U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

5.2.5 REACTOR COOLANT PRESSURE BOUNDARY LEAKAGE DETECTION

REVIEW RESPONSIBILITIES

Primary - ~~Auxiliary Systems Branch (ASB)~~ Plant Systems Branch (SPLB)[1]

Secondary - None

I. AREAS OF REVIEW

The reactor coolant pressure boundary (RCPB) leakage detection systems are designed to provide a means of detecting and to the extent practical, identifying the source of the reactor coolant leakage. The ~~ASB~~ SPLB[2] reviews those areas of the SAR relating to the system design to determine its adequacy to perform the detection and monitoring function to assure conformance with the requirements of General Design Criteria 2 and 30. The ~~ASB~~ SPLB[3] reviews the system design with respect to the following:

1. The system is capable of identifying to the extent practical, the source of the reactor coolant leakage.

2. The system is capable of separately monitoring and collecting leakage from both identifiable and unidentifiable sources.

3. The system is adequately equipped with indicators and alarms for each leakage detection system in the main control room, and readily permits qualitative interpretations of such indicators.

4. The system provides for the monitoring of systems connected to the RCPB for signs of intersystem leakage.

Review Interfaces:[4]

SPLB also reviews the environmental capability of those portions of the system necessary to perform their design safety functions under abnormal, accident, and postaccident environments as part of its primary review responsibility for SRP section 3.11.[5]

In addition, the ~~ASB~~ SPLB[6] will coordinate other branches' evaluations that interface with the overall review of the system as follows:

1. The ~~Instrumentation and Control Systems Branch (ICSB)~~ Instrumentation and Controls Branch (HICB)[7] ~~and the Power Systems Branch (PSB)~~ determines the adequacy of the design, installation, testing and inspection of electrical components (sensing~~,~~ and control~~,~~ ~~power~~) required for proper operation as part of ~~their~~its primary review responsibility for SRP Sections 7.5 ~~and 8.3 respectively~~[8].

2. The Electrical Engineering Branch (EELB) determines the adequacy of the design, installation, testing and inspection of electrical components (power) required for proper operation as part of its primary review responsibility for SRP Section 8.3.[9]

3. The ~~Equipment Qualifications Branch (EQB)~~ Mechanical Engineering Branch (EMEB)[10] reviews the seismic qualification of Category I instrumentation of mechanical and electrical equipment as part of its primary review responsibility for SRP Sections 3.10 ~~and 3.11 respectively~~[11].

4. The ~~Containment Systems Branch (CSB)~~ Containment Systems and Severe Accident Branch (SCSB)[12] reviews the containment isolation capability of the system as part of its primary review responsibility for SRP Section 6.2.4.

5. The ~~Mechanical Engineering Branch (MEB)~~ Mechanical Engineering Branch (EMEB)[13] determines that the components and piping are designed in accordance with applicable codes and standards as part of its primary review responsibility for SRP Sections 3.9.1 through 3.9.3. The ~~MEB~~EMEB[14], also, determines the acceptability of the seismic and quality group classifications for system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2.

6. The ~~Materials Engineering Branch (MTEB)~~ Civil Engineering and Geosciences Branch (ECGB)[15] verifies that inservice inspection requirements are met for system components as part of its primary review responsibility for SRP Section 6.6, and upon request, verifies the compatibility of the materials of construction with service conditions.

7. The review for Technical Specifications ~~and Quality Assurance are~~is coordinated and performed by the ~~Licensing Guidance Branch~~Technical Specifications Branch (TSB)[16] ~~and Quality Assurance Branch~~ as part of ~~their~~its primary review responsibility for SRP Section~~s~~ 16.0 ~~and 17.0 respectively~~.[17]

8. The review for Quality Assurance is coordinated and performed by the Quality Assurance and Maintenance Branch (HQMB) as part of its primary review responsibility for SRP Chapter 17.[18]

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

II. ACCEPTANCE CRITERIA

The acceptability of the design of the RCPB Leakage Detection Systems as described in the applicant's safety analysis report (SAR) is based on specific general design criteria and regulatory guides. The design of the system is acceptable if the integrated design of the system is in accordance with the following criteria:

1. General Design Criterion 2 as it relates to the capability of the systems to maintain and perform their safety functions following an earthquake. Acceptance is based on meeting the guidelines of Regulatory Guide 1.29, positions C-1 and C-2.

