NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

5.4.7 RESIDUAL HEAT REMOVAL (RHR) SYSTEM

REVIEW RESPONSIBILITIES

Primary - Reactor Systems Branch (~~RSB~~ SRXB)[1]

Secondary - None

I. AREAS OF REVIEW

The residual heat removal (RHR) system is used in conjunction with the main steam and feedwater systems (main condenser), or the reactor core isolation cooling (RCIC) system in conjunction with the safety/relief valves in a boiling water reactor (BWR), or auxiliary feedwater system in conjunction with the atmospheric dump valves in a pressurized water reactor (PWR) to cool down the reactor coolant system following shutdown. Parts of the RHR system also act to provide low pressure emergency core cooling and are reviewed as described in SRP Section 6.3. Some parts of the RHR system also provide containment heat removal capability and are reviewed as described in SRP Section 6.2.2. The reviews of SRP Section 6.2.2 also address PWR sump and BWR RHR suction screen inlet design and evaluation guidance central to ensuring containment sumps provide a reliable, long-term recirculation cooling capability and RHR pump performance will not be adversely affected by post-LOCA conditions impacting the sumps.[2] The review by ~~RSB~~ SRXB[3] is to ensure that the design of the RHR system is in conformance with General Design Criteria 2, 4, 5, 19, and 34.

Both PWRs and BWRs have RHR systems which provide long-term cooling once the reactor coolant temperature has been decreased by the main condenser, RCIC, or auxiliary feedwater systems. In both types of plants, the RHR is typically a low pressure system which takes over the shutdown cooling function when the reactor coolant system (RCS) temperature is reduced to

about 150°C (300°F).[4] Although the RHR system function is similar for the two types of plants, the system designs[5] are different.

The RHR system in PWRs takes water from the RCS hot legs, cools it, and pumps it back to the cold legs or core flooding tank nozzles. The suction and discharge lines for the RHR pumps have appropriate valving to assure that the low pressure RHR system is always isolated from the RCS when the reactor coolant pressure is greater than the RHR system design pressure. The heat removed in the heat exchangers is transported to the ultimate heat sink by the component cooling water or service water system. In PWRs, the RHR system is also used to fill, drain, and remove heat from the refueling canal during refueling operations, to circulate coolant through the core during plant startup prior to RCS pump operation, and in some to provide an auxiliary pressurizer spray.

The RHR system in BWRs is typically composed of four subsystems. The containment heat removal and low pressure emergency core cooling subsystems are discussed in SRP Sections 6.2.2 and 6.3. The shutdown cooling and steam condensing (via RCIC) subsystems are covered by this SRP section. These subsystems make use of the same hardware, consisting of pumps, piping, heat exchangers, valves, monitors, and controls. In the shutdown cooling mode, the BWR RHR system can also be used to supplement spent fuel pool cooling. As in the PWR, the low pressure RHR piping is protected from high RCS pressure by isolation valves.

The steam condensing mode of RCIC operation in BWRs (when included in the plant design) provides an alternative to the main condenser or normal RCIC mode of operation during the initial cooldown. Steam from the reactor is transferred to the RHR heat exchangers where it is condensed. The condensate is piped to the suction side of the RCIC pump. The RCIC pump returns the condensate to the reactor vessel. The heat removed in the heat exchangers is transported to the ultimate heat sink by the service water system.

Other means of removing decay heat in the event that the RHR system is inoperable have been proposed for some BWRs. These approaches use some of the piping that is used for the steam condensing mode of RCIC. These approaches are also covered by this SRP section.

The RHR system in PWRs is utilized to cool the core during shutdown operations, including reduced inventory and mid-loop operations. High RHR system availability and reliability during shutdown conditions is important to mitigating risk and maintaining an appropriate level of safety. The methods used to ensure high reliability of the RHR system under these conditions are reviewed in this SRP section.[6]

The reactor coolant temperatures and pressure must be decreased before the low pressure RHR system can be placed in operation; therefore, the review of the decay heat removal function must consider all conditions from shutdown at normal reactor operating pressure and temperature to the cold depressurized condition. ~~RSB~~ SRXB[7] reviews the requirements for leakage detection and control ~~reliability and capability of removing decay heat~~[8] identified in ~~NUREG-0660 (II.E.3.2 and II.E.3.3), NUREG-0718 (II.B.7), and~~[9] NUREG-0737 (Reference 23) item ~~(~~III.D.1.1~~)~~.[10]

Review Interfaces:[11]

SRXB also performs the following reviews under the SRP sections indicated:[12]

1. As part of its primary review responsibility for SRP Section 3.12 (proposed), the SRXB reviews the design of the RHR systems for new light-water reactor designs to verify, to the extent practical, that low-pressure portions of the RHR that interface with the RCS will withstand full RCS pressure. If designing the RHR 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 provided in SRP Section 3.12 (proposed).[13]

2. With respect to the staff review for compliance with Branch Technical Position RSB 5-1 (Reference~~.~~ ~~5~~7)[14], the ~~Auxiliary Systems Branch (ASB)~~ Plant Systems Branch (SPLB), Materials and Chemical Engineering Branch (~~CMEB~~ EMCB)[15], and ~~RSB~~SRXB[16] effort is divided as follows:

   a~~1~~. For BWRs, the ~~RSB~~ SRXB[17] reviews the processes and systems used in the cooldown of the reactor for the entire spectrum of potential reactor coolant system pressures and temperatures during decay heat removal.

   b~~2~~. For PWRs, the ~~RSB~~ SRXB[18] reviews the approach used to meet the functional requirements of BTP RSB 5-1 with respect to cooldown to the conditions permitting operation of the RHR system. Since an alternate approach to that normally used for cooldown may be specified, the reviewers identify all components and systems used. The ~~CMEB~~ EMCB[19] has primary review responsibility for the review of the pertinent portions of the CVCS (SRP Section 9.3.4). The ~~ASB~~ SPLB[20], as part of its primary review responsibility for SRP Sections 10.3 and 10.4.9 reviews the atmospheric dump valves and the source for auxiliary feedwater, respectively, for conformance to BTP RSB 5-1. The ~~RSB~~ SRXB[21] reviews the pressurizer relief valve and ECCS, if used. PWR depressurization systems used for cooldown are reviewed by the SRXB as part of its primary review responsibility for SRP Section 6.8 (proposed).[22] In addition, the ~~RSB~~ SRXB[23] reviews the tests and supporting analysis concerning mixing of borated water and cooldown under natural circulation as required in BTP RSB 5-1.

   c~~3~~. For both PWRs and BWRs, the ~~ASB~~ SPLB[24] reviews the component cooling or service water systems that transfer decay heat from the RHR system to the ultimate heat sink as part of its primary review responsibility for SRP Sections 9.2.1 and 9.2.2.

   d~~4~~. The ~~RSB~~ SRXB[25] reviews the design and operating characteristics of the RHR system with respect to its shutdown and long-term cooling function. Where the RHR system interfaces with other systems (e.g., RCIC system, component cooling water system) the effect of these systems on the RHR system is reviewed.

Overpressure protection provided by the valving between the RCS and RHR system is also reviewed.

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

1. The Containment Systems and Severe Accident Branch (SCSB) performs the following reviews:[26]

   a. SCSB reviews the containment heat removal capability and the containment sump designs as part of its review responsibility for SRP Section 6.2.2.[27]

   b. SCSB [28]verifies that portions of the RHR system penetrating the containment barrier are designed with acceptable isolation features to maintain containment integrity for all operating conditions including accidents as part of its primary review responsibility for SRP Section 6.2.4~~;~~.[29]

2. The ~~Structural and Geotechnical Engineering Branch (SGEB)~~ Civil Engineering and Geosciences Branch (ECGB)[30] determines the acceptability of the design analysis, procedures and criteria used to establish the ability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena such as safe shutdown earthquake (SSE), the probable maximum flood (PMF), and tornado missiles as part of its primary review responsibility for SRP Sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4 and 3.8.5. The ECGB also verifies that inservice inspection requirements are met for system components as part of its primary review responsibility for SRP Section 6.6.[31]

3. The Materials and Chemical Engineering Branch (~~MTEB~~ EMCB)[32] ~~verifies that inservice inspection requirements are met for system components as part of its primary review responsibility for SRP Section 6.6 and~~[33], upon request, verifies the compatibility of the materials of construction with service conditions as part of its primary review responsibility for SRP Section 6.1.1.[34]

4. The Mechanical Engineering Branch (EMEB) performs the following reviews:[35]

   a. The ~~MEB~~ EMEB ~~also~~[36] determines the acceptability of the seismic and quality group classifications for system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2. In addition, as part of its primary review responsibility for SRP Section 3.2.2, if the PWR PORVs and block valves are relied upon to perform a safety-related function, such as plant cooldown in accordance with BTP 5-1, EMEB will confirm the classification of the PORVs and block valves.[37]

   b. The effects of pipe breaks inside and outside of containment, such as pipe whip and jet impingement, are reviewed by ~~MEB~~ EMEB[38] and ~~ASB~~ as part of ~~their~~its primary review responsibilities for SRP Section~~s~~ 3.6.2.~~ and 3.6.1, respectively.~~[39]

c. The ~~Mechanical Engineering Branch (MEB~~ EMEB[40] determines that the components, piping and structures are designed and tested in accordance with applicable codes and standards as part of its primary review responsibility for SRP Sections 3.9.1 through 3.9.3.

d. The ~~MEB~~ EMEB[41] also reviews adequacy of the inservice testing program of pumps and valves as part of its primary review responsibility for SRP Section 3.9.6. For new plant designs, the SRXB review should coordinate with EMEB to ensure the RHR system configuration allows for full flow testing of safety related pumps and check valves and provisions are made to allow for the use of advanced techniques to detect degradation and to monitor system performance.[42]

5. The Quality Assurance and Maintenance Branch (HQMB) performs the following reviews:[43]

a. The ~~Procedures and Systems Review Branch (PSRB)~~ HQMB[44] reviews the proposed preoperational and startup test programs to confirm that they are in conformance with the intent of Regulatory Guide 1.68 as part of its primary review responsibility for SRP Section 14.2.

b. The ~~PSRB~~ HQMB[45] also has primary review responsibility for Task Action Plan items ~~II.K.1 (C.1.10) of NUREG-0737 (OLs only)~~I.C.2[46] and I.C.6 of NUREG-~~0718~~0737 ~~(CPs only)~~[47] regarding procedures to ensure that system operability status is known, as part of its review responsibility for SRP Section 13.5.1.1.[48]

c. The HQMB also performs a review of Quality Assurance as part of its primary review responsibility for SRP sections 17.1, 17.2 and 17.3.[49]

6. The SPLB performs the following reviews:[50]

a. The ~~ASB~~ SPLB[51] reviews flood protection as part of its primary review responsibility for SRP Section 3.4.1.

b. The ~~ASB~~ SPLB[52] identifies the structures, systems, and components (SSCs)[53] to be protected against externally generated missiles and reviews the adequacy of protection against such missiles as part of its primary review responsibility for SRP Section 3.5.1.4 and 3.5.2. The ~~ASB~~ SPLB[54] also reviews protection against internally generated missiles both inside and outside of containment as part of its primary review responsibility for SRP Sections 3.5.1.1 and 3.5.1.2.

c. Plant design for the protection against postulated piping failures outside containment is reviewed by SPLB as part of its primary review responsibility for SRP Section 3.6.1.[55]

d. The SPLB, as part of its review responsibility for SRP Section 3.11, will review the acceptability of, and environmental qualification test program for, RHR equipment exposed to a post-accident environment. This review includes

consideration of the post-accident environmental design and source term considerations described in TMI action plan item II.B.2 of NUREG-0737 and NUREG-0718 (Reference 22).[56]

e. The SPLB also performs a review for fire protection as part of its primary review responsibility for SRP section 9.5.1.[57]

7. The ~~Power Systems Branch (PSB)~~ Electrical Engineering Branch (EELB)[58] identifies the safety-related electrical loads and determines that power systems supplying motive or control power for the RHR system meet acceptable criteria and will perform these intended functions during all plant operating and accident conditions as part of its primary review responsibility for SRP Sections 8.1, 8.2, 8.3.1, and 8.3.2. In addition, the EELB, as part of its review under SRP Section 8.4 (proposed), reviews the capability to withstand or cope with, and recover from a station blackout (SBO) and coordinates with the review of RHR if the system is required to ensure adequate core cooling and/or decay heat removal.[59]

8. The Instrumentation and ~~Control Systems~~ Controls Branch (~~ICSB~~ HICB)[60], as part of its primary review responsibility for SRP Sections 7.1 and 7.4 reviews the instrumentation and control systems for the RHR system to determine that it will perform its design function as required and conform to all applicable acceptance criteria. The ~~ICSB~~ HICB[61] also reviews the provisions taken to meet GDC 19 with respect to equipment outside of the control room for hot and cold shutdown.

