U.S. NUCLEAR REGULATORY COMMISSION

DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER^{TM} iPWR DESIGN

9.2.5 ULTIMATE HEAT SINK AND NORMAL POWER HEAT SINK

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of cooling water systems

Secondary - Organization responsible for the review of chemical control
Organization responsible for the review of safety related ventilation
Organization responsible for the review of meteorological data
Organization responsible for radiation protection and monitoring
Organization responsible for the review of the ultimate heat sink and passive containment

I. AREAS OF REVIEW

Active Plants

The ultimate heat sink (UHS) typically consists of an assured supply of water that is credited for dissipating reactor decay heat and essential station heat loads after a normal reactor shutdown or a shutdown following an accident or transient, including a loss-of-coolant accident (LOCA). Many commercial nuclear power plants also rely upon the atmosphere for performing the UHS function to some extent in conjunction with the assured supply of cooling water, such as in the case of spray ponds and cooling towers.

Passive Plants

The mPower^{TM} design relies on heat removal from the core and the containment through heat transfer from the containment structure to the UHS tank. The design basis is to remove decay heat after a shutdown or an LOCA for 72 hours without ac power or operator action. The mPower^{TM} containment heat removal system and UHS tank is further described and reviewed in Design-Specific Review Standard (DSRS) Section 6.2.2.

The mPower^{TM} plant may rely upon the atmosphere and cooling towers for performing the normal power heat sink function in conjunction with the reliable supply of cooling water or other equipment such as mechanical chillers. The heat sink associated with the turbine and turbine bypass with the main condensers is described and reviewed in DSRS Section 10.4.1, “Main Condenser.”

The normal power heat sink consists of a reliable supply of water (or mechanical equipment such as chillers) that can remove normal station heat loads during normal power operations and dissipating reactor decay heat after a normal reactor shutdown or a shutdown following an accident or transient (post 72 hours). The normal power heat sink, the makeup water supply to the normal power heat sink and the makeup water supply to the UHS tank are reviewed in this DSRS section.

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The normal power heat sink may perform cooling water functions to nonsafety-related risk-significant and nonsafety-related nonrisk-significant equipment as part of the mPower^{TM} plant design. For these designs, the normal power heat sink may be subject to special regulatory treatment of nonsafety-related system (RTNSS) considerations. The criteria for classifying nonsafety-related systems that perform risk-significant or important functions as RTNSS are provided by SECY-94-084, and SECY-95-132 (Reference 1). As indicated in Standard Review Plan (SRP) Section 19.3, the RTNSS process uses Criteria A through E to determine the structure, system, and component (SSC) functions.

For the passive designs, normal power heat sink may be classified as either RTNSS Criterion B (RTNSS B) or RTNSS Criterion C (RTNSS C), which is defined below (Reference 1):

1. Criterion B – Required to address the function of SSCs relied upon to resolve long-term (post 72 hours) safety and to address seismic events. This criterion pertains to SSCs required after 72 hours of a design basis accident (DBA) initiation that are key to maintaining core cooling, containment integrity, control room habitability, and post accident monitoring that would require a RTNSS evaluation. RTNSS Criterion B SSCs are nonsafety-related backups to safety-related SSCs.

   Note: Long-term safety is defined as the period beginning 72 hours after a design basis event and lasting the following four days (168 hours) hereafter referred to as the "post-72 hour period[1]."

2. Criterion C – Required to meet safety goals of core damage frequency (CDF) less than $1.0E^{-4}$ and large release frequency (LRF) less than $1.06E^{-6}$, each reactor year. This criterion pertains to active nonsafety-related components relied upon to reduce initiating event frequencies, CDF and LRF in the focused probabilistic risk assessment (PRA) sensitivity study, the baseline PRA, or in the assessment of uncertainties that would require a RTNSS evaluation. RTNSS Criterion C SSCs are considered nonsafety-related defense-in-depth backups.

Defense-in-depth principles consist in a number of elements as described in Reference 2.

