



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

5.4.6 REACTOR CORE ISOLATION COOLING SYSTEM (BWR)

REVIEW RESPONSIBILITIES

- Primary** - Organization responsible for the review of reactor systems in boiling-water reactors
- Secondary** - Organizations responsible for nuclear performance and code review, balance of plant, containment systems, instrumentation and electrical control systems, geosciences, electrical engineering, mechanical engineering, civil engineering, technical specifications, and quality assurance

I. AREAS OF REVIEW

The reactor core isolation cooling (RCIC) system in a boiling-water reactor (BWR) is a safety system that serves as a standby source of cooling water to provide a limited decay heat removal capability whenever the main feedwater system is isolated from the reactor vessel. Abnormal events that could cause such a situation include an inadvertent isolation of all main steamlines, loss of condenser vacuum, pressure regulator failures, loss of feedwater, and loss of offsite power. Chapter 15 of the applicant's safety analysis report (SAR) analyzes each of these transients. For each of these events, the high-pressure part of the emergency core cooling system (ECCS) provides a backup function to the RCIC system. The performance of this review of the RCIC system ensures conformance with the requirements of General Design Criteria (GDC) 4, 5, 29, 33, 34, and 54. In some plant designs, the RCIC system, in conjunction with the high-pressure core flooder (HPCF) system, may be part of the ECCS. In such cases, the ECCS function of the RCIC system is reviewed under SRP Section 6.3. In addition, the RCIC system may provide the decay heat removal necessary for coping with a station blackout

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USNRC STANDARD REVIEW PLAN

This Standard Review Plan, NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant/licensee meets the NRC's regulations. The Standard Review Plan 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 an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in the Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of the standard format have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) will be based on Regulatory Guide 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," until the SRP itself is updated.

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRR_SRP@nrc.gov.

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(SBO). The RCIC system capability to perform this function is reviewed as necessary to ensure conformance with 10 CFR 50.63.

The RCIC system consists of a steam-driven turbine pump unit and associated valves and piping capable of delivering makeup water to the reactor vessel. Fluid removed from the reactor vessel following a shutdown from power operation is normally made up by the feedwater system, supplemented by inleakage from the control rod drive system. If the feedwater system is inoperable, the RCIC turbine pump unit starts automatically, or the operator starts it from the control room. The water supply for the RCIC system comes from the condensate storage tank (CST), with a secondary supply from the suppression pool.

The review of the RCIC system includes the system design bases, design criteria, description, and points noted below. The Reactor Systems organization is responsible for performing the technical review of the RCIC system. The specific areas of review are as follows:

1. The review of the piping and instrumentation diagrams confirms that the system is capable of performing its intended function and undergoing preoperational and operational testing.
2. The review of the degree of separation of the RCIC system from the high-pressure core spray (HPCS) system, the high-pressure coolant injection (HPCI) system, or the HPCF system addresses protection against common mode failure of redundant systems.
3. The process flow diagram review confirms that the RCIC system design parameters are consistent with expected pressures, temperatures, and flow rates.
4. The review of the complete sequence of operation confirms that the system can function as intended and that the system is capable of manual operation.
5. The system review assesses compliance with the applicable guidance of NUREG-0737.
6. Inspection, Test, Analysis, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the applicant's proposed information on the ITAAC associated with the systems, structures, and components (SSCs) related to this SRP section is reviewed in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria - Design Certification." The staff recognizes that the review of ITAAC is performed after review of the rest of this portion of the application against acceptance criteria contained in this SRP section. Furthermore, the ITAAC are reviewed to assure 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 identified 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

The listed SRP sections interface with this section as follows:

1. As part of its primary review responsibility for SRP Section 3.12, the Reactor Systems organization reviews the design of the RCIC system for evolutionary light-water reactor designs to verify, to the extent practical, that the low-pressure portions of the RCIC that interface with the reactor coolant system (RCS) will withstand full RCS pressure. If designing the RCIC with an ultimate rupture strength capable of withstanding full RCS pressure is not possible, the reviewer verifies that appropriate compensating measures have been taken in accordance with the review specified in SRP Section 3.12.
2. If applicable to the plant design under review, the Reactor Systems organization performs a review of the ECCS functions of the RCIC system as part of their primary review responsibility for SRP Section 6.3.

