



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

SECTION 9.3.5 STANDBY LIQUID CONTROL SYSTEM (BWR)

REVIEW RESPONSIBILITIES

Primary - Auxiliary Systems Branch (ASB)

Secondary - None

I. AREAS OF REVIEW

Boiling water reactor (BWR) plants include a standby liquid control system (SLCS) that provides backup capability for reactivity control independent of the control rod system. The SLCS functions by injecting a boron solution into the reactor to effect shutdown. This system has the capability for controlling the reactivity difference between the steady-state operating condition at any time in core life and the cold shutdown condition. The review covers the SLCS design to the point where the system connects to the reactor coolant system (RCS). The ASB reviews the system to determine its adequacy to perform the shutdown function to assure conformance with the requirements of General Design Criteria 2, 26, and 27. Other points reviewed by ASB are as follows:

1. The functional performance characteristics of SLCS components and the effects of adverse environmental occurrences, abnormal operational conditions, or accident conditions such as those due to a loss-of-coolant accident (LOCA).
2. The system to determine that a malfunction or a single failure of a component will not reduce the safety-related functional performance capabilities of the system.
3. The system design with respect to the capability to detect, collect, and control system leakage and the capability to isolate portions of the system in case of excessive leakage or component malfunctions.
4. The capability of the system to prevent precipitation of the neutron absorber in components and lines containing the absorber solutions.
5. The provisions for operational testing and the instrumentation and control features that verify that the system is available to operate in the correct mode.

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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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6. ASB also performs the following reviews under the SRP sections indicated:
- a. Review of flood protection is performed under SRP Section 3.4.1;
  - b. Review of the protection against internally generated missiles is performed under SRP Sections 3.5.1.1 and 3.5.1.2;
  - c. Review of the structures, systems and components to be protected against externally generated missiles is performed under SRP Section 3.5.2;
  - d. Review of high- and moderate-energy pipe breaks is performed under SRP Section 3.6.1; and
  - e. Review to verify that redundant reactivity control systems are not vulnerable to common mode failures is performed under SRP Section 4.6.

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

The Core Performance Branch (CPB) determines the adequacy of the specified boron neutron absorber quantities and concentrations required in the primary coolant to assure that the plant can be brought from rated power to cold shut-down at any time in core life with the control rods withdrawn in the rated power pattern as part of its primary review responsibility for SRP Section 4.3. The Structural Engineering Branch (SEB) determines the acceptability of the design analyses, procedures, and criteria used to establish the ability of Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as the safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4, and 3.8.5. The Mechanical Engineering Branch (MEB) determines that the components, piping, and structures 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 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. The MEB also reviews the adequacy of the inservice testing program of pumps and valves as part of its primary review responsibility for SRP Section 3.9.6. The Materials Engineering Branch (MTEB) 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. The Instrumentation and Control Systems Branch (ICSB) and Power Systems Branch (PSB) determine the adequacy of the design, installation, inspection, and testing of electrical components (sensing, control, and power) required for proper operation as part of their primary review responsibility for SRP Sections 7.1 and 8.1, respectively. The review for fire protection, technical specifications, and quality assurance are coordinated and performed by the Chemical Engineering Branch, Licensing Guidance Branch, and Quality Assurance Branch as part of their primary review responsibility for SRP Sections 9.5.1, 16.0, and 17.0, respectively. The Equipment Qualification Branch (EQB) reviews the seismic qualification of Category I instrumentation and electrical equipment and the environmental qualification of mechanical and electrical equipment as part of its primary review responsibility for SRP Sections 3.10 and 3.11, respectively. 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 referenced SRP sections of the corresponding primary branch.

## II. ACCEPTANCE CRITERIA

Acceptability of the SLCS design, as described in the applicant's Safety Analysis Report (SAR), is based on specific general design criteria and regulatory guides. The design of the SLCS is acceptable if the integrated design of the system is in accordance with the following criteria:

1. General Design Criterion 2, as related to structures housing the system and the system itself being capable of withstanding the effects of earthquakes. Acceptance is based on meeting the guidance of Regulatory Guide 1.29, Position C-1.
2. General Design Criterion 26, as related to the requirement that two independent reactivity control systems of different design principles be provided, and the requirement that one of the systems shall be capable of holding the reactor subcritical in the cold condition.
3. General Design Criterion 27, as related to the requirement that the reactivity control systems have a combined capability in conjunction with poison addition by the emergency core cooling system, of reliably controlling reactivity changes under postulated accident conditions. To meet GDC 27, the system should have suitable redundancy in components and features to assure system safety function assuming a single failure.

## 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 review of operating license (OL) applications, 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 I of this SRP section. The primary reviewer obtains and uses such input as required to assure that this review procedure is complete.

For the purpose of this SRP section, a typical system is assumed for use as a guide. It is assumed that the SLCS consists of a boron solution tank, a test water tank, two positive displacement pumps, two explosive valves, and associated local valves and controls. For cases where there are variations from this system, the reviewer would adjust the review procedures given below. However, the system design would be required to meet the acceptance criteria given in subsection II of this SRP section.