For the mPower^{TM} design the normal power heat sink should be available to maintain core cooling in the post-72 hour period and to support bringing the plant to cold shutdown (CSD) conditions for inspection and repairs. The nonsafety-related normal power heat sink should be reliable and may not be subject to RTNSS Criterion, (Reference 1).

The reliable nonsafety-related SSCs are evaluated under SRP 17.6, Maintenance Rule (Reference 22). These nonsafety-related components should be monitored for performance against licensee-established goals, in a manner sufficient to provide reasonable assurance that these structures, systems, and components, are capable of fulfilling their intended functions. The mPower^{TM} plant design requires water makeup to the UHS tank associated with the containment heat removal system, post DBA and beyond 7 days. Onsite water sources may

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1 The "Post 72-hour period" is stated in SRP 19.3 as the period beginning 72 hours after a design basis event and lasting the following 4 days. This period is important from a safety perspective because passive plants are designed such that safety-related SSCs can satisfy all safety functions for a period up to 72 hours following a design basis event, but additional equipment and procedural action will be needed to either extend the ability of safety-related SSCs to accomplish the safety functions or perform the safety functions themselves until systems designed to bring the plant to a long-term cold shutdown condition can be put in service.

vary and may be supplied from a reliable water source, such as the fire protection system or condensate storage. Offsite water sources should also be considered such as water connections, flanges, or hose connections so that local fire truck pumpers can be utilized. The UHS tank water makeup system is evaluated for RTNSS consideration in accordance with SRP Section 19.3.

Depending on the design and RTNSS analysis, the makeup water to the UHS tank and the makeup water to the normal power heat sink may be classified as:

Safety-related risk-significant

Safety-related nonrisk-significant

Nonsafety-related risk-significant, which includes RTNSS B and RTNSS C

Nonsafety-related nonrisk-significant, which may include functions to support CSD

The mPower™ application will include the classification of SSCs, a list of risk-significant SSCs, and a list of RTNSS equipment. Based on this information, the staff will review according to DSRS Section 3.2, SRP Sections 17.4 and 19.3 to confirm the determination of the safety-related and risk-significant SSCs.

The specific area of review for the safety-related UHS is listed below. In addition, the normal power heat sink, makeup water to the UHS tank and the makeup water to the normal power heat sink is shown below. The nonsafety-related areas of review and RTNSS B and C functions, if they apply, are shown below in ***bold-italics***. For nonsafety-related nonrisk-significant normal power heat sink, nothing applies unless noted below in ***bold-italics***.

The specific areas of review are as follows:

1. Review safety/risk-significant classification as discussed above.

   RTNSS B and C and nonsafety-related (nonrisk-significant): Safety/risk-significant classifications are to be verified.

2. The type of cooling water supply for the UHS tank.

   RTNSS B and C and nonsafety-related: apply.

3. The type of cooling water supply for the normal power heat sink.

   RTNSS B and C and nonsafety-related: apply.

4. The ability to dissipate the normal power heat load.

   RTNSS B and C: apply. The capability of the normal power heat sink to support the auxiliary cooling systems for SSCs in the post-72 hour period or to meet NRC safety goal guidelines (defense-in-depth).

   Nonsafety-related (nonrisk-significant): apply. The capability of the normal power heat sink to support the auxiliary cooling systems for normal and abnormal conditions.

5. The effect of environmental conditions on normal power heat sink capability to furnish the required quantities of cooling water at appropriate temperatures and with any required chemical and purification treatment for extended times after shutdown.

RTNSS B: applies. The capability of the normal power heat sink to support auxiliary cooling systems in the post-72 hour period.

Risk-significant functions are expected to be available in the post-72 hour period[2] with onsite SSCs with available water sources.

RTNSS C: applies. The capability of the normal power heat sink to support auxiliary cooling systems defense-in-depth SSCs, in order to meet NRC safety goal guidelines.

Nonsafety-related (nonrisk-significant): may apply. The capability of the normal power heat sink to support auxiliary cooling systems for normal and abnormal conditions. Revise paragraph to:

The effect of environmental conditions (such as freezing) on normal power heat sink capability to furnish the required quantities of cooling water at appropriate temperatures and with any required chemical and purification treatment for extended times after shutdown. SSCs in support of CSD should be available in the post-72 hour period with onsite SSCs with available water sources.

