters exceed the ranges recommended by the engine manufacturer.
- g. The system has been designed to minimize the potential fire hazard from lube oil leaking and accumulating on the engine exhaust manifold and in the turbocharger housing as a result of excessively long prelubrication of the engine prior to starting. The prelube time interval prior to manual starting of the engine should be limited to 3 to 5 minutes unless otherwise recommended by the diesel engine manufacturer.
- h. The system has been designed to preclude dry starting of the diesel engine during emergency starts, that is, the momentary lack of lubrication at the various moving parts or bearing surfaces resulting from the tendency for the lube oil system to drain during long periods of standby. It is necessary for the system to establish as quickly as possible an oil film on the wearing parts of the diesel engine; otherwise, damage to the bearing surface will result causing unavailability of the engine. To remedy this situation, any one of the following may be used and should be confirmed with the diesel engine manufacturer:
 - (1) An electrically driven lubricating oil pump powered from a reliable DC power supply, and installed to operate in parallel with the engine-driven main lube oil pump. The electric-driven prelube

pump should operate only during the engine cranking cycle or until satisfactory lube oil pressure is established in the engine main lube oil distribution header.

- (2) Installation of a continuously operated prelube system which would provide lube oil to all moving parts and bearing surfaces during the standby condition of operation. Appropriate alarms should be provided to alert operators to pump failure or low system pressure.
 - (3) Installation of an intermittently operated prelube system which would provide lube oil to all moving parts and bearing surfaces during the standby condition of operation. This system would operate automatically for a minimum of 5 minutes per day to prelube the moving parts. Appropriate alarms should be provided to alert operators of pump failure to start.
- i. The design provides for the total heat removal rates required by the system and the margin in the design heat removal rate capability.
2. The reviewer determines that the system is designed to maintain its function under adverse environmental phenomena. The reviewer, using engineering judgment and the results of failures modes and effects analyses, determines that:
 - a. The failure of systems not designed to seismic Category I requirements or of nonseismic Category I structures that house, support, or are close to the EDELS, will not preclude functioning of the system. Chapters 2 and 3 of the SAR describe related site features and provide the general structural arrangement and layout drawings and a tabulation of seismic design classifications for the structures and systems. Statements in the SAR to the effect that the above design requirements are met are acceptable.
 - b. The essential portions of the system are protected from the effects of floods, hurricanes, tornadoes, and internally and externally generated missiles.
 3. The reviewer verifies that the EDELS is protected from the effects of breaks in high- and moderate-energy lines. The system description in the SAR is reviewed to verify that there are no high- or moderate-energy piping systems close to the lube oil system or that protection from effects of failure will be provided. The means of providing such protection are given in Chapter 3 of the SAR and procedures to review the information presented are given in the corresponding SRP sections.
 4. The descriptive information, P&IDs, related system drawings, and system analyses in the SAR are reviewed to assure that essential portions of the system will function following design basis accidents, assuming a concurrent single active component failure. The reviewer evaluates the results of failure modes and effects analyses presented in the SAR to assure functioning of required components, traces the availability of these components on system drawings, and checks that minimum system requirements are met for each degraded situation over required time spans. For each case, the design is acceptable if minimum system requirements are met.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and his review supports conclusions of the following type, to be included in the staff's safety evaluation report:

The emergency diesel engine lubrication system (EDELS) includes the pumps, heat exchangers, valves, piping, makeup piping, and the points of connection or interfaces with other systems. The scope of review of the emergency diesel engine lubrication system for the _____ plant included layout drawings, flow diagrams, piping and instrumentation diagrams, and descriptive information for the system and supporting systems that are essential to its operation. The essential portions of the EDELS that are necessary for the safe shutdown of the reactor or necessary to mitigate the consequences of an accident are designed to seismic Category I and Quality Group C.

The staff concludes that the design of the emergency diesel engine lubrication system is acceptable and meets the requirements of GDC 2, 4, 5, and 17. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," with respect to the ability of structures housing the EDELS and the system itself to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, and GDC 4, "Environmental and Missile Design Bases" with respect to structures housing the system and the system itself being capable of withstanding the effects of externally and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks. The EDELS is housed in a seismic Category I structure which provides protection from the effects of tornado, tornado missiles, turbine missiles, and floods. This meets the positions of Regulatory Guides 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and 1.117, "Tornado Design Classification," Appendix Position 13.
2. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems and Components," with respect to the capability of shared systems and components important to safety to perform required safety functions. Each unit of the _____ plant has its own emergency diesel generators, whose EDELS is not shared between the diesel generators.
3. The applicant has met the requirements of GDC 17, "Electric Power Systems," with respect to the capability of the lubrication system to meet independence and redundancy criteria. Each EDELS is independent and physically separated from the other system serving the redundant diesel generator. A single failure in any one of the systems will affect only the associated diesel generator. The EDELS for each diesel engine provides the necessary engine lubrication during operation and maintains the lube oil at a temperature that improves first-start reliability. This meets the positions of Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel Generator Units

Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants." The applicant has also met the positions of Branch Technical Position ICSB-17 (PSB), "Diesel Generator Protective Trip Circuit Bypasses," and NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability." The applicant has met the requirements of the following industry standards: IEEE Standard 387, "IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations," and Diesel Engine Manufacturer Association (DEMA) Standard.

V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides and NUREG.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."
2. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."
3. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems, and Components."
4. 10 CFR Part 50, Appendix A, General Design Criterion 17, "Electric Power Systems."
5. Regulatory Guide 1.9, "Selection, Design, and Qualification of Diesel-Generator Units Used as Standby (Onsite) Electric Power Systems at Nuclear Power Plants."
6. Regulatory Guide 1.68, "Initial Test Programs for Water Cooled Reactor Power Plants."
7. Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles."
8. Regulatory Guide 1.117, "Tornado Design Classification."
9. Branch Technical Position ASB 3-1, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," attached to SRP Section 3.6.1.
10. Branch Technical Position MEB 3-1, "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," attached to SRP Section 3.6.2.

11. Branch Technical Position ASB 9.5-1, "Guidelines for Fire Protection for Nuclear Power Stations," attached to SRP Section 9.5.1.
12. Branch Technical Position ICSB-17 (PSB), "Diesel-Generator Protective Trip Circuit Bypasses," attached to SRP Section 8.3.2, Appendix 8A.
13. IEEE Standard 387, "IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations."
14. Diesel Engine Manufacturers Association (DEMA) Standards.
15. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Operating Reliability."