9. The ~~Radiological Assessment Branch (RAB)~~ Emergency Preparedness and Radiation Protection Branch (PERB)[62] has primary review responsibility for SRP Section 12.1 through 12.5 including Task Action Plan items II.B.2 of NUREG-0737 and NUREG-0718 which involve a radiation and shielding design review and corrective actions taken to ensure adequate access to vital areas and protection of safety equipment ~~(CPs and OLs)~~.[63]

10. The Technical Specifications Branch (TSB) reviews the Technical Specifications as part of their primary review responsibility for SRP Section 16.0.[64]

~~The review for Fire Protection, Technical Specifications, and Quality Assurance are coordinated and performed by the CMEB, Standardization and Special Projects Branch (SSPB) and Quality Assurance Branch (QAB) as part of their primary review responsibility for SRP Sections 9.5.1, 16.0 and 17.0, respectively.~~[65]

For those areas of review identified above as being reviewed as part of the ~~primary~~ review ~~responsibility of~~under other ~~branches~~SRP sections, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP ~~S~~sections ~~of the corresponding primary branch~~.[66]

II. ACCEPTANCE CRITERIA

The ~~Reactor Systems Branch~~ SRXB[67] acceptance criteria are based on meeting the requirements of the following regulations:

A. General Design Criterion 2 with respect to the seismic design of ~~systems, structures and components~~ SSCs[68] whose failure could cause an unacceptable reduction in the capability of the residual heat removal system. Acceptability is based on meeting position C-2 of Regulatory Guide 1.29 or its equivalent.

B. General Design Criterion 4, as related to dynamic effects associated with flow instabilities and loads (e.g., water hammer).

C. General Design Criterion 5 which requires that any sharing among nuclear power units of ~~structures, systems and components~~ SSCs[69] important to safety will not significantly impair their safety function.

D. General Design Criterion 19 with respect to control room requirements for normal operations and shutdown~~, and;~~.[70]

E. General Design Criterion 34 which specifies requirements for a residual heat removal system.

F. TMI Action Plan item III.D.1.1 of NUREG-0737, equivalent to 10 CFR 50.34(f)(2)(xxvi) for applicants subject to 10 CFR 50.34(f), with respect to the provisions for a leakage detection and control program to minimize the leakage from those portions of the RHR system outside of the containment that contain or may contain radioactive material following an accident.[71]

Specific criteria necessary to meet the requirements of General Design Criteria 2, 4, 5, 19, and 34 are as follows:

1. The system or systems are to satisfy the functional, isolation, pressure relief, pump protection and test requirements specified in Branch Technical Position RSB 5-1.

2. In order to meet the requirements of General Design Criterion 4 ~~(Ref 11)~~[72], design features and operating procedures shall be provided to prevent damaging water hammer due to such mechanisms as voided pump discharge lines, water entrainment in steam lines and steam bubble collapse.

3. Interfaces between the RHR system and RCIC and component or service water systems should be designed so that operation of one does not interfere with, and provides proper support (where required) for, the other. In relation to these and other shared systems (e.g., emergency core cooling and containment heat removal systems), the RHR system must conform to GDC 5.

~~4. The requirements for the reliability and capability of removing decay heat under the following Task Action Plan items must also be satisfied.~~[73]

~~a. Meeting Task Action Plan item II.E.3.2 of NUREG-0660 which involves systems reliability. NRR will conduct a generic study to assess the capability and reliability of shutdown heat removal systems under various transients and degraded plant conditions including complete loss of all feedwater. Deterministic and probabilistic methods will be used to identify design weaknesses and possible system modifications that could be made to improve the capability and reliability of these systems under all shutdown conditions (CPs and OLs). Specific requirements will be based on the results of this study.~~[74]

~~b. Meeting Task Action Plan item II.E.3.3 of NUREG-0660 which involves a coordinated study of shutdown heat removal requirements. An effort to evaluate shutdown heat removal requirements in a comprehensive manner is required, thereby permitting a judgment of adequacy in terms of overall system requirements. As part of this project, NRR will conduct a study to assess the desirability of and possible requirement for a diverse heat-removal path, such as feed and bleed, particularly if all secondary-side cooling is unavailable. The NRC staff will work with the recently established ACRS Ad Hoc Subcommittee on this matter to develop a mutually acceptable overall study program (CPs and OLs). Specific requirements will be based on the results of this study.~~[75]

~~c. Meeting Task Action Plan item II.B.8 of NUREG-0718 (Ref. 7) which involves description by the applicants of the degree to which the designs conform to the proposed interim rule on degraded core accidents (CPs only).~~[76]

~~d. Meeting Action Plan item III.D.1.1 of NUREG-0737 (Ref. 8) and NUREG-0718 (Ref. 7) which involves primary coolant sources outside of containment (CPs and OLs).~~[77]

4~~5~~.[78] When the RHR system is used to control or mitigate the consequences of an accident, it must meet the design requirements of an engineered safety feature system. This includes meeting the guidelines of Regulatory Guide 1.1 regarding net positive suction head.

Technical Rationale:[79]

The technical rationale for application of the above acceptance criteria to the residual heat removal system is addressed in the following paragraphs:

1. GDC 2 requires that SSCs important to safety be designed to withstand the effects of natural phenomena, such as earthquakes, without the loss of capability to perform their safety functions. The RHR system is relied upon to provide residual heat removal from the reactor core which is necessary for maintaining the reactor in a safe shutdown condition. In addition, the RHR system may be capable of cooling the spent fuel pool. Regulatory Guide 1.29 provides guidance for determining which systems should be designated Seismic Category I; position C.1 provides guidance for safety related portions

and position C.2 provides guidance for nonsafety related systems and components. Meeting the requirements of GDC 2 will enhance plant safety by ensuring that the RHR system will be available to cool the core and/or the spent fuel pool during and following a seismic event.

2. GDC 4 requires that SSCs important to safety be designed to accommodate the effects of and be compatible with the environmental conditions associated with normal operation, maintenance, testing and postulated accident conditions including such effects as pipe whip and jet impingement. The safety function of the RHR system is to transfer heat from the reactor to the environment after plant shutdown. In order to ensure the availability of decay heat removal, the RHR system must be capable of performing the heat transfer function under the expected operational and postulated accident conditions for the plant. These conditions include consideration of the dynamic effects of flow instabilities and the loadings caused by water hammer events. Compliance with GDC 4 enhances plant safety by providing assurance that dynamic effects of events such as flow instabilities and water hammer will not affect the capability of the RHR systems to remove decay heat.

3. GDC 5 prohibits the sharing of SSCs among nuclear power units unless it can be shown that such sharing will not significantly impair the ability of the SSCs to perform their safety functions, including, in the event of an accident in one unit, and orderly shutdown and cooldown of the remaining units. The RHR systems are relied upon to transfer decay heat from the reactor to the environment after a reactor shutdown. The RHR system must be designed such that the ability to perform this and other designated safety-related functions are not compromised for each unit regardless of equipment failures or other events that may occur in another unit. Meeting the requirements of GDC 5 enhances plant safety by providing assurance that unacceptable effects of equipment failures or other events occurring in one unit of a multi-unit site will not prevent an orderly shutdown and cooldown of to the unaffected unit(s).

4. GDC 19 requires that a control room be provided from which actions can be taken to operate the nuclear power unit during both normal operating and accident conditions, including the loss of coolant accident. Branch Technical Position RSB 5-1 provides guidance for compliance with GDC 19 with regard to achieving cold shutdown from the control room using only safety grade equipment. The residual heat removal systems are required for safe shutdown and cooldown of the reactor during normal and accident conditions. Compliance with GDC 19 enhances plant safety by ensuring the availability of adequate instrumentation and controls in the control room to perform the required safety functions of the residual heat removal systems under all anticipated conditions.

5. GDC 34 requires the capability to transfer decay heat and other residual heat from the reactor such that fuel and pressure boundary design limits are not exceeded. In addition, the system must be designed with sufficient redundancy and isolation capability to ensure the safety function can be accomplished assuming a single failure of an active component with or without a coincident loss of offsite power. The residual heat removal systems function to transfer the fission product decay and other residual heat from the reactor core. Removal of decay and residual heat is necessary to prevent core damage under

both normal and accident shutdown conditions. Branch Technical Position RSB 5-1 provides an acceptable approach to assure compliance with GDC 34 with regard to accomplishing the RHR system safety functions assuming a single failure. Compliance with GDC 34 enhances plant safety by providing assurance that decay and residual heat removal will be accomplished and the reactor coolant system pressure boundary and fuel cladding integrity will be maintained, thereby minimizing the potential for release of fission products to the environment.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to assure that the design criteria and bases and the preliminary design as set forth in the Preliminary Safety Analysis Report meet the acceptance criteria given in subsection II.

For operating license (OL) reviews, the procedures are utilized to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the Final Safety Analysis Report. The OL review also includes the proposed technical specifications, to assure that they are adequate in regard to limiting conditions of operation and periodic surveillance testing.

As noted in subsections I and II, the ~~RSB~~ SRXB[80] review for PWRs is limited to the low pressure - low temperature RHR system. For BWRs, the review is to include all of the systems used to transfer residual heat from the reactor over the entire range of potential reactor coolant temperatures and pressures. The following steps are to be applied by the reviewer for the appropriate systems, depending on whether a PWR or BWR is being reviewed. These steps should be adapted to CP or OL reviews as appropriate.

1. Using the description given in the applicant's Safety Analysis Report (SAR), including component lists and performance specifications, the reviewer determines that the system(s) piping and instrumentation are such to allow the system(s) to operate as intended, with or without offsite power and given any single active component failure. This is accomplished by reviewing the piping and instrumentation diagrams (P&IDs) to confirm that piping arrangements permit the required flow paths to be achieved and that sufficient process sensors are available to measure and transmit required information. A failure modes and effects analysis (or similar system safety analysis) provided in the SAR is used to determine conformance to the single failure criterion.