2. General Design Criterion 30 as it relates to the detection, identification and monitoring of the source of reactor coolant leakage. Acceptance is based on meeting the guidelines of Regulatory Guide 1.45, positions C-1 through C-9.

Technical Rationale:[19]

The technical rationale for application of the above acceptance criteria to the reactor coolant pressure boundary leakage detection systems is discussed in the following paragraphs:

1. GDC 2 requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena, including earthquakes, without loss of capability to perform their intended safety functions. The RCPB Leakage Detection system detects leakage in the RCPB after the occurrence of an earthquake to provide an early indication of degradation so that corrective action can be taken before such degradation becomes sufficiently severe to cause a leak rate greater than the capability of the makeup system to replenish the coolant loss. Regulatory Guide 1.29 describes an acceptable method of identifying and classifying those portions of the system that should be designed to withstand the effects of an SSE. Application of GDC 2 and RG 1.29 to the RCPB leakage detection system assures that plant operators have the capability to detect and respond to RCPB leakage after the occurrence of an earthquake. The prompt detection of, and response to, leakage from the RCPB after an earthquake reduces the possibility of a severe loss of coolant accident.

2. GDC 30 establishes the requirement for a system to detect and, to the extent practical, identify the location of reactor coolant leakage. The RCPB Leakage Detection system provides the capability to detect and identify RCPB leakage. Regulatory Guide 1.45 describes acceptable methods for implementing the requirement established in GDC 30 with regard to the selection of leakage detection systems for the reactor coolant pressure boundary. Compliance with GDC 30 and RG 1.45 assures operators an early indication of RCPB degradation thus minimizing the likelihood that a leak in the RCPB may go undetected and result in a severe loss of coolant accident.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to determine 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 the operating license (OL) review, the procedures are utilized 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.

Upon request from the primary reviewer, the coordinating review branches will provide input for the areas of review stated in subsection ~~III~~[20] of this SRP section. The primary reviewer obtains and uses such input as required to assure that the review procedures are complete.

The reviewer will select and emphasize material from the procedures described below, as may be appropriate for a particular case.

1. The reviewer verifies that identified leakage will be collected in tanks or sumps where its rate of accumulation will be monitored to obtain an identified leak rate. The reviewer should establish that the identified leakage is not only collected and monitored, but also done in such a fashion as to prevent identified leakage~~s~~[21] from masking unidentified leaks.

2. The reviewer verifies that the provisions for collecting, detecting and monitoring unidentified leakage are separate from identified leakage. The floor drainage system is reviewed to assure that leakage will flow readily to the sump or tank where it is collected without getting held up in any "reservoirs." The containment air coolers are reviewed to assure that leakage from "hot" systems which flashes into water vapor is readily condensed and that the condensate flows directly to the sump.

3. The reviewer determines that all potential intersystem leakage paths have been identified by the applicant. The reviewer determines that the instrumentation used in each path is appropriate and adequate to provide positive indication of intersystem leakage in the affected system and provides adequate monitoring capability so the limits assumed in the accident analyses are not exceeded. Intersystem leak detection methods include radioactivity, pressure, temperature, flow and pressure relief valve actuation indications, and the water inventory balance method. Table I shows some of the systems that require intersystem leakage monitoring.

4. The reviewer verifies that the leakage detection systems will remain functional for all seismic events not requiring a shut down and that the airborne particulate radioactivity monitoring system (APM) remains functional when subjected to the safe shutdown earthquake (SSE).

5. The reviewer verifies that all of the leakage detection systems have readouts in the control room and are provided with alarms. Direct reading systems, such as sumps, will normally indicate in liters per minute (L/m) (gpm)[22]. The indirect reading systems, such as the APM, will indicate in counts per minute. The reviewer determines that control room operators will have a chart or graph that permits rapid conversion of count rate into L/m (gpm)[23], that conversion procedures take into account the isotope being monitored

and the activity of the primary coolant, and that the plant will maintain a running record of background leakage, so that its effect may be factored out from any sudden increases in leak indication, which may be "unidentified" leakage and require prompt action. If monitoring is computerized, backup procedures should be available to the operator.

