



U.S. NUCLEAR REGULATORY COMMISSION  
**STANDARD REVIEW PLAN**  
OFFICE OF NUCLEAR REACTOR REGULATION

3.5.1.1 INTERNALLY GENERATED MISSILES (OUTSIDE CONTAINMENT)

REVIEW RESPONSIBILITIES

Primary - ~~Auxiliary~~ Plant Systems Branch (~~ASB~~)(SPLB)<sup>1</sup>

Secondary - None

I. AREAS OF REVIEW

The ~~ASB~~SPLB<sup>2</sup> reviews all structures, systems, and components (SSC) provided to support the reactor facility that require protection from internally generated missiles (outside containment) to assure conformance with the requirements of General Design Criterion 4. The review concerns missiles that could result from in-plant component overspeed failures and high-pressure system ruptures.

The ~~ASB~~SPLB<sup>3</sup> reviews the functional operations and performance requirements for all structures, systems, and components outside containment and identifies the SSC that are necessary for the safe shutdown of the reactor facility and the SSC whose failure could result in a significant release of radioactivity. All SSC will be reviewed to assure adequate protection from internally generated missiles if the SSC are necessary to perform functions required for attaining and maintaining a safe shutdown condition or if the SSC are necessary to mitigate the consequences of an accident.

The review of internally generated missile protection includes the following: structures, systems or portions<sup>4</sup> of systems, and components that require protection from internally generated missiles are identified; pressurized components and systems are reviewed to determine their potential for generating missiles such as valve bonnets and hardware retaining bolts, relief valve parts, and instrument wells; high speed rotating machinery are reviewed to determine their

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**USNRC STANDARD REVIEW PLAN**

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

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potential for generating missiles from component overspeed or failure, such as failure of the pump itself (resulting from seizure), pump or component parts, and rotating segments (e.g., impellers and fan blades).

If safety-related systems or components are located in areas containing non-safety-related<sup>5</sup> SSC, then the non-safety-related<sup>6</sup> SSC are reviewed with respect to internal missile effects if the failure could preclude the intended safety function of the safety-related SSC.

#### Review Interfaces:<sup>7</sup>

~~In addition, the~~<sup>8</sup> ASBSPLB<sup>9</sup> will coordinate with other branches' evaluations and reviews with the Structural Engineering Branch (SEB) review that interfaces with the overall review of this area as follows:

1. The Civil Engineering and Geosciences Branch SEB(ECGB)<sup>10</sup> determines the acceptability of the analysis and criteria used for the design of structures or barriers that protect essential systems and components from internally generated missiles (SRP Section 3.5.3). The results are used by the ASBSPLB<sup>11</sup> to complete the overall evaluation of protection against internally generated missiles.
2. The Materials and Chemical Engineering Branch (EMCB) performs the review of turbine generator analyses in regard to turbine missiles under SRP section 3.5.1.3.<sup>12</sup>
3. The Mechanical Engineering Branch (EMEB) performs the review of dynamic effects associated with any postulated rupture of piping under SRP section 3.6.2.<sup>13</sup>

For the areas of review identified above, the acceptance criteria and their methods of application are contained in the referenced SRP sections<sup>14</sup>.

## II. ACCEPTANCE CRITERIA

Acceptability of the design information on protection of ~~essential systems and components~~SSC important to safety<sup>15</sup> from internally generated missiles presented in the applicant's safety analysis report (SAR) is based on meeting specific general design criteria and regulatory guides.

The design of ~~structures, systems, and components~~SSC<sup>16</sup> is acceptable if the integrated design affords missile protection in accordance with General Design Criterion 4, with respect to protecting ~~structures, systems, and components~~SSC<sup>17</sup> important to safety against the effects of internally generated missiles that may result from equipment failures, in order to maintain their essential safety functions. Acceptance is based on the design meeting the guidelines of Regulatory Guide 1.115, as related to the identification and protection of SSC important to safety from the effects of turbine missiles, and the NRC staff verification that the applicant's ~~essential~~ SSC important to safety<sup>18</sup> will be protected from internally generated missiles (outside containment) by location in individual missile-proof structures or by special localized protective shields or barriers.

### Technical Rationale:<sup>19</sup>

The technical rationale for application of the above acceptance criteria to internally generated missiles (outside containment) is discussed in the following paragraph.

GDC 4 establishes requirements regarding the ability of SSC important to safety to be protected from dynamic effects, including the effects of internally generated missiles. The potential for generating missiles may result from equipment failure outside of the containment and internal to the facility such as pressurized components, high-energy piping and rotating equipment. The initiation of an internally generated missile is a dynamic effect of such failures and the impact of those missiles on SSC important to safety must be evaluated. Regulatory Guide 1.115 describes methods acceptable to the NRC staff for identification and protection of SSC important to safety from the effects of missiles resulting from turbine failure. Cumulative failure data for conventional plants indicate that the protection of SSC important to safety from the effects of missiles is an appropriate safety consideration. Protecting those SSC that are important to safety from the effects of internally generated missiles ensures: the integrity of the reactor coolant pressure boundary; the capability to shutdown the reactor and maintain it in a shutdown condition; and the capability to prevent significant uncontrolled release of radioactivity.