2. Using the comparison tables of SAR Section 1.3, the RHR system is compared to designs and capacities of such systems in similar plants to see that there are no unexplained departures from previously reviewed plants. Where possible, comparisons should be made with actual performance data from similar systems in operating plants.

3. From the system description and P&IDs, the reviewer determines that the isolation requirements of Branch Technical Position RSB 5-1 ~~(Ref. 5)~~[81] are satisfied.

4. The reviewer determines that the RHR system design has provisions to prevent damage to the RHR pumps in accordance with Branch Technical Position RSB 5-1 ~~(Ref. 5)~~.[82]

The reviewer checks the isolation valves in the suction line for potential closure, NPSH requirements, pump run out, and potential loss of miniflow line during pump testing. If operator action is required to protect the pumps, the reviewer evaluates the instrumentation required to alert the operator and the adequacy of the time frame for operator action.

The reviewer verifies that the applicant has considered the following guidance regarding the design of the RHR miniflow systems necessary to ensure safety related RHR pump protection (see References 15, 18 and 19).

a. Ensure that the minimum cooling flow provided for the RHR pumps is adequate under all conditions, including verification that the system configuration precludes pump-to-pump interaction during miniflow operation that could result in dead-heading one or more of the pumps. The miniflow must be sufficient to prevent damage to the pump(s) under all conditions.

b. The miniflow system shall be designed such that the miniflow function can be performed assuming a single failure. A single failure should not result in conditions causing no flow through the RHR pumps.

c. In cases where only the miniflow return line is available for pump testing, flow instrumentation must be installed on the miniflow return line. This instrumentation is necessary to provide flow rate measurements during pump testing so this data can be evaluated with the measured pump differential pressure to monitor for pump hydraulic degradation.[83]

5. The RHR systems ~~is~~are[84] reviewed to evaluate the adequacy of design features that have been provided to prevent damaging water (steam) hammer due to such mechanisms as voided discharge lines, water entrainment in steam lines and steam bubble collapse. For systems with a water supply above the discharge lines, voided lines are prevented by proper vent location and filling and venting procedures. The vents should be located for ease of operation and testing on a periodic basis. If the normal alignment of suction valves is to a source below the highest level of the pump discharge lines (e.g., the suppression pool for RHR systems of BWRs) back leakage through the pump discharge check valves will result in line voiding.

Proper vent location and filling and venting procedures are still needed. In addition, a special keep-full system with appropriate alarms is needed to supply water to the discharge lines at sufficiently high pressure to prevent voiding. Operating and maintenance procedures shall be reviewed by the applicant to assure that adequate measures are taken to avoid water hammer due to voided line conditions.

For RHR systems of BWRs which use the steam condensing mode of operation, the evaluation should include consideration of water hammer due to (a) water entrainment in the steam supply line during startup, (b) formation of steam bubbles in the RHR system pump discharge lines and heat exchangers resulting from leakage past valves in the steam supply line, and (c) water entrainment in the discharge line of the pressure relief valve

used to prevent over pressurization of the system during operation in the steam condensing mode.

Guidance for water hammer prevention and mitigation is found in NUREG-0927 (Reference 26).[85]

6. Using the system process diagrams, P&IDs, failure modes and effects analysis, and component performance specifications, the reviewer determines that the system(s) has the capacity to bring the reactor to conditions permitting operation of the RHR system in a reasonable period of time, assuming a single failure of an active component with only either onsite or offsite electric power available. For the purposes of this review, 36 hours is considered a reasonable time period. The ~~ASB~~ SPLB[86] is responsible for the review of the initial cooldown phase for PWRs. Therefore, this review effort is to be coordinated with that branch. For the purposes of the review of both PWRs and BWRs, only the operation of safety grade equipment is to be assumed. For PWRs, if the PORVs are relied upon in the performance of a safety-related function such as plant cooldown for compliance with Branch Technical Position RSB 5-1, the PORVs must meet the guidance contained in Generic Letter 90-06 (see References 16 and 24) as reviewed in SRP Section 6.8 (proposed).[87] For new PWRs that utilize PORVs, the valves shall be safety-related.[88]

7. The cooldown function is to be reviewed to determine if it can be performed from the control room assuming a single failure of an active component, with only either onsite or offsite electric power available. Any operation required outside of the control room is to be justified by the applicant. Like Item ~~5~~6,[89] the initial cooldown for PWRs is to be reviewed by ~~ASB~~ SPLB.[90]

8. By reviewing the system description and the P&IDs, the reviewer confirms the RHR system satisfies the pressure relief requirements of Branch Technical Position RSB 5-1 ~~(Ref. 5)~~.[91]

9. By reviewing the piping arrangement and system description of the RHR system, the reviewer confirms that the RHR system meets the requirements of GDC 5 ~~(Ref. 2)~~[92] concerning shared systems.

10. The ~~RSB~~ SRXB[93] reviewer contacts the ~~ASB~~ SPLB[94] reviewer in conjunction with ~~his~~the[95] review of the RHR system heat sink and refueling system interaction to interchange information and assure that the reviews are consistent with regard to the interfacing parameters. For example, the ~~ASB~~ SPLB[96] review determines the maximum service or component cooling water temperature. The ~~RSB~~ SRXB[97] reviewer then reviews the RHR system description to determine that this maximum temperature has been allowed for in the RHR system design.

11. The ~~RSB~~ SRXB[98] reviewer contacts ~~his counterpart in~~ the ~~ICSB~~ HICB[99] reviewer[100] to obtain any needed information from their review. Specifically, ~~ICSB~~ HICB[101] confirms 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 RHR system are to have sufficient redundancy to satisfy the single failure criterion.

12. The RSB SRXB[102] reviewer contacts ~~his counterpart in~~ the (SCSB)~~CSB~~[103] reviewer[104] so that the information needed concerning their reviews will be interchanged.

13. The ~~RSB~~ SRXB[105] reviewer contacts ~~his counterpart in PSRB~~ the HQMB[106] reviewer[107] to discuss any special test requirements and to confirm that the proposed preoperational test program for the RHR system is in conformance with the intent of Regulatory Guide 1.68.

14. The proposed plant technical specifications are reviewed to:

    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 due to repairs and maintenance.

    b. Verify that the frequency and scope of periodic surveillance testing is adequate.

15. The reviewer contacts the ~~SGEB~~ ECGB[108] reviewer to confirm that the systems employed to remove residual heat are housed in a structure whose design and design criteria provide adequate protection against wind, tornadoes, floods, and missiles, as appropriate.

16. For PWRs, the reviewer confirms that the auxiliary feedwater supply satisfies the requirements of Branch Technical Position RSB 5-1.

17. The ~~RSB~~ SRXB[109] reviewer provides information to other branches in those areas where the ~~RSB~~ SRXB[110] has a review responsibility that is not explicitly covered in steps 1-15 above. These additional areas of review responsibility include:

    a. Identification of engineered safety features (ESF) and safe shutdown electrical loads, and verification that the minimum time intervals for the connection of the ESF to the standby power systems are satisfactory.

    b. Identification of vital auxiliary systems associated with the RHR system and determination of cooling load functional requirements and minimum time intervals.

    c. Identification of essential components associated with the main steam supply and the auxiliary feedwater system that are required to operate during and following shutdown.

18. The reviewer considers compliance with acceptance criteria II.F by verifying that those portions of the RHR systems located outside of containment that contain or may contain radioactive material following an accident are included in a leakage control program.

The leakage control program should include periodic leak testing and measures to minimize leakage from the RHR systems.[111]

~~The RSB review evaluates the applicant responses to the following Task Action Plan items:~~[112]

~~a. II.E.3.2 of NUREG-0660 (CPs and OLs)~~

~~b. II.E.3.3 of NUREG-0660 (CPs and OLs)~~[113]

~~c. II.B.8 of NUREG-0718 (CPs only)~~[114]

~~d. III.D.1.1 of NUREG-0737 and NUREG-0718 (CPs and OLs)~~[115]

19. The reviewer verifies that actions have been taken to ensure continued availability and high reliability of the decay heat removal systems during shutdown operations.

For PWRs, design features should be incorporated to prevent a loss of RHR functions under reduced inventory mid-Loop operations. The reviewer should verify that the RHR-specific guidance and measures contained in Generic Letter 88-17 (Reference 14) are satisfied. The RHR-specific guidance contained in Generic Letter 88-17 is summarized as follows:

a. The reviewer verifies that the applicant/licensee will have measures in place to assure that the RCS will remain in a stable and controlled condition while in a reduced inventory condition. These measures include both prevention of a loss of RHR and enhanced monitoring requirements to ensure timely response to a loss of RHR, should such a loss occur.

b. The reviewer verifies that the applicant/licensee has the capability of continuously monitoring RHR system performance whenever a RHR system is being used for cooling the RCS.

c. The reviewer verifies that the RHR system has visible and audible indications of abnormal conditions in temperature, level, and RHR system performance parameters.[116]

20. The reviewer verifies that new light water reactor applicants have ensured high reliability of the shutdown decay heat removal system as follows (See References 10 through 13 and 25):

a. The reviewer verifies that design provisions exist to help ensure continuity of flow through the core and RHR system with low-liquid levels at the junction of the RHR system suction lines and the RCS (new PWR applicants only).

b. The reviewer verifies that provisions exist to ensure availability of reliable systems for decay heat removal.

c. The reviewer verifies that the applicant has provided reliable measurements of liquid levels at the junction of the RHR system suction lines and the RCS (new PWR applicants only).[117]

d. The reviewer verifies that automatic closure interlocks for the RHR suction isolation valves, if provided, are designed in such a manner as to minimize inadvertent valve closure during system operation (new PWR applicants only).[118]

21. The reviewer verifies that the applicant has reviewed their RHR system design configurations to identify any unisolable piping connected to the RCS that could be subjected to temperature distributions that could result in unacceptable thermal stresses. This review should consider the potential for thermal stratification, thermal cycling and thermal fatigue, given the RHR system configuration. The reviewer verifies that appropriate action has been taken, where such piping is identified, to ensure that the piping will not be subjected to unacceptable thermal stresses (Reference 20). This review should focus on RHR system configurations; reviewing the stress analysis and ensuring the analysis is in accordance with the ASME code is the responsibility of EMEB in SRP Section 3.9.3.[119]

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[120]

IV. EVALUATION FINDINGS

The reviewer verifies that the SAR contains sufficient information and ~~his~~the[121] review supports the following kinds of statements and conclusions, which should be included in the staff's Safety Evaluation Report (SER)[122]:

For PWRs

The residual heat removal function is accomplished in two phases: the initial cooldown phase and the residual heat removal (RHR system) operation phase. In the event of loss of offsite power, the initial phase of cooldown is accomplished by use of the auxiliary feedwater system and the atmospheric dump valves. This equipment is used to reduce the reactor coolant system temperature and pressure to values that permit operation of the RHR system. The review of the initial cooldown phase is discussed in Section ___ of the SER. The review of the RHR system operational phase is discussed below. The residual heat removal (RHR) system removes core decay heat and provides long-term core cooling following the initial phase of reactor cooldown. The scope of review of the RHR system for the ___ plant included piping and instrumentation diagrams, equipment layout drawings, failure modes and effects analysis, and design performance specifications for essential components. The review has included the applicant's proposed design criteria

and design bases for the RHR system and ~~his~~the[123] analysis of the adequacy of those criteria and bases and the conformance of the design to these criteria and bases.