6. The reviewer verifies that the sensitivity and response of the detection system is acceptable over the entire range of expected plant operating conditions of which it is monitoring. The reviewer verifies that the instrumentation and methodology used to determine leak rates are adequate.

7. The reviewer determines that the radiation monitoring systems have a radioactive source built into the system (the SAR refers to this feature as a "check source") to permit operability testing and calibration during operation. The reviewer determines that provisions are made to test and calibrate the sump level detection system. He also determines that a method for calibrating the air cooler condensate flow system exists, wherever the radiation monitors are used, and that a method to calibrate them to RCPB leakage exists. The frequency of testing and calibration should be provided and justified. The reviewer also determines that periodic testing of the floor drainage system will be performed to check for blockage and ensure operability.

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.[24]

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and his review supports conclusions of the following type, to be included in the staff's safety evaluation report:

> The reactor coolant pressure boundary (RCPB) leakage detection system provides reliable monitoring of reactor coolant leakage from components of the reactor coolant pressure boundary by the use of combinations of atmospheric particulate monitors, radiogas monitors, level indicators and pressure, humidity and temperature indicators.
>
> The leakage detection systems provided to detect leakage from components of the reactor coolant pressure boundary furnish reasonable assurance that structural degradation, which may develop in pressure-retaining components of the RCPB and result in coolant leakage during service, will be detected on a timely basis, so that corrective actions can be made before such degradation could become sufficiently severe to jeopardize the safety of the system, or before the leakage could increase to a level beyond the capability of the makeup system to replenish the coolant loss.

The staff concludes that the design of the RCPB leakage detection systems is acceptable and meets the requirements of General Design Criterion 2 with respect to the capability to maintain and perform their safety functions in the event of earthquakes, and General Design Criterion 30

with respect to the detection, identification and monitoring of the source of reactor coolant leakage. This conclusion is based on the following:

1. The applicant has met the requirements of General Design Criterion 2 with respect to the systems capability to maintain and perform their safety functions in the event of earthquakes by meeting regulatory positions C-1 and C-2 of Regulatory Guide 1.29, and

2. The applicant has met the requirements of General Design Criterion 30 with respect to the detection, identification, and monitoring of the source of reactor coolant leakage by meeting regulatory positions C-1 through C-9 of Regulatory Guide 1.45.

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, analysis, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[25]

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.[26] 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.[27]

Implementation schedules for conformance to parts of the method discussed herein as contained ~~is~~in[28] the referenced regulatory guides.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design[29] Criterion 2, "Design Basis for Protection Against Natural Phenomena."

2. 10 CFR Part 50, Appendix A, General Design[30] Criterion 30, "Quality of Reactor Coolant Pressure Boundary."

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

4. Regulatory Guide 1.45, "Reactor Coolant Pressure Boundary Leakage Detection Systems."

Table 1. Systems and Components Connected to Reactor Coolant System and Require Intersystem Leakage Monitoring

I. In PWRs:

1. Accumulators
2. Safety Injection Systems (High and Low Pressure)
3. Pressurizer Relief Tank
4. Secondary Side of Steam Generators
5. Residual Heat Removal System (Inlet and Discharge)
6. Secondary Side of Reactor Coolant Pump Thermal Barriers
7. Secondary Side of Residual or Decay Heat Removal Heat Exchangers
8. Secondary Side of Letdown Line Heat Exchangers
9. Secondary Side of Reactor Coolant Pump Seal Water Heat Exchangers

II. In BWRs:

1. Safety Injection Systems (High and Low Pressure Core Spray and Coolant Injection Systems, High Pressure Core Flooder System[31])
2. Residual Heat Removal System (Inlet and Discharge)
3. Reactor Core Isolation Cooling System
4. Steam Side of High Pressure Coolant Injection (BWR-4)
5. Secondary Side of Reactor Water Cleanup System Heat Exchangers
6. Secondary Side of Reactor Coolant Pump Integral Heat Exchangers
7. Secondary Side of Residual Heat Removal Heat Exchangers

