U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

5.4.11 PRESSURIZER RELIEF TANK

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of reactor thermal-hydraulic systems in pressurized-water reactors

Secondary - None

I. AREAS OF REVIEW

The typical pressurized-water reactor (PWR) primary systems include a pressurizer relief tank (a pressure vessel) to condense and cool the discharge from the pressurizer safety and relief valves. Discharges from small relief valves located inside the containment may also be piped to the tank. Tank capacity is based on a requirement to absorb the pressurizer discharge during a specified step load decrease.

Not all PWR primary systems contain a pressurizer relief tank. However, all PWR pressurizers are expected to have one or more sources of effluent during normal operations, anticipated operational occurrences (AOOs), or accident events. That effluent must be routed away from the pressurizer to appropriate locations. To that end, all PWR primary systems are expected to have one or more components and/or systems that perform functions similar to those of the pressurizer relief tank system, as described herein. The staff should review those components and/or systems in accordance with this section, to the extent practical.

The review of the pressurizer relief tank, as described in the applicant's safety analysis report (SAR), includes the tank, piping connections from the tank to the pressurizer relief and safety valves, tank spray system and associated piping, nitrogen supply piping, and piping leaving the tank to the cover gas analyzer and to the reactor coolant drain tank. The pressurizer relief tank system is nonsafety related; the review focuses primarily on ensuring, in accordance with applicable criteria, that its operation is consistent with transient analyses of related systems and that a failure or malfunction of the system could not adversely affect essential systems or components.

The specific areas of review are as follows:

1. Review of the seismic design classification of the pressurizer relief tank and its supporting systems.

2. Review of the quality standards to which the tank and its supporting systems will be designed, fabricated, erected, and tested.

3. Review of the design measures taken to prevent system performance degradation that falls below acceptable levels as a result of failures of other nearby systems or as a result of a tank failure during an anticipated abnormal occurrence.

4. Review of the steam condensing capacity of the tank compared to the largest anticipated plant step load decrease.

5. Review of the instrumentation provided to measure and indicate pressurizer relief tank pressure, temperature, and liquid level and to signal the operator in the event of abnormal parameters.

6. Review of the tank rupture disk relief capacity compared to the capacity of the pressurizer relief and safety valves.

7. 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.

8. 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 will determine that the anticipated and maximum pressurizer relief and safety valve discharge rates are acceptable based on a review of the limiting transient and that the size of the piping between the valves and the tank is adequate as part of the primary review responsibility for SRP Section 5.2.2.

2. The reviewer will verify that inservice inspection requirements are met for system components as part of the primary review responsibility for SRP Section 6.6.

3. The reviewer, upon request, will verify the compatibility of the construction materials with service conditions.

4. The reviewer will confirm that the system design complies with applicable codes and standards as part of the primary review responsibility for SRP Sections 3.9.1 through 3.9.3. The reviewer will also determine the acceptability of the seismic and quality group classifications for system components as part of the primary review responsibility for SRP Sections 3.2.1 and 3.2.2.

5. The responsible reviewers for SRP Sections 9.5.1, 16.0, and Chapter 17 will coordinate and perform the reviews for fire protection, technical specifications, and quality assurance, respectively.

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

II. ACCEPTANCE CRITERIA

Requirements

Because the pressurizer relief tank system is inside the containment, possibly in close proximity to essential systems and components, acceptance is based on the ability of the system, in the event of a failure or malfunction, to avoid an adverse effect on the equipment necessary to bring the plant to a safe shutdown condition, prevent accidents, or mitigate the consequences of an accident.

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

1. General Design Criterion (GDC) 2, as it relates to the protection of essential systems from the effects of earthquakes. Acceptance is based on meeting the guidelines in Position C.2 of Regulatory Guide 1.29 regarding the location of the tank in relation to other plant systems (the design of the tank system should be such that the plant safety-related systems would continue to perform their safety functions in the event of a tank failure) and in Position C.3 regarding the extension of seismic Category I boundaries.

2. GDC 4, as it relates to a failure of the system that results in missiles or adverse environmental conditions that could produce unacceptable damage to safety-related systems or components.

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. Acceptance as it relates to the protection of essential systems from the effects of earthquakes is based on meeting the guidelines in Position C.2 of Regulatory Guide 1.29 regarding the location of the tank in relation to other plant systems (the design of the tank system should be such that the plant safety-related systems would continue to perform their safety functions in the event of a tank failure) and in Position C.3 regarding the extension of seismic Category I boundaries.

2. The staff uses the following specific criteria to determine whether the requirements of GDC 4 are met:

   A. The rupture disks have a relief capacity that at least equals the combined capacity of the pressurizer relief and safety valves, with sufficient allowance for rupture disk tolerance.

   B. The pressurizer relief tank volume and the quantity of water initially stored in the tank should be such that no steam or water will be released to containment under any normal operating conditions or AOOs. It should be assumed that the initial temperature of water inside the tank will be no lower than 49 °C (120 °F). Systems performing similar functions should also be shown to have no release to containment during normal operations and AOOs.

   C. The design of the pressurizer relief tank and rupture disk should accommodate full vacuum so that the tank will not collapse if the contents are cooled after a discharge of steam without the addition of nitrogen.

D. Alarms for high temperature, high pressure, and high and low liquid levels for the pressurizer relief tank have been provided. Systems performing similar functions should also have appropriate instrumentation to inform the operator about the condition of the systems.