The staff concludes that the design of the ~~R~~residual ~~H~~heat ~~R~~removal ~~S~~system[124] is acceptable and meets the requirements of General Design Criteria 2, 4, 5, 19, ~~and~~ 34 and 10 CFR 50.34(f)(2)(xxvi)[125]. This conclusion is based on the following:

(1) The applicant has met the General Design Criterion 2 with respect to position C-2 of Regulatory Guide 1.29 concerning the seismic design of systems, structures and components (SSCs)[126] whose failure could cause an unacceptable reduction in the capability of the residual heat removal system.

(2) The applicant has met the General Design Criterion 4 with respect to dynamic effects associated flow instabilities and loads (e.g., water hammer).

(3) The applicant has met the requirements of General Design Criterion 5 with respect to sharing of ~~structure, systems and components~~SSCs[127] by demonstrating that such sharing does not significantly impair the ability of the ~~R~~residual ~~H~~heat ~~R~~removal ~~S~~system[128] to perform its[129] safety function including, in the event of an accident to one unit, an orderly shutdown and cooldown of the remaining units.

(4) The applicant has met General Design Criterion 19 with respect to the main control room requirements for normal operations and shutdown and General Design Criterion 34 which specifies requirements for the residual heat removal system by meeting the regulatory positions[130] in Branch Technical Position RSB 5-1.

(5) The applicant has met III.D.1.1 of NUREG-0737, equivalent to 10 CFR 50.34(f)(2)(xxvi) for applicants subject to 10 CFR 50.34(f), with respect to leakage detection and control in the design of RHR systems outside containment that contain (or may contain) radioactive material following an accident.[131]

~~In addition, the applicant has met the requirements of the following Task Action Plan Items:~~[132]

~~(1) Task Action Plan item II.E.3.2 of NUREG-0660 (Ref. 10) as it relates to systems capability and reliability of shutdown heat removal systems under various transients.~~

~~(2) Task Action Plan item II.E.3.3 of NUREG-0660 (Ref. 10) as it relates to a coordinated study of shutdown heat removal requirements.~~[133]

~~(3) Task Action Plan item II.B.8 of NUREG-0718 (Ref. 7) as it relates to description by the applicants of the degree to which the designs conform to the proposed interim rule on degraded core accidents (CPs only).~~[134]

~~(4) Task Action Plan item III.D.1.1 of NUREG-0737 (Ref. 8) and NUREG-0718 (Ref. 7) as they relate to primary coolant sources outside of containment (CPs and Ols).~~[135]

For BWRs

The residual heat removal function is accomplished in two phases: the initial cooldown phase and a low pressure-temperature operation phase. In the event of loss of offsite electrical power, the initial cooldown phase is accomplished using the reactor core isolation cooling (RCIC) system and the safety/relief valves. The low pressure-temperature mode of operation is usually accomplished by the residual heat removal (RHR) system. However, certain single failures can render the RHR system inoperative. In that event, two alternate systems that use components of the RCIC and RHR system are available to bring the reactor to cold shutdown conditions.

The scope of review of these systems for the ___ plant included piping and instrumentation diagrams, equipment layout drawings, failure modes and effects analysis, and design performance specifications for essential components. The review has included the applicant's proposed design criteria and design bases for these systems and ~~his~~the[136] analysis of the adequacy of those criteria and bases and of the conformance of the design to these criteria and bases.

The staff concludes that the design of the ~~R~~residual ~~H~~heat ~~R~~removal ~~S~~system[137] is acceptable and meets the requirements of General Design Criteria 2, 4, 5, 19,~~ and~~ 34 and 10 CFR 50.34(f)(2)(xxvi)[138]. This conclusion is based on the following:

(1) The applicant has met General Design Criterion 2 with respect to position C-2 of Regulatory Guide 1.29 concerning the seismic design of systems, structures and components (SSCs)[139] whose failure could cause an unacceptable reduction in the capability of the residual heat removal system.

(2) The applicant has met the General Design Criterion 4 with respect to dynamic effects associated flow instabilities and loads (e.g., water hammer).

(3) The applicant has met the requirements of General Design Criterion 5 with respect to sharing of~~ structures, systems, and components~~ SSCs[140] by demonstrating that such sharing does not significantly impair the ability of the ~~R~~residual ~~H~~heat ~~R~~removal ~~S~~system[141] to perform its safety function including, in the event of an accident to one unit, an orderly shutdown and cooldown of the remaining units.

(4) The applicant has met General Design Criterion 19 with respect to the main control room requirements for normal operations and shutdown and General Design Criterion 34 which specifies requirements for the residual heat removal system by meeting the regulatory positions[142] in Branch Technical Position RSB 5-1.

(5) The applicant has met III.D.1.1 of NUREG-0737, equivalent to 10 CFR 50.34(f)(2)(xxvi) for applicants subject to 10 CFR 50.34(f), with respect to leakage detection and control in the design of RHR systems outside containment that contain (or may contain) radioactive material following an accident.[143]

~~In addition, the applicant has met the requirements of the following Task Action Plan Items:~~[144]

~~(1) Task Action Plan item II.E.3.2 of NUREG-0660 (Ref. 10) as it relates to systems capability and reliability of shutdown heat removal systems under various transients.~~

~~(2) Task Action Plan item II.E.3.3 of NUREG-0660 (Ref. 10) as it relates to a coordinated study of shutdown heat removal requirements.~~[145]

~~(3) Task Action Plan item II.B.8 of NUREG-0718 (Ref. 7) as it relates to description by the applicants of the degree to which the designs conform to the proposed interim rule on degraded core accidents (CPs only).~~[146]

~~(4) Task Action Plan item III.D.1.1 of NUREG-0737 (Ref. 8) and NUREG-0718 (Ref. 7) as they relate to primary coolant sources outside of containment (CPs and Ols).~~[147]

In addition to the above criteria, the acceptability of the RHR system may be based on the degree of design similarity with previously approved plants. Deviations from these criteria from other types of RHR systems (e.g., systems that are designed to withstand reactor coolant system operating pressure or systems located entirely inside containment) will be considered on an individual basis.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[148]

V. IMPLEMENTATION

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

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[149] Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

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.[150]

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced BTP RSB 5-1, regulatory guides, NUREGs and implementation of acceptance criterion subsections II.B and II.2 is as follows:

(a) ~~Operating plants and OL applicants need not comply with the provisions of this revision.~~Plants with an operating license issued prior to April 1984 and operating license applications docketed prior to April 1984 need not comply with the provisions of this item but may do so voluntarily.[151]

(b) ~~CP applicants will be required to comply with the provisions of this revision.~~Applicants for a construction permit will be required to comply with the provisions of this item.[152]

(c) Operating license, design certification, and combined license applications docketed on or after April 1984 will be reviewed according to the provisions of this item.[153]

VI. REFERENCES[154]

1. 10 CFR Part 50, § 50.34(f), "Additional TMI-related Requirements."[155]

~~1~~2. 10 CFR Part 50, Appendix A, General Design Criterion 2, "Design Bases for Protection Against Natural Phenomena."

~~2~~3. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and ~~Missile~~Dynamic Effects Design Bases."[156]

4~~2~~. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures, Systems and Components."

5~~3~~. 10 CFR Part 50, Appendix A, General Design Criterion 19, "Control Room."

6~~4~~. 10 CFR Part 50, Appendix A, General Design Criterion 34, "Residual Heat Removal."

7~~5~~. Branch Technical Position RSB 5-1, "Design Requirements of the Residual Heat Removal System," attached to SRP Section 5.4.7.

8~~9~~. Regulatory Guide 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal Systems."

9~~6~~. Regulatory Guide 1.29, "Seismic Design Classification."

10. SECY 90-016, "Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationship to Current Regulatory Requirements," dated January 12, 1990.[157]

11. Staff Requirements Memorandum, “SECY 90-016 - Evolutionary Light Water Reactor (LWR) Certification Issues and Their Relationships to Current Regulatory Requirements,” dated June 26, 1990.[158]

12. SECY 93-087, “Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs,” dated April 2, 1993.[159]

13. Staff Requirements Memorandum, “SECY 93-087 - Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs,” dated July 21, 1993.[160]

14. NRC Letter to all Holders of Operating Licenses and Construction Permits for Pressurized Water Reactors (PWRs), “Loss of Decay Heat Removal (Generic Letter 88-17),” October 17, 1988.[161]

15. NRC Letter to All Holders of Light Water Reactor Operating Licenses and Construction Permits, "Guidance on Developing Acceptable Inservice Testing Programs (Generic Letter 89-04)," April 3, 1989.[162]

16. NRC Letter to all Pressurized Reactor Licensees and Construction Permit Holders, “Resolution of Generic Issue 70, ‘Power-Operated Relief-Valve and Block Valve Reliability,’ and Generic Issue 94, ‘Additional Low-Temperature Overpressure Protection For Light-Water Reactors, (Generic Letter 90-06)," June 25, 1990.[163]

17. NRC Letter to all Holders of Operating Licenses or Construction Permits for Pressurized Water Reactors (PWRs), "Resolution of Generic Issue 79, 'Unanalyzed Reactor Vessel (PWR) Thermal Stress During Natural Convection Cooldown' (Generic Letter 92-02)," March 6, 1992.[164]

18. NRC Bulletin 86-01, "Minimum Flow Logic Problems That Could Disable RHR Pumps," May 23, 1986.[165]

19. NRC Bulletin 88-04, "Potential Safety-Related Pump Loss," May 5, 1988.[166]

20. NRC Bulletin 88-08, “Thermal Stresses in Piping Connected to Reactor Coolant Systems,” June 22, 1988 and its Supplements 1 through 3.[167]

21.~~10~~ NUREG-0660, "NRC Action Plan Developed as a Result of the TMI-2 Accident."

22~~7~~. NUREG-0718, "Licensing Requirements for Pending Applications for Construction Permits and Manufacturing License."

23~~8~~. NUREG-0737, "Clarification of TMI Action Plan Requirements."

24. NUREG-1316, “Technical Findings and Regulatory Analysis Related to Generic Issue 70 - Evaluation of Power-Operated Relief Valve and Block Valve Reliability in PWR Nuclear Power Plants.”[168]

25. NUREG-1449, “Shutdown and Low-Power Operation at Nuclear Power Plants in the United States.”[169]

26. NUREG-0927, Revision 1, "Evaluation of Water Hammer Occurrences in Nuclear Power Plants," March 1984.[170]

BRANCH TECHNICAL POSITION RSB 5-1
(CURRENTLY THE RESPONSIBILITY OF REACTOR SYSTEMS BRANCH - SRXB)[171]
DESIGN REQUIREMENTS OF THE RESIDUAL HEAT REMOVAL SYSTEM

BACKGROUND

GDC 19 states that, "A control room shall be provided from which actions can be taken to operate the nuclear power unit under normal conditions..."

Normal operating conditions include~~ing~~[172] the shutting down of a reactor; therefore, since the residual heat removal (RHR) system is one of several systems involved in the normal shutdown of all reactors, this system must be operable from the control room.

GDC 34 states that "Suitable redundance...shall be provided to assure that for onsite electrical power system operation (assuming offsite power is not available) and for offsite electrical power system operation (assuming onsite power is not available), the system safety function can be accomplished, assuming a single failure."

In most current plant designs the RHR system has a lower design pressure than the reactor coolant system (RCS), is located outside of containment and is part of the emergency core cooling system (ECCS). However, it is possible for the RHR system to have different design characteristics. For example, the RHR system might have the same design pressure as the RCS, or be located inside of containment. Plants which may have RHR systems that deviate from current designs will be reviewed on a case-by-case basis. The functional, isolation, pressure relief, pump protection, and test requirements for the RHR system are included in this position.