In addition, the Reactor Systems organization will coordinate other evaluations that interface with the overall review of the system as follows:

1. The Balance of Plant organization reviews the RCIC system and the HPCI, HPCS, or HPCF system for protection against common mode failures from missiles as part of the primary review responsibility for SRP Sections 3.5.1.1, 3.5.1.2, 3.5.1.4, 3.5.1.5, 3.5.1.6, and 3.5.2.
2. The Balance of Plant organization reviews protection against flooding of the RCIC system and redundant equipment as part of the primary review responsibility for SRP Section 3.4.1.
3. Protection against damage from pipe whip and jet impingement is reviewed by the Balance of Plant and Mechanical Engineering organizations as part of the primary review responsibilities for SRP Sections 3.6.1 and 3.6.2, respectively.
4. The Technical Specifications organization reviews the proposed technical specifications as part of the primary review responsibility for SRP Section 16.0.
5. The Quality Assurance organization reviews the proposed preoperational and critical startup test programs as part of the primary review responsibility for SRP Section 14.2.
6. The Mechanical Engineering organization reviews the RCIC system to ensure that it has the proper seismic and quality organization classification as part of the primary review responsibility for SRP Sections 3.2.1 and 3.2.2.
7. The RCIC must be enclosed in a seismic Category I structure or building. The Civil Engineering and Geosciences organizations evaluate the design adequacy of this structure or building as part of the primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.4.2, 3.5.3, 3.7.1, 3.7.2, 3.7.3, 3.8.1, 3.8.3, 3.8.4, and 3.8.5.
8. The Containment Systems and Severe Accident organization reviews the RCIC system as part of the primary review responsibility for SRP Sections 6.2.2, 6.2.4, and 6.2.6 to confirm that the design is compatible with the containment system and can be isolated. This organization also reviews the containment heat removal capability and the suppression pool suction strainers as part of the review responsibility for SRP Section 6.2.2.
9. The Instrumentation and Electrical Control Systems organization, as part of the primary review responsibility for SRP Sections 7.3 and 7.4, evaluates the adequacy of controls and instrumentation of the RCIC system regarding the required features of automatic actuation, remote sensing and indication, and remote control.

10. The Electrical Engineering organization, as part of the primary review responsibility for SRP Chapter 8, evaluates the adequacy and reliability of offsite and emergency onsite power, the sufficiency of battery capacity, the use of direct current power only to support operation of specified systems/subsystems, and the plant's capabilities to cope with an SBO, as required by 10 CFR 50.63.
11. The Mechanical Engineering organization, as part of the primary review responsibility for SRP Section 3.9.3, ensures that the design and installation of the RCIC system meet applicable codes and are adequate for its proper functioning.
12. The Mechanical Engineering organization reviews RCIC system equipment to verify that it is seismically qualified for its intended use as part of the primary review responsibility for SRP Section 3.10.
13. The Balance of Plant organization, as part of the primary review responsibility for SRP Section 3.11, reviews RCIC system equipment to confirm that it is environmentally qualified for its intended use.
14. The Mechanical Engineering organization reviews the inservice testing of pumps and valves for the RCIC system as part of the primary review responsibility for SRP Section 3.9.6.
15. The Balance of Plant organization reviews the CST level detection and activation of switchover of suction of the RCIC pump to the suppression pool as part of the primary review responsibility for SRP Section 9.2.6.
16. The Balance of Plant organization reviews the RCIC pump room cooling as part of the primary review responsibility for Section 9.4.5.

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

II. ACCEPTANCE CRITERIA

Requirements

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

1. GDC 4, which requires, in part, that SSCs important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. These SSCs shall be appropriately protected against dynamic effects.
2. GDC 5, which requires, in part, that structures, systems, and components important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.
3. GDC 29, which requires that the protection and reactivity control systems be designed to assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences.