6. The effect of earthquakes, tornadoes, missiles, floods, and hurricane winds on the availability of the source water.

RTNSS B and C: apply for functions in the post-72 hour period or to meet NRC safety goal guidelines (defense-in-depth).

Note: RTNSS B SSCs are designed to withstand the effects of natural phenomena without loss of function. RTNSS C SSCs are evaluated, utilizing the "graded approach philosophy", against the effects of the most probable hazards (e.g. floods, winds, missiles, seismic events). As a result of this evaluation, RTNSS C maybe designed against the effects of natural phenomena. SRP Section 19.3 provides further guidance related to the reliability and availability missions of RTNSS B and C SSCs.

Nonsafety-related (nonrisk-significant): does not apply.

7. Sharing of UHS tank makeup sources in multi-unit stations.

RTNSS B and C: apply.

SSCs that support risk-significant functions shall be designed not to be shared among nuclear power units unless it can be shown that sharing will not significantly impair their ability to perform their post-72 hours functions (RNTSS B) or defense-in-depth functions (RTNSS C).

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[2] The staff has previously accepted that defense-in-depth functions are to be available in the post-72 hour period and lasting the following 4 days (168 hours) for the Economic Simplified Boiling Water Reactor and AP1000 DCs.

8. Applicable design requirements for the makeup water to the UHS tank.

   RTNSS B: applies for functions that support UHS tank make up in the post-72 hour period.

   RTNSS C: applies for defense-in-depth functions that support UHS tank makeup in order to meet NRC safety goal guidelines.

9. Heat input for the normal power heat sink design as to reactor system heat, sensible heat, pump work, and station auxiliary system individual and total heat loads.

   RTNSS B: applies for functions in the post 72 hours period of a DBA initiation.

   RTNSS C: applies for defense-in-depth functions in order to meet NRC safety goals guidelines.

   Nonsafety-related (nonrisk-significant): apply for functions that support achieving and maintaining CSD in the post-72 hour period.

10. <u>Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC)</u>. For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the SSCs related to this DSRS section in accordance with DSRS Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this DSRS section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with DSRS Section 14.3 and Regulatory Guide (RG) 1.206 (Reference 24).

    RTNSS B: applies for functions that support UHS tank make up in the post-72 hour period.

    RTNSS C: applies for defense-in-depth functions that support UHS tank makeup in order to meet NRC safety goal guidelines.

11. <u>COL Action Items and Certification Requirements and Restrictions</u>. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

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

    RTNSS B: applies for functions that support UHS tank make up in the post-72 hour period.

    RTNSS C: applies for defense-in-depth functions that support UHS tank makeup in order to meet NRC safety goal guidelines

12. The provisions for minimization of contamination of the facility and environment, the

generation of radioactive waste, and the provisions to facilitate eventual decommissioning.

RTNSS B and C and nonsafety-related: apply.

Review Interfaces

Other DSRS sections interface with this section for UHS and normal power heat sink as follows:

1. DSRS Sections 3.2.1 and 3.2.2: review of the acceptability of the seismic and quality group classifications for safety-related SSCs.

2. DSRS Sections 3.3.1, 3.3.2, 3.4.2, 3.5.3, 3.7.2, and SRP Sections 3.7.1, 3.7.3, 3.7.4, 3.8.4, and 3.8.5: review of the acceptability of the design analyses, procedures, and criteria establishing the capability of seismic Category I structures housing the system and supporting systems to withstand the effects of natural phenomena like the safe-shutdown earthquake (SSE), the probable maximum flood, and the tornado missiles.

3. DSRS Section 3.4.1: review of flood protection.

4. DSRS Section 3.5.1.1: review of the protection against internally-generated missiles.

5. DSRS Section 3.5.2: review of SSCs to be protected against externally-generated missiles.

6. DSRS Section 3.6.1: review of high- and moderate-energy pipe breaks.

7. DSRS Section 6.1.1: review of the inservice inspection requirements for system components and the compatibility of materials of construction with service conditions.