BRANCH POSITION

A. Functional Requirements

The system(s) which can be used to take the reactor from normal operating conditions to cold shutdown[1] shall satisfy the functional requirements listed below.[173]

1. The design shall be such that the reactor can be taken from normal operating conditions to cold shutdown using only safety-grade systems. These systems shall satisfy General Design Criteria 1 through 5.

2. The system(s) shall have suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities to assure that for onsite electrical power system operation (assuming offsite power is not available) and for offsite electrical power system operation (assuming onsite

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[1] Processes involved in cooldown are heat removal, depressurization, flow circulation, and reactivity control. The cold shutdown condition, as described in the Standard Technical Specifications, refers to a sub critical reactor with a reactor coolant temperature no greater than 93.3 °C (200 °F) for a PWR and 100 °C (212 °F) for a BWR.

power is not available) the system function can be accomplished assuming a single failure.

3. The system(s) shall be capable of being operated from the control room (including instrumentation for monitoring and control functions)[174] with either only onsite or only offsite power available. In demonstrating that the system can perform its function assuming a single failure, limited operator action outside of the control room would be considered acceptable if suitably justified.

4. The system(s) shall be capable of bringing the reactor to a cold shutdown condition, with only offsite or onsite power available, within a reasonable period of time following shutdown, assuming the most limiting single failure.

B. RHR System Isolation Requirements

The RHR system shall satisfy the isolation requirements listed below.

1. The following shall be provided in the suction side of the RHR system to isolate it from the RCS.

   (a) Isolation shall be provided by at least two power-operated valves in series. The valve positions shall be indicated in the control room.

   (b) The valves shall have independent diverse interlocks to prevent the valves from being opened unless the RCS pressure is below the RHR system design pressure. Failure of a power supply shall not cause any valve to change position.

   (c) The valves ~~shall~~ should have independent diverse interlocks to protect against one or both valves being open during an RCS increase above the design pressure of the RHR system, to the extent that such interlocks will not degrade high system reliability during shutdown operations (see Reference 14).[175]

2. One of the following shall be provided on the discharge side of the RHR system to isolate it from the RCS:

   (a) The valves, position indicators, and interlocks described in item 1(a) through 1(c) above,

   (b) One or more check valves in series with a normally closed power-operated valve. The power-operated valve position shall be indicated in the control room. If the RHR system discharge line is used for an ECCS function, the power-operated valve is to be opened upon receipt of a safety injection signal once the reactor coolant pressure has decreased below the ECCS design pressure.

(c) Three check valves in series, or

(d) Two check valves in series, provided that there are design provisions to permit periodic testing of the check valves for leak tightness and the testing is performed at least annually.

C. Pressure Relief Requirements

The RHR system shall satisfy the pressure relief requirements listed below.

1. To protect the RHR system against accidental over pressurization when it is in operation (not isolated from the RCS), pressure relief in the RHR system shall be provided with relieving capacity in accordance with the ASME Boiler and Pressure Vessel Code. The most limiting pressure transient during the plant operating condition when the RHR system is not isolated from the RCS shall be considered when selecting the pressure relieving capacity of the RHR system. For example, during shutdown cooling in a PWR with no steam bubble in the pressurizer, inadvertent operation of an additional charging pump or inadvertent opening of an ECCS accumulator valve should be considered in selection of the design bases.

2. Fluid discharged through the RHR system pressure relief valves must be collected and contained such that a stuck open relief valve will not:

   (a) Result in flooding of any safety-related equipment.

   (b) Reduce the capability of the ECCS below that needed to mitigate the consequences of a postulated LOCA.

   (c) Result in a non-isolatable situation in which the water provided to the RCS to maintain the core in a safe condition is discharged outside of the containment.

3. If interlocks are provided to automatically close the isolation valves when the RCS pressure exceeds the RHR system design pressure, adequate relief capacity shall be provided during the time period while the valves are closing.

D. Pump Protection Requirements

The design and operating procedures of any RHR system shall have provisions to prevent damage to the RHR system due to overheating, cavitation or loss of adequate pump suction fluid.

E. Test Requirements

The isolation valve operability and interlock circuits must be designed so as to permit on line testing when operating in the RHR mode. Testability shall meet the requirements of IEEE Standard 338-1977[176177] and Regulatory Guide 1.22.

The preoperational and initial startup test program shall be in conformance with Regulatory Guide 1.68. The programs for PWRs shall include tests with supporting analysis to (a) confirm that adequate mixing of borated water added prior to or during cooldown can be achieved under natural circulation conditions and permit estimation of the times required to achieve such mixing, and (b) confirm that the cooldown under natural circulation conditions can be achieved within the limits specified in the emergency operating procedures. Comparison with performance of previously tested plants of similar design may be substituted for these tests.

F. Operational Procedures

The operational procedures for bringing the plant from normal operating power to cold shutdown shall be in conformance with Regulatory Guide 1.33. For pressurized water reactors, the operational procedures shall include specific procedures and information required for cooldown under natural circulation conditions. These natural circulation cooldown procedures and analyses should consider the potential for a voiding event in the reactor vessel head and incorporate appropriate controls to address such an occurrence (Reference 17).[178]

G. Auxiliary Feedwater Supply

The seismic Category I water supply for the auxiliary feedwater system for a PWR shall have sufficient inventory to permit operation at hot shutdown for at least 4 hours, followed by cooldown to the conditions permitting operation of the RHR system. The inventory needed for cooldown shall be based on the longest cooldown time needed with either only onsite or only offsite power available with an assumed single failure.

H. Implementation

For the purposes of implementing the requirements for plant heat removal capability for compliance with this position, plants are divided into the following three classes:

Class 1 - Full compliance with this position for all plant~~s (custom or standard) for which CP or PDA~~ applications that[179] are docketed on or after January 1, 1978. See Table 1 for possible solutions for full compliance.

Class 2 - Partial implementation of this position for all plants (custom or standard) for which CP or PDA applications are docketed before January 1, 1978, and for which an OL issuance is expected on or after January 1, 1979. See table 1 for recommended implementation for Class 2 plants.

Class 3 - The extent to which the implementation guidance in Table 1 will be back fitted for all operating reactors and all other plants (custom or standard) for which

issuance of the OL is expected before January 1, 1979, will be based on the combined I&E and DOR review of related plant features for operating reactors.

TABLE 1. POSSIBLE SOLUTION FOR FULL COMPLIANCE WITH BTP RSB 5-1
AND RECOMMENDED IMPLEMENTATION FOR CLASS 2 PLANTS

Design Requirements of BTP RSB 5-1	Process and [System or Component]	Possible Solution for Full Compliance	Recommended Implementation for Class 2 Plants (see Note 1)
I. Functional Requirement for Taking to Cold Shutdown a. Capability Using Only Safety Grade Systems b. Capability with either only onsite or only offsite power and with single failure (limited action outside CR to meet SF) c. Reasonable time for cooldown assuming most limiting SF and only offsite or only onsite power.	Long-term cooling [RHR drop line]	Provide double drop line (or valves in parallel) to prevent single valve failure from stopping RHR cooling function. (Note: This requirement in conjunction with meeting effects of single failure for long-term cooling and isolation requirements involve increased number of independent power supplies and possibly more than four valves).	Compliance will not be required if it can be shown that correction for single failure by manual actions inside or outside of containment or return to hot standby until manual actions (or repairs) are found to be acceptable for the individual plant.
	Heat removal and RCS circulation during cooldown to cold shutdown (Note: Need SG cooling to maintain RCS circulation even after RHR in operation when under natural circulation [steam dump valves].)	Provide safety-grade dump valves, operators, and power supply, etc. so that manual action should not be required after SSE except to meet single failure.	Compliance required.
	Depressurization (Pressurizer auxiliary spray or power-operated relief valves).	Provide upgrading and additional valves to ensure operation of auxiliary pressurizer spray using only safety-grade subsystem meeting failure criteria. Possible alternative may involve using pressurizer power-operated relief valves which have been upgraded (see References 16, 24 and SRP Section 3.2.2).[180] Meet SSE and single failure without manual operation inside containment.	Compliance will not be required if a) dependence on manual actions inside containment after SSE or single failure or b) remaining at hot standby until manual actions or repairs are complete are found to be acceptable for the individual plant.

TABLE 1. POSSIBLE SOLUTION FOR FULL COMPLIANCE WITH BTP RSB 5-1
AND RECOMMENDED IMPLEMENTATION FOR CLASS 2 PLANTS

Design Requirements of BTP RSB 5-1	Process and [System or Component]	Possible Solution for Full Compliance	Recommended Implementation for Class 2 Plants (see Note 1)
	Boration for cold shutdown [CVCS and boron sampling]	Provide procedure and upgrading where necessary such that boration to cold shutdown concentration meets the requirements of I. Solution could range from (1) upgrading and adding valves to have both letdown and charging paths safety grade and meet single failure to (2) use of backup procedures involving less cost. For example, boration without letdown may be acceptable and eliminate need for upgrading letdown path. Use of ECCS for injection of borated water may also be acceptable. Need surveillance of boron concentration (boronometer and/or sampling). Limited operator action inside or outside of containment if justified.	Same as above.
II. RHR Isolation	RHR System	Comply with one of allowable arrangements given.	Compliance required. (Plants normally meet the requirement under existing SRP Section 5.4.7).
III. RHR Pressure Relief Collect and contain relief discharge	RHR System	Determine piping etc. needed to meet requirement to provide in design.	Compliance will not be required if it is shown that adequate alternate methods of disposing of discharge are available.
V. Test Requirement Meet R.G. 1.68. For PWRs test plus analysis for cooldown under natural circulation to confirm adequate mixing and cooldown within limits specified in EOP.		Run tests confirming analysis to meet requirement.	Compliance required.

TABLE 1. POSSIBLE SOLUTION FOR FULL COMPLIANCE WITH BTP RSB 5-1
AND RECOMMENDED IMPLEMENTATION FOR CLASS 2 PLANTS

Design Requirements of BTP RSB 5-1		Process and [System or Component]	Possible Solution for Full Compliance	Recommended Implementation for Class 2 Plants (see Note 1)
VI.	Operational Procedure Meet R.G. 1.33. For PWRs include specific procedures and information for cooldown under natural circulation.		Develop procedures and information from tests and analysis.	Compliance required.
VII.	Auxiliary Feedwater Supply Seismic Category I supply for auxiliary FW for at least four hours at hot shutdown plus cooldown to RHR cut-in based on longest time for only onsite or only offsite power and assumed single failure.	Emergency Feedwater Supply	From tests and analysis obtain conservative estimate of auxiliary FW supply to meet requirement and provide seismic Category I supply.	Compliance will not be required if it is shown that an adequate alternate seismic Category I source is available.

Note 1: The implementation for Class 2 plants does not result in a major impact while providing additional capability to go to cold shutdown. The major impact results from the requirement for safety-grade steam dump valves.

