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 thermal hydraulic systems in boiling-water reactors

Secondary - None

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

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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. 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 cannot be completed until after the rest of this portion of the application has been 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. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other 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 RCIC system and the HPCI, HPCS, or HPCF system for protection against common mode failures from missiles is reviewed under 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 protection against flooding of the RCIC system and redundant equipment is reviewed under SRP Section 3.4.1.

3. Protection against damage from pipe whip and jet impingement is reviewed under SRP Sections 3.6.1 and 3.6.2.

4. The proposed technical specifications is reviewed under SRP Section 16.0.

5. The proposed preoperational and critical startup test programs are reviewed under SRP Section 14.2.

6. The RCIC system is reviewed to ensure that it has the proper seismic and quality organization classification under SRP Sections 3.2.1 and 3.2.2.

7. The RCIC must be enclosed in a seismic Category I structure or building. The design adequacy of this structure or building is reviewed under 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 RCIC system is reviewed under 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. Also, the containment heat removal capability and the suppression pool suction strainers are reviewed under SRP Section 6.2.2.

9. SRP Sections 7.3 and 7.4 are used to evaluate 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. SRP Chapter 8 is used evaluate 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. SRP Section 3.9.3 is used to ensure that the design and installation of the RCIC system meet applicable codes and are adequate for its proper functioning.

12. SRP Section 3.10 is used to review RCIC system equipment to verify that it is seismically qualified for its intended use.

13. SRP Section 3.11 is used reviews RCIC system equipment to confirm that it is environmentally qualified for its intended use.

14. The inservice testing of pumps and valves for the RCIC system is reviewed under SRP Section 3.9.6.

15. The CST level detection and activation of switchover of suction of the RCIC pump to the suppression pool is reviewed under SRP Section 9.2.6.

16. The RCIC pump room cooling is reviewed under 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(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 Atomic Energy Act, and the NRC's regulations;

9. 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 that 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. 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) 5-4, "Design Requirements of the Residual Heat Removal System."

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 martgin 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 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 material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

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 5-4.

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 review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document (DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

    For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

    For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

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 the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

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 submitted 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 5-4, “Design Requirements of the Residual Heat Removal System.”