



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

9.5.6 EMERGENCY DIESEL ENGINE STARTING SYSTEM

REVIEW RESPONSIBILITIES

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

Secondary - None

I. AREAS OF REVIEW

The review of the emergency diesel engine starting system (EDESS) covers system features necessary for reliable emergency diesel engine starting following a loss of offsite power to assure compliance with the requirements of General Design Criteria (GDCs) 2, 4, 5, and 17. The review includes the system air compressors, air dryers, air receivers, devices to crank the diesel engine, valves, piping up to the connection to the engine interface¹, filters, and ancillary instrumentation and control systems.

The specific areas of review are as follows:

1. The EDESS is reviewed to verify whether:
 - A. Each emergency diesel engine has an independent starting air system with adequate starting capacity.
 - B. The system is designed, fabricated, erected, and tested to acceptable quality standards.

¹As defined by the engine manufacturer.

Revision 3 - March 2007

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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- C. The system has boundary divisions between safety-related and nonsafety-related sections.
 - D. Failures of any non-seismic Category I structure, system, and component (SSC) will not affect system safety functions adversely.
 - E. System sections important to safety are housed within seismic Category I structures.
 - F. The consequences of a single, active failure in a starting air system will not lead to a loss of more than one diesel generator.
 - G. Instrumentation and control features permit operational testing of the system and assure that normal protective interlocks do not preclude engine operation during emergency conditions.
 - H. The design includes the capability to detect and control system leakage, including isolation of portions of the system for excessive leakage or component malfunction.
 - I. 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 review of the EDESS is performed for the compatibility of construction materials 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 EDESS 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 EDESS to withstand the effects of natural phenomena like the safe shutdown earthquake, the probable maximum flood, and tornado missiles.
5. Sections 3.4.1: EDESS review for whether protection against flooding is required.
6. Section 3.5.1.1: EDESS review for whether protection against internally-generated missile is required.
7. Section 3.5.2: EDESS 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 EDESS.
9. Sections 3.9.1 through 3.9.3: review of EDESS components, piping, and structures for design per applicable codes and standards.
10. Section 7.1: review of all essential EDESS instrumentation and controls to determine design, installation, inspection, and testing.
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 EDESS operation, including interlocks.
12. Section 9.5.1: EDESS 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 EDESS technical specifications.
15. Chapter 17: reviewing quality assurance requirements.

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

II. ACCEPTANCE CRITERIA

Requirements

Acceptability of the diesel engine starting system, as described in the applicant's safety analysis report (SAR), combined operating license submissions, or design control documents 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 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 natural phenomena like earthquakes, tornadoes, hurricanes, and floods as established in SAR Chapters 2 and 3.
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 systems and components important to safety shared between units to perform required safety functions.
4. GDC 17 as it relates to the capability of the diesel engine air starting 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 SSCs to withstand or be protected from the effects of natural phenomena like earthquakes, tornadoes, hurricanes, and floods apply to safety-related EDESS SSCs. The identification of SSC required to withstand earthquakes without 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 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 EDESS 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 an independent starting system.
4. GDC 17 as to the capability of the diesel engine air starting system to meet independence and redundancy criteria. Specific criteria and guidance necessary to meet GDC 17 requirements are as follow:
 - A. NUREG/CR-0660 "Enhancement of Onsite Emergency Diesel Generator Reliability."
 - B. Each diesel engine should have a dedicated air starting system consisting of an air compressor, an air dryer, one or more air receiver(s), piping, injection lines and valves, and devices to crank the engine as recommended by the engine manufacturer.
 - C. As a minimum, the air starting system should be capable of cranking a cold diesel engine five times without recharging the receiver(s). The air starting system capacity should be determined as follows: (i) each cranking cycle duration should be approximately three seconds, (ii) consist of two to three engine revolutions, or (iii) air start requirements per engine start provided by the engine manufacturer, whichever air start requirement is larger.
 - D. Alarms should alert operating personnel if the air receiver pressure falls below the minimum allowable value.
 - E. Provisions for the periodic or automatic blowdown of accumulated moisture and foreign material in the air receiver(s) and other system critical points.
 - F. Starting air should be dried to a dew point of not more than 10°C (50°F) when installed in a normally-controlled 21°C (70°F) environment; otherwise, the starting air dew point should be controlled to at least 5.5°C (10°F) less than the lowest expected ambient temperature.