E. The location of the tank should be such that the rupture discs do not pose a missile threat to safety-related equipment.

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 the design of SSCs important to safety will withstand the effects of expected natural phenomena, combined with the appropriate effects of normal and accident conditions, without losing the capability to perform their safety functions. The design of nonsafety-related equipment, such as the pressurizer relief tank, should be consistent with this objective.

   GDC 2 applies to SRP Section 5.4.11 and the reviewer must verify that the design of the pressurizer relief system is consistent with transient analyses of related or adjacent systems and that a failure or malfunction of the pressurizer relief tank system will not adversely affect the performance (in accordance with applicable criteria) of safety-related SSCs.

   Meeting the requirements of GDC 2 provides assurance that the failure of the pressurizer relief tank system will not prevent SSCs important to safety from performing their intended safety functions.

2. Compliance with GDC 4 requires that the design of components important to safety accommodates the effects of, and is compatible with, environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents and dynamic effects such as pipe whip, missiles, and discharging fluids. The design of nonsafety-related equipment such as the pressurizer relief tank should be consistent with that design objective.

   GDC 4 applies to SRP Section 5.4.11 and the reviewer must verify that a failure of the pressurizer relief tank system will not generate missiles or adverse environmental conditions that could damage safety-related SSCs.

   Meeting the requirements of GDC 4 provides assurance that the pressurizer relief tank system will not generate missiles or cause adverse environmental conditions that could damage safety-related SSCs to the degree that they cannot perform their intended safety functions.

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.

The NRC staff uses the procedures below in the construction permit review to confirm that the design criteria and bases and the preliminary design described in the SAR meet the acceptance criteria in Subsection II of this SRP section. For operating license reviews, the staff uses these procedures to verify that the final design appropriately implements initial design criteria and bases.

For DC and COL applications submitted under Part 52, the level of information reviewed should be consistent with that of a FSAR submitted in an OL application. However, verification that the as-built facility conforms to the approved design is performed through the ITAAC process.

1. The staff reviews the SAR to establish that the pressurizer relief tank system description and related diagrams clearly delineate both system operation and the system's capability to accept the steamflow released from the pressurizer for step load decreases.

2. The staff reviews the SAR to verify that the rupture disks on the relief tank have a relief capacity that at least equals the combined capacity of the pressurizer relief and safety valves. The reviewer determines that the tank design pressure provides a conservative margin above the calculated pressure resulting from the maximum design relief and safety valve discharge (i.e., the maximum surge resulting from complete loss of load). The reviewer verifies that the tank and rupture disks are designed for full vacuum to prevent tank collapse if the contents are cooled after a discharge without the addition of nitrogen.

3. The staff reviews the pressure suppression capability of the system to ensure proper system operation. The reviewer verifies the mass and energy blowdown data, including rate of energy release, to evaluate the above effects.

4. The staff reviews the piping and instrumentation diagrams to verify that alarms for high temperature and pressure and alarms for high and low liquid levels have been provided for the pressurizer relief tank.

5. The reviewer verifies that the system will function following anticipated abnormal occurrences. The reviewer evaluates the failure modes and effects analysis presented in the SAR to ensure the function of required components, traces the availability of these components on system drawings, and confirms that the SAR information includes verification that minimum system flow and heat transfer requirements are met for each degraded situation over the required time spans. For each case, the design is acceptable if minimum system requirements are met.

6. The reviewer determines that a failure of the pressurizer relief tank systems or portions of the systems located close to safety-related systems will not preclude essential operations of these safety systems. Reference to the general arrangement and layout drawings for structures and systems will be necessary.

7. The reviewer determines that other systems inside the containment are protected from the effects of high-energy line breaks and moderate-energy leakage cracks in the pressurizer relief system. The reviewer examines the layout drawings to ensure that other systems are not located close to the pressurizer relief system and that protection from the effects of failure are provided.

8. 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 pressurizer relief tank system includes components and piping such as the pressurizer relief and safety valve connections to the tank, relief tank spray system piping, nitrogen supply piping, and piping leaving the tank to the cover gas analyzer and reactor coolant drain tank. The design of the pressurizer relief tank system conforms to nonnuclear safety and Quality Group D (see Regulatory Guide 1.26) requirements because the system is not necessary for safe shutdown, accident prevention, or accident mitigation.

1. The applicant’s design meets the requirements of GDC 4 as it relates to protection against the effects of earthquakes through conformance with Positions C.2 and C.3 of Regulatory Guide 1.29. Position C.2 indicates that the failure of nonsafety-related systems should not have an adverse effects on safety-related systems. Position C.3 indicates that seismic Category 1 design requirements should extend to the first seismic restraint beyond the defined boundaries (i.e., the piping from the safety and relief valves to the first downstream restraint).

2. The applicant’s design meets the requirements of GDC 4 as it relates to the protection of safety-related equipment from adverse environmental effects and from missiles generated by rupture disc failure. This criterion is met because the system design prevents steam or water release to containment under any normal operating conditions or anticipated abnormal occurrences and because the tank is orientated such that the rupture discs do not pose a missile hazard to safety-related equipment.

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 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. 10 CFR Part 52.

4. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

5. Regulatory Guide 1.29, "Seismic Design Classification."