8. DSRS Section 6.2.2: review of the UHS for mPower™ designs

9. DSRS Chapter 7: review of the adequacy of the design, installation, inspection, and testing of all instrumentation and control systems required for proper operation.

10. DSRS Section 8.3.1: review of the adequacy of the design, installation, inspection, and testing of all electrical systems required for proper operation.

11. DSRS Section 9.2.2: review of the component CWS.

12. SRP Section 9.5.1: review of fire protection.

13. DSRS Section11.5, as it relates to the review for radiation monitoring systems and specified detection sensitivity in response Table 2 of DSRS Section 11.5 in the context of IE Bulletin 80-10 about uncontrolled and unmonitored releases for systems not covered by the ODCM.

14. DSRS Section 12.3-12.4: review for radiation protection design features and minimization of contamination.

15. DSRS Sections 14.2 and 14.3.7: review of the proposed pre-operational and startup test programs and ITAAC.

16. DSRS Section 16.0: review of Technical Specifications and Short Term Availability Controls.

17. SRP Section 17.5: review for quality assurance.

18. SRP Section 19.0: review for PRA and for the applicable risk classification.

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

II. <u>ACCEPTANCE CRITERIA</u>

<u>Requirements</u>

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations. The specific areas of review for the safety-related UHS are shown below. Additionally, the nonsafety-related requirements are shown in ***bold-italics.*** RTNSS B and C functions, if they apply, are also shown below. For nonsafety-related (nonrisk-significant) normal power heat sink, nothing applies unless noted below.

1. General Design Criterion (GDC) 1 as to SSCs important to safety being designed, fabricated, erected and tested to quality standards commensurate with the importance of the safety functions to be performed.

2. GDC 2 to SSCs important to safety being designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, tsunami, seiches and floods without loss of capability to perform their safety functions.

   Note: RTNSS B SSCs are designed to withstand the effects of natural phenomena without loss of function. RTNSS C SSCs are evaluated, utilizing the "graded approach philosophy", against the effects of the most probable hazards (e.g. floods, winds, missiles, seismic events). As a result of this evaluation, RTNSS C maybe designed against the effects of natural phenomena. SRP Section 19.3 provides further guidance related to the reliability and availability missions of RTNSS B and C SSCs.

3. GDC 4 as to SSCs important to safety being appropriately protected against dynamic effects, including the effects of missiles, pipe whipping and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.
   Note: RTNSS B SSCs are analyzed and designed to withstand adverse effects associated with internal hazards, i.e., those created from conditions inside the plant (e.g., turbine missiles, pipe whip).

4. GDC 5 as to SSCs important to safety being designed not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions.

5. GDC 44 as to:

   A. A system to transfer heat from safety-related SSCs to the heat sink under both normal operating and accident conditions.

B. Suitable component redundancy so that safety functions can be performed assuming a single, active component failure coincident with loss of offsite power.

GDC 44 is applicable to the mPower™ containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

6. GDC 45, as to design provisions for appropriate periodic inspection of important components, such as heat exchanges and piping, to assure the integrity and capability of the system..

   GDC 45 is applicable to the passive containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

7. GDC 46 as to design provisions to permit appropriate periodic pressure and functional test to assure;

   A. The structure and leaktight integrity of its components.

   B. The operability and the performance of active components of the system.

   C. The operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation for reactor shutdown and for loss-of-coolant accidents, including operation of applicable portions of the protection system and the transfer between normal and emergency power sources

   GDC 46 is applicable to the passive containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

7. CFR 52.47(b)(1), which requires that a DC application contain the proposed ITAAC that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission's (NRC's) rules and regulations.

   RTNSS B and C apply for the review for ITAAC to the importance of functions in the post-72 hour period or defense-in-depth functions.

8. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the COL, the provisions of the Atomic Energy Act or AEA, and the NRC's rules and regulations.

   RTNSS B and C apply for the review for ITAAC to the importance of functions in the post-72 hour period or defense-in-depth functions.

9. 10 CFR 20.1406(a), which requires that a DC or COL applicant describe how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

   RTNSS B and C and nonsafety-related (nonrisk-significant): apply.

