



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN

9.5.4 EMERGENCY DIESEL ENGINE FUEL OIL STORAGE AND TRANSFER SYSTEM**REVIEW RESPONSIBILITIES**

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

Secondary - Organization responsible for the review of fuel oil quality and testing

I. AREAS OF REVIEW

Nuclear power plants are required to have redundant onsite emergency power sources of sufficient capacity to power safety-related equipment. In almost all cases, the onsite power sources include diesel engine-driven generator sets. Standard review plan (SRP) Sections 9.5.4 through 9.5.8 cover the review of various essential elements of the emergency diesel engine sets. This SRP section covers the fuel oil storage and transfer system for these diesel engines up to the engine housing. The specific areas of review are as follow:

The review of the emergency diesel engine fuel oil storage and transfer system (EDEFSS) assures compliance with the requirements of General Design Criteria (GDCs) 2, 4, 5, and 17 by all piping up to the connection to the engine interface,¹ the fuel oil storage tanks, the fuel oil transfer pumps, day tanks, and the tank storage vaults. In addition, the review covers the quality and the quantity of fuel oil stored onsite and the availability and procurement of additional fuel from offsite sources.

¹ As 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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The specific areas of review are as follows:

1. The EDEFSS is reviewed to verify whether:
 - A. Each emergency diesel engine has an independent and reliable fuel oil storage and transfer system.
 - B. The system has been designed, fabricated, erected, and tested to acceptable quality standards.
 - C. The system has boundary divisions between safety-related and nonsafety-related sections.
 - D. Sections of the system important to safety are housed within seismic Category I structures.
 - E. Failures of any non-seismic Category I structure, system, and component (SSC) will not adversely affect any EDEFSS safety function.
 - F. The consequences of a single active failure in a fuel oil system will not lead to a loss of more than one diesel generator.
 - G. The design includes the capability to detect and control system leakage, including isolating system portions in the event of excessive leakage or component malfunction.
 - H. A minimum of seven days supply of fuel oil for each diesel generator system is onsite to meet the engineered safety feature load requirements following a loss of offsite power and a design-basis accident (DBA).
 - I. Adequate and acceptable sources of fuel oil are available, including the means of transporting and recharging the fuel storage tank, following a DBA to enable each redundant diesel generator system to supply uninterrupted emergency power for as long as required
 - J. Instrumentation and control features permit operational testing of the system and assure that normal protective interlocks do not preclude engine operation during emergency conditions.
 - K. Suitable precautions will prevent deleterious material from degrading the stored fuel and periodic tests will verify whether fuel degradation affects engine performance.
 - L. 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. Upon request, EDEFSS review is performed for compatibility of materials of construction with service conditions.
2. Chapter 2: review of functional capability during abnormally high site water levels (probable maximum flood).
3. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EDEFSS components.
4. 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 establishing the ability of structures housing the EDEFSS to withstand the effects of natural phenomena like the safe shutdown earthquake (SSE), the probable maximum flood, and tornado missiles.
5. Sections 3.4.1: EDEFSS review for whether protection against flooding is required.
6. Section 3.5.1.1: EDEFSS review for whether protection against internally-generated missiles is required.
7. Section 3.5.2: EDEFSS review for whether protection from tornado missiles is required.
8. 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 EDEFSS.

9. Sections 3.9.1 through 3.9.3: review of EDEFSS components, piping, and structures for whether they are designed per the applicable codes and standards.
10. Section 7.1: review of instrumentation and controls to determine the design, installation, inspection, and testing of all essential EDEFSS control and instrumentation.
11. 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 EDEFSS operation including interlocks.
12. Section 9.5.1: EDEFSS review for fire protection requirements.
13. Section 14.0: review of the acceptability of the pre-operational and startup tests.
14. Section 16.0: review of EDEFSS technical specifications.
15. Chapter 17: review of quality assurance requirements.

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

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of the EDEFSS, as described in the applicant's safety analysis report (SAR), COL submission, or design control document is based on specific regulations, general design criteria (GDCs), and regulatory guides (RGs). The reviewer also utilizes information from other federal agencies and published reports, industry standards, military specifications, available technical literature on commercially available products, and operational performance data from similarly designed systems at other plants having satisfactory operational 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 such natural phenomena as earthquakes, tornadoes, hurricanes, and floods, as established in Chapters 2 and 3 of the SAR.
2. GDC 4 as it relates to 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 shared systems and components important to safety between units to perform required safety functions.
4. GDC 17 as it relates to the capability of the diesel engine fuel oil system 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 which SSCs must be protected from, or be capable of withstanding, the effects of such natural phenomena as earthquakes, tornadoes, hurricanes, and floods apply to safety-related EDEFSS SSCs. The identification of SSC required to withstand earthquakes without the loss of capability 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 which SSCs 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 apply to safety-related EDEFSS 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) and each diesel generator has an independent fuel oil system.
4. GDC 17 as to the capability of the fuel oil system to meet independence and redundancy criteria and the guidance and positions of the following:
 - A. RG 1.137 as to the diesel engine fuel oil system design, fuel oil quality, and tests which are specified in regulatory positions C1 and C2. The regulatory position C1 addresses the design criteria for the fuel oil system such as materials, physical arrangement, and applicable codes and regulations. The physical arrangements

