



## UNITED STATES NUCLEAR REGULATORY COMMISSION

# STANDARD REVIEW PLAN

### 3.5.1.1 INTERNALLY GENERATED MISSILES (OUTSIDE CONTAINMENT)

#### REVIEW RESPONSIBILITIES

**Primary -** Organization responsible for the review plant design for protection of structures, systems, and components from internal and external hazards

**Secondary -** None

#### I. AREAS OF REVIEW

All structures, systems, and components (SSCs) ( outside containment) are to be protected from internally-generated missiles to ensure compliance with 10 CFR 50, Appendix A, General Design Criterion (GDC) 4 requirements. The review includes internally-generated missiles from component overspeed failures, missiles that could originate from high-energy fluid systems failures, and missiles caused by or as a consequence of gravitational effects.

The review includes functional operations and performance requirements for all SSCs outside containment, identification of SSCs necessary for the safe shutdown of the reactor facility and the failure of SSCs that could cause a significant release of radioactivity. The review also includes adequacy of methods of protection from internally-generated missiles for all SSCs necessary to perform functions required to attain and maintain a safe shutdown or to mitigate the consequences of an accident.

The specific areas of review are as follows:

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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](mailto:NRR_SRP@nrc.gov).

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1. Protection from internally-generated missiles (outside containment) including identification of structures, systems or portions of systems, components and the methods of protection provided. Determination of the potential of pressurized components and systems for generating missiles such as valve bonnets and hardware-retaining bolts, relief valve parts, turbine blades, and instrument wells. Determination of the potential of high-speed rotating machinery for generating missiles from component overspeed or such failures as the pump itself (from seizure), pump or component parts, and rotating segments (e.g., impellers and fan blades).
2. Internal missile effects on nonsafety-related SSCs in areas with safety-related SSCs if the failure of the nonsafety-related SSCs could affect an intended safety function of the safety-related SSCs.
3. Plausible secondary missiles generated as a result of impact with primary missiles.
4. 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.
5. 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. Review of the acceptability of the analytical procedures and criteria for structures or barriers that protect the essential systems, and safety-related components from internally-generated missiles is performed under SRP Section 3.5.3. The results of this review can be utilized to complete the overall evaluation of the protection against internally-generated missiles.
2. Review of dynamic effects associated with the postulated rupture of piping inside the containment, is performed under SRP Section 3.6.2. Typically included in SRP Section 3.6.2 is the review of any high-energy line spatial separation analyses by an applicant. The results of this review can be utilized to complete the overall evaluation of the protection against internally-generated missiles.

3. Review of turbine generator analyses for turbine missiles is performed under SRP Section 3.5.1.3.

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

## II. ACCEPTANCE CRITERIA

### Requirements

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

1. 10 CFR 50, Appendix A, GDC 4 as it relates to the design of the SSCs important to safety if the design affords protection from the internally generated missile that may result from equipment failure.
2. 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;
3. 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.

The design of the SSCs important to safety is acceptable if the integrated design affords protection from the internally generated missiles (outside containment) that may result from equipment failure, in order to maintain their safety functions in accordance with GDC 4. Acceptance is based on the design meeting the guidance as described in Regulatory Guide (RG) 1.115, as related to the protection of SSCs important to safety from the effects of turbine missiles.

1. The applicant's statistical significance of an identified missile can be evaluated by a probability analysis. Its statistical significance is determined by calculating the probability of missile occurrence. If this probability is less than  $10^{-7}$  per year, the missile is not considered statistically significant. If the probability of occurrence is greater than  $10^{-7}$  per year, the probability of impact on a significant target is determined. If the product of these two probabilities is less than  $10^{-7}$  per year, the missile is not considered statistically significant. If the product is greater than  $10^{-7}$  per year, the probability of significant damage is determined. If the combined probability (product of all three) is less than  $10^{-7}$  per year, the missile is not considered statistically significant. If the combined probability is greater than  $10^{-7}$  per year, missile protection of SSCs important to safety, and of nonsafety-related SSCs whose failure could affect an intended safety function of the safety related SSCs, should be provided by one or more of the six methods listed below.
2. Missile protection for SSCs important to safety is adequate if provided by one or more of the following methods: (1) locating the system or component in a missile-proof structure, (2) separating redundant systems or components for the missile path or range, (3) providing local shields and barriers for systems and components, (4) designing the equipment to withstand the impact of the most damaging missile, (5) providing design features to prevent the generation of missiles, or (6) orienting missile sources to prevent missiles from striking equipment important in safety. RG 1.117 provides guidance on the SSCs that should be protected.

