U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

9.3.5 STANDBY LIQUID CONTROL SYSTEM (BWR)

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of reactor systems (BWR)

Secondary - None

I. AREAS OF REVIEW

The standby liquid control system (SLCS) may be part of the emergency core cooling system (ECCS) network for a boiling water reactor (BWR). For example, the SLCS for the economic simplified BWR (ESBWR) is part of the emergency core cooling system (ECCS). In these instances, Standard Review Plan (SRP) Section 6.3 is also applicable and should be used in conjunction with SRP Section 9.3.5.

BWR plants include an SLCS that provides backup capability for reactivity control independent of the control rod drive (CRD) system. The SLCS functions by injecting a boron solution into the reactor to effect shutdown. This system has the capability to control 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 at which the system connects to the reactor coolant system (RCS). The NRC staff reviews the system to determine its adequacy to perform the shutdown function in conformance with the requirements of General Design Criteria (GDC) 2, 4, 5, 26, and 27 and 10 CFR 50.62(c)(4).

The specific areas of review 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 resulting from a loss-of-coolant accident

2. The system design to ensure 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 its capability to detect, collect, and control system leakage and 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

6. 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 is performed after review of the rest of this portion of the application is 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.

7. COL Action Items and Certification Requirements and Restrictions. COL action items may be included in the NRC staff's final safety evaluation report (FSER) for each certified design to identify information that COL applicants must address in the application. Additionally, DCs contain requirements and restrictions (e.g., interface requirements) that COL applicants must address in the application. For COL applications referencing a DC, the review performed under this SRP section includes information provided in response to COL action items and certification requirements and restrictions pertaining to this SRP section, as identified in the FSER for the referenced certified design.

Review Interfaces

Other SRP sections interface with this section as follows:

1. The review of the design of the SLCS for new designs to verify, to the extent practicable, that the low-pressure portions of the SLCS that interface with the RCS will withstand full RCS pressure, or if it is not possible to design the SLCS with an ultimate rupture strength capable of withstanding full RCS pressure, that appropriate compensating measures have been taken, is reviewed under SRP Section 3.12 (proposed).

2. The review to determine the acceptability of the seismic and quality group classifications for system components is performed under SRP Sections 3.2.1 and 3.2.2.

3. The review of 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, and tornado missiles is performed under 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.

4. The review for flood protection is performed under SRP Section 3.4.1.

5. The review for protection against internally generated missiles is performed under SRP Sections 3.5.1.1 and 3.5.1.2.

6. The review of the SSCs to be protected against externally generated missiles is performed under SRP Section 3.5.2.

7. The review of high- and moderate-energy pipe breaks is performed under SRP Section 3.6.1.

8. The review to determine that the components, piping, and structures are designed in accordance with applicable codes and standards is performed under SRP Sections 3.9.1 through 3.9.3.

9. The review of the adequacy of the inservice testing program of pumps and valves is performed under SRP Section 3.9.6.

10. The review of the seismic qualification of Category I instrumentation and electrical equipment is performed under SRP Section 3.10.

11. The review of the environmental qualification of mechanical and electrical equipment is performed under SRP Section 3.11.

12. The review of 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 is performed under SRP Section 4.3.

13. The review for the reactivity control and neutronic aspect of the SLCS is performed under SRP Sections 4.3, 4.4 and 4.6.

14. The verification that redundant reactivity control systems are not vulnerable to common mode failures is performed under SRP Section 4.6.

15. The review to verify the compatibility of the materials of construction with service conditions is performed under SRP Sections 5.2.3, and 6.6.

16. The review of the ECCS functions of the SLCS is performed under SRP Section 6.3.

17. The review to verify that inservice inspection requirements are met for system components is performed under SRP Section 6.6.

18. The review to determine the adequacy of the design, installation, inspection, and testing of instrumentation and electrical components (sensing, control, and power) required for proper operation is performed under SRP Sections 7.1 and 8.1, respectively.