of the fuel oil system should provide for inservice inspection and testing in accordance with ASME Boiler and Pressure Vessel Code Section XI, "Rules for Inservice Inspections." Criteria for oil quality are addressed in the position C2. The fuel oil stored in the fuel supply tank or used for filling or refilling the supply tank should meet the Federal Fuel Oil, ASTM, or diesel-generator manufacturer requirements. The quality of fuel oil is determined by performing suitable tests and when it does not meet the prescribed standards it is replaced. Also, prior to adding new fuel oil to the supply tank the test for specific gravity, water sediment and viscosity testing should be performed and the fuel oil not meeting the test requirements should not be added to the tank.

- B. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability"
- C. Each diesel engine with its own EDEFSS.
- D. ANSI/ANS-59.51 regarding the onsite fuel oil storage for each diesel generator being sufficient to operate the diesel generator following any design basis event and a continuous loss of off-site power either for seven days, or for the time required to replenish the fuel from sources outside the plant site following any design event without interruption of the operation of the diesel generator, whichever is longer.

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, tsunamis, and seiches without loss of capability to perform safety functions. The EDEFSS safety function is to store quality fuel and transfer it to the emergency diesel engine following an engine start signal. Compliance with GDC 2 requirements ensures that natural phenomena will not affect EDEFSS capability to supply fuel oil to the emergency diesel engines.
2. GDC 4 requires that SSCs important to safety be designed to withstand the dynamic effects of pipe ruptures like pipe whip and jet impingement and externally- or internally-generated missiles. The EDEFSS safety function is to store quality fuel and transfer it to the emergency diesel engine following an engine start signal. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures and events external to the plant will not affect EDEFSS capability to supply fuel 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 the event of an accident in one unit an orderly shutdown and cooldown of the remaining unit. The EDEFSS safety function is to store quality fuel and transfer the fuel to the emergency diesel engine following an engine start signal. Compliance with GDC 5 provides assurance that EDEFSS failures in one unit will not affect other units of the site.

4. GDC 17 requires an onsite electric power system for the functioning of SSCs important to safety. GDC 17 requirements include sufficient independence and redundancy for the onsite electric power system to perform safety functions, assuming a single failure. RG 1.137 provides regulatory positions on the emergency diesel engine and fuel oil system design criteria and features subject to GDC 17 requirements, which provide assurance that electric power will be available for systems necessary (i) to prevent fuel damage in 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.

Plant-to-plant variations in the design of fuel oil storage and transfer systems occur due to the number of architect-engineering companies having design responsibility in this area. Differences may occur in the number of redundant systems, in piping interconnections between diesel engines, and in sharing requirements between units. The reviewer selects and emphasizes material from the following paragraphs to fit the particular design under review.

1. The SAR is reviewed to verify whether the EDEFSS description and related diagrams clearly indicate all modes of system operation, including the means for indicating, controlling, and monitoring fuel oil level, temperature, and pressure as required for uninterrupted operation.
2. The reviewer verifies whether the system is designed to withstand the effects of seismic events, other design bases, natural phenomena, and internally- and externally-generated missiles. Review of internally-generated missiles considers the relative locations and orientations of components in the facility.
3. Piping and interconnections between systems are reviewed to verify whether single active failures will cause unacceptable results. Drawings are examined to ascertain whether sufficient space around the components permits inspection, cleaning, maintenance, and repair.
4. The seismic design bases and the seismic and quality group classifications are reviewed by interfacing reviewers as indicated in subsection I of this SRP section. The primary reviewer verifies whether essential EDEFSS portions including the isolation valves separating essential and nonessential portions are classified Quality Group C and seismic Category I. SAR component and system descriptions of mechanical and performance characteristics are reviewed to verify whether the seismic and quality group classifications are included and whether the piping and instrumentation drawings indicate any points of change at the system or system component interfaces.