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SRP Draft Section 5.4.7

Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
2.	**Integrated Impact # 111**	A discussion under the Areas of Review was added to address the review performed in SRP Section 6.2.2 covering the containment emergency sump interface with the RHR system. SRP Section 6.2.2 contains the reviews necessary to ensure that all of the design guidance of Regulatory Guide 1.82, Rev. 1 “Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident” are addressed.
3.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
4.	SRP-UDP Format Item, Metrication Policy Implementation	The Areas of Review contains a discussion stating, "In both types of plants, the RHR is typically a low pressure system which takes over the shutdown cooling function when the reactor coolant system (RCS) temperature is reduced to about 300 °F." The temperature was converted to Celsius in accordance with the metrication policy.
5.	Editorial.	The word design in this usage should be plural "designs" not "design."
6.	**Integrated Impacts # 103 and 105**	A new Area of Review was added to discuss the review of shutdown operations. The Area of Review discusses high reliability of the RHR systems during shutdown operations, which is central to mitigating risk and maintaining an appropriate level of safety.
7.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
8.	**Integrated Impact #1015**	Actions addressed in Integrated Impacts 1018 and 1082 detail the deletion of the other TMI Action Plan items listed in this sentence. Therefore, the Areas of Review sentence discussing these items was modified to address the remaining item covering NUREG-0737 item III.D.1.1 on leakage detection and controls.
9.	**Integrated Impact # 1082 and 1018**	Removed references to TMI action plan items II.E.3.2, II.E.3.3 and II.B.7. These TMI action plan items were subsumed into other initiatives and resolved using other methods.
10.	SRP-UDP Format Item, Reference Update	Added a parenthetical reference for NUREG-0737 and added "item" prior to III.D.1.1.

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Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
11.	SRP-UDP format item, Reformat Areas of Review.	Added "Review Interfaces" heading to Areas of Review. Reformatted existing description of review interfaces in numbered paragraph format to describe how SRXB reviews aspects of the RHR under other SRP sections and how other branches support the review.
12.	SRP-UDP Format Item, Reformat Areas of Review.	Added an introductory sentence for those areas of review performed by the SRXB in other SRP sections. Note that the areas of review discussion relative to the staff review for compliance with Branch Technical Position RSB 5-1 has been moved to this section of the review interfaces as steps 2.a. through 2.d.
13.	**Integrated Impact # 102**	Added an Areas of Review (review interface) discussion for SRXB to clearly describe the reviews applicable to ISLOCA. Proposed new SRP section 3.12 will address the NRC staff positions for ISLOCA and will provide the detailed review procedures necessary to verify an evolutionary plant design has met the applicable positions. Because the details for an ISLOCA review will be contained in SRP Section 3.12, no additional Review Procedures are proposed for inclusion in the RHR SRP Section.
14.	SRP-UDP Format Item, Update References	The reference citation was updated to the current reference number.
15.	SRP-UDP Format Item, Update PRB names.	Changed PRB names to reflect latest responsibility assignments for the Materials and Chemical Engineering Branch (EMCB) and the Plant Systems Branch (SPLB).
16.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
17.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
18.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
19.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP section 9.3.4.
20.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 10.3 and 10.4.9.
21.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
22.	**Integrated Impact 109.**	Added a review interface with SRP Section 6.8 (proposed) for the review of reactor coolant depressurization systems (e.g., PORVs) that are used for cooldown to RHR conditions.

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Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
23.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
24.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 9.2.1 and 9.2.2.
25.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
26.	SRP-UDP Format Item, Update PRB names.	Added an introductory sentence and changed PRB name to reflect latest responsibility assignments for SRP section 6.2.2 and 6.2.4
27.	**Integrated Impact # 111.**	Added a review interface to address the reviews performed in SRP Section 6.2.2 by SCSB addressing containment heat removal and containment sump designs.
28.	SRP-UDP Format Item, Editorial.	Added SCSB to the first sentence as this review interface is now the second review in the list performed by SCSB.
29.	SRP-UDP Format Item, Editorial	Revisions to the Areas of Review (review interfaces) format requires replacing semicolons with periods.
30.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 3.3.1, 3.3.2, 3.5.3, 3.7.1 through 3.7.4, 3.8.4 and 3.8.5.
31.	Current PRB review responsibilities	Revised to reflect that ECGB is the current PRB for SRP Section 6.6.
32.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 6.1.1 and 6.6.
33.	Current PRB review responsibilities	Revised to reflect that ECGB is the current PRB for SRP Section 6.6.
34.	Editorial.	The correct SRP section number for the referenced section is 6.1.1, "Engineered Safety Features Materials." not 6.1.
35.	SRP-UDP Format Item, Reformat Areas of Review.	Added an introductory sentence for the reviews performed by the EMEB.
36.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 3.2.1 and 3.2.2. To make the sentence grammatically correct for its current position in the list the word "also" was deleted.

Item	Source	Description
37.	**Integrated Impact # 109**	Added a review interface to address the resolution of Generic Issue 70 "Power Operated Relief Valve and Block Valve Reliability." This review interface references the reviewer to SRP section 3.2.2 when evaluating an upgrade of the PORVs and the associated block valves for use in safety related functions such as plant cooldown.
38.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP section 3.6.2.
39.	SRP-UDP Format Item, Update PRB names.	Changed the sentence to remove the reference to the PRB responsibility assignments for SRP section 3.6.1. SRP section 3.6.1 is reviewed by SPLB, therefore, the portion of this review interface applicable to the SPLB was moved to the SPLB review interface summary.
40.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 3.9.1 through 3.9.3.
41.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP section 3.9.6.
42.	Disposition of Potential Impact 23024	An existing review interface was expanded and clarified to address the staff positions for evolutionary plants regarding additional inservice testing provisions that must be considered for safety-related pumps and valves. The potential impact identifies the staff positions to be applied to all safety related pumps and valves.
43.	SRP-UDP Format Item, Reformat Areas of Review.	Added an introductory sentence for the reviews performed by the HQMB.
44.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP section 14.2.
45.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for items I.C.2 and I.C.6 of NUREG-0737. These items are reviewed by HQMB under SRP Section 13.5.1.1.
46.	**Integrated Impact # 1108**	Deleted the reference to II.K.1(C.1.10) in the Areas of Review (review interfaces) and replaced the reference with one combined reference to TMI action plan items I.C.2 and I.C.6. This is a review interface only, there are no other references to these TMI Action Plan items in the Acceptance Criteria or the Review Procedures.

Item	Source	Description
47.	**Integrated Impact # 1035**	When discussing Task Action Plan item I.C.6 the reference to NUREG-0718 should more appropriately be a reference to NUREG-0737. NUREG-0718 does not indicate that this is a TMI action plan item to be addressed in an application for a construction permit. Therefore, the reference to NUREG-0718 was changed to NUREG-0737 and "(CP) only" was stricken.
48.	SRP-UDP Format Item, Reformat Areas of Review	Added a short pointer to SRP section 13.5.1, in regard to HQMB reviewing procedures for operability status.
49.	SRP-UDP Format Item, Editorial and Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 17.1, 17.2 and 17.3. This review interface was adapted and moved from the final review interface sentence because it is a HQMB review and should be listed for consistency with the other reviews performed by the HQMB.
50.	SRP-UDP Format Item, Reformat Areas of Review.	Added an introductory sentence for the reviews performed by the SPLB.
51.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP section 3.4.1.
52.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 3.5.1.4 and 3.5.2.
53.	Editorial.	Added the acronym SSCs for the phrase "structures, systems and components."
54.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 3.5.1.1 and 3.5.1.2.
55.	SRP-UDP Format Item, Revise Areas of Review.	The review interface for SRP Section 3.6.1 was separated and moved from the combined interface discussing both 3.6.1 and 3.6.2.
56.	**Integrated Impact # 1106**	A review interface to SRP Section 3.11 was added to address the equipment shielding and qualification aspects of TMI Action Plan item II.B.2. Other aspects of TMI Action Plan item II.B.2 are addressed elsewhere.
57.	SRP-UDP Format Item, Editorial and Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP section 9.5.1. This review interface was adapted and moved from the final review interface sentence because it is an SPLB review and should be listed for consistency with the other reviews performed by the SPLB.
58.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 8.1, 8.2, 8.3.1 and 8.3.2.

Item	Source	Description
59.	**Integrated Impact # 113**	A review interface was added to direct the reviewer to proposed SRP Section 8.4 when reviewing the capability of the RHR system design to meet the requirements and guidance for a station blackout event. Regulatory Guide 1.155 describes a means acceptable to the NRC staff for implementing the requirements of 10 CFR 50.63. This review interface ensures that the necessary reviews will be considered in regard to the RHR system and the impacts of the station blackout requirements.
60.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 7.1 and 7.4.
61.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for reviews to meet the provisions of GDC 19 for the control room.
62.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for SRP sections 12.1 through 12.5.
63.	SRP-UDP Format Item, Revise Areas of Review.	Identifying CPs and OLs in this review interface is redundant as the applicability limitations for this review interface will be addressed in SRP Sections 12.1 through 12.5.
64.	SRP-UDP Format Item, Disposition of PI-22482 and Editorial.	Changed PRB name to reflect latest responsibility assignments for SRP section 16.0. This sentence was adapted from the last interface sentence to accommodate relocation to other PRB interfaces. This review interface covers technical specification issues related to RHR consistent with those contained in PI-22482.
65.	Editorial.	The reviews in this combined review interface were moved to the appropriate primary review branch section of the review interfaces.
66.	SRP-UDP Format Item	The review interface conclusion paragraph was modified to conform to the standard format used in the SRP-UDP program, which accommodates same branch review interfaces.
67.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
68.	Editorial.	Added the acronym SSCs for the phrase, "structures, systems and components."
69.	Editorial.	Added the acronym SSCs for the phrase, "structures, systems and components."
70.	SRP-UDP Format Item, Editorial.	The "and;" has been deleted because additional Acceptance Criteria items have been added to the list.

Item	Source	Description
71.	**Integrated Impact # 1015**	10 CFR 50.34(f)(2)(xxvi) including the clarification of Item III.D.1.1 of NUREG-0737 was added to the Acceptance Criteria (III.D.1.1 was formerly addressed in the specific criteria section). Citation in the Acceptance Criteria of both the 10 CFR 50.34(f)(2)(xxvi) requirements and the requirements contained in NUREG-0737 Item III.D.1.1 was done to bound the applicability of this issue to the necessary license applicants without the need to discuss applicability issues in the Acceptance Criteria.
72.	SRP-UDP Format Item, Reformat References.	Removed the parenthetical reference for GDC 4, references for Acceptance Criteria are not necessary.
73.	Editorial change	Deleted the introductory sentence to the TMI Task Action Plan items as the only remaining item was moved to II.F.
74.	**Integrated Impact # 1082**	Deleted paragraph covering TMI Task Action Plan item II.E.3.2. There are no requirements or guidance specifically associated with TMI Action Plan item II.E.3.2; the activities covered by this action plan item were subsumed by other initiatives, and there is no requirement for applicants to respond to this item.
75.	**Integrated Impact # 1082**	Deleted paragraph covering TMI Task Action Plan item II.E.3.3. There are no requirements or guidance specifically associated with TMI Action Plan item II.E.3.3; the activities covered by this action plan item were subsumed by other initiatives, and there is no requirement for applicants to respond to this item.
76.	**Integrated Impact #1059**	Deleted the specific criteria paragraph addressing Task Action Plan item II.B.8 of NUREG-0718. As documented in NUREG-0933 and the Commission Policy Statement on severe accidents (50 FR 32138), the interim degraded core accident rulemaking that was proposed under Task Action Plan item II.B.8 of NUREG-0718 will not be pursued further.
77.	**Integrated Impact #1015**	This specific criteria on TMI Action Plan Item III.D.1.1 was modified to incorporate requirements of 10 CFR 50.34(f)(2)(xxvi). Since this is part of the Code of Federal Regulations, this Acceptance Criteria is now addressed as item II.F.
78.	SRP-UDP Format Item, Editorial.	Item 4 in the list of specific criteria was deleted necessitating a renumbering of the remaining specific criteria.
79.	SRP-UDP Format Item, Adding Technical Rationale.	Technical rationale were developed and added for the following Acceptance Criteria: GDC 2, 4, 5, 19, and 34.