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 EDESS safety function is to assure reliable starting of the emergency diesel engine following a loss of offsite power. Compliance with GDC 2 requirements ensures that natural phenomena events will not affect EDESS capability to start the emergency diesel engines.
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 EDESS safety function is to assure reliable starting of the emergency diesel engines following a loss of offsite power. Compliance with GDC 4 provides assurance that the dynamic effects of equipment failures and events outside the plant will not affect EDESS capability to start 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 EDESS safety function is to assure reliable starting of the emergency diesel engines in a loss of offsite power. Compliance with GDC 5 provides assurance that EDESS failures occurring 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 the onsite electric power system to have sufficient independence and redundancy to perform their 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 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. The interfacing reviewers review the seismic design bases and the quality and seismic classifications as indicated in subsection I of this SRP section. The primary reviewer assures that essential EDESS 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 for whether the seismic and quality classifications are included and whether the piping and instrumentation drawings (P&IDs) indicate any points of change at the system or system component interfaces.

2. The reviewer establishes whether the EDESS description and P&IDs clearly delineate all modes of operation and include the means for monitoring, indicating, and controlling receiver air pressure as required by the engine starting service. The P&IDs are reviewed to determine whether a pressure gauge, relief valve, drain valve, automatic means of maintaining the receiver pressure within an allowable range, and suitable low pressure alarms are provided for the receiver(s). Piping interconnections between the dedicated air start systems are reviewed for whether a failure in the interconnecting piping could lead to the loss of starting for more than one diesel engine. The building layout drawings are examined for sufficient space around the components for inspection. The reviewer verifies whether the air starting system meets the specific criteria of Subsection II, SRP Acceptance Criteria.
3. The SAR is reviewed for whether each diesel engine air start system has its own compressor and whether the compressor capacity is adequate for the air receiver capacities of the dedicated air starting system.
4. The reviewer verifies whether the system is designed for operation and maintenance in adverse environmental like hurricanes, tornadoes, or floods, and is protected against the effects of internally-or externally-generated missiles.
5. The reviewer determines whether the failure of nonseismic Category I systems, structures, or components close to the EDESS will preclude system operation.
6. The reviewer determines whether the EDESS design precludes fouling of the air start valve or filter with moisture and contaminants like oil and rust carryover. Air dryers should be installed upstream of air receivers to remove entrained moisture.
7. The reviewer determines whether essential EDESS portions are protected from the effects of high-and moderate-energy line breaks. Layout drawings are reviewed for whether high-or moderate-energy piping systems are close to the system or for protection from the effects of failure. Provisions for such protection are addressed in SAR Section 3.6 and the procedures for reviewing this information are in the corresponding SRP sections.
8. The SAR information, P&IDs, related system drawings, and failure mode and effect analyses are reviewed for whether minimum requirements of the system will be met following design basis accidents, assuming a concurrent, single, active failure and loss of offsite power. The analyses presented in the SAR are reviewed for function of required components following postulated accidents. Utilizing the descriptions, related drawings, and analyses, the reviewer verifies whether 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.

9. For reviews under 10 CFR Part 50, the procedures are used during the construction permit or 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 are used to verify whether the initial design criteria and bases are implemented appropriately in the final design as set forth in the final SAR. The review procedures for OL applications determine whether the content and intent of the applicant's technical specifications agree with the requirements for system testing, minimum performance, and surveillance developed in the staff review as indicated in subsection I of this SRP section.
10. 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.

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 EDESS has an air compressor, air dryer(s), filters, valves, and all components and piping connecting to the engine interfaces necessary for the system to be available and capable of starting the diesel engine following a loss of offsite power. The scope of review of the system for the plant included layout drawings, flow diagrams, piping and instrumentation diagrams, and descriptive information for the EDESS and supporting systems essential to its operation. The essential EDESS portions necessary to shut down the reactor down safely or to mitigate the consequences of an accident are designed to seismic Category I and Quality Group C.

The staff concludes that the EDESS 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 EDESS 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 EDESS 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 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 an EDESS not shared between other diesel generators.
3. The applicant has met the requirements of GDC 17, "Electric Power Systems," for the ability of the air starting system to meet independence and redundancy criteria. Each EDESS 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. Each of the starting systems can crank a cold diesel engine five times without air receiver recharging. 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 Generator Reliability.," University of Dayton Research Institute; UDR-TR-79-07; February 1979.
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

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