1. The SAR is reviewed to determine that the system description and piping and instrumentation diagrams (P&IDs) delineate the SLCS equipment. The reviewer, using the results of failure modes and effects analyses, comparisons with previously approved systems, or independent calculations, as appropriate, determines that the system can sustain the loss of any active component and meet the minimum system requirements for the safe shutdown and accident mitigation. The system P&IDs, layout drawings, and component descriptions and characteristics are reviewed to determine the following:

- a. The SLCS is classified Quality Group B and seismic Category I. Component and system descriptions in the SAR are reviewed by the ASB to verify that the above classifications have been included, and the P&IDs should indicate any points of change in piping quality group classification. The review for seismic design is performed by the SEB and the review for seismic and quality classification is performed by the MEB as indicated in subsection I of this SRP section.
  - b. Design provisions have been made that permit appropriate inservice inspection and functional testing of the system. It will be acceptable if the SAR information delineates a testing and inspection program and if the system drawings show the connections and special piping and equipment required by this program.
  - c. Using the results of the evaluation performed by the Core Performance Branch, the ASB determines that the system has the capability to store the required quantity of neutron absorber in solution and that the injection rate is sufficient to bring the reactor from rated power to cold shutdown at any time in core life with the control rods remaining withdrawn in the rated power pattern, taking into account the reactivity gains from complete decay of the rated power xenon inventory, an allowance for imperfect mixing and leakage, and dilution by the residual heat removal system.
  - d. The system P&IDs indicate that adequate means are provided to maintain the system temperature above the saturation temperature of the neutron absorber solution.
  - e. The controls and the summary of operating and test procedures for neutron absorber addition are adequate.
2. The reviewer verifies that the safety function of the system will be maintained as required in the event of adverse environmental phenomena such as earthquakes, tornadoes, hurricanes, and floods, or in the event of certain pipe breaks or loss of offsite power. The reviewer uses engineering judgment, failure modes and effects analyses, and the results of reviews performed under other SRP sections, as applicable, to determine the following:
- a. The failure of systems not designed to seismic Category I standards and located close to essential portions of the system, or of non-seismic structures that house, support, or are close to essential portions of the SLCS, will not preclude operation of the SLCS. Reference to SAR sections describing site features and the general arrangement and layout drawings will be necessary, as well as the SAR tabulation of seismic design classifications for structures and systems. Statements in the SAR that verify that the above conditions are met are acceptable. (CP)
  - b. The SLCS is protected from the effects of floods, hurricanes, tornadoes, and internally or externally generated missiles. Flood protection and missile protection criteria are discussed and evaluated in detail under the SRP Section 3 series. The location and the design of the system, structures, and pump rooms (cubicles) are reviewed to determine that the degree of protection provided is adequate. A statement to the effect that the system is located in a seismic Category I structure that is tornado missile and flood protected, or that components of

the system will be located in individual cubicles or rooms that will withstand the effects of both flooding and missiles is acceptable.

- c. Essential components and subsystems (i.e., those necessary for safe shutdown) can function as required in the event of loss of offsite power. The system design is acceptable if the SLCS meets minimum system requirements as stated in the SAR assuming a failure of a single active component within the system or in the auxiliary electric power source which supplies the system. Statements in the SAR and the results of failure modes and effects analyses are considered in assuring that the system meets these requirements. This will be an acceptable verification of system functional reliability.
3. The descriptive information, P&IDs, layout drawings, and failure modes and effects analyses in the SAR are reviewed to assure that essential portions of the system will function following design basis accidents assuming a single active component failure. The reviewer evaluates the information in the SAR to assure function of required components, traces the availability of these components on system drawings, and checks that the SAR contains verification that minimum system flow requirements are met for each accident situation for the required time spans. For each case, the design will be acceptable if minimum system requirements are met.

#### 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 standby liquid control system (SLCS) includes storage tanks, pumps, valves, and piping to the point where the system connects to the reactor coolant boundary. The SLCS, which is provided for BWRs only, provides reactivity control in the event the control rods cannot be inserted. The basis for acceptance in the staff review of the standby liquid control system is the conformance of the applicant's design and design criteria to the Commission's regulations as set forth in the General Design Criteria and to the positions of applicable regulatory guides, staff technical positions, and industry standards.

The staff concludes that the design of the standby liquid control system is acceptable and conforms to the requirements of General Design Criteria 2, 26, and 27 with respect to seismic design, reactivity control system redundancy, and reactivity control system capability. This conclusion is based on the following:

1. The applicant has met the requirements of General Design Criterion 2 with respect to seismic design by meeting regulatory position C-1 of Regulatory Guide 1.29.
2. The applicant has met the requirements of General Design Criterion 26 with respect to the redundancy of reactivity control systems by providing two independent reactivity control systems of different design principles and with respect to the capability of holding the reactor core subcritical under cold conditions.

3. The applicant has met the requirements of General Design Criterion 27 with respect to the combined capabilities of the reactivity control systems to reliably control reactivity changes under postulated accident conditions since the SLCS has the capability to shut down the reactor with all control rods withdrawn, assuming a single failure.

#### V. IMPLEMENTATION

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

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 regulatory guide.

#### 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 26, "Reactivity Control System Redundancy and Capability."
3. 10 CFR Part 50, Appendix A, General Design Criterion 27, "Combined Reactivity Control Systems Capability."
4. Regulatory Guide 1.29, "Seismic Design Classification."