Item	Source	Description
80.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
81.	SRP-UDP Format Item, Reference Verification	Parenthetical reference for BTP RSB 5-1 is unnecessary.
82.	SRP-UDP Format Item, Reference Verification	Parenthetical reference for BTP RSB 5-1 is unnecessary.
83.	**Integrated Impact # 110.**	Added a new review procedure to address the reviews necessary to verify proper design of the miniflow systems required to ensure RHR pump protection. The guidance provided is consistent with the NRC staff positions as described in Generic Letter 89-04 and NRC Bulletins 88-04 and 86-01.
84.	SRP-UDP Format Item, Editorial	This sentence is plural, therefore, "is" was replaced with "are."
85.	PRB Comment	Added reference to NUREG-0927 in response to PRB comment, NRC Memo Li to Lyons dated November 1, 1995.
86.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing initial cooldown.
87.	**Integrated Impact 109.**	Revised the Review Procedure to identify SRP Section 6.8 as providing for review of Generic Letter 90-06 compliance.
88.	**Integrated Impact # 109**	Added a sentence to clarify the functional requirements if the PORVs are relied upon during a plant cooldown in compliance with Branch Technical Position 5-1. A requirement was also added for evolutionary PWR PORVs to be safety related. The specific guidance for classification of the PORVs, as stated in the review interfaces, will be contained in SRP Section 3.2.2 and will not be duplicated in this Review Procedure. However, if the PORVs are relied upon in a plant cooldown they must meet the guidance of the references indicated.
89.	Editorial.	This reference was changed from item 5 to item 6. Item 5 of the review procedures discusses water hammer, item 6 discusses the reviews for cooldown.
90.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing initial cooldown.
91.	SRP-UDP Format Item, Reference Verification	Parenthetical reference for BTP RSB 5-1 is unnecessary.

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Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
92.	SRP-UDP Format Item, Reference Verification	Parenthetical reference for GDC 5 is unnecessary.
93.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
94.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing the heat sink and refueling systems.
95.	SRP-UDP Format Item, Editorial.	Changed "his" to "the" to make the sentence gender neutral.
96.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing service or component cooling water temperatures.
97.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
98.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
99.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing the instrumentation and controls.
100.	SRP-UDP Format Item, Editorial.	Deleted "his counterpart in" and replaced it with the reviewer to make this sentence gender neutral.
101.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing instrumentation and controls.
102.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
103.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing containment systems.
104.	SRP-UDP Format Item, Editorial.	Deleted "his counterpart in" and replaced it with the reviewer to make this sentence gender neutral.
105.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
106.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing preoperational testing.
107.	SRP-UDP Format Item, Editorial.	Deleted "his counterpart in" and replaced it with the reviewer to make this sentence gender neutral.

Item	Source	Description
108.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for the reviews addressing adequate structures in which to house the RHR systems.
109.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
110.	SRP-UDP Format Item, Update PRB names.	Changed PRB name to reflect latest responsibility assignments for this SRP section.
111.	**Integrated Impact # 1015**	Revised step 18 to address the review of leakage detection and control in the design of systems outside containment that contain (or might contain) radioactive material following an accident to address item III.D.1.1 of NUREG-0737. The other TMI action plan items were deleted necessitating revision of this step to only address the review for 10 CFR 50.34(f)(2)(xxvi) and TMI Action Plan item III.D.1.1.
112.	**Integrated Impact # 1059 and 1082**	References to all of the TMI Task Action Plan items except for III.D.1.1 are being deleted. Therefore, the introductory sentence to this review procedure was deleted.
113.	**Integrated Impact # 1082**	References to TMI Task Action Plan items II.E.3.2 and II.E.3.3 are being deleted. There are no requirements or guidance specifically associated with these TMI action plan items, these activities were ultimately subsumed by other initiatives, so the references to them in this review procedure is being deleted.
114.	**Integrated Impact #1059**	The reference in this Review Procedure to TMI Action Plan Item II.B.8 has been deleted. As documented in NUREG-0933 and the Commission Policy Statement on severe accidents (50 FR 32138), the interim degraded core accident rulemaking that was proposed under TMI Action Plan Item II.B.8 will not be pursued further.
115.	**Integrated Impact #1015**	The discussion covering 10 CFR 50.34(f)(2)(xxvi) and TMI Task Action Plan item III.D.1.1 is now covered by an individual review procedure step.

Item	Source	Description
116.	**Integrated Impact # 103 and 108**	Review Procedures were added to address NRC staff guidance covering mid-loop operation contained in Generic Letter 88-17 and staff positions for evolutionary reactors found in SECY 90-016 and its associated staff requirements memorandum. These documents describe guidance specific to the RHR system that should be considered when operating in reduced inventory, mid-loop and shutdown conditions. This review was split into two sections the first section (step 19) covering all plants and specific PWRs (including evolutionary PWRs) and the second section (step 20) being applicable only to new PWRs.
117.	**Integrated Impacts # 103 and 105.**	Added a review procedure for new applicants to address RHR design specific aspects of the shutdown operations guidance. The review procedures address guidance covering mid-loop operations contained in SECY 90-016 and its associated staff requirements memorandum. New plant applicants should conduct studies to identify RHR design-specific vulnerabilities and weaknesses and then document design features to mitigate these vulnerabilities. Examples of design features utilized by evolutionary designs to address the concerns of generic safety issue 99 include instrumentation consistent with the guidance of Generic Letter 88-17 and suction isolation valves that do not have an auto-closure interlock (covered in step 20.d.). A reference to NUREG-1449 which documents the staff's evaluation of the shutdown and low-power issue was also added.
118.	**Integrated Impact # 108**	Added a review procedure specifically addressing the RHR auto-closure interlock guidance for new PWR applicants.
119.	**Integrated Impact # 112**	A Review Procedure was added to address the review of the RHR system configuration to ensure that there are no unisolable sections of piping connected to the reactor coolant systems that could be subject to temperature distributions causing unacceptable thermal stresses. This review procedure is consistent with the requested actions of NRC Bulletin 88-08 and is also consistent with the staff guidance contained in the FSERs for the ABWR and the ABB-CE System 80+.
120.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
121.	SRP-UDP Format Item, Editorial.	Replaced "his" with "the" to make the sentence gender neutral.

Item	Source	Description
122.	Editorial	Revised for consistency with the introduction to evaluation findings in most SRP sections.
123.	SRP-UDP Format Item, Editorial.	Replaced "his" with "the" to make the sentence gender neutral.
124.	SRP-UDP Format Item, Editorial	Replaced initial caps with lower case letters on residual heat removal system.
125.	**Integrated Impact # 1015**	Added 10 CFR 50.34(f)(2)(xxvi) to the list of Acceptance Criteria to be consistent with the addition of this Section of the CFRs to the Acceptance Criteria of Section II.
126.	SRP-UDP Format Item, Editorial.	Added the acronym SSCs for the phrase "structures systems and components."
127.	SRP-UDP Format Item, Editorial.	Added the acronym SSCs for the phrase "structures systems and components."
128.	SRP-UDP Format Item, Editorial	Replaced initial caps with lower case letters on residual heat removal system.
129.	SRP-UDP Format Item, Editorial.	Changed "it" to "its".
130.	SRP-UDP Format Item, Editorial.	Changed "position" to "positions" as it is plural.
131.	**Integrated Impact # 1015**	The Evaluation Finding covering NUREG-0737 item III.D.1.1 and 10 CFR 50.34(f)(2)(xxvi) was modified and moved to step (5) as a stand alone Evaluation Finding. The Evaluation Finding is consistent with the requirement in the Code of Federal Regulations, Acceptance Criteria, and with the old TMI Task Action Plan item III.D.1.1 Evaluation Finding. Previously this issue was listed with several other TMI Task Action Plan items which in the revision process were removed leaving only item III.D.1.1.
132.	SRP-UDP Format Item, Editorial.	References to all of the TMI Task Action Plan items except for III.D.1.1 are being deleted. Therefore, the introductory sentence to this evaluation finding was deleted.
133.	**Integrated Impact # 1082**	There are no requirements or guidance specifically associated with TMI action plan items II.E.3.2 and II.E.3.3, these activities were ultimately subsumed by other initiatives so the references to them are being deleted from the Evaluation Findings.
134.	**Integrated Impact #1059**	The Evaluation Finding covering Task Action Plan item II.B.8 of NUREG-0718 has been deleted.
135.	**Integrated Impact # 1015**	The discussion covering 10 CFR 50.34(f)(2)(xxvi) and TMI Task Action Plan item III.D.1.1 is now covered by an individual Evaluation Finding step.

Item	Source	Description
136.	SRP-UDP Format Item, Editorial.	Replaced "his" with "the" to make the sentence gender neutral.
137.	SRP-UDP Format Item, Editorial	Replaced initial caps with lower case letters on residual heat removal system.
138.	**Integrated Impact # 1015**	Added 10 CFR 50.34(f)(2)(xxvi) to the list of Acceptance Criteria to be consistent with the addition of this Section of the CFRs to the Acceptance Criteria of Section II.
139.	SRP-UDP Format Item, Editorial.	Added the acronym SSCs for the phrase "structures, systems, and components."
140.	SRP-UDP Format Item, Editorial.	Added the acronym SSCs for the phrase "structures, systems, and components."
141.	SRP-UDP Format Item, Editorial	Replaced initial caps with lower case letters on residual heat removal system.
142.	SRP-UDP Format Item, Editorial.	Changed "position" to "positions" as it is plural.
143.	**Integrated Impact # 1015**	The Evaluation Finding covering NUREG-0737 item III.D.1.1 and 10 CFR 50.34(f)(2)(xxvi) was modified and moved to step (5) as a stand alone Evaluation Finding. The Evaluation Finding is consistent with the requirement in the Code of Federal Regulations, Acceptance Criteria, and with the old TMI Task Action Plan item III.D.1.1 Evaluation Finding. Previously this issue was listed with several other TMI Task Action Plan items which in the revision process were removed leaving only item III.D.1.1.
144.	SRP-UDP Format Item, Editorial.	References to all of the TMI Task Action Plan items except for III.D.1.1 are being deleted. Therefore, the introductory sentence to this evaluation finding was deleted.
145.	**Integrated Impact # 1082**	There are no requirements or guidance specifically associated with TMI action plan items II.E.3.2 and II.E.3.3, these activities were ultimately subsumed by other initiatives so the references to them are being deleted from the Evaluation Findings.
146.	**Integrated Impact #1059**	The Evaluation Finding covering Task Action Plan item II.B.8 of NUREG-0718 has been deleted.
147.	**Integrated Impact # 1015**	The discussion covering 10 CFR 50.34(f)(2)(xxvi) and TMI Task Action Plan item III.D.1.1 is now covered by an individual Evaluation Finding step.