4. GDC 33, which requires, in part, that a system shall be provided to supply reactor coolant makeup for protection against small breaks in the reactor coolant pressure boundary so that specified acceptable fuel design limits are not exceeded.
5. GDC 34, which requires a system to remove fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded.
6. GDC 54, as it relates to providing leak detection and isolation capabilities to piping systems that penetrate primary containment.
7. 10 CFR 50.63, as it relates to design provisions to support the plant's ability to withstand and recover from an SBO of a specified duration.
8. 10 CFR 52.47(a)(1)(vi), as it relates to ITAAC (for design certification) sufficient to assure that the SSCs in this area of review will operate in accordance with the certification.
9. 10 CFR 52.97(b)(1), as it relates to ITAAC (for combined licenses) sufficient to assure that the SSCs in this area of review have been constructed and will be operated in conformity with the license and the Commission'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 Subsection I of 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. The general objective of the review is to determine that the RCIC system—in conjunction with the HPCS (or HPCI) system, the safety and relief valves (SRVs), and the suppression pool cooling mode of the residual heat removal (RHR) system—meets the requirements of GDC 34 by providing the capability for decay heat removal to enable complete shutdown of the reactor under conditions requiring its use. The system must maintain the reactor water inventory above the top of the active fuel until the reactor is sufficiently depressurized to permit operation of the low-pressure cooling systems. The RCIC system—in conjunction with the HPCS (or HPCI) system, SRVs, and suppression pool cooling mode of the RHR system—must be capable of removing fission product decay heat and other residual heat from the reactor core following shutdown thus precluding fuel damage or reactor coolant pressure boundary overpressurization. Because the RCIC system, in conjunction with the HPCS (or HPCI) system, provides makeup inventory in some modes of RHR, these systems should jointly meet the guidelines of Branch Technical Position (BTP) RSB 5-1, attached to SRP Section 5.4.7.
2. The RCIC system also supplies reactor coolant makeup for small leaks. Accordingly, the system must meet the relevant requirements of GDC 33.
3. Historically, credit has been taken for the RCIC system capability to mitigate the consequences of certain abnormal events; however, because the cooling function is

redundant to the HPCI, HPCS, or HPCF system, the RCIC system itself is not required to meet the single failure criterion, but it must do so in conjunction with the HPCS, HPCI, or HPCF system. In addition, the RCIC system must perform its function without the availability of any alternating current (ac) power, per the requirements of GDC 34, and, in conjunction with the HPCS, HPCI, or HPCF system, must be designed to ensure an extremely high probability of accomplishing its safety function, as required by GDC 29.

4. As a system that must respond to certain abnormal events, the design of the RCIC system must conform to seismic Category I standards (as discussed in SRP Section 3.2.1), and must not be shared among nuclear power units, except as permitted by GDC 5.
5. The RCIC system and the HPCS, HPCI, or HPCF system must be protected against natural phenomena, external or internal missiles, pipe whip, and jet impingement forces so that such events cannot cause both systems to fail simultaneously. SRP Sections 3.3.1 through 3.6.2 discuss relevant acceptance criteria.
6. The RCIC system must meet the requirements of GDC 54 regarding leak detection and isolation provisions for lines passing through the primary containment. SRP Sections 6.2.4 and 6.2.6 describe other containment isolation criteria for the RCIC system.
7. The RCIC system should meet the following task action plan item recommendations of NUREG-0737 and NUREG-0718:
 - A. Section II.K.1.22 with regard to actions, both automatic and manual, necessary for proper functioning of the auxiliary heat removal systems that are used when the main feedwater system is not operable. The regulations at 10 CFR 50.34(f)(2)(xxi) establish an equivalent requirement for those applicants subject to the requirements of 10 CFR 50.34(f).
 - B. Section II.K.3.13 with regard to separation of the initiation levels of the HPCI and RCIC systems so that the RCIC system initiates at a higher water level than the HPCI system and so that the RCIC system initiation logic will restart the RCIC system on a low water level. The regulations at 10 CFR 50.34(f)(1)(v) establish an equivalent requirement for those applicants subject to the requirements of 10 CFR 50.34(f).
 - C. Section II.K.3.15 with regard to preventing spurious isolation of the RCIC system from the line break detection logic.
 - D. Section II.K.3.22 with regard to automatic switchover of the RCIC system suction from the CST to the suppression pool when the CST level is low.
 - E. Section II.K.3.24 with regard to space cooling to ensure reliable long-term operation of the RCIC system following a complete loss of offsite power to the plant for at least 2 hours. The regulations at 10 CFR 50.34(f)(1)(ix) establish an equivalent requirement for those applicants subject to the requirements of 10 CFR 50.34(f).

- F. Section III.D.1.1 with regard to leakage detection and control in the design of systems outside containment that include (or might include) radioactive source term materials following an accident. The regulations at 10 CFR 50.34(f)(2)(xxvi) establish an equivalent requirement for those applicants subject to the requirements of 10 CFR 50.34(f).
8. If the RCIC system is used to control or mitigate the consequences of an accident, either by itself or as a backup to another system, it must meet the requirements of an engineered safety feature (ESF). The RCIC system should have adequate margin with the containment at atmospheric pressure.
 9. To satisfy the requirements of GDC 4, design features and operating procedures that are designed to prevent damaging water hammer attributable to mechanisms such as voided discharge lines, steam bubble collapse, and water entrainment in steamlines shall be provided.
 10. If the RCIC system supports the demonstration of adequate plant SBO coping capability as required by 10 CFR 50.63, acceptance may be based on the positions in Regulatory Guide 1.155 regarding RCIC system design.