<u>DSRS Acceptance Criteria</u>

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are set forth below. The DSRS is not a substitute for the NRC's regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), "Contents of applications; technical information." The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

The specific areas of review for the safety-related UHS are as listed below. Additional, the nonsafety-related acceptance criteria are shown in ***bold-italics***. RTNSS B and C functions, if they apply, are also shown below. For nonsafety-related (nonrisk-significant) normal power heat sink, nothing applies unless noted below.

1. <u>Protection Against Natural Phenomena</u>. Information that addresses the requirements of GDC 2 regarding the capability of structures housing the UHS and the UHS itself to withstand the effects of natural phenomena will be considered acceptable if the guidance of RG 1.27, Positions C.2 and C.3 are appropriately addressed.

   Note: RTNSS B SSCs are designed to withstand the effects of natural phenomena without loss of function. RTNSS C SSCs are evaluated, utilizing the "graded approach philosophy", against the effects of the most probable hazards (e.g. floods, winds, missiles, seismic events). As a result of this evaluation, RTNSS C maybe designed against the effects of natural phenomena. SRP Section 19.3 provides further guidance related to the reliability and availability missions of RTNSS B and C SSCs.

2. <u>Environmental and Dynamic Effects</u>. Information that addresses the requirements of GDC 4 regarding consideration of environmental and dynamic effects will be considered acceptable if the acceptance criteria in the following DSRS sections, as they apply to the normal power heat sink and water makeup to the UHS tank, are met: DSRS Sections 3.5.1.1, 3.5.1.4, 3.5.2, and 3.6.1.

   Note: RTNSS B SSCs are analyzed and designed to withstand adverse effects associated with internal hazards, i.e., those created from conditions inside the plant (e.g., turbine missiles, pipe whip).

3. <u>Sharing of Structures, Systems, and Components</u>. Information that addresses the requirements of GDC 5 regarding the capability of shared systems and components important to safety to perform required safety functions will be considered acceptable if the use of the UHS in multiple-unit plants during an accident in one unit does not significantly affect the capability to conduct a safe and orderly shutdown and cool-down in

the other unaffected unit(s).

GDC 5 is applicable to the passive containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

Note: GDC 5 is not applicable to RTNSS B or C functions. Water makeup to the UHS tank should be reviewed for system interaction, flow rate capacities, and system isolation between reactors for a multiple reactor site.

4. <u>Cooling Water System</u>. Information that addresses the requirements of GDC 44 regarding consideration of the cooling water system (CWS) will be considered acceptable if the guidance of RG 1.27, Positions C.2 and C.3; RG 1.72, Positions C.1, C.4, C.5, C.6, and C.7; and American National Standards Institute/American Nuclear Society (ANSI/ANS) 5.1 are applied appropriately.

   GDC 44 is applicable to the mPower™ containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

5. <u>Cooling Water System Inspection</u>. Information that addresses the requirements of GDC 45 regarding the inspection of CWSs will be considered acceptable if the design of the UHS permits inservice inspection of safety-related components and equipment.

   GDC 45 is applicable to the mPower™ containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

6. <u>Cooling Water System Testing</u>. Information that addresses the requirements of GDC 46 regarding the testing of CWSs will be considered acceptable if the UHS is designed for testing of safety-related systems or components for structural integrity and leak-tightness, operability, performance of active components, and the capability of the system to function as intended under accident conditions.

   GDC 46 is applicable to the passive containment heat removal system and the UHS tank, which is further described in DSRS 6.2.2.

7. <u>10 CFR 20.1406</u>. Minimization of contamination to the facility and the environment, and designs to facilitate eventual decommissioning, will be considered acceptable if the design identifies provisions to detect contamination that may enter as inleakage from other systems, identifies potential collection points such as water treatment systems or system low points, and addresses the long term control of radioactive material in the system.

   RTNSS B and C and nonsafety-related (nonrisk-significant): apply.

