



U.S. NUCLEAR REGULATORY COMMISSION
STANDARD REVIEW PLAN

9.5.8 EMERGENCY DIESEL ENGINE COMBUSTION AIR INTAKE AND EXHAUST SYSTEM

REVIEW RESPONSIBILITIES

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

Secondary - None

I. AREAS OF REVIEW

The emergency diesel engine combustion air intake and exhaust system (EDECAIES) supplies combustion air of reliable quality to the diesel engines and exhausts combustion products from the diesel engines to the atmosphere. The system is reviewed from the outside air intake to the combustion air supply lines connected to the diesel engine interface and from the exhaust connections at the diesel engine interface¹ to the discharge point outside the building for compliance with General Design Criteria (GDCs) 2, 4, 5, and 17.

The specific areas of review are as follow:

1. EDECAIES review verifies that:
 - A. Each diesel engine has an independent combustion air intake and exhaust system.

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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- B. The components are designed, fabricated, erected, and tested to acceptable quality standards.
 - C. The system has boundary divisions between safety-related and nonsafety-related sections.
 - D. Failures of any non-seismic Category 1 structure, system, or component (SSC) (or failures of other non-seismic components or systems) will not affect the safety functions of the system adversely.
 - E. Sections of the system important to safety are housed in or on a seismic Category I structure.
 - F. The consequences of a single, active failure in an engine combustion air intake or exhaust system will not lead to the loss of function 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. 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) is performed under this chapter.

2. Sections 3.2.1 and 3.2.2: review of the seismic and quality group classifications for EDECAIES components is performed under this section.
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 EDECAIES to withstand the effects of natural phenomena like the safe shutdown earthquake, the probable maximum flood, and tornado missiles is performed under these sections.
4. Sections 3.4.1: review of EDECAIES whether protection against flooding is required is performed under this section.
5. Section 3.5.1.1: review of EDECAIES whether protection against internally-generated missile is required is performed under this section.
6. Section 3.5.2: review of EDECAIES whether protection from tornado missiles is required is performed under this section.
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 EDECAIES is performed under this section.
8. Sections 3.9.1 through 3.9.3: review of EDECAIES components, piping, and structures for design per applicable codes and standards is performed under this section.
9. Section 7.1: review of all essential EDECAIES control and instrumentation for design, installation, inspection, and testing is performed under this section.
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 operation of the EDECAIES, including interlocks is performed under this section.
11. Section 9.5.1: review of EDECAIES for fire protection requirements .
12. Section 14.0: review of the acceptability of the pre-operational and startup tests is performed under this section.
13. Chapter 16.0: review of EDECAIES technical specifications is performed under this section.
14. Chapter 17: review of quality assurance requirements is performed under this section.
15. Review of EDECAIES for 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 the EDECAIES design as described in the applicant's safety analysis report (SAR), combined operating license (COL) submittal, 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, available technical literature on commercial 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 associated with pipe breaks.
3. GDC 5 as it relates to safety-related systems and components shared between units able to perform required safety functions.
4. GDC 17 as it relates to the capabilities of the EDECAIES 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 EDECAIES SSCs. The identification of SSCs required to withstand earthquakes without the loss of capabilities to perform safety function is listed in RG 1.29. Compliance with GDC 2 is reviewed under other SRP sections as specified in subsection I of this SRP section.
2. GDC 4 requirements of 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 EDECAIES SSCs. 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 SSC important to safety are met when each diesel generator has its own independent and reliable combustion air intake and exhaust system.
4. GDC 17 as related to the capabilities of the diesel engine combustion and air intake exhaust system to meet independence and redundancy criteria. Acceptance is based on meeting the following specific criteria:
 - A. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability."
 - i. Engine combustion air should be through piping directly from outside the building with the air intake sufficiently (20 feet) above ground level and filtered to preclude any degradation of continuous engine function.
 - ii. The piping for room ventilation air should be separate from that for engine combustion air.
 - iii. Engine exhaust gas should not circulate back into the diesel generator room, fuel storage room, or any part of the power plant.
 - B. Each emergency diesel engine should have an independent and reliable combustion air intake and exhaust system sized and physically arranged for no degradation of engine function when the diesel generator set must operate continuously at the maximum rated power output.

- C. The combustion air intake system must have a means of reducing airborne particulate material over the entire time period requiring emergency power, assuming the maximum airborne particulate concentration at the combustion air intake.
- D. Suitable design precautions must preclude degradation of the diesel engine power output due to exhaust gases and other diluents that could reduce oxygen content below acceptable levels.

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 EDECAIES safety function is to supply quality combustion air and an exhaust path for the emergency diesel engine following a loss of offsite power. Compliance with GDC 2 requirements provide assurances that natural phenomena events will not affect EDECAIES capability to supply quality combustion air and an exhaust path for the emergency diesel engine.
2. GDC 4 requires that SSCs important to safety be designed to withstand the dynamic pipe rupture effects like pipe whip, jet impingement, and externally- or internally-generated missiles. The EDECAIES safety function is to provide combustion air and an exhaust path for 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 the EDECAIES capability to provide combustion air and an exhaust path for the emergency diesel engine.
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 EDECAIES safety function is to provide combustion air and an exhaust path for the emergency diesel engines in a loss of offsite power. Compliance with GDC 5 provides assurance that EDECAIES failures and events in one unit will not propagate to other units of the site.
4. GDC 17 requires provision of 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 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.

For reviews under 10 CFR Part 50, 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 SAR meet the acceptance criteria of 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 are implemented appropriately in the final design as set forth in the final safety analysis report (FSAR). The review procedures for OL applications include a determination that the content and intent of the applicant's technical specifications are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff review, as indicated in subsection I of this SRP section.

