



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

3.4.1 INTERNAL FLOOD PROTECTION FOR ONSITE EQUIPMENT FAILURES

REVIEW RESPONSIBILITIES

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

Secondary - Organization responsible for hydrology reviews

I. AREAS OF REVIEW

The review of the plant internal flood protection includes all structures, systems, and components (SSCs) whose failure could prevent safe shutdown of the plant or result in uncontrolled release of significant radioactivity. The facility design and equipment arrangements presented in the applicant's safety analysis report (SAR) are reviewed with respect to both internal (e.g. pipe break, tank failure) and external (e.g. failure of exterior tanks) causes. The review of external flood protection from natural phenomena (e.g. probable maximum flood, tsunami, etc.) is performed in a separate review as listed in the Review Interfaces subsection of this Standard Review Plan (SRP) Section.

The specific areas of review are as follows:

1. The safety-related SSCs that must be protected against flooding from both external and internal causes.

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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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2. The location of the safety-related SSCs relative to the internal flood level in various buildings, rooms, and enclosures that house safety-related SSCs.
3. Possible flow paths from interconnected non-safety-related areas to buildings, rooms, and enclosures that house safety-related SSCs (e.g., leakage through interconnecting doorways).
4. The adequacy of the isolation of safety-related systems and equipment between redundant trains and from non-safety systems that could be sources of internal flooding.
5. Provisions for protection against possible in-leakage sources, such as non-mechanistic cracks in structures and exterior openings and penetrations in structures located at a lower elevation than the internal flood level.
6. SSCs that could be a potential source of internal flooding (e.g. pipe breaks and cracks, tank and vessel failures, backflow through drains).
7. Design features that will be used to mitigate the effects of internal flooding (e.g. adequate drainage, sump pumps, etc.).
8. Safety-related structures that are protected from below-grade groundwater seepage by means of a permanent dewatering system.
9. 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.
10. 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. The reviewer evaluates the potential causes of external flooding from natural phenomena and assesses the adequacy of techniques for flood protection in accordance with SRP Sections 2.4.1 through 2.4.14.

2. The reviewer evaluates postulated site flooding parameters in accordance with SRP Section 2.4 and provides for inclusion in SRP Section 2.0 review for a standard DC application.
3. The reviewer evaluates the acceptability criteria used for the design of structures that should withstand the effects of the design basis flood in accordance with SRP Section 3.4.2.
4. The reviewer evaluates the adequacy of the technical specifications related to low-water conditions in accordance with SRP Section 2.4.14 and reviews the adequacy of overall plant technical specifications in accordance with SRP Section 16.0.
5. The reviewer evaluates the adequacy of the applicant's listing of SSCs, the failure of which could prevent safe shutdown of the plant, in accordance with SRP Sections 3.2.1 and 3.2.2.
6. The reviewer evaluates the adequacy of the applicant's plant- and/or site-specific probabilistic risk assessment, including an internal and external flooding analysis, in accordance with SRP Section 19.0.
7. The reviewer evaluates the environmental effects of a pipe rupture on safety-related systems in accordance with SRP Section 3.6.1.
8. The reviewer evaluates the environmental qualifications of mechanical and electrical equipment in accordance with SRP Section 3.11.
9. The reviewer evaluates possible break locations in high and moderate energy systems during normal plant operation and the dynamic effects (e.g. pipe whip, jet impingement) of pipe breaks in accordance with SRP Section 3.6.2.
10. The reviewer evaluates the instrumentation needed for flood protection, including the adequacy of detectors and alarms necessary to detect rising water levels within structures, and the consequences of flooding on other safety-related instrumentation and electrical equipment in accordance with SRP Section 7.5.

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

II. ACCEPTANCE CRITERIA

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

Acceptability of internal flood protection as described in the applicant's SAR is based on certain requirements of 10 CFR Part 50, Appendix A, General Design Criteria (GDC) and other regulations.

1. The requirements of 10 CFR Part 50, Appendix A, GDC 2 relate to the SSCs important to safety being designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without loss of capability to perform their safety functions. Meeting the requirements of GDC 2 includes evaluating

the effects of flooding from full circumferential failures of non-seismic, moderate-energy piping, which is not considered in SRP Section 3.6.2.

2. The requirements of 10 CFR Part 50, Appendix A, GDC 4 relate to the SSCs important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing and postulated accidents, including loss-of-coolant accidents.
3. 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;
4. 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. Guidance acceptable for meeting the seismic design and classification requirements of GDC 2 is found in Regulatory Guide (RG) 1.29, Position C.1 for safety-related SSCs and Position C.2 for nonsafety-related SSCs.
2. The requirements of GDC 4 are met if SSCs important to safety are designed to accommodate the effects of discharged fluid resulting from high and moderate energy line breaks that are postulated in SRP sections 3.6.1 and 3.6.2.

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. Compliance with GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. Meeting the requirements of GDC 2 is necessary to ensure that flooding due to failures of non-seismic piping does not affect the ability of the plant to shut down safely and remain in safe shutdown condition. The application of GDC 2 to this SRP Section

ensures that consideration is given to full-circumferential ruptures of non-seismic moderate energy piping. These ruptures are not considered in SRP Section 3.6.2, which only applies to normal conditions, not seismic events. However, internal flooding caused by seismically full-circumferential ruptures should be considered.

