



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN

9.5.7 EMERGENCY DIESEL ENGINE LUBRICATION SYSTEM**REVIEW RESPONSIBILITIES**

Primary - Organization responsible for the review of diesel generator support systems

Secondary - None

I. AREAS OF REVIEW

The emergency diesel engine lubrication system (EDELS) provides essential lubrication to emergency diesel engine components. Review of the EDELS and its auxiliary systems assures compliance with the requirements of General Design Criteria (GDCs) 2, 4, 5, and 17. The review includes system piping, pumps, components, and auxiliary equipment essential for system operation up to the engine interface.¹ The specific areas of review are as follow:

1. The EDELS is reviewed to verify whether:
 - A. Each emergency diesel engine has an independent and reliable lubrication system.
 - B. The system is designed, fabricated, erected, and tested to acceptable quality standards.
 - C. The system has boundary divisions between safety-related and nonsafety-related sections.

¹As defined by the engine manufacturer.

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USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of Regulatory Guide 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRR_SRP@nrc.gov.

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- D. Sections of the system important to safety are housed within seismic Category I structures.
 - E. Failure of any nonseismic Category I system, structure, or component (SSC) will not affect any EDELS safety-related function.
 - F. The consequences of a single failure in an EDELS or the loss of a cooling source will not lead to a loss of more than one diesel generator.
 - G. The design includes the capability for detection and control of system leakage, including the capability for isolating system portions in the event of excessive leakage or component malfunction.
 - H. The design includes measures to assure lubricating oil quality.
 - I. Instrumentation and control features permit operational testing of the system and assure that normal protective interlocks do not preclude engine operation during emergency conditions.
 - J. The design includes measures for cooling the system and removing system heat load.
 - K. Sufficient space permits inspection, cleaning, maintenance, and repair of the system.
2. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.
3. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Chapter 2: review of functional capability during abnormally high site water levels (probable maximum flood).
2. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EDELS components.
3. Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5: review of the design analyses, procedures, and criteria that establish the ability of structures housing the EDELS to withstand the effects of natural phenomena like the safe shutdown earthquake, the probable maximum flood, and tornado missiles.
4. Sections 3.4.1: review of EDELS to determine whether protection against flooding is required.
5. Section 3.5.1.1: review of EDELS to determine whether protection from internally-generated missiles is required.
6. Section 3.5.2: review of EDELS to determine whether protection from tornado missiles is required.
7. Section 3.6.1: review of the plant design for protection against postulated piping failures in fluid systems, including high-energy and moderate-energy piping systems outside containment and effects upon the EDELS.
8. Sections 3.9.1 through 3.9.3: review of EDELS components, piping, and structures to verify they are designed per applicable codes and standards.
9. Section 7.1: review of all essential EDELS control and instrumentation for design, installation, inspection, and testing.
10. Section 8.3.1: review of the adequacy of the design, installation, inspection, and testing of all electrical components (sensing, control, and power) required for proper EDELS operation, including interlocks.
11. Section 9.5.1: review of EDELS for fire protection requirements.
12. Section 14.0: review of the acceptability of the pre-operational and startup tests.
13. Section 16.0: review of EDELS technical specifications.
14. Chapter 17: review of quality assurance requirements.
15. Upon request, EDELS review is performed for the compatibility of materials of construction with service conditions.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of EDELS, as described in the applicant's safety analysis report (SAR), COL, or design control document (DCD) is based on specific regulations, GDCs, and regulatory guides (RGs). The reviewer also utilizes information from other federal agencies and published reports, industry standards, military specifications, technical literature on commercially available products, and operational performance data from similarly designed systems at other plants with satisfactory operating experience.