Technical Rationale

The technical rationale for application of these requirements and/or SRP acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. GDC 4 requires, in part, that structures, systems, and components important to safety shall be designed to (1) accommodate the effects of, and be compatible with, the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents and (2) be appropriately protected against dynamic effects—including the effects of missiles, pipe whipping, and discharging fluids—that may result from equipment failures and external events. The RCIC system - in conjunction with the HPCS (or HPCI) system, the SRVs, and the suppression pool cooling mode of the RHR system - provides the cooling water necessary for decay heat removal, but the dynamic effects of water hammer could degrade system effectiveness. Compliance with GDC 4 ensures that the RCIC system will remain functional.
2. GDC 5 prohibits the sharing of structures, systems, and components 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. The RCIC system - in conjunction with the HPCS (or HPCI) system, the SRVs, and the suppression pool cooling mode of the RHR system - provides the essential cooling water necessary for decay heat removal. The RCIC system should be designed so 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 reasonable assurance that the unacceptable effects of equipment failures or other events in one unit of a multiunit site will not propagate to the unaffected unit(s).
3. GDC 29 requires that the protection and reactivity control systems be designed to ensure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences. The RCIC system provides a standby source of cooling water and limited decay heat removal capability whenever the main feedwater system is isolated from the reactor vessel. This system can mitigate the consequences

of anticipated operational occurrences such as loss of feedwater, inadvertent isolation of main steam, or loss of offsite power; therefore, it must have an extremely high probability of accomplishing its function. The reactor protection or ESF system activates initiation of the RCIC system during appropriate anticipated operational occurrences. The design of the RCIC interface with this system must continue to provide an extremely high probability of accomplishing its safety functions. Compliance with GDC 29 provides reasonable assurance that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences.

4. GDC 33 specifies requirements for a system to supply reactor coolant makeup for protection against small breaks in the reactor coolant pressure boundary and in the event that either onsite or offsite ac power is unavailable. The RCIC system is designed as a high-pressure reactor coolant makeup system with flow rates sufficient to meet the criteria for small breaks in the reactor coolant pressure boundary without ac power. Compliance with GDC 33 ensures that specified acceptable fuel design limits are not exceeded because of reactor coolant pressure boundary leakage or the rupture of small piping or other small components that are part of the boundary.
5. GDC 34 requires a system to transfer fission product decay heat and other residual heat from the reactor core at a rate such that specified acceptable fuel design limits and the design conditions of the reactor coolant pressure boundary are not exceeded. The RCIC system provides the capability for decay heat removal. Compliance with GDC 34 precludes fuel damage or reactor coolant pressure boundary overpressurization in the event of anticipated operational occurrences that would adversely affect the functions of systems that provide normal heat removal from the reactor core.
6. GDC 54 requires that piping systems penetrating primary reactor containment shall be provided with leak detection, isolation, and containment capabilities having redundancy, reliability, and performance capabilities that reflect the importance to safety of isolating these piping systems. The design of such piping systems must have the capability to test periodically the operability of the isolation valves and associated apparatus and to determine whether valve leakage is within acceptable limits. Piping in the RCIC system passes through the containment boundary and is provided with isolation valves and integrity verification capabilities. Containment isolation and leak detection, as required by GDC 54, provide reasonable assurance that the containment will perform its safety function in the event of a postulated accident and will maintain the capability to prevent a significant uncontrolled release of radioactivity.
7. 10 CFR 50.63 imposes explicit requirements on LWRs regarding the plant's ability to withstand for a specified duration and recover from an SBO. 10 CFR 50.63(b), in particular, requires that the reactor core and associated coolant, control and protection systems must provide sufficient capacity and capability to ensure that the core is cooled and appropriate containment integrity is maintained in the event of an SBO for the specified duration. The RCIC system provides decay heat removal from the reactor core. Its design capability to operate regardless of ac power source availability enables performance of the decay heat removal function to support the plant in coping with an SBO. Regulatory Guide 1.155 identifies acceptable methods for complying with the requirements of 10 CFR 50.63. Compliance with 10 CFR 50.63 provides reasonable assurance that the RCIC system is capable of performing its intended function if an SBO occurs.