Item	Source	Description
148.	SRP-UDP Format Item, Implement 10 CFR 52 Related Changes	To address design certification reviews a new paragraph was added to the end of the Evaluation Findings. This paragraph addresses design certification specific items including ITAAC, DAC, site interface requirements, and combined license action items relevant to the SRP section.
149.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
150.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
151.	SRP-UDP Format Item, Update Implementation Section	The implementation statements that are specific to a particular revision must be modified to reflect the associated revision date of the item. In this case the date specific item was related to water hammer guidance and the incorporating revision to the SRP occurred in April 1984 (the last revision date for 5.4.7).
152.	SRP-UDP Format Item, Update Implementation Section	The implementation statements that are specific to a particular revision must be modified to reflect the associated revision date of the item. In this case the date specific item was related to water hammer guidance and the incorporating revision to the SRP occurred in April 1984 (the last revision date for 5.4.7). However, as indicated CP applicants were required to comply with the provisions of the April 1984 revision so no date restriction was added.
153.	SRP-UDP Format Item, Update Implementation Section	The implementation statements that are specific to a particular revision must be modified to reflect the associated revision date of the item. In this case the date specific item was related to water hammer guidance and the incorporating revision to the SRP occurred in April 1984 (the last revision date for 5.4.7).
154.	SRP-UDP Format Item, Reformat References.	The references were reordered and renumbered in accordance with the format requirements of the SRP-UDP procedures.
155.	**Integrated Impact # 1015**	Added a reference to 10 CFR Part 50, §50.34(f), “Additional TMI-Related Requirements,” to fully address the addition of 10 CFR 50.34(f)(2)(xxvi) to the Acceptance Criteria.
156.	SRP-UDP Format Item, Reference Verification and Disposition of PI-21745.	The reference to 10 CFR Part 50, Appendix A, General Design Criterion 4 was moved from the old position to its new position as reference number 3. The title to GDC 4 was also revised to reflect the amendment documented in 52 FR 41288 (see PI-21745).

Item	Source	Description
157.	**Integrated Impact # 103**	Added a reference to SECY 90-016 to support the Review Procedure added to address Mid-Loop operations.
158.	**Integrated Impact # 103**	Added a reference to the SRM for SECY 90-016 to support the Review Procedure added to address Mid-Loop operations.
159.	**Integrated Impact # 105**	Added a reference to SECY 93-087 to support the Review Procedure added to cover shutdown and low power operations.
160.	**Integrated Impact # 105**	Added a reference to the SRM for SECY 93-087 to support the Review Procedure added to cover shutdown and low power operations.
161.	**Integrated Impact # 103, 105 and 108**	Added a reference to Generic Letter 88-17 to support the new Review Procedure covering RHR concerns related to Mid-loop operations, RHR reliability and RHR suction valve interlock concerns.
162.	**Integrated Impact # 110.**	Added a reference covering Generic Letter 89-04, "Guidance on Developing Acceptable Inservice Testing Programs." This Generic Letter contains guidance on the design of the miniflow systems for the RHR system.
163.	**Integrated Impact # 109**	Added a reference to Generic Letter 90-06 which provides guidance and staff positions on the resolution of Generic Issue 70 “Power Operated Relief Valve and Block Valve Reliability.”
164.	**Integrated Impact # 109.**	Added a reference to Generic Letter 92-02 to address the potential for voiding in the reactor vessel head during natural circulation cooldown.
165.	**Integrated Impact # 110**	Added a reference for NRC Bulletin 86-01, "Minimum Flow Logic Problems that Could Disable RHR Pumps." This Bulletin contains guidance on miniflow design considerations including adverse single failure conditions.
166.	**Integrated Impact #110**	Added a reference for NRC Bulletin 88-04, "Potential Safety-Related Pump Loss." This Bulletin contains guidance on miniflow design considerations including parallel pump operation under miniflow conditions.
167.	**Integrated Impact # 112**	Added a reference to NRC Bulletin 88-08 to provide additional information on the review of RHR systems in regard to thermal stratification of unisolable piping connected to the reactor coolant system.

Item	Source	Description
168.	**Integrated Impact # 109**	Added a reference to NUREG-1316 which provides technical findings and regulatory analysis related to the resolution of Generic Issue 70 “Power Operated Relief Valve and Block Valve Reliability.”
169.	**Integrated Impact # 105**	Added a reference to NUREG-1449 which documents the staff’s evaluation of the shutdown and low-power issue. This reference supports the new Review Procedure developed to address RHR specific issues related to shutdown and low-power operations.
170.	PRB Comment	Added reference to NUREG-0927 in response to PRB comment, NRC Memo Li to Lyons dated November 1, 1995.
171.	SRP-UDP Format Item, Editorial	Added a parenthetical reference for the current PRB responsibility for BTP RSB 5-1. Reactor Systems Branch is currently responsible for this branch technical position.
172.	SRP-UDP Format Item, Editorial.	Changed "including" to "include" to make this sentence grammatically correct.
173.	SRP-UDP format item, Metrication Policy Implementation	The cold shutdown condition, as described in the Standard Technical Specifications, refers to a sub critical reactor with a reactor coolant temperature no greater than 200 °F for a PWR and 212 °F for a BWR. The temperature values were converted to Celsius in accordance with the metrication policy.
174.	**Integrated Impact # 109**	Added a parenthetical statement to address the inclusion of instrumentation for monitoring and control functions consistent with the discussion on natural circulation cooldown contained in the FSER for the ABB-CE System 80+.
175.	**Integrated Impact # 108**	Added a clarification to the Branch Technical Position on RHR system isolation valve interlocks. To improve overall reliability the NRC staff has recommended but not required that the autoclosure interlock be removed. The sentence was revised to eliminate the "shall" statement and to ensure the review considers the potential degradation of overall system reliability during shutdown operations.
176.	**Integrated Impact 1493**	Added version date for IEEE Std. 338 as recommended.
177.	**Integrated Impact # 659** SRP-UDP standard citation update.	Consideration should be given to updating the citation of IEEE 338 pending the completion of the associated standard comparison.

Item	Source	Description
178.	**Integrated Impact # 109.**	Added a discussion to address the concern regarding the potential for voiding in the reactor vessel head during natural circulation cooldown. This clarification incorporates information presented in Generic Letter 92-02.
179.	SRP-UDP Format Item, Update of Implementation Statements	The implementation statement addressing full compliance was modified to remove the reference to the application types. This and the remaining implementation statements already contain the date specific information relative to the appropriate revisions. The other implementation statements remain valid and need not be revised.
180.	**Integrated Impact # 109**	Added a reference to the applicable documents contained in the reference section of SRP Section 5.4.7 and to SRP Section 3.2.2.

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Integrated Impact No.	Issue	SRP Subsections Affected
102	Incorporate staff guidance to address intersystem LOCA	Areas of Review (review interface) step 1 under SRXB reviews.
103	Develop Areas of Review and Review Procedures to address staff guidance for mid-loop operations.	Areas of Review new introductory paragraph. Review Procedures add new steps 19 and 20. Add supporting References 10, 11 and 14.
104	This integrated impact was not processed further. See integrated impact #1082 for details.	None
105	Develop Areas of Review and Review Procedures to address concerns and staff positions regarding RHR reliability during shutdown and low power operations. Including reduced inventory operations.	Areas of Review new introductory paragraph. Review Procedures add new step 20. Add supporting References 12, 13, 14 and 25.
106	This integrated impact was not processed further. See integrated impact #1082 for details.	None
107	This integrated impact was not processed further. See integrated impact #1059 for details.	None
108	Add Review Procedures to address the staff recommendations for removal of the auto-closure interlock.	Add new steps 19 and 20 to the Review Procedures. Modify the Branch Technical Position RSB 5-1 Branch Position B.1.(c). Add supporting reference item 14.
109	Incorporate staff guidance and positions on the use of the PORVs in conjunction with RHR. For PWRs if the PORVs are relied upon in the performance of a safety-related function such as plant cooldown in compliance with BTP RSB 5-1, the PORVs must meet the necessary guidance and staff positions. Also incorporate clarifications in the BTP regarding reactor vessel voiding concerns during natural circulation cooldown.	Add a new Areas of Review (review interfaces) step 4.a. Add a sentence to the Review Procedures step 6. Add supporting references 16 and 24. Add a clarification to BTP position A.3 and position F. Add a clarification to Table 1 of the BTP.
110	Incorporate staff guidance on the design of the miniflow system required to ensure RHR pump protection.	Add a substep to the Review Procedures step 4 addressing miniflow design. Add supporting References 15, 18 and 19.
111	Add a review interface to address coordination and review of the RHR suction intake located in the containment sump.	Add a discussion in the Areas of Review to clarify the review responsibility. Add an Areas of Review (review interface) step 1.a.

112	Incorporate appropriate staff guidance to ensure that the RHR system design has provisions to ensure that thermal stratification and thermal stresses, which may occur in the unisolable portions of piping connected to the RCS, are properly accounted for.	Add new step 21 to the Review Procedures. Add supporting Reference 20.
113	Add a review interface to address coordination and review of the capability of the RHR system to provide core cooling and decay heat removal following a station blackout.	Add a sentence to step 7 of the Areas of Review (review interfaces).
114	This integrated impact was not processed further. See integrated impact #1015 for the details.	None
659	This is a placeholder impact for a standard comparison on IEEE 338.	None
1015	Update the Acceptance Criteria of the SRP Section to reflect the requirement of 10 CFR 50.34(f)(2)(xxvi) and NUREG-0737 TMI action plan item III.D.1.1 related to leakage detection and control.	Revise the Areas of Review for NUREG-0737 (item III.D.1.1). Add new Acceptance Criteria step II.F (delete specific criteria step 4.d). Review Procedures revise step 18. Revise the Evaluation Findings and added reference 1 to incorporate 10 CFR 50.34(f).
1018	Delete the current citation of NUREG-0718 TMI Action Plan item II.B.7.	Removed the citation of II.B.7 from the Areas of Review. No other changes were required.
1035	Revise the Areas of Review discussion associated with TMI action plan item I.C.6 regarding verification of correct performance of operator activities.	Revised Areas of Review Step 5.b.
1059	Delete superseded Acceptance Criteria and Review Procedures related to interim degraded core accident rulemaking (NUREG-0660 TMI Action Plan Item II.B.8).	Deleted Acceptance Criteria item 4.c. Deleted Review Procedure item 18.c. Deleted Evaluation Findings addressing II.B.8.
1082	Delete Acceptance Criteria and Review Procedures related to TMI Action Plan items II.E.3.2 and II.E.3.3 regarding reliability and performing studies on shutdown heat removal requirements. These activities were subsumed by other activities and there was no requirement for applicants to respond to these items.	Revise the Areas of Review to delete the reference to these items. Remove the discussion of these items from the Acceptance Criteria specific criteria section. Remove the Review Procedure references to these items. Delete the references to these items in the Evaluation Findings.
1106	Add review interfaces related to TMI Action Plan item II.B.2 and plant shielding for post accident operation.	Revised the Areas of Review (review interface) step 6.d for SRP Section 3.11 to include item II.B.2.

1108	Revise the current citation of TMI action plan item II.K.1.10 regarding procedures for removing safety-related systems from service.	Revise the Areas of Review (review interface) step 5.b to remove II.K.1.10 and replace with a citation of I.C.2 and I.C.6 of NUREG-0737.
1203	Revise the SRP to incorporate proposed rulemaking specific to shutdown and low power operations.	This is a place holder II there are no changes at this time.
1493	Consider updating the citation of IEEE 338 to cite the 1977 version.	BTP RSB 5-1, BRANCH POSITION E