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. GDC 2 as it relates to SSCs that must be protected from, or be capable of withstanding, the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods, as established in SAR Chapters 2 and 3.
2. GDC 4 as it relates SSCs that must be protected from, or be capable of withstanding, the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks.
3. GDC 5 as it relates to the capability of systems and components important to safety shared between units to perform required safety functions.
4. GDC 17 as it relates to EDELS capability to meet independence and redundancy criteria.
5. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;
6. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. GDC 2 requirements for SSCs to withstand or be protected from the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods apply to safety-related EDELS SSCs. The identification of SSCs required to withstand earthquakes without the loss of capabilities to perform safety functions is listed in RG 1.29. Comprehensive compliance with GDC 2 is reviewed under other SRP sections as specified in subsection I of this SRP section.
2. GDC 4 requirements for SSCs to be protected against the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks apply to safety-related EDELS SSCs. Comprehensive compliance with GDC 4 is reviewed under other SRP sections as specified in subsection I of this SRP section.
3. GDC 5 requirements for sharing of SSCs important to safety among nuclear power units are met if each unit has its own diesel generator(s), each with an independent lubrication system.
4. GDC 17 requirements of independence and redundancy criteria are applicable to the EDELS. Acceptance is based on the following specific criteria:
 - A. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."
 - B. System operating pressure, temperature differentials, flow rate, and heat removal rate external to the engine in accordance with engine manufacturer recommendations.
 - C. Sufficient system protective measures to maintain required oil quality during engine operation.
 - D. Protective measures (e.g., relief ports) to prevent unacceptable crankcase explosions and to mitigate consequences of such events.
 - E. A keep-warm oil lubricating system to maintain engine lubricating oil passages in a warmed and filled state when the diesel engine is in the standby mode.
 - F. System design to circulate lubricating oil to the diesel engine during standby to enhance starting capability in conditions under which the engine-driven oil pump can pressurize the system quickly following engine starts.

- G. Each diesel engine lubricating oil system completely independent of other diesel engines so a single failure will not cause a loss of the required minimum diesel generator capacity as specified in ANSI/ANS-59.52.
- H. Onsite lubricating oil storage capacity for each diesel engine sufficient for seven days operation after any design basis event and a continuous loss of off-site power as specified in ANSI/ANS-59.52.

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform safety functions. The EDELS safety function is to provide essential lubrication to the emergency diesel engine under standby, startup, and operating conditions. Compliance with GDC 2 requirements provides assurance that natural phenomena events will not affect EDELS capability to provide essential lubrication to the diesel engine.
2. GDC 4 requires that SSCs important to safety be designed to withstand such dynamic effects of pipe ruptures as pipe whip and jet impingement and externally- or internally-generated missiles. The EDELS safety function is to provide essential lubrication to the emergency diesel engines under standby, startup, and operating conditions. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures, and events external to the plant, will not affect EDELS capability to provide lubrication to the emergency diesel engines.
3. GDC 5 prohibits the sharing of SSCs important to safety among nuclear power units unless such sharing can be demonstrated not to impair their ability to perform safety functions, including in an accident in one unit an orderly shutdown and cooldown of the remaining unit. The EDELS safety function is to provide essential lubrication to the emergency diesel engines under standby, startup, and operating conditions. Compliance with GDC 5 provides assurance that an EDELS failure in one unit will not propagate to other units of the site.
4. GDC 17 requires an onsite electric power system for the functioning of SSCs important to safety. GDC 17 requires that the onsite electric power system have sufficient independence and redundancy for safety functions, assuming a single failure. GDC 17 requirements provide assurance that electric power will be available for systems necessary (i) to prevent fuel damage in the event of anticipated operational occurrences and (ii) to maintain core cooling and containment integrity in postulated accidents.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. For reviews under 10 CFR Part 50, the procedures below are used during the construction permit review to determine whether the design criteria and bases and the preliminary design as set forth in the preliminary SAR meet the acceptance criteria of subsection II of this SRP section. For the review of operating license (OL) applications, the procedures verify whether the initial design criteria and bases are implemented appropriately in the final design as set forth in the final SAR. The OL review determines whether the content and intent of the applicant's technical specifications agree with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review as indicated in subsection I of this SRP section.
2. For review of a DC application, the reviewer should follow the procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

3. The SAR is reviewed for whether the EDELS is a dedicated system and whether the description and related diagrams clearly delineate system operation, including the means for indicating and monitoring oil levels, temperatures, and pressures required for continuous operation of the system. The reviewer verifies the following:
 - A. Interfacing reviewers review the seismic design bases and the quality and seismic classification as indicated in subsection I of this SRP section. The primary reviewer assures that essential EDELS portions including the isolation valves separating essential and nonessential portions are classified Quality Group C and seismic Category I. Components and systems 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 piping and instrumentation diagrams (P&IDs) indicate any points of change at systems or systems components interfaces.
 - B. Failure of a piping interconnection between subsystems as shown on the system P&IDs will not cause total degradation of the lube oil system function. The results of failure modes and effects analyses are used in this verification.