III. REVIEW PROCEDURES

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.

For the combined operating license (COL) review, the procedures verify that the initial design criteria and bases have been appropriately implemented in the final design in the final SAR. The COL and design certification (DC) reviews also include the proposed technical specifications to ensure that they are adequate in regard to limiting conditions of operation and periodic surveillance testing.

Upon request from the primary reviewer, other reviewers will provide input for the areas of review as noted in subsection I. The primary reviewer obtains and uses such input as necessary to ensure that this review is complete, including the following activities:

1. Using the RCIC operating requirements specified in SAR Section 5.4.6 and Chapter 15, the reviewer confirms that the RCIC system can maintain coolant inventory in the reactor vessel to keep the core covered and ensure cladding integrity. This determination is based on engineering judgment and independent calculations (as necessary), using the information specified in items 2 and 3 below. The reviewer verifies that the decay heat loads used in the RCIC analyses are applicable, consistent with SRP Section 4.2, and suitably conservative.
2. Using the description in Section 5.4.6 of the SAR, including component lists and performance specifications, the reviewer determines whether the RCIC system piping and instrumentation will allow the system to operate as intended. This is accomplished by reviewing the piping and instrumentation diagrams to confirm that piping arrangements permit achievement of the required flowpaths and that sufficient process sensors are available to measure and transmit required information.
3. Using the comparison tables of SAR Section 1.3, the RCIC system is compared to the designs and capacities of such systems in similar plants to confirm that there are no unexplained departures from previously reviewed plants. If possible, comparisons should use actual performance data from similar systems in operating plants.
4. The reviewer checks the piping and instrumentation diagrams and equipment layout drawings for the RCIC system and the HPCS, HPCI, or HPCF system to confirm that the systems are physically separated and can function independently.
5. The reviewer examines the system design in SAR Section 5.4.6 to verify that the capability for automatic switchover of suction from the CST to the suppression pool has been provided, pursuant to the guidance of item II.K.3.22 of NUREG-0737. The reviewer also judges whether adequate control and monitoring information is available to allow the operator to actuate the system manually or to realign the RCIC system manually within the time allowed (i.e., change the RCIC system suction from the CST to the suppression pool or to the steam condensing mode of the RHR system).

6. The reviewer contacts the Instrumentation and Electrical Control Systems organization to confirm that automatic actuation and remote-manual valve controls are capable of performing the functions required and that sensor and monitoring provisions are adequate. The instrumentation and controls of the RCIC system—in conjunction with the HPCS, HPCI, or HPCF system—must have sufficient redundancy to satisfy the single failure criterion.
7. The reviewer contacts the Instrumentation and Electrical Control Systems organization to ascertain that the RCIC system operation is not dependent on ac power sources, that battery capability is sufficient to permit operation of the RCIC system for a period of 2 hours without the availability of ac power, and that the RCIC pump room coolers meet the power supply guidance of task action plan item II.K.3.24 of NUREG-0737.
8. The reviewer checks with the Mechanical Engineering organization to verify that essential RCIC system components are designated as seismic Category I.
9. The reviewer contacts the Quality Assurance organization to verify that the applicant's proposed preoperational and initial startup test programs comply with Regulatory Guide 1.68. At the COL stage, the reviewer confirms with Quality Assurance that the applicant provided sufficient information to identify the test objectives, methods of testing, and test acceptance criteria (see Positions C.2, C.3, and C.4 of Regulatory Guide 1.68). Quality Assurance also verifies that the proposed test programs will provide reasonable assurance that the RCIC system will perform its safety function. As an alternative to this detailed evaluation, the reviewer may compare the RCIC system design to that of previously reviewed plants. If the designs are essentially identical and if the proposed test programs are essentially the same, the reviewer may conclude that the proposed test programs are adequate for the RCIC system. If the RCIC system design differs significantly from previously reviewed designs, the review of the impact of the proposed changes on the required preoperational and initial startup testing programs occurs at the construction permit stage. This effort should particularly evaluate the need for any special design features required to perform acceptable test programs.
10. The Technical Specifications organization is contacted regarding the proposed plant technical specifications for the following purposes:
 - A. Confirm the suitability of the limiting conditions of operation, including the proposed time limits and reactor operating restrictions for periods when system equipment is inoperable because of repairs and maintenance.
 - B. Verify the adequacy of the frequency and scope of periodic surveillance testing
11. The reviewer confirms that the RCIC is housed in a structure with a design and design criteria that have been reviewed by other organizations (i.e., Balance of Plant, Geosciences, Civil Engineering, and Mechanical Engineering) to ensure that it provides adequate protection against wind, tornadoes, floods, and missiles, as appropriate.
12. The reviewer checks the automatic and manual actions necessary for proper functioning of the RCIC system (in conjunction with the HPCS or HPCI system, the SRVs, and the suppression pool cooling mode of RHR) for completeness and practicality when used for RHR, per the requirements of item II.K.1.22 of NUREG-0737.