### III. REVIEW PROCEDURES

The review procedures set forth below are used during the construction permit (CP) application review to determine that the design criteria and bases and the preliminary design in applicant's preliminary safety analysis report meet the acceptance criteria given in subsection II of this SRP section. For the review of the operating license (OL) application, the review procedures and acceptance criteria are used to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report. The reviewer selects and emphasizes areas within the scope of this SRP section as may be appropriate in a particular case.

The reviews of the effects of internally generated missiles on structures are performed by SEBECGB<sup>20</sup> as part of its primary responsibility for SRP Section 3.5.3. The objective in the review of the reactor facility, ~~structures, systems and components~~ SSC<sup>21</sup>, with regard to protection requirements for internally generated missiles, is to identify the SSC that are needed to perform a safety function. Some structures and systems are designed as safety-related in their entirety, others have portions that are safety-related, and others are classified as not needed for safety. In order to determine their safety category, the ASBSPLB<sup>22</sup> evaluates the SSC with regard to their function in achieving and maintaining a safe reactor shutdown condition or in preventing accidents or mitigating the consequences of such accidents. The single failure criterion is used in the analysis. The safety functions to be performed by the SSC in the various plant designs are essentially the same. However, the location and arrangement of the SSC and the methods used vary from plant to plant depending upon the individual design. The review identifies variations in plant designs that must be evaluated on an individual case basis. SSC that perform a safety function, or which by virtue of their failure could have an adverse effect on a safety function, should be protected from the effects of internally generated missiles. Regulatory

Guide 1.115 position C.1 provides guidance on the SSC important to safety that should be protected.<sup>23</sup>

Missile protection provided for SSC important to safety is adequate if the protection is provided by one or more of the following: (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, (6) orienting missile sources to prevent missiles from striking equipment important to safety.<sup>24</sup> The information provided in the SAR pertaining to 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 to identify potential sources of missiles and to determine the SSC that require protection in order 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 specific SSC and the origin of possible missiles, in identifying the SSC that require protection from internally generated missiles and the adequacy of the protection provided. The protection provided is reviewed and is adequate if the SSC important to safety are afforded protection that meets the guidance of Regulatory Guide 1.115 position C.3.<sup>25</sup> In addition, the components within one train of a system containing redundant trains need not be protected from missiles originating from the same train.<sup>26</sup>

For new applications, the statistical significance of an identified missile can be evaluated utilizing a probability analysis. Once a potential missile is identified, 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 significant. If the probability of occurrence is greater than  $10^{-7}$  per year, the probability that it will impact a significant target is determined. If the product of these two probabilities is less than  $10^{-7}$  per year, the missile is not considered significant. If the above 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 significant. If the combined probability is greater than  $10^{-7}$  per year, missile protection of SSC important to safety should be provided by one or more of the methods listed above.<sup>27</sup>

The reviewer determines that non-<sup>28</sup>safety-related SSC are protected from internally generated missiles if their failure by a missile impact could prevent a required safety function of the SSC.

The reviewer determines that procedures, analysis and design details are provided to ensure that pressurized gas bottles will not become missiles capable of damaging SSC 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 to identify potential safety hazards. The results of these studies are documented in NUREG/CR-3551 (Reference 3).<sup>29</sup>

For applicants referencing a certified design the reviewer determines that adequate protection is provided in the design details in regard to pressurized gas bottles and the details of missile protection features for SSC that are outside of the design certification scope.<sup>30</sup>

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.<sup>31</sup>

#### IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided to satisfy the requirements of this SRP section and that his evaluation is complete and adequate to support conclusions of the following type, to be included in the staff's safety evaluation report:

The review of possible effects of internally generated missiles (outside containment) included structures, systems, and components (SSC)<sup>32</sup> whose failure could prevent safe shutdown of the plant or result in significant uncontrolled release of radioactivity. Based on the review of the applicant's design bases and criteria for ~~essential structures, systems, and components~~ SSC important to safety<sup>33</sup> necessary to maintain a safe plant shutdown, the staff concludes that the structures, systems, and components to be protected from internally generated missiles (outside containment) meet the requirements of General Design Criterion 4. This conclusion is based on our determination that the applicant has met the requirement of GDC 4 with respect to protection of ~~safety-related SSC~~ SSC important to safety<sup>34</sup> from internal missiles outside containment as the applicant:

1. Has met regulatory positions C.1 and C.3 of Regulatory Guide 1.115 "Protection Against Low Trajectory Turbine Missiles" as related to the identification and protection of SSC important to safety from the effects of turbine missiles;
2. Has used methods for identification of potential sources of internal missiles and for demonstrating the adequacy of the protection provided which have been reviewed by the staff in this or in previous applications and found acceptable;
3. Has shown that ~~essential SSC~~ the functions of SSC important to safety<sup>35</sup> will be protected from internally generated missiles (outside containment) by locating the systems or components in individual missile-proof structures or providing special localized protective shields or barriers.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.<sup>36</sup>

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 SSC that are outside of the design certification scope.<sup>37</sup>

## V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.<sup>38</sup> Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.<sup>39</sup>

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guide.

## VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Dynamic Effects<sup>40</sup> 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."<sup>41</sup>

**SRP Draft Section 3.5.1.1**  
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
2.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
3.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
4.	Editorial	Corrected "portion" to "portions".
5.	Editorial.	Added a hyphen between "non" and "safety" to be consistent with the remainder of the section.
6.	Editorial.	Added a hyphen between "non" and "safety" to be consistent with the remainder of the section.
7.	SRP-UDP format item.	Revised review interface section of Areas of Review to be consistent with SRP-UDP required format that uses a number/paragraph format to distinguish individual reviews and supporting reviews performed by other PRBs.
8.	Editorial.	Revised the introductory sentence for the review interface section to be consistent with the format used in the SRP-UDP. The sentence had to be revised to be more general rather than just specific to the Structural Engineering Branch to allow for review interfaces to other branches.
9.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
10.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for SRP section 3.5.3.
11.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
12.	SRP-UDP format item, adding review interfaces.	A review interface to SRP section 3.5.1.3 was added to be consistent with the review interfaces described in section 3.5.1.1 of the ABWR FSER and the ABB-CE FSER.

**SRP Draft Section 3.5.1.1**  
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
13.	Areas of Review, Consistency Check issue.	A review of the consistency check performed for this section identified PI-21142 that was consistency checked as not directly applicable to this section based upon the review by the Mechanical Engineering Branch performed under SRP section 3.6.2. The Mechanical Engineering Branch performs the review of dynamic effects associated with the postulated rupture of piping. To address this specific review, a review interface to SRP section 3.6.2 was added. In addition, the ABWR FSER documents the review of dynamic effects associated with this type of break as being addressed in Section 3.6, therefore, section 3.6.2 was included in this review interface.
14.	Editorial.	Changed "area" to "areas" to reflect the fact that there is more than one SRP section referenced in the review interfaces. Added the word "referenced" to the sentence to be consistent with the SRP-UDP format and to make the sentence grammatically correct. Changed "section" to "sections" to reflect the fact that there is more than one SRP section referenced in the review interfaces.
15.	Editorial.	Use of the term "essential systems and components" was replaced with the term "SSC important to safety". Use of the term "SSC important to safety" is consistent with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
16.	Editorial.	Substituted the acronym SSC for Structures Systems and Components as is consistent with the remainder of the section.
17.	Editorial.	Substituted the acronym SSC for Structures Systems and Components as is consistent with the remainder of the section.
18.	Editorial.	Use of the term "essential SSC" was replaced with the term "SSC important to safety". Use of the term "SSC important to safety" is consistent with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
19.	SRP-UDP format item, adding technical rationale.	Technical Rationale were developed and added for the Acceptance Criteria covering GDC 4 and Regulatory Guide 1.115. The SRP-UDP requires that technical rationale be developed for each of the Acceptance Criteria.
20.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB names and responsibilities for SRP Section 3.5.3.



**SRP Draft Section 3.5.1.1**  
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
21.	Editorial.	Substituted the acronym SSC for Structures Systems and Components as is consistent with the remainder of the section.
22.	Current PRB names and abbreviations	Editorial change made to reflect current PRB names and responsibilities for this SRP section.
23.	Editorial.	Added a reference to Regulatory Guide 1.115 position C.1 which provides guidance on identifying those SSC important to safety that should be protected. Incorporation of Regulatory Guide 1.115 positions is consistent with the Acceptance Criteria and with the Evaluation Findings.
24.	Editorial.	Two new sentences were added to address the methods for affording protection to the SSC important to safety. A reference to the guidelines contained in Regulatory Guide 1.115 position C.3 was added at the end of this paragraph in addition to a listing of protection methods that are inclusive of the guidelines in Regulatory Guide 1.115 and the guidelines documented in section 3.5.1 of the ABWR FSER (see PI-24280). These guidelines are consistent with the current Acceptance Criteria and with the current Evaluation Findings.
25.	Editorial.	Added a reference to Regulatory Guide 1.115 position C.3 which provides guidance on identifying those SSC important to safety that should be protected. Incorporation of Regulatory Guide 1.115 positions is consistent with the Acceptance Criteria and with the Evaluation Findings.
26.	Editorial	Added the phrase "In addition, the..." for consistency with previous wording changes. Also changed "Components" to "components" based on a comment from the PRB.
27.	<b>Integrated Impact #514.</b>	A new paragraph was added to the Review Procedures to address the application of probability calculations to evaluate the statistical significance of identified missiles. Because this change is based upon reviews documented in the ABWR FSER, the applicability of this new review procedure was limited to new applications only. The review procedure is consistent with the staff positions documented in section 3.5.1 of the ABWR FSER.
28.	Editorial.	Added a hyphen between "non" and "safety" to be consistent with the remainder of the section.