1. The SAR is reviewed for whether the EDECAIES is a dedicated system and whether the description and related diagrams clearly delineate system components and modes of system operation. The interfacing branches review the seismic design bases and the quality and seismic classifications as indicated in subsection I of this SRP section. The interfacing branches assure that essential EDECAIES 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 whether the seismic and quality classifications have been included and whether the piping and instrumentation diagrams (P&IDs) indicate any points of change at system or system component interfaces.
2. The SAR is reviewed to ascertain that sufficient space has been provide around the components to permit inspection of the system components.
3. The SAR is reviewed to assure that the combustion air intake and exhaust are arranged and located to prevent dilution or contamination of the intake air by exhaust products, fire extinguishing (gaseous) media, or other gases intentionally or accidentally released on site from precluding operation of the diesel engines at rated power output or causing engine shutdown as a consequence of any meteorological or accident condition.
4. The SAR is reviewed to verify that if the intake air flow or engine exhaust depends upon the actuation of flow control devices (louvers, dampers), the EDECAIES will function if there is a failure of an active component.
5. The SAR is reviewed to assure that the system components exposed to atmospheric conditions (dust storms, rain, ice, snow) are protected from possible clogging during standby or operation system.

6. The reviewer verifies whether the system will function as required in other adverse natural phenomena. The reviewer evaluates the system to determine that:
 - A. The failure of nonessential portions of the system or of other systems not designed to seismic Category I requirements and located close to essential portions of the system, or of non-seismic Category I structures that house, support, or are close to essential portions of the EDECAIES, will not preclude operation of the system. Reference to SAR sections describing site features and the general arrangement and layout drawings and SAR tabulation of seismic design classifications for structures and systems will be necessary. Statements in the SAR that verify that the above conditions are met are acceptable.
 - B. Essential EDECAIES portions are protected from the effects of floods, hurricanes, tornadoes, and internally or externally-generated missiles. Flood protection and missile protection criteria are discussed and evaluated in detail under the SRP sections for Chapter 3 of the SAR. The location and the design of the systems and structures are reviewed to determine that the degree of protection provided is adequate. A statement to the effect that the system is located in a seismic Category I structure that is tornado- missile and flood-protected, or that components of the system will be located in individual cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable.
 - C. Essential portions of the system are protected from the effects of high-energy and moderate-energy line breaks. Layout drawings are reviewed to assure that no high- or moderate-energy piping systems are close to the essential portions of the system, or that protection from the effects of failure will be provided. The means of providing such protection will be given in Section 3.6 of the SAR and procedures for reviewing this information are in the corresponding SRP sections.
7. The descriptive information, P&IDs, EDECAIES layout drawings, and failure modes and effects analyses in the SAR are reviewed to assure that functional requirements of the system will be met following design basis accidents, assuming a concurrent single, active component failure. The reviewer evaluates the effects of failure of components, traces the availability of redundant components on system drawings, and checks that the SAR contains verification that the system functional requirements are met.
8. The SAR is reviewed for provisions in the diesel generator combustion air intake design to minimize the ingestion of airborne particulate material over the entire time requiring emergency power. The reviewer also verifies the following:
 - A. The bottom of the intake opening is located a minimum of 6.1 meters (20 feet) above grade.
 - B. Provisions are made to minimize the generation of dust, particularly in multi-unit plants when one unit is operating and the other is under construction (abnormal generation of dust).

Dust control in the ventilation system for the diesel generator rooms is reviewed by interfacing branches under SRP Section 9.4.5. In SRP Section 8.3.1, interfacing branches review the SAR for whether electrical equipment for starting the diesel generators (e.g., auxiliary relay contacts, control switches, individually or panel mounted) are protected from dust accumulation, other deleterious material entering diesel generator rooms, and dust generated from concrete floors and walls.

9. 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 EDECAIES includes all components and piping of the air intake system from the atmospheric air intake to its connection to the engine interface and all components and piping of the exhaust system from its connection to the engine interface to where it exhausts to the atmosphere. The scope of the EDECAIES review included layout drawings, P&IDs, and descriptive information for the EDECAIES and auxiliary supporting systems essential to its safe operation. The essential portions of the EDECAIES necessary for 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 EDECAIES design is acceptable and meets the requirements of GDC 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 EDECAIES 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 structures housing the system and the system itself able to withstand the effects of externally and internally generated missiles, pipe whip, and jet impingement forces of pipe breaks. The EDECAIES is housed in a seismic Category I structure

which protects it from the effects of tornados, tornado missiles, turbine missiles, and floods. The exposed portions of the system are also protected from tornadoes, 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 with an EDECAIES not shared between other diesel generators.
3. The applicant has met the requirements of GDC 17, "Electric Power Systems," for the ability of combustion air intake and exhaust systems to meet independence and redundancy criteria. Each EDECAIES is independent and physically separated from the other system serving the redundant diesel generators. A single failure in any one of the two systems will affect only its own diesel generator. Each system is sized and physically arranged for no degradation of engine function when the diesel generator set must operate continuously at maximum rated power output. The air intakes are located ___ meters (___feet) above plant grade and adequate filters are provided to minimize airborne particulate material (dust) from entering the system. Suitable design precautions preclude degradation of the diesel engine power output due to recirculation of exhaust gases and ingestion of other adulterates that would reduce the oxygen content below acceptable levels. 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. NUREG/CR-0660, "Enhancement of Onsite Emergency Diesel Generator Reliability.," University of Dayton Research Institute; UDR-TR-79-07; February 1979.
7. RG 1.115, "Protection Against Low-Trajectory Turbine Missiles."
8. RG 1.117, "Tornado Design Classification."
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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