Where barriers are used as a method of protection of SSCs from internal missiles, the design of the barriers is acceptable if it meets the guidance of RG 1.115 position C.3. Components within one train of a system with redundant trains need not be protected from missiles originating from the same train.

### 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. 10 CFR 50, Appendix A, GDC 4 establishes requirements for the protection of SSCs important to safety from dynamic effects, including those of internally-generated missiles. The failure of such internal facility equipment as pressurized components, high-energy piping, and rotating equipment outside the containment may generate missiles. An internally-generated missile is a dynamic effect of such failures and its impact on SSCs important to safety must be evaluated. RG 1.115 describes methods acceptable to the staff for protection of SSCs important to safety from the effects of missiles resulting from turbine failure. Cumulative failure data for conventional plants indicate that the protection of SSCs important to safety from the effects of missiles is an appropriate safety consideration. Protecting SSCs important to safety from the effects of internally-generated missiles ensures the integrity of the reactor coolant pressure boundary, the capability to shut down and maintain the reactor in a shutdown condition, and the capability to prevent significant uncontrolled release of radioactivity.

### 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. Review of the effects of internally-generated missiles on structures is a primary responsibility under SRP Section 3.5.3. The first objective in the review of SSCs requiring protection against internally-generated missiles is to determine whether the equipment is needed to perform a safety function. Some structures and systems are designed as entirely safety-related, others with safety-related portions, and others as not needed for safety. To determine the safety category, the SSCs are evaluated for their functions in achieving safe reactor shutdown conditions, preventing significant uncontrolled release of radioactivity, preventing accidents, or mitigating their consequences. The reviewer evaluates such input as required for completion of this review. The safety functions of the SSCs in the various plant designs are essentially the same; however, the location and arrangement of the SSCs and the methods used vary from plant to plant depending upon individual design. The reviewer must evaluate variations in plant designs as individual cases. SSCs that perform safety functions or which by virtue of their failure could affect a safety function adversely should be protected from the effects of internally-generated missiles.

RG 1.115 position C.1 provides guidance on the SSCs important to safety that should be protected.

2. The SAR information on SSC design bases and criteria, system descriptions and safety evaluations, piping and instrumentation diagrams, station layout drawings, and system and component characteristic and classification tables are reviewed for potential sources of missiles and for SSCs requiring protection to maintain their safety-related functions. The reviewer may use failure mode and effect analyses and the results of reviews by other branches in evaluating SSCs to identify those requiring protection from internally-generated missiles, the origins of possible missiles, and the adequacy of the protection.
3. The reviewer determines whether nonsafety-related SSCs are protected from internally-generated missiles by whether their failure by a missile impact could prevent an SSC required safety function.
4. The reviewer determines whether the applicant's procedures, analysis, and design details ensure that pressurized gas bottles will not become missiles capable of damaging SSCs important to safety to the extent that safety-related functions are compromised. The storage and handling of compressed gases at nuclear power plants was studied by Oak Ridge National Laboratory for potential safety hazards. The results of these studies are documented in NUREG/CR-3551.

5. For applicants referencing a certified design, the reviewer determines whether adequate protection is included in the design details for pressurized gas bottles and in the details of missile protection features for SSCs or is outside the scope of the DC.
6. 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.

1. The review of possible effects of internally-generated missiles (outside containment) included SSCs whose failure could prevent safe shutdown or cause significant uncontrolled release of radioactivity. The staff's review concluded that the applicant's design bases and criteria for SSCs important to safety necessary to maintain a safe plant shutdown meet the 10 CFR 50, Appendix A, GDC 4 requirements for SSCs to be protected from internally-generated missiles (outside containment), because the applicant:
  - A. Has met guidance recommended in RG 1.115, "Protection Against Low Trajectory Turbine Missiles," Sections C.1 and C.3, as to the identification and protection of SSCs important to safety from the effects of turbine missiles, respectively;
  - B. Has used methods to identify potential sources of internal missiles and demonstrated the adequacy of the protection methods, as reviewed by the staff in this or in previous applications and found acceptable; and
  - C. Has shown that the functions of SSCs important to safety will be protected from internally-generated missiles (outside containment) by individual missile-proof structures, adequate physical separation for redundant systems or the component of systems, or special localized protective shields or barriers for the systems or components.

2. For those applicants referencing a certified design, the findings will summarize the staff's evaluation of the design details for pressurized gas bottles as well as details of missile protection features for SSCs outside the DC scope.

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, General Design Criteria 4, "Environmental and Dynamic Effects Design Bases."
2. Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles."
3. NUREG/CR-3551, "Safety Implications Associated with In-Plant Pressurized Gas Storage and Distribution Systems in Nuclear Power Plants."

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### **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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