- C. The system layout drawings are examined for sufficient space to permit inspection of components.
- D. The design contains an independent circulation loop to maintain crankcase oil temperature above a minimum value during the standby mode.
- E. 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.
- F. The system is designed to minimize the potential fire hazard from leaking lube oil accumulating on the engine exhaust manifold and in the turbocharger housing from excessively long prelubrication of the engine prior to starting. The prelude time interval prior to manual starting of the engine should be limited to three to five minutes unless otherwise recommended by the diesel engine manufacturer.
- G. The system is designed to preclude dry starting of the diesel engine during emergency starts, that is, the momentary lack of lubrication at various moving parts or bearing surfaces caused by the tendency for lube oil to drain during long standby periods. It is necessary for the system to establish as quickly as possible an oil film on the wearing parts of the diesel engine; causing damage to a bearing surface resulting in engine unavailability. To remedy this situation, any one of the following may be used and should be confirmed with the diesel engine manufacturer:
 - i. An electrically-driven lubricating oil pump powered from a reliable direct current 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.
 - ii. Installation of a continuously-operated prelube system to provide lube oil to all moving parts and bearing surfaces during standby. Appropriate alarms should alert operators to pump failure or low system pressure.
 - iii. Installation of an intermittently-operated prelube system to provide lube oil to all moving parts and bearing surfaces during standby. This system would operate automatically for a minimum time per day as specified by the diesel engine manufacture to prelube the moving parts. Appropriate alarms should alert operators of pump failure to start.
- H. The design provides for the total heat removal rates required by the system and the margin in the design heat removal rate capability.
- I. The system inventory, including the engine sump and onsite storage capacity, is designed with sufficient volume to support continuous, full-load diesel engine operation for seven days.

4. The reviewer determines whether 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 whether:
 - A. The failure of either systems not designed to seismic Category I requirements or 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.
5. The reviewer verifies whether the EDELS is protected from the effects of high-and moderate-energy line breaks. System description in the SAR is reviewed for high-or moderate-energy piping systems close to the EDELS or that protection from effects of failure will be provided. SAR Chapter 3 presents the means of such protection, and procedures for reviewing the information presented are in the corresponding SRP sections.
6. The descriptive information, P&IDs, related system drawings, and system analyses in the SAR are reviewed to assure that essential EDELS portions 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 it meets minimum system requirements.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

The EDELS includes the pumps, heat exchangers, valves, piping, makeup piping, and connection or interface points with other systems. The scope of EDELS review for the plant included layout drawings, flow diagrams, P&IDs, and descriptive information for the system and supporting systems essential to its operation. The essential EDELS portions that are necessary for the safe shut down 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 EDELS design is acceptable and meets the requirements of GDCs 2, 4, 5, and 17. This conclusion is based on the following findings:

1. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," for the ability of structures housing the EDELS and the system itself to withstand the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods and GDC 4, "Environmental and Dynamic Effects Design Bases," for the ability of structures housing the system and the system to withstand the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks. The EDELS is housed in a seismic Category I structure which protects it from the effects of tornados, tornado missiles, turbine missiles, and floods. This protection meets the positions of RGs 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," for 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, each with an EDELS not shared between the diesel generators.
3. The applicant has met the requirements of GDC 17, "Electric Power Systems," for EDELS capability 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 its own 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. The applicant has also met the positions of NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."
3. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."
4. 10 CFR Part 50, Appendix A, GDC 17, "Electric Power Systems."
5. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."
6. RG 1.115, "Protection Against Low-Trajectory Turbine Missiles."
7. RG 1.117, "Tornado Design Classification."
8. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Operating Reliability," University of Dayton Research Institute; UDR-TR-79-07; February 1979.
9. ANSI/ANS-59.52-1998, Lubricating Oil Systems for Safety-Related Diesel Generators.
10. Diesel Engine Manufacturers Association (DEMA) Standards 1974.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

PUBLIC PROTECTION NOTIFICATION

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.