**SRP Draft Section 3.5.1.1**  
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
29.	<b>Integrated Impact # 513</b>	In addition to the specific Review Procedure for those applicants referencing a certified design, recommended by this integrated impact (see item 28), a more general Review Procedure was developed. Information from Inspection Manual number 71707, "Plant Operations," (PI-24282), NRC Notice 91-37, "Compressed Gas Cylinder Missile Hazards" (PI-24278), and NUREG/CR-3551, "Safety Implications Associated with In-Plant Pressurized Gas Storage and Distribution Systems in Nuclear Power Plants" (PI-24281) was utilized to develop a general Review Procedure that is not specific to any one type of plant design. The Review Procedure focuses on the protection of SSC important to safety and is consistent with the reviews documented in the FSER for the ABWR regarding missile protection features. A reference to the studies on this subject performed by Oak Ridge National Laboratory and documented in NUREG/CR-3551 was included for the benefit of the reviewer.
30.	<b>Integrated Impact # 513</b>	A Review Procedure, specific to applicants referencing a certified design, was added to verify that design details provide adequate protection in regard to pressurized gas bottles and SSC outside of the design certification scope. This Review Procedure is consistent with the positions on this subject identified in section 3.5.1.1 of the ABWR FSER.
31.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
32.	Editorial.	Provided the acronym SSC for Structures Systems and Components as is consistent with the remainder of the section.
33.	Editorial.	Use of the term "essential SSC" was replaced with the term "SSC important to safety". Use of the term "SSC important to safety" is consistent with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.

**SRP Draft Section 3.5.1.1**  
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
34.	Editorial.	Use of the term "safety-related SSC" is not comprehensive and was therefore replaced with the broader term "SSC important to safety". Use of the term "SSC important to safety" is consistent with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection. Use of the term "SSC important to safety" is also consistent with the use of this term in the ABWR FSER (see PI-24297)
35.	Editorial.	Use of the term "essential SSC" was replaced with the term "SSC important to safety". Use of the term "SSC important to safety" is consistent with the terminology used in the remainder of the section to identify those SSC that have a safety concern involving missile protection.
36.	SRP-UDP Format Item, Implement 10 CFR 52 Related Changes	To address design certification reviews a new paragraph was added to the end of the Evaluation Findings. This paragraph addresses design certification specific items including ITAAC, DAC, site interface requirements, and combined license action items.
37.	10 CFR 52 applicability issues and <b>Integrated Impact # 513.</b>	Two Evaluation Findings were added to address design certification and combined license reviews. The design certification Evaluation Finding statement is consistent with the general statement utilized in the SRP-UDP. The combined license Evaluation Finding statement is consistent with the evaluation findings as stated in the ABWR FSER section 3.5.1.1.
38.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
39.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
40.	Reference verification.	The title of 10 CFR Part 50, Appendix A, GDC 4 was revised and now reads, "Environmental and Dynamic Effects."
41.	<b>Integrated Impact # 513.</b>	A reference to NUREG/CR-3551 was added to identify the most current studies regarding the safety implications of pressurized gas storage. This study contains information and recommendations concerning pressurized gas bottle missiles.

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**SRP Draft Section 3.5.1.1**  
Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
513	<p>Incorporate appropriate Review Procedures and Evaluation Findings in regard to missile protection features, such as those concerning pressurized gas bottles, that are outside of the design certification scope. In addition, use NRC informational documents to develop a Review Procedure addressing pressurized gas bottle missile hazards which would be applicable to a broader class of plants.</p>	<p>Subsection III: Added a review procedure (last paragraph) addressing pressurized gas bottle missile hazards for all plants and for COL applicants to address the reviews required for components that are outside the design certification scope.</p> <p>Subsection IV: Added an Evaluation finding (last paragraph) to discuss the findings for COL applicants in regard to components that are outside the design certification scope.</p> <p>Section V: Added reference 3 for NUREG/CR-3551.</p>
514	<p>Incorporate appropriate Review Procedures to address the use of probabilistic criteria in evaluating the need to provide missile protection.</p>	<p>Subsection III: Added a Review Procedure (fourth paragraph) that addresses probabilistic analysis for identified missiles.</p>