<u>Technical Rationale</u>

The technical rationale for application of these acceptance criteria to the areas of review addressed by this DSRS section is discussed in the following paragraphs. The specific areas of review for the safety-related UHS are as listed below. Additionally, the nonsafety-related technical rationales are shown in ***bold-italics***. RTNSS B and C functions, if they apply, are also shown below. For nonsafety-related (nonrisk-significant) normal power heat sink, nothing applies unless noted below.

1. GDC 1 requires that SSCs important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions. Appropriate records of the design, fabrication, erection, and testing of structures, systems, and components important to safety shall be maintained by or under the control of the nuclear power unit licensee throughout the life of the unit.
2. GDC 2 requires that SSCs important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena and (3) the importance of the safety functions to be performed

   Note: RTNSS B SSCs are designed to withstand the effects of natural phenomena without loss of function. RTNSS C SSCs are evaluated, utilizing the "graded approach philosophy", against the effects of the most probable hazards (e.g. floods, winds, missiles, seismic events). As a result of this evaluation, RTNSS C maybe designed against the effects of natural phenomena. SRP Section 19.3 provides further guidance related to the reliability and availability missions of RTNSS B and C SSCs.

3. GDC 4 requires that SSCs important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.

   Note: RTNSS B SSCs are analyzed and designed to withstand adverse effects associated with internal hazards, i.e., those created from conditions inside the plant (e.g., turbine missiles, pipe whip).

4. GDC 5 requires that SSCs important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.

   .RG 1.27 describes staff positions on UHS design for sharing of SSCs. GDC 5 applies to any multi-unit facility in which a UHS portion is shared by two or more units.

GDC 5 requirements provide assurance that, in an active or a passive failure at a multi-unit site, the sharing of UHS SSCs will not affect the safe-shutdown of any unit.

GDC 5 is applicable to the passive containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

Note: GDC 5 is not applicable to RTNSS B or C functions. Water makeup to the UHS tank should be reviewed for system interaction, flow rate capacities, and system isolation between reactor for a multiply reactor site.

5. GDC 44 requires that SSC*s* important to safety, to an ultimate heat sink shall be provided. The system safety function shall be to transfer the combined heat load of these structures, systems, and components under normal operating and accident conditions.

   Suitable redundancy in components and features, and suitable interconnections, leak detection, and isolation capabilities shall be provided to assure that for onsite electric power system operation (assuming offsite power is not available) and for offsite electric power system operation (assuming onsite power is not available) the system safety function can be accomplished, assuming a single failure.

   GDC 44 applies to this DSRS section because the reviewer evaluates the UHS design, including assumptions for heat loads, redundancy of components, capability to isolate components, and single failures. In addition, ANSI/ANS-5.1 describes methods acceptable to the staff for calculating residual decay energy.

   GDC 44 requirements provide assurance that the UHS will function as designed to transfer heat from SSCs as required under normal and accident conditions, assuming a single failure.

   GDC 44 is applicable to the mPower™ containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

6. GDC 45 requires that the cooling water system shall be designed to permit appropriate periodic inspection of important components, such as heat exchangers and piping, to assure the integrity and capability of the system.

   GDC 45 is applicable to the mPower™ containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

7. GDC 46 as to design provisions to permit appropriate periodic pressure and functional test to assure;

   A. The structure and leaktight integrity of its components.

   B. The operability and the performance of active components of the system.

   C. The operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation for reactor shutdown and for loss-of-coolant accidents, including operation of applicable portions of the protection system and the transfer between normal and emergency power sources

Meeting the requirements of GDC 46 provides assurance that components and equipment of the UHS can and will be tested, thereby ensuring that the system will perform its intended safety function.

GDC 46 is applicable to the mPower^{TM} containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

8. 10 CFR 20.1406(a) requires that a DC or COL applicant describe how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

   10 CFR 20.1406(a) applies to this DSRS section because the possibility of leakage of radioactive water the UHS exists.

   RTNSS B and C and nonsafety-related (nonrisk-significant): apply.

III. REVIEW PROCEDURES

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

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

The specific areas of review for the safety-related UHS are as listed below. Additionally, the nonsafety-related review procedures are shown in ***bold-italics***. RTNSS B and C functions, if they