2. Compliance with GDC 4 for flood protection requires that SSCs important to safety being designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing and postulated accidents, including loss-of-coolant accidents. Meeting the requirements of GDC 4 ensures that the SSCs important to safety will be appropriately protected from potential flooding from liquid-carrying components in the plant.

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. An evaluation of the SSCs in the SAR that are safety-related and should be protected against floods or flood conditions.
2. An evaluation using the plant arrangement, layout drawings and any other acceptable methods to assess the adequacy of techniques such as enclosures, pumping systems, drains, internal curbs, and watertight doors used to prevent flooding of safety-related systems or components. The measures for protecting against external flooding are reviewed by and coordinated with the organization responsible for the review of SRP Sections 2.4.1 through 2.4.14.
3. An assessment of the potential flooding of SSCs important to safety due to the operation of the fire protection system and the postulated failure of piping in accordance with SRP Section 3.6.2, as well as postulated failures of non-seismic and non-tornado protected piping, tanks, and vessels. For the purposes of flood analysis, the reviewer need only assume, for each analyzed area, the rupture of the single, worst-case pipe (or non-seismic tank/vessel).

Moderate energy piping that is not seismically supported should be considered for full circumferential ruptures, not just cracks. Appendix A to SRP Section 3.6.2, only considers cracks in moderate energy piping. However, this Appendix applies during normal conditions, not seismic events.

This assessment should consider ways to mitigate the consequences of potential internal flooding to safety-related systems, such as drains and sump pumps. If a postulated break is in a non-seismically supported system, then only seismically-qualified systems should be assumed to be available to mitigate the effects of the analyzed break (since a seismic event may have caused the failure).

The environmental effects of piping failures are assessed in accordance with SRP Section 3.6.1, and the determination of mechanistic rupture locations and the resulting dynamic effects are evaluated in accordance with SRP Section 3.6.2.

4. A review of the applicant's risk assessment of external and internal flooding should be performed in consultation with the organization responsible for the review of the probabilistic risk assessment to identify potentially significant vulnerabilities to flooding, including an analysis of flooding during shutdown conditions. A failure modes and effects analysis may be performed to determine whether the flooding consequences resulting from failures of such liquid-carrying systems close to essential equipment will not preclude required functions of safety systems.
5. A review of the SAR to ascertain if safety-related systems or components are capable of normal function while completely or partially flooded.
6. A review of plant arrangement and layout drawings to determine if safety-related equipment or components are located within individual compartments or cubicles which act as positive barriers against possible means of flooding, and if barriers or other means of physical separation are utilized between redundant safety-related trains. The review also will identify possible flow paths from interconnected nonsafety-related areas to rooms that house safety-related SSCs (e.g., leakage through interconnecting doorways).
7. A review of the design features that will be used to mitigate the effects of internal flooding (e.g. adequate drainage, sump pumps, etc.) if these features are safety-related to ensure adequate time to perform a safe shutdown. Only seismically-qualified systems should be assumed to be available to mitigate the effects of the flooding from non-seismic systems.
8. A review of plant structure design drawings to determine if the flood protection of any safety-related structure, such as below-grade groundwater seepage depends on a permanent dewatering system. If so, the dewatering system should be designed as a safety-related system and should meet the single failure criterion requirements. In addition, a review of the accidental release of liquid effluents into the groundwater should be performed in accordance with SRP Section 2.4.13.
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 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 internal flood protection review included all systems and components whose failure could prevent safe shutdown of the plant and maintenance thereof or result in significant uncontrolled release of radioactivity. Based on the review of the applicant's proposed design criteria, design bases, and safety classifications for safety-related SSCs necessary for a safe plant shutdown during and following the flood condition from either external or internal causes, the staff concludes that the design of the facility for flood protection conforms to the requirements as set forth in 10 CFR 50, Appendix A, GDC 2 and GDC 4. This conclusion is based on the applicant having met these requirements with respect to protection of SSCs important to safety from the effects of external and internal flooding by:

1. Identifying all possible sources of internal flooding, including all pipe breaks postulated in SRP Sections 3.6.1 and 3.6.2, full circumferential breaks of non-seismic moderate energy piping, failures of non-seismic internal and external tanks and vessels, backflow through drains, and operation of the fire protection system. The application also considers possible flow paths from non-safety related areas into areas containing safety-related SSCs.
2. Using a method that has been reviewed and found acceptable by the staff to protect SSCs important to safety from flooding by external and internal causes. The design includes the separation of redundant trains of safety-related SSCs, the use of protective barriers and enclosures wherever necessary, the placement of essential SSCs above internal flood levels, and an analysis that shows that any safety-related SSCs subject to flooding will retain their safety function if submerged.
3. Using a safety-related dewatering system that meets single-failure criteria if safety-related SSCs depend on its operation to maintain their safety function.

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 SRP 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 Criterion 2, "Design Bases for Protection Against Natural Phenomena."
2. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Bases."
3. Regulatory Guide 1.29, "Seismic Design Classification."

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.

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