13. The reviewer checks the RCIC system break detection provisions to confirm that the system is protected against spurious trip signals, per the direction of item II.K.3.15 of NUREG-0737 and NUREG-0718. For plants using a time delay for this protection, the reviewer verifies that the design is consistent with the staff positions in Generic Letter No. 83-02 regarding minimum and maximum expected response times.

For plants that do not use a time delay for spurious isolation protection, the reviewer verifies that the applicant has properly justified the design and that the applicant's test program and test results demonstrate that the system satisfies the intent of II.K.3.15 in preventing spurious isolation of the RCIC system on initiation.
14. The reviewer confirms, in conjunction with Balance of Plant as necessary, that the RCIC system can withstand a loss of offsite power to its support systems, including space coolers, for at least 2 hours, per item II.K.3.24 of NUREG-0737 and NUREG-0718.
15. The reviewer confirms, per the criteria in item II.K.3.13 of NUREG-0737, that analyses have been provided or referenced to determine the need to separate the RCIC and the HPCS (or HPCI) initiation levels. On the basis of these study results, the reviewer checks the RCIC design for appropriate provisions. In addition, the reviewer verifies that the RCIC system has an automatic restart capability.
16. The reviewer checks (by calculation as necessary) to confirm that adequate net positive suction head is available for RCIC suction from all potential sources (i.e., CST or suppression pool).
17. The reviewer examines the RCIC in conjunction with the HPCS or HPCI, the SRVs, and the suppression pool cooling mode of the RHR system for conformance to the recommendations of BTP RSB 5-1, attached to SRP Section 5.4.7 regarding RHR.
18. The review of the RCIC system evaluates the adequacy of design features that prevent damaging water (steam) hammer attributable to mechanisms such as voided discharge lines, water entrainment, and steam bubble collapse. If the normal water supply is above the discharge lines, proper vent location and filling and venting procedures will prevent voided lines. The location of the vents should enhance the ease of operation and periodic testing. If the normal alignment of the suction valves is to a source below the highest level of the pump discharge lines (e.g., the suppression pool), back leakage through the pump discharge check valves will result in line voiding. Proper vent location and filling and venting procedures therefore are still necessary. In addition, a special keep-full system with appropriate alarms is necessary to supply water to the discharge lines at sufficiently high pressure to prevent voiding. NUREG-0927 provides guidance for water hammer prevention and mitigation.
19. The reviewer confirms that the RCIC system capability is sufficient with respect to the plant's ability to cope with, and recover from, an SBO of a specified duration by assessing compliance with the SBO Rule. Acceptable ways to confirm RCIC system capability are found in Regulatory Guide 1.155, Positions C.3.2, C.3.3, and C.3.5, as they relate to the design of the RCIC system. This review is coordinated with the review of the SBO event under SRP Section 8.3.1.
20. The reviewer contacts the Mechanical Engineering organization to verify that test results on the steamline containment isolation valves demonstrate that the valves will isolate under expected conditions, as discussed in Supplement 3 to Generic Letter No. 89-10.

21. The reviewer verifies that a leakage reduction program has been implemented and that the program and RCIC system design meet the criteria of action plan item III.D.1.1 of NUREG-0737.
22. The reviewer contacts the Severe Accident and Containment Systems organization to verify that the design of the suppression pool suction strainers, as reviewed in SRP Section 6.2.2, are adequate and satisfy the specified requirements for operation of the RCIC pump.
23. The reviewer checks the RCIC pump minimum flow design capacity and minimum flow testing to verify that the flow rate meets the pump manufacturer's recommendations to prevent pump damage and overheating.

The RCIC system uses a steam-driven turbine. Typical design features for the steam supply line include (1) drain pots, (2) sloped lines, and (3) limitations on opening and closing sequences and seal-ins for manual operation of the isolation valves to preclude introducing water slugs into the line. The turbine exhaust line features include sloped lines and vacuum breakers.