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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 name for this SRP section.
2.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name for this SRP section.
3.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name for this SRP section.
4.	SRP-UDP format item, Reformat Areas of Review.	Added "Review Interfaces" heading to Areas of Review. Reformatted existing description of review interfaces in numbered format to describe how SPLB reviews aspects of the RCPB leakage detection system under other SRP sections and how other branches support the review.
5.	SRP-UDP format item, current PRB names and abbreviations.	Moved reference to SRP section 3.11 to the beginning of the Review Interface section since SPLB has the primary review responsibility for this section.
6.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name for this SRP section.
7.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name and responsibility for SRP section 7.5.
8.	SRP-UPD format item, current PRB names and abbreviations.	Editorial change made to separate review interfaces for different PRBs 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.
9.	SRP-UDP format item, current PRB names and abbreviations.	Editorial change made to separate reviews by different PRBs into separate numbered paragraphs and to reflect the current PRB name and responsibility for SRP section 8.3.
10.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB for SRP section 3.10.
11.	Current PRB names and abbreviations.	Deleted reference to SRP Section 3.11 and moved it to the beginning of the Review Interface section since SPLB has the primary review responsibility for that section.

Item	Source	Description
12.	Current PRB names and abbreviations.	Editorial change to reflect current PRB for SRP section 6.2.4.
13.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name and responsibility for SRP sections 3.9.1 through 3.9.3.
14.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name and responsibility for SRP Sections 3.2.1 and 3.2.2.
15.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name and responsibility for SRP section 6.6.
16.	Current PRB names and abbreviations.	Editorial change made to reflect current PRB name and responsibility for SRP section 16.0.
17.	SRP-UDP format item, current PRB names and abbreviations.	Separated review interfaces for different PRBs 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.
18.	Current PRB names and abbreviations.	Editorial change made to separate text and reflect current PRB name and responsibility for SRP Chapter 17. Section 17.0 was changed to Chapter 17 since there is no Section 17.0 and the QA interface involves three sections in Chapter 17.
19.	SRP-UDP format item, develop Technical Rationales.	Technical rationale were developed and added for the Acceptance Criteria GDC 2 and 30. The SRP-UDP program requires that Technical Rationale be developed for the Acceptance Criteria.
20.	Editorial	Replaced incorrect reference to subsection II with the correct reference to subsection I.
21.	Editorial	Removed the "s" from leakages to correct a typographical error in the original document.
22.	SRP-UDP format item - NRC Metrication policy implementation.	Added liters per minute (L/m) and placed gpm in parentheses. The units were chosen based on usage in evolutionary plant FSERs.
23.	SRP-UDP format item - NRC Metrication policy.	Added liters per minute (L/m) and placed gpm in parentheses. The units were chosen based on usage in evolutionary plant FSERs.
24.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.

Item	Source	Description
25.	10 CFR 52 implementation.	Added a general description of items that should be discussed in the Evaluation Findings for the design certification reviews.
26.	SRP-UDP Format Item	Added boiler-plate statement regarding the applicability of the SRP to 10 CFR 52 license applications.
27.	SRP-UDP Format Item	Added boiler-plate statement regarding the applicability of the revised SRP to existing and future applications.
28.	Editorial	Replaced the word "is" with "in" to correct a typographical error in the original document.
29.	Editorial	Added the words, “General Design” to be consistent with how the reference is cited in other SRP sections.
30.	Editorial	Added the words, “General Design” to be consistent with how the reference is cited in other SRP sections.
31.	Potential Impact No. 25136	Updated Table 1 to include system nomenclature regarding the High Pressure Core Flooder System in the ABWR design which requires intersystem leakage monitoring. This system is part of the ABWR safety injection system.

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Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
697	Consider future work to revise RG 1.45 to incorporate the results of code comparison between IEEE 279 and IEEE 603.	No SRP change. This item will be tracked with IPD-7.0 Form 5.2.5-1.