5. The reviewer verifies whether the design minimizes turbulence of the sediment at the bottom of the fuel oil storage tank or any chance of deleterious material entering the system during recharging, by operator error, or due to natural phenomena.
6. The SAR descriptive information and drawings are reviewed to verify whether:
 - A. Each storage tank is equipped with an outside fill and vent line located and protected to minimize any chance of damage from vehicles, tornado, tornado missiles, and floods. The fill and vent point should be located higher than the probable maximum flood level. Each tank also has a stick gauge connection for determining its fuel level.
 - B. The minimum onsite inventory of fuel oil for each diesel generator system is sufficient to enable the diesel generators to power required engineered safety features for a period of seven days or longer as specified by ANSI/ANS-59.51 following any DBA and loss of offsite power.
 - C. The physical location of the day tank for each diesel-generator set is located at an elevation for a slight positive pressure at the engine-driven fuel oil pump(s). Where this requirement is contrary to manufacturer recommendations, the SAR must provide justification and a detailed system description. Additionally, justification for locating the day tank otherwise must confirm that the diesel-generator unit can start automatically and attain the required voltage and frequency within an acceptable time. Any required booster pump must be powered from a reliable power supply, operate when the engine receives a start signal, and operate during the engine starting cycle or until system fuel oil pressure is established by the engine-driven fuel oil pump.
 - D. A day or integral tank overflow line returns excess fuel oil delivered by the transfer pump back to the fuel oil storage tank.
 - E. A low-level alarm enables the operator to accomplish minor repairs or maintenance before all fuel in the day or integral tank is consumed (assuming full-power operation).
 - F. The day or integral tank and storage tanks for each diesel-generator set include provisions for removal of accumulated water.
7. The reviewer verifies whether suitable precautions will be taken, after the fuel oil tank has been filled, to exclude sources of ignition like open flames or hot surfaces and whether protective measures like compartmentation of redundant elements minimize the potential for and consequences of fires and explosions.
8. The reviewer verifies whether the system function will be maintained as required in any failure of nonseismic Category I systems or structures near the system. Reference to SAR sections describing site features and general arrangement and layout drawings is necessary in this verification. Plant arrangement features and the protections obtained by location and the design of the system and structures are considered in determining the ability of the system to maintain functions in such failures.

9. The EDEFSS is reviewed for protection from the effects of breaks in high and moderate energy lines. Layout drawings are reviewed for whether high or moderate energy piping systems are located close to the fuel oil system and for protection from the effects of failure. Provisions for such protection are in SAR Section 3.6 and procedures for reviewing this information are in the corresponding SRP sections.
10. The SAR descriptive information, related system drawings, and results of failure modes and effects analyses are reviewed to verify whether minimum system requirements will be met following DBAs, assuming a concurrent single active component failure. For each case the design is acceptable if minimum system requirements are met.
11. For review of a DC application, the reviewer should follow the above 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.

12. For review under 10 CFR Part 50, the procedures determine during the construction permit (CP) review whether design criteria and bases and the preliminary design meet the acceptance criteria of subsection II of this SRP section. For review of operating license (OL) applications, the procedures verify whether the initial design criteria and bases are implemented appropriately in the final design. The OL review verifies whether the content and intent of the applicant's technical specifications agree with requirements for system testing, minimum performance, and surveillance developed in the staff review as indicated in subsection I of this SRP section.

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.

1. The EDEFSS includes storage tanks, fill, vent, stick gauge drain, and overflow return lines, fuel oil transfer pumps, strainers, filters, valves, day tanks, and all components and piping up to the connections to the engine interfaces. The scope of review of the diesel engine fuel oil storage and transfer system for the plant included layout drawings, piping and instrumentation diagrams, and descriptive information for the system and

auxiliary supporting systems essential to its operation. Essential EDEFSS portions necessary for safe shutdown of the reactor or for mitigation of the consequences of an accident are designated to seismic Category I and Quality Group C.

The basis for acceptance of the EDEFSS in our review was compliance of the design criteria and bases with NRC regulations as stated in the GDCs of Appendix A to 10 CFR Part 50. The staff concludes that the design is acceptable and meets the requirements of GDC 2, 4, 5 and 17. This conclusion is based on the following findings:

- A. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," for the ability of structures housing the EDEFSS 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 itself to withstand the effects of externally- and internally-generated missiles, pipe whip, and jet impingement forces of pipe breaks. The EDEFSS, except for the buried fuel oil storage tanks and related components and piping, is housed in a seismic Category I structure which protects against the effects of tornadoes, tornado missiles, turbine missiles, and floods. The buried portions also are protected from tornadoes, tornado and turbine missiles, and floods. This protection meets the positions of RG 1.115, "Protection Against Low-Trajectory Turbine Missiles," Position C.1, and "Tornado Design Classification," Appendix Position 13.
- B. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems, and Components," for the ability of shared systems and components important to safety to perform required safety functions. Each unit of the plant has its own emergency diesel generators with EDEFSS not shared between them.
- C. The applicant has met the requirements of GDC 17, "Electric Power Systems," for the ability of the fuel oil system to meet independence and redundancy criteria. Each EDEFSS is independent and physically separated from the other system serving the redundant diesel generator. A single failure in any one EDEFSS will affect only its diesel generator. This arrangement meets the position of RG1.137 "Diesel Generator Fuel Oil Systems." The applicant has also met the positions of NUREG/CR-0660, "Enhancement Of Onsite Emergency Diesel Generator Reliability."

The staff concludes that the EDEFSS design complies with all applicable GDCs, regulatory guide positions cited, NUREG/CR-0660, staff positions, and industry standards and is therefore acceptable.

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 1.137, "Diesel Generator Fuel Oil Systems."
7. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability.," University of Dayton Research Institute; UDR-TR-79-07; February 1979.
8. ANSI/ANS-59.51-1997, "Fuel Oil Systems for Safety-Related Emergency Diesel Generators."
9. Diesel Engine Manufacturers Association (DEMA) Standard 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.