24. 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 if applicable, site 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 Tier I information for the design, including the postulated site parameters, interface criteria, and 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.

The RCIC system includes the piping, valves, pumps, turbines, instrumentation, and controls used to maintain water inventory in the reactor vessel whenever it is isolated from the main feedwater system. Certain ESFs (HPCS, HPCI, or HPCF) provide a redundant backup for this function. The scope of review of the RCIC system for the _____ plant included piping and instrumentation diagrams, equipment layout drawings, and functional specifications for essential components. The review has included the applicant's proposed design criteria and design bases for the RCIC system, its analysis of the adequacy of the criteria and bases, and conformance of the design to these criteria and bases.

The staff concludes that the reactor core isolation cooling system design is acceptable and meets the requirements of GDC 4, 5, 29, 33, 34, 54 and 10 CFR 50.63. This conclusion is based on the following:

1. The applicant has met the requirements of (cite regulation) with respect to (state limits of review) by completing the following (use one or more of the following as applicable):
 - A. Meeting the regulatory position in Regulatory Guide _____.

- B. Providing and using an alternative method to the regulatory position in Regulatory Guide _____, which the staff has reviewed and found acceptable.
- C. Meeting the regulatory position in BTP _____.
- D. The applicant for (state) used a calculational method that the staff has previously reviewed and found acceptable; the staff has reviewed the key parameters in this case and found them to be suitably conservative.
- E. The applicant has met the requirements of (industry standard, number, and title), which the staff has reviewed and determined to be appropriate for this application.

2. Repeat the above discussion for each GDC listed.

In addition, SRP Section 6.2 discusses conformance with GDC 55, 56, and 57 regarding containment isolation. Sections 3.3 through 3.6 of this report discuss conformance with GDC 2 and 4 for protection against natural phenomena, environmental hazards, and potential missiles.

The RCIC system and HPCS (or HPCI) system, in conjunction with the SRVs and the suppression pool cooling mode of the RHR system, have removed core decay heat following feedwater system isolation and reactor shutdown so that sufficient coolant inventory is maintained in the reactor vessel to keep the core covered and ensure cladding integrity. This capability was available even with a loss of offsite power and with a single active failure.

The capability and capacity of the RCIC system are sufficient with respect to the plant's ability to cope with, and recover from, an SBO of a specified duration by complying with the guidance set forth in Positions C.3.2, C.3.3, and C.3.5 of Regulatory Guide 1.155, as they relate to the design of the RCIC system. SRP Section 8.4 discusses conformance with 10 CFR 50.63 for SBOs.

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, unless superseded by a later revision.

The referenced regulations, regulatory guides, and NUREGs include implementation schedules for conformance to parts of the method discussed herein. However, implementation of Acceptance Criteria Subsection II, Requirements item 1 and SRP Acceptance Criteria item 9 are as follows:

- 1. Plants with operating license applications docketed before April 1984 need not comply with the provisions of these items, but may do so voluntarily.

2. Operating license, construction permit, DC, and COL applications docketed on or after April 1984 will be reviewed according to the provisions of these items.

VI. REFERENCES

1. 10 CFR Part 50.34(f), "Additional TMI-Related Requirements."
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 29, "Protection Against Anticipated Operational Occurrences."
6. 10 CFR Part 50, Appendix A, General Design Criterion 33, "Reactor Coolant Makeup."
7. 10 CFR Part 50, Appendix A, General Design Criterion 34, "Residual Heat Removal."
8. 10 CFR Part 50, Appendix A, General Design Criterion 54, "Systems Penetrating Containment."
9. 10 CFR Part 50, Appendix A, General Design Criterion 55, "Reactor Coolant Pressure Boundary Penetrating Containment"
10. 10 CFR Part 50, Appendix A, General Design Criterion 56, "Primary Containment Isolation"
11. 10 CFR Part 50, Appendix A, General Design Criterion 57, "Closed Systems Isolation Valves"
12. 10 CFR Part 52, "Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants."
13. 10 CFR Part 50.63, "Loss of All Alternating Current Power."
14. Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants."
15. Regulatory Guide 1.155, "Station Blackout."
16. NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License," Revision 2.
17. NUREG-0737, "Clarification of TMI Action Plan Requirements," November 1980.
18. NUREG-0927, Revision 1, "Evaluation of Water Hammer Occurrences in Nuclear Power Plants," March 1984.
19. NRC Letter to Boiling-Water Reactor Licensees, "NUREG-0737 Technical Specifications (Generic Letter No. 83-02)," January 10, 1983.