19. The review to determine that design and quality assurance criteria specified for instrumentation required by the ATWS rule are consistent with criteria established in conjunction with the ATWS rulemaking is performed under SRP Section 7.8.

20. The review of fire protection is performed under SRP Section 9.5.1.

21. The reviews of the functions of the SLCS that relate to anticipated transient without scram (ATWS), along with the examination of boron mixing issues associated with the advanced BWR (ABWR), ESBWR and its ATWS response, performed under SRP Section 15.8.

22. The review of technical specifications is performed under SRP Section 16.0.

23. The review of quality assurance is performed under SRP Chapter 17.

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

II. ACCEPTANCE CRITERIA

Requirements

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

1. GDC 2, as it relates to the ability of structures housing the system and the system itself to withstand the effects of earthquakes.

2. GDC 4, as it relates to the dynamic effects associated with flow instabilities and loads, such as water hammer.

3. GDC 5, as it relates to structures, systems, and components important to safety not being shared among nuclear power units unless it can be demonstrated that sharing will not impair their ability to perform their safety function.

4. GDC 26, as it relates to the requirement that two independent reactivity control systems of different design principles be provided and the requirement that one of the systems be capable of holding the reactor subcritical in the cold condition.

5. GDC 27, as it relates to the requirement that the reactivity control systems have a combined capability, in conjunction with poison addition by the ECCS, to reliably control reactivity changes under postulated accident conditions.

6. 10 CFR 50.62(c)(4), as it relates to the SLCS being capable of reliably injecting a borated water solution into the reactor pressure vessel (RPV) at a boron concentration, boron enrichment, and flow rate that provides sufficient reactivity control and the need for the system to have automatic initiation, where required under the rule, to satisfy ATWS risk reduction requirements.

7. 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 Act, and the Commission's regulations;

8. 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 which 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 for meeting the relevant aspects of GDC 2 is based on meeting the guidance of Regulatory Guide 1.29, Position C-1.

2. Acceptance for meeting the relevant aspects of GDC 4 is embodied within SRP Section 3.9.2.

3. Acceptance for meeting the relevant aspects of GDC 5 is based on not sharing the SSCs important to safety between the units (except as identified).

4. Acceptance for meeting the relevant aspects of GDC 26 is based on the provision of two independent reactivity control systems of different design principles (control rod drive system and SLCS system).

5. Acceptance for meeting the relevant aspect of GDC 27 is based on the system having suitable redundancy in components and features to assure system safety function assuming a single failure. For some newer designs such as the ESBWR, GDC 27 is met by the provision of SLCS as part of the ECCS.

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 nuclear power plant SSCs important to safety be designed to withstand the effects of seismic events and other natural phenomena without loss of capability to perform their safety functions. The subject SSCs are those necessary to ensure (1) the integrity of the reactor coolant pressure boundary, (2) the capability to shut down the reactor and maintain it in a safe-shutdown condition, or (3) the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposures comparable to the guideline exposures of 10 CFR Part 100. Since the SLCS provides one means to shut down the reactor and maintain it in a safe-shutdown condition, the SLCS, and structures housing the SLCS, must be capable of withstanding the effects of natural phenomena.

   Based on reviewing a number of safety analysis reports (SARs) for light-water reactor nuclear power plants, a seismic design classification system was developed for identifying those plant features that should be designed to withstand the effects of the SSE. Regulatory Guide 1.29, Position C-1, states that systems required for safe shutdown, including their foundations and supports, are designated as Seismic Category I and should be designed to withstand the effects of the SSE and remain functional. Compliance with Regulatory Guide 1.29 provides assurance that the SLCS will perform its intended safety function in the event of an earthquake.

2. GDC 4 requires SSCs that are important for safety to be designed to accommodate the effects of, and to be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents and to be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from external events. The SLCS provides backup reactivity control, and the dynamic effects of water hammer could degrade system effectiveness. Compliance with GDC 4 assures that the SLCS will remain functional and provide backup reactivity control.

