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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

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U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

5.2.2 OVERPRESSURE PROTECTION

REVIEW RESPONSIBILITIES

Primary - Reactor Systems Branch (SRXB)

Secondary - None

I. AREAS OF REVIEW

A. Overpressure protection for the reactor coolant pressure boundary (RCPB), during power operation of the reactor, is ensured by application of relief and safety valves and the reactor protection system. For boiling water reactors (BWRs), the area of review includes relief and safety valves on the main steam lines and piping from these valves to the suppression pool. For pressurized water reactors (PWRs), the area of review includes pressurizer relief and safety valves and the piping from these valves to the quench tank, on the primary and steam generator relief and safety valves on the secondary.

The adequacy of the proposed preoperational and initial startup test programs is examined as a part of this review. The reviewer also evaluates the proposed technical specifications to assure that they are adequate with regard to limiting conditions of operation and periodic surveillance testing.

B. Overpressure protection for the RCPB, during low temperature operation of the plant (startup, shutdown), is ensured by the application of pressure relieving systems that function during the low temperature operation. For PWRs the area of review includes relief valves with piping to the quench tank, the makeup and letdown system, and the RHR system which may be operating when the primary system is water solid. For BWRs, no special area of review is required since BWRs never operate in water-solid conditions.

In addition, the SRXB will coordinate its review with the evaluations of other branches that have primary review responsibility for other portions of the overpressure protection as follows: The Human Factors Assessment Branch (LHFB), as part of its primary review responsibility for SRP Section 14.2, reviews proposed preoperational and initial startup test programs to assure that overpressure components will perform their safety function. The Mechanical Engineering Branch (EMEB), as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2, reviews seismic design criteria for components of the overpressure protection system. The EMEB, as part of its primary review responsibility for SRP Section 3.10 and the Plant Systems Branch (SPLB) for SRP Section 3.11, review installation criteria for components of the overpressure protection system. The Instrumentation and Control Systems Branch (SICB), as part of its primary review responsibility for SRP Section 7.6, reviews the adequacy of controls and instrumentation for the automatic and manual actuation of overpressure protection components. The Technical Specifications Branch (OTSB), as part of its primary review responsibility for SRP Section 16.0, reviews technical specifications. The Performance and Quality Evaluation Branch (PQEB), as part of its primary review responsibility for SRP Sections 17.1 and 17.2, reviews quality assurance requirements.

For those areas of review identified above as being reviewed as part of the primary review responsibility of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The SRXB acceptance criteria for the overpressure protection system are based on meeting the relevant requirements of the following regulations:

1. General Design Criterion 15, as it relates to the reactor coolant system and associated auxiliary, control, and protection systems being designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.

2. General Design Criterion 31, as it relates to the reactor coolant pressure boundary being designed with sufficient margin to assure that boundary behaves in a nonbrittle manner and the probability of rapidly propagating fracture is minimized.

Applications for construction permit should meet recommendations of Task Action Plan items II.D.1 and II.D.3 of NUREG-0718 (Ref. 4). Applications for operating license shall meet recommendations of Task Action Plan items II.D.1 and II.D.3 of NUREG-0737 (Ref. 5). Other specific acceptance criteria necessary to meet the requirements of GDC 15 and 32 are as follows:

A. For overpressure protection, during power operation of the reactor, the relief valves shall be designed with sufficient capacity to preclude actuation of safety valves, during normal operational transients, when assuming the following conditions at the plant:

   a. The reactor is operating at licensed core thermal power level.

b. All system and core parameters are at values within normal operating range that produce the highest anticipated pressure.

c. All components, instrumentation, and controls function normally.

Safety valves shall be designed with sufficient capacity to limit the pressure to less than 110% of the RCPB design pressure (as specified by the ASME Boiler and Pressure Vessel Code [Ref. 2]), during the most severe abnormal operational transient with reactor scram. Also, sufficient margin shall be available to account for uncertainties in the design and operation of the plant assuming:

(1) The reactor is operating at a power level that will produce the most severe overpressurization transient.

(2) All system and core parameters are at values within normal operating range, including uncertainties and technical specification limits that produce the highest anticipated pressure.

(3) The reactor scram is initiated by the second safety-grade signal from the reactor protection system.

(4) The discharge flow is based on the rated capacities specified in the ASME Boiler and Pressure Vessel Code (Ref. 2), for each type of valve.

3. Full credit is allowed for spring-loaded safety valves designed in accordance with the requirements of the ASME Boiler and Pressure Vessel Code (Ref.7).

B. The low temperature, overpressure protection (LTOP) system shall be designed in accordance with the requirements of Branch Technical Position RSB 5-2 attached to this SRP section (Ref. 3). The LTOP system shall be operable during startup and shutdown conditions below the enable temperature defined in paragraph B.2. of RSB 5-2.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to assure that the design criteria and bases and the preliminary design as set forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II of this SRP section.