20. NRC Letter to All Licensees and Applicants, Generic Letter No. 89-10, and Supplements 1 through 7, "Safety Related Motor-Operated Valve Testing," June 28, 1989.
21. Branch Technical Position RSB 5-1, "Design Requirements of the Residual Heat Removal System," attached to SRP Section 5.4.7.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

PUBLIC PROTECTION NOTIFICATION

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

SRP Draft Section 5.4.6 Description of Changes

This SRP section affirms the technical accuracy and adequacy of the guidance previously provided in (Draft) Revision 3, dated June 1996 of this SRP. See ADAMS accession number ML063330003.

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 4, [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

As stated in the ABWR FSER, the RCIC system is part of the ECCS in the ABWR. This RCIC safety function is not currently addressed in the SRP. The appropriate Acceptance Criteria and Review Procedures for reviewing the ECCS function of RCIC are contained in SRP Section 6.3.

Revised Areas of Review to discuss RCIC functions related to Station Blackout events and to cite 10 CFR 50.63 similar to existing citations of GDCs 4, 5, 29, 34, and 54.

Review Interface was added to identify the HPCF system as requiring separation from the RCIC system for protection against common-mode failures in plants where the RCIC system is part of the ECCS.

II. ACCEPTANCE CRITERIA

Added 10 CFR 50.63 to include criteria for SBO.

Added citation to 10 CFR 50.34(f)(2)(xxi) which is related to the existing SRP citation of II.K.1.22.

Added citation to 10 CFR 50.34(f)(1)(v) which is related to the existing SRP citation of II.K.3.13.

Added citation to 10 CFR 50.34(f)(1)(ix) which is related to the existing citation of II.K.3.24.

Added citation to 10 CFR 50.34(f)(2)(xxvi) which is related to the existing citation of III.D.1.1.

Added reference to Regulatory Guide 1.155 to Acceptance Criteria, which provides specific requirements for plant ability to withstand a Station Blackout.

Technical Rationales were developed and added for the Acceptance Criteria GDC 4, 5, 29, 33, 34, 54, and 10 CFR Part 50.63.

III. REVIEW PROCEDURES

Statement was modified to indicate that Technical Specification reviews are also part of the review of the design certification applications. Technical Specifications are part of the DC application as established in 10 CFR 50.34(b)(vi)(6) and 10 CFR 52.47(a)(1)(i).

Added verification of adequacy of power supply for the pump room HVAC cooler as required by TMI item II.K.3.24. The adequacy of the power supply is not currently addressed in the SRP. TMI item II.K.3.24 provides the appropriate Acceptance Criteria for this review.

Revised to incorporate guidance of Generic Letter No. 83-02 and staff findings in the ABWR FSER.

Added procedure for compliance with Regulatory Guide 1.155 to assure that the RCIC will support core cooling during an SBO.

Added procedure to verify MOV operability verification test results as identified in Generic Letter No. 89-10.

Added procedure to verify that the leakage reduction program meets the requirements of NUREG-0737, Action Plan Item III.D.1.1.

Added procedure to verify proper design of the suppression pool suction strainers.

Added procedure for providing verification of RCIC pump minimum flow capacity in accordance with pump manufacturer's recommendations.

IV. EVALUATION FINDINGS

Added 10 CFR 50.63 to include criteria for SBO.

Added reference to SRP Section 8.4 (or SER Section 8.4) for evaluation of conformance with 10 CFR 50.63 and results of the review of SBO.

V. IMPLEMENTATION

Revised two items in this subsection to reflect the implementation date which are dependent on the existing SRP revision date of April 1984.

VI. REFERENCES

Added or revised the following references:

10 CFR Part 50.34(f), "Additional TMI-Related Requirements."

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

Regulatory Guide 1.155, "Station Blackout."

NUREG-0737, "Clarification of TMI Action Plan Requirements," November 1980.

NUREG-0927, Revision 1, "Evaluation of Water Hammer Occurrences in Nuclear Power Plants," March 1984.

NRC Letter to Boiling-Water Reactor Licensees, "NUREG-0737 Technical Specifications (Generic Letter No. 83-02)," January 10, 1983.

NRC Letter to All Licensees and Applicants, Generic Letter No. 89-10, and Supplements 1 through 7, "Safety Related Motor-Operated Valve Testing," June 28, 1989.

Deleted Regulatory Guide 1.53, "Single Failure Criterion."