3. GDC 5 prohibits the sharing of SSCs among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units. In general, the SLCS provides backup reactivity control; however, in some newer designs such as the ESBWR the SLCS provides ECCS functions. The SLCS needs to be designed such that the ability to accomplish these safety-related functions is not compromised for each unit, regardless of equipment failures or other events that may occur in another unit. Meeting the requirements of GDC 5 provides assurance that unacceptable effects of equipment failures or other events occurring in one unit of a multiunit site will not propagate to the unaffected unit(s).

4. Compliance with GDC 26 requires that two independent reactivity control systems of different design principles be provided, with one of the systems being capable of holding the reactor core subcritical under cold conditions. In a BWR, the normal method of reactivity control utilizes control rods, which are capable of maintaining the reactor

subcritical, including an allowance for a stuck rod, without the addition of any poison to the reactor coolant. The SLCS acts as an emergency backup to the insertion of control rods to provide a diverse means of making the reactor subcritical. Making provisions for the storage of an adequate amount of neutron absorber in solution, along with the capability for injection at a rate 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), assures that the SLCS will the meet the performance requirements of GDC 26.

5. Compliance with GDC 27 requires that two independent reactivity control systems of different design principles be provided, with the reactivity control systems having a combined capability of reliably controlling reactivity changes under design-basis accident conditions. The primary means for fine and coarse control of reactivity in a BWR are the control rods and their drive system, with the SLCS serving as a backup system. As such, the SLCS is a reliable means and for newer designs is an automatic means of making the reactor subcritical following an anticipated transient with a failure of the shutdown rods to insert. Acting in conjunction with other features to mitigate an ATWS, the SLCS provides additional protection and safety for all barriers to the release of fission products by reducing the potential for exceeding fuel, reactor coolant pressure boundary, and containment integrity limits.

6. Compliance with 10 CFR 50.62(c)(4) invokes explicit requirements regarding the performance of the SLCS. In essence, 10 CFR 50.62(c)(4) states that each BWR must have an SLCS with a minimum flow capacity and boron content providing equivalent reactivity control to 326 Lpm (86 gpm) of 13 weight percent sodium pentaborate solution. As discussed in NRC Generic Letter (GL) 85-03 (Ref. 9), the “equivalent in control capacity” wording was chosen to allow flexibility in the implementation of the requirement (e.g., the equivalence can be obtained by appropriately adjusting flow rate, boron concentration, or boron enrichment). GL 85-03 also states that the 326 Lpm (86 gpm) and 13 weight percent sodium pentaborate were values used in the General Electric Company Licensing Topical Report, NEDE-24222, for BWR/4, BWR/5 and BWR/6 plants with a 638-cm (251-in.) vessel inside diameter (Ref. 10). NEDE-24222 recognized that different values would be equivalent for smaller plants. The important parameters to consider in establishing equivalence are the vessel boron concentration required to achieve shutdown and the time required to achieve that vessel boron concentration. The minimally acceptable system should show an equivalency in these parameters to the 638-cm (251-in.) diameter vessels studied in NEDE-24222. Invoking specific requirements concerning equivalent reactivity control capacity for the minimum flow capacity and boron content in the SLCS ensures that sufficient boron can be injected at a rate sufficient to bring the reactor from rated power to cold shutdown. By providing automatic initiation (where required), further assurance is provided with respect to the timeliness of injection and thus of the initiation of reactivity control.

   The NRC previously reviewed and accepted General Electric Company Licensing Topical Report, NEDE-31096P-A, (Ref. 11), which details conceptual designs to satisfy the 10 CFR 50.62 requirements for BWRs. This topical report further provides methods for determining equivalency specifics set forth by GL 85-03 (Ref. 9). This ensures that

the SLCS can operate in conjunction with other features to mitigate an ATWS and will increase safety by reducing the potential for exceeding fuel, reactor coolant pressure boundary, and containment integrity limits.

III. REVIEW PROCEDURES

The procedures below are used during the design certification 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 combined license (COL) applications, the procedures are also 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 for older BWRs 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. The applicant may submit designs that deviate from this typical system. For example for the ABWR, the two explosive valves are replaced with two motor-operated injection valves and two motor-operated pump suction valves. For the newer ESBWR, the system consists of two identical 50-percent capacity loops, each having an accumulator, two parallel (squib-actuated) explosive valves, and associated local valves and controls.

Also, for the purpose of this SRP section, it is assumed for the typical SLCS in older BWRs that the sodium pentaborate solution is injected into the RPV at the bottom of the vessel below the core support plate. In some newer BWR designs, the solution is injected into the high-pressure core spray discharge piping and into the RPV via the spray sparger. For example in ABWR designs, the solution is injected into the high-pressure core flooder injection line, and in the ESBWR design, the solution is directly injected into the RPV through a nozzle located above core midplane, then directed to a downcomer located outside the core shroud that is connected to a header connected to two downcomers, each of which has four injection nozzles at different elevations below core midplane.

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

For each area of review specified in Subsection I of this SRP section, the review procedure is identified below. These review procedures are based on the identified SRP acceptance criteria. For deviations from these specific acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives to the SRP criteria provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

1. The SAR is reviewed to determine that the system process diagram 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 safe shutdown and accident mitigation. The system process diagram, P&IDs, layout drawings, and component descriptions and characteristics are reviewed to determine the following:

A. The SLCS is classified as Quality Group B and seismic Category I. The reviewer verifies that the component and system descriptions in the SAR include the above classifications and that the P&IDs should indicate any points of change in piping quality group classification. The organization responsible for reviews of seismic and geotechnical issues performs the review for seismic design, and the organization responsible for the review of mechanical engineering issues performs the review for seismic and quality classification, as indicated in Subsection I of this SRP section.

B. The reviewer verifies that 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. For new applications, the reviewer evaluates the SLCS design provisions to test motor-operated valves under design-basis differential pressure and the piping design provisions for full-flow testing (at maximum design flow) of pumps and check valves, as applicable. In accordance with the staff's position described in SECY 93-087 (Ref. 8), design features should support inservice valve tests under the maximum practicable differential pressure and flow when it is not practicable to achieve design-basis differential pressure during an inservice test. Where it is not practicable to conduct inservice pump testing at design flow and pressure, the NRC permits analysis to extrapolate to design pressure.

C. Using the results of the evaluation performed under SRP Section 4.3, the reviewer 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. To verify compliance with relevant ATWS rule requirements, the reviewer determines whether the system has the capability to inject into the RPV a borated water solution at such a flow rate, level of boron concentration, and boron-10 isotope enrichment, accounting for RPV volume, that the resulting reactivity control is at least equivalent to that resulting from injection of 326 Lpm (86 gpm) of 13-weight-percent sodium pentaborate decahydrate solution at the natural boron-10 isotope abundance into a 638-cm (251-in.) inside diameter RPV for a given core design. The requirement allows flexibility in its implementation (i.e., the equivalence can be obtained by increasing flow rate, boron concentration, or boron enrichment). The important parameters considered in establishing equivalence are the vessel boron concentration required to achieve

shutdown and the time required to achieve that vessel boron concentration (see GL 85-03). The reviewer evaluates the system arrangement and associated features, including the injection location(s), to determine that they will facilitate reliable, undiverted injection of borated solution to the reactor vessel. The reviewer should also confirm that sufficient allowance is provided for imperfect mixing and leakage. For BWRs, that are required to provide automatic SLCS initiation under the rule, the reviewer coordinates with the organization responsible for the review of instrumentation and controls systems, as described in Subsection I, to verify that the system has acceptable provisions for automatic initiation.

E. The reviewer verifies that the SAR and the system P&IDs indicate that adequate means are to be provided to maintain the system temperature above the saturation temperature of the neutron absorber solution for all designs (i.e., BWRs, ABWRs, and ESBWRs).

The reviewer also verifies that the SAR and the system P&IDs indicate that means are to be provided to maintain the minimum boron solution tank level and maximum solution temperature to ensure net positive suction head for the positive displacement pumps for the older BWRS, as indicated by NRC Information Notice (IN) 91-012. In addition, adequate means should also be provided to maintain system equivalent flow capacity in ATWS transient scenarios, considering system relief valve settings and capacity, as indicated in IN 2001-013.

F. The reviewer determines that 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 nonseismic 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.

B. The SLCS is protected from the effects of floods, hurricanes, tornadoes, and internally or externally generated missiles. The SRP Section 3 series discusses and evaluates in detail flood protection and missile protection criteria. 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 a 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. The reviewer also evaluates the information contained in the SAR to determine that the SLCS and CRD systems are located in different parts of the reactor building and at different elevations to ensure that these systems are not vulnerable to common mode failures. For each case, the design will be acceptable if minimum system requirements are met.

4. Some SLCS (e.g., ABWR) designs no longer use squib-activated (explosive) injection valves and instead incorporate motor-operated storage tank discharge valves. Because of the importance of valve reliability for the SLCS storage tank discharge valves, the reviewer verifies that the motor-operated discharge valves, where provided, will be covered by adequate reliability assurance requirements under a Reliability Assurance Program (RAP).

5. Newer SLCS (e.g., ESBWR) designs use accumulators instead of positive displacement pumps. Because of the importance of accumulator reliability, the reviewer verifies that the accumulators will be covered by adequate reliability assurance requirements under a RAP.

6. For reviews of DC and COL applications under 10 CFR Part 52, the reviewer should follow the above procedures to verify that the design set forth in the safety analysis report, and, for DC applications, that the interface requirements meet the acceptance criteria. For DC applications, the reviewer should identify necessary COL action items. With respect to COL applications, the scope of the review is dependent on whether the COL applicant references a DC, an ESP or other NRC-approved material, applications, and/or reports.

After this review, SRP Section 14.3 should be followed for the review of ITAAC.

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.

1. The SLCS includes storage tanks, accumulators, pumps, valves, and piping to the point where the system connects to the reactor coolant boundary. The SLCS, which is provided in BWRs only, provides reactivity control in the event the control rods cannot be inserted. The staff review will find the SLCS acceptable if the applicant's design and design criteria conform to the Commission's regulations, as set forth in the GDC and the applicable sections of 10 CFR 50.62, and to the positions of applicable regulatory guides, staff technical positions, and industry standards.

2. The staff reviewers conclude that the design of the SLCS is acceptable and conforms to the requirements of GDC 2, 4, 5, 26, and 27 and the applicable sections of 10 CFR 50.62 with respect to seismic design, reactivity control system redundancy, and reactivity control system capability. This conclusion is based on the following:

   A. The applicant has met the requirements of GDC 2 with respect to seismic design by meeting Position C-1 of Regulatory Guide 1.29.

   B. The applicant has met the requirement of GDC 4 with respect to the dynamic effects associated with flow instabilities and loads.

   C. The applicant has met the requirements of GDC 5 with respect to structures, systems, and components important to safety not being shared among nuclear power units unless it can be demonstrated that sharing will not impair their ability to perform their safety function.

   D. The applicant has met the requirements of GDC 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.

   E. The applicant has met the requirements of GDC 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.

   F. The applicant has met the requirements of 10 CFR 50.62(c)(4) by providing a reliable SLCS having the capability to inject a borated water solution into the RPV that meets, or exceeds, the reactivity control requirements specified in the rule.

   G. Where applicable, the following conclusion should be included—The applicant has also provided a system with acceptable provisions for automatic initiation.

H. Where applicable, for designs incorporating motor-operated SLCS storage tank discharge valves, the following conclusion should be included—The applicant has acceptably incorporated the SLCS storage tank discharge valves into a RAP.

I. Where applicable, for designs incorporating accumulators, the following conclusion should be included—The applicant has acceptably incorporated the SLCS accumulators RAP.

For DC and COL reviews, the findings will also summarize (to the extent that the review is not discussed in other SER sections) the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable, and interface requirements and combined license action items relevant to this SRP section.

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 docketed six months or more after the date of issuance of this SRP section.

VI. REFERENCES

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

2. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

3. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Bases."

4. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems, and Components."

5. 10 CFR Part 50, Appendix A, General Design Criterion 26, "Reactivity Control System Redundancy and Capability."

6. 10 CFR Part 50, Appendix A, General Design Criterion 27, "Combined Reactivity Control Systems Capability."

7. 10 CFR 50.62, "Requirements for Reduction of Risk from Anticipated Transients Without Scram (ATWS) Events for Light-Water-Cooled Nuclear Power Plants," particularly 10 CFR 50.62(c)(4).

8. SECY-93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs,” April 2, 1993.

9. NRC Letter to all Boiling Water Reactor Licensees and Applicants, “Clarification of Equivalent Control Capacity for Standby Liquid Control Systems (Generic Letter 85-03),” January 28, 1985.

10. General Electric Company Licensing Topical Report, “Assessment of BWR Mitigation of ATWS,” Volumes I and II, NEDE-24222, December 1979.

11. General Electric Company Licensing Topical Report, “Anticipated Transient Without Scram; Response to ATWS Rule, 10 CFR 50.62,” NEDE-31096P-A, 1986.

12. NRC Information Notice 1991-012, “Potential Loss of Net Positive Suction Head (NPSH) of Standby Liquid Control System Pumps,” February 15, 1991.

13. NRC Information Notice 2001-013, “Inadequate Standby Liquid Control System Relief Valve Margin,” August 10, 2001.

SRP Section 9.3.5
Description of Changes

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in (Draft) Revision 3, dated April 1996 of this SRP. See ADAMS accession number ML052070538.

In addition this SRP section was administratively updated in accordance with NRR Office Instruction, LIC-200, Revision 1, "Standard Review Plan (SRP) Process." The revision also adds standard paragraphs to extend application of the updated SRP section to prospective submittals by applicants pursuant to 10 CFR Part 52.

The technical changes are incorporated in Revision 3, dated [Month] 2007:

Review Responsibilities - Reflects changes in review branches resulting from reorganization and branch consolidation. Change is reflected throughout the SRP.

I. AREAS OF REVIEW

A. Added a description of the relationship between SLCS and ECCS and the possible applicability of SRP Section 6.3

C. Added a description of the SLCS function related to boron injection and mixing during ATWS

II. ACCEPTANCE CRITERIA

A. Made editorial changes adding GDC 4 and 5 as references

B. Formulated the technical rationale associated with GDC 4 and 5 and added it to this section in accordance with the specified Standard Review Plan Update and Development Program

C. Made editorial changes adding GL 85-03 and a GE Licensing Topical Report as references

D. Cited GL 85-03 and a GE Licensing Topical Report regarding the determination of SLCS equivalency capacity

III. REVIEW PROCEDURES

A. Expanded the general system description to include examples of deviations from the typical system for newer designs. As examples, the SLCS designs were described for the ABWR and ESBWR.

C. Added a paragraph to describe the location of boron injection into the reactor vessel for older BWR designs, and some possible variations for newer designs such as the ABWR and ESBWR

D. Made an editorial change adding INs 91-012 and 2001-013 as references

E. Added a paragraph to describe maintaining minimum net positive suction head for the positive displacement pumps used in older model BWRs and maintaining system flow capacity during ATWS scenarios while accounting for relief valve settings

F. Added directions for the reviewer to evaluate the physical separation between the CRD system and SLCS

G. Added a paragraph directing the reviewer to verify that the newer SLCS accumulators are included in an adequate RAP

IV. EVALUATION FINDINGS

A. Added two paragraphs to include GDC 4 and 5 in the evaluation determination

B. Added a paragraph to include the SLCS accumulators in the applicant's RAP

V. IMPLEMENTATION

VI. REFERENCES

A. Added six new references as described above

B. Renumbered the references per the SRP update format