For operating license (OL) applications, the procedures 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 and in the report on overpressure protection. The latter report is required by the ASME Code (Ref. 2) and is used as the basis for many of the individual review steps outlined below during the OL review. The OL review also includes the proposed technical specifications, to assure that they are adequate in regard to limiting conditions of operation and periodic surveillance testing.

The following steps are taken by the SRXB reviewer in determining that the acceptance criteria of subsection II have been met. These steps should be applied to CP and OL reviews as appropriate. Previously reviewed designs may be used as a guide; however, the reviewer must verify that any changes are justified.

1. The piping and instrumentation diagrams are examined to determine the number, type, and location of the safety and relief valves in both the primary and secondary systems, and of discharge lines, instrumentation, and other components.

2. All other functions of the components, instruments, or controls used for overpressure protection and the interfaces with all other systems are identified. The effects of these other functions or systems on operation of the overpressure protection system are determined. For PWRs, failure of the makeup and letdown system or the RHR system is examined to assure overpressure protection during low temperature operation of the plant.

3. The capacities, setpoints, and setpoint tolerances for all safety and relief valves are identified.

4. All of the reactor trip signals which occur during overpressure transients, including their setpoints and setpoint tolerances, are identifed.

5. All transients analyzed in Chapter 15 of the SAR that result in an increase in the pressure experienced by the RCPB are examined. The predicted peak pressures are identified and the operating conditions and setpoints used in the analysis are reviewed to assure that they are suitably conservative.

6. The proposed plant technical specifications are reviewed to:

   a. Confirm the suitability of the limiting conditions of operation, including the proposed time limits and reactor operating restrictions for periods when system equipment is inoperable due to repairs and maintenance.

   b. Verify that the frequency and scope of periodic surveillance testing is adequate.

IV. EVALUATION FINDINGS

The reviewer verifies that the SAR contains sufficient information and the review supports the following kinds of statements and conclusions, which should be included in the staff's safety evaluation report:

The staff concludes that the overpressurization protection system is acceptable and meets the relevant requirements of GDC 15 and 31 and Appendix G to 10 CFR Part 50. This conclusion is based on the following:

1. BWRs

   The overpressure protection system prevents overpressurization of the reactor coolant pressure boundary under the most severe transients and limits the reactor pressure during normal operational transients. Overpressure protection is provided by __________ safety and relief valves located on the four main steam lines between the reactor vessel and the first isolation valve inside the drywell. The relief and safety valves are distributed among the four main steam lines such that a single accident cannot disable the automatic overpressure protection function. The valves discharge through piping to the suppression pool.

The valves have setpoints that range from ________ to ___________ psig. Their total capacity at their setpoint is ________ % of rated steam flow.

To determine the ability of the overpressure protection system to prevent overpressurization, the applicant has analyzed the most severe overpressure transients. The analysis was performed assuming that: (a) the plant is in operation at design conditions *% of rated steam flow and a reactor vessel dome pressure of * psig), and (b) the reactor is shut down by _________. The calculated peak pressure at the bottom of the vessel is ________ psig, a value within the code allowable of _____ psig (110% of vessel design pressure).

2. PWRs

The overpressure protection system prevents overpressurization of the reactor coolant pressure boundary under the most severe transients and limits the reactor pressure during normal operational transients. Overpressurization protection is provided by _________ safety valves. These valves discharge to the pressurizer quench tank through a common header from the pressurizer. The safety and relief valves in the primary, in conjunction with the steam generator safety and relief valves in the secondary, and the reactor protection system, will protect the primary system against overpressure in the event of a complete loss of heat sink.

The peak primary system pressure following the worst transient is limited to the ASME Code allowable (110% of the design pressure) with no credit taken for nonsafety-grade relief systems. The _________ plant was assumed to be operating at design conditions (% of rated power) and the reactor is shut down by a _______ scram. The calculated pressure at the bottom of the vessel is _________ psig, a value within the code allowable of ______ psig (110% of vessel design pressure).

Overpressure protection during low temperature operation (defined in Branch Technical Position RSB 5-2) of the plant is provided by ________ .

The applicant has met GDC 15 and 31 and Appendix G since they have implemented the guideline of BTP RSB 5-2. In addition, the applicant has incorporated into their design the recommendations of Task Action Plan items II.D.1 and II.D.3 of NUREG-0718 and NUREG-0737.

V. IMPLEMENTATION

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

*Normally, BWRs are analyzed at 105% rated steam flow at a pressure of 1040 psig. 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.

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

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 15, "Reactor Coolant System Design."

2. ASME Boiler and Pressure Vessel Code, Section III, Article NM-7000, "Protection Against Overpressure," American Society of Mechanical Engineers.

3. Branch Technical Position RSB 5-2, "Overpressurization Protection of Pressurized Water Reactors While Operating at Low Temperatures," attached to this SRP section.

4. NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License."

5. NUREG-0737, "Clarification of TMI Action Plan Requirements."

6. 10 CFR Part 50, Appendix G, "Fracture Toughness Requirements."

7. ASME Boiler and Pressure Vessel Code, Section III, Article NB-7611, "Spring-Loaded Safety Valves."

8. 10 CFR Part 50, Appendix A, General Design Criterion 31, "Fracture Prevention of Reactor Coolant Pressure Boundary."

BRANCH TECHNICAL POSITION RSB 5-2

OVERPRESSURIZATION PROTECTION OF PRESSURIZED WATER REACTORS WHILE OPERATING AT LOW TEMPERATURES

A. Background

General Design Criterion 15 of Appendix A of 10 CFR Part 50 requires that "the Reactor Coolant System and associated auxiliary, control, and protection systems shall be designed with sufficient margin to assure that the design conditions of the reactor coolant pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences."

Anticipated operational occurrences, as defined in Appendix A of 10 CFR Part 50, are "those conditions of normal operation which are expected to occur one or more times during the life of the nuclear power unit and include but are not limited to loss of power to all recirculation pumps, tripping of the turbine generator set, isolation of the main condenser, and loss of all offsite power."

Appendix G of 10 CFR Part 50 provides the fracture toughness requirements for reactor pressure vessels under certain conditions. To assure that the Appendix G limits of the reactor coolant pressure boundary are not exceeded during any anticipated operational occurrences, technical specification pressure-temperature limits are provided for operating the plant.

The primary concern of this position is that during startup and shutdown conditions at low temperature, especially in a water-solid condition, the reactor coolant system pressure might exceed the reactor vessel pressure-temperature limitations in the technical specifications established for protection against brittle fracture. This inadvertent overpressurization could be generated by any one of a variety of malfunctions or operator errors. Many incidents have occurred in operating plants as described in Reference 1.

Additional discussion on the background of this position is contained in Reference 1.

B. Branch Position

1. A system should be designed and installed which will prevent exceeding the applicable technical specifications and Appendix G limits for the reactor coolant system while operating at low temperatures. The system should be capable of relieving pressure during all anticipated overpressurization events at a rate sufficient to satisfy the technical specification limits, particularly while the reactor coolant system is in a water-solid condition.

2. The low temperature overpressure protection system should be operable during startup and shutdown conditions below the enable temperature,

defined as the water temperature corresponding to a metal temperature of at least RT_{NDT} + 90°F at the beltline location (1/4t or 3/4t) that is controlling in the appendix G limit calculations.

3. The system should be able to perform its function assuming any single active component failure. Analyses using appropriate calculational techniques must be provided which demonstrate that the system will provide the required pressure relief capacity assuming the most limiting single active failure. The cause for initiation of the event, e.g., operator error, component malfunction should not be considered as the single active failure. The analyses should assume the most limiting allowable operating conditions and systems configuration at the time of the postulated cause of the overpressure event.

   All potential overpressurization events should be considered when establishing the worst-case event. Some events may be prevented by protective interlocks or by locking out power. These events should be identified on an individual basis. If the events are excluded from the analyses, the controls to prevent these events should be in the plant technical specifications.

4. The system should be designed using IEEE Std.-279 as guidance (see implementation). The system may be manually enabled; however, an alarm to alert the operator to enable the system at the correct plant condition during cooldown, should be provided. Positive indication should be provided to indicate when the system is enabled. An alarm should be provided when the protective action is initiated.

5. To assure operational readiness, the overpressure protection system should be testable. Technical specification surveillance requirements should include:

   a. A test performed to assure operability of the system (exclusive of relief valves) prior to each shutdown.

   b. A test for valve operability, as a minimum, be conducted as specified in the ASME Code Section XI.

6. The system must meet the requirements of Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants," and Section III of the ASME Code.

7. The overpressure protection system should be designed to function during an Operating Basis Earthquake. It should not compromise the design criteria of any other safety-grade system with which it would interface, such that the requirements of Regulatory Guide 1.29, "Seismic Design Classification," are met.

8. The overpressure protection system should not depend on the availability of offsite power to perform its function. The system should be operable from battery-backed power sources, not necessarily Class 1E buses.

9. Overpressure protection systems which take credit for an active component(s) to mitigate the consequences of an overpressurization

event should include additional analyses considering inadvertent system initiation/actuation or provide justification to show that existing analyses bound such an event.

10. If pressure relief is from a low pressure system, not normally connected to the primary system, the overpressure protection function should not be defeated by interlocks which would isolate the low pressure system from the primary coolant system. (See BTP ICSB3)

D. REFERENCES

1. NUREG-0138, Staff Discussion of Fifteen Technical Issues Listed in Attachment to November 3, 1976 Memorandum from Director, NRR, to NRR Staff.