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 and Power Conversion Systems Branch (APCSB)

Secondary - Core Performance Branch (CPB)
Mechanical Engineering Branch (MEB)
Materials Engineering Branch (MTEB)
Structural Engineering Branch (SEB)
Electrical, Instrumentation and Control Systems Branch (EICSB)
Reactor Systems Branch (RSB)

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 APCSB reviews the system to determine its adequacy to perform the shutdown function. Other points reviewed by APCSB 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 with respect to the effects of postulated breaks and cracks in high and moderate energy piping.

4. To determine that quality group and seismic design requirements are met for the system.

5. 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.

6. The capability of the system to prevent precipitation of the neutron absorber in components and lines containing the absorber solutions.

7. The provisions for operational testing and the instrumentation and control features that verify that the system is available to operate in the correct mode.

8. The applicant's proposed technical specifications for operating license applications as they relate to areas covered in this plan.

Secondary review evaluations are performed by other branches to complete the overall evaluation of the system. The secondary reviews are as follows. The 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 shutdown at any time in core life with the control rods withdrawn in the rated power pattern. The 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. The MEB reviews the seismic qualification testing of components and confirms that components, piping, and structures are designed in accordance with applicable codes and standards. The RSB determines that the assigned seismic and quality group classifications for system components are acceptable. The MTEB verifies that inservice inspection requirements are met for system components and upon request verifies the compatibility of the materials of construction with service conditions. The EICSB determines the adequacy of the design, installation, inspection, and testing of electrical components (sensing, control, and power) required for proper operation.

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. Additional bases for determining the acceptability of the SLCS include the degree of similarity of the design with that for previously reviewed plants with satisfactory operating experience and independent calculations by the staff. Listed below are specific acceptance criteria related to the SLCS.

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 natural phenomena such as earthquakes, tornadoes, hurricanes, and floods.

2. General Design Criterion 4, with respect to structures housing the system and the system itself being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks.

3. General Design Criterion 21, as related to system design requirements for high functional reliability, inservice testability, and capability to meet the single failure criterion.

4. 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.

5. General Design Criterion 27, as related to the SLCS capability to control the rate of reactivity changes resulting from normal power changes and the capability to maintain the reactor core subcritical under cold conditions.

6. Regulatory Guide 1.26, as related to the quality group classification of system components.

7. Regulatory Guide 1.29, as related to the seismic design classification of system components.

8. Branch Technical Positions APCSB 3-1 and MEB 3-1, as related to breaks in high and moderate energy piping systems outside the drywell.

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 Section II of this plan. 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.

The procedures for OL applications include a determination that the technical specifications prepared by the applicant are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review.

For the purpose of this review plan, 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 Section II.

1. The SAR is reviewed to determine that the system description section 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 of 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 or higher and seismic Category I. Component and system descriptions in the SAR should verify that these classifications have been included, and the P&IDs should indicate any points of change in piping quality group classification.

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 APCSB 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 PID's 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 review plans, 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 missles. Flood protection and missile protection criteria are discussed and evaluated in detail under the standard review plans for Chapter 3 of the SAR. 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 portions of the system are protected from the effects of high and moderate energy line breaks. Layout drawings of the system are reviewed to assure that no high or moderate energy piping systems are close to essential portions of the SLCS or that protection from the effects of failure is provided. The means of providing such protection will be given in Section 3.6 of the SAR and procedures for reviewing the information presented are given in the corresponding review plans.

d. 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, PID's, 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 systems 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 is provided on BWR's only. The scope of review of the SLCS for the _____ plant included layout drawings, process flow diagrams, piping and instrumentation diagrams, and descriptive information for the systems and for the supporting systems

that are essential to its operation. [The review has determined the adequacy of the applicant's proposed design criteria and design bases for the standby liquid control system, and the requirements for system functions to provide reactivity control during normal, abnormal, and accident conditions. (CP)] [The review has determined that the design of the standby liquid control system and supporting systems is in conformance with the design criteria and bases. (OL)]

"The basis for acceptance in the staff review has been conformance of the applicant's design, design criteria, and design bases for the SLCS and supporting systems to the Commission's regulations as set forth in the general design criteria, and to applicable regulatory guides, staff technical positions, and industry standards.

"The staff concludes that the design of the SLCS conforms to all applicable regulations, guides, staff positions, and industry standards, and is acceptable."

V. 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 Missile Design Bases."

3. 10 CFR Part 50, Appendix A, General Design Criterion 21, "Protection System Reliability and Testability."

4. 10 CFR Part 50, Appendix A, General Design Criterion 26, "Reactivity Control System Redundancy and Capability."

5. General Design Criterion 27, "Combined Reactivity Control Systems Capability."

6. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants," Revision 1.

7. Regulatory Guide 1.29, "Seismic Design Classification," Revision 1.

8. Branch Technical Positions APCSB 3-1, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," attached to Standard Review Plan 3.6.1, and MEB 3-1, "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," attached to Standard Review Plan 3.6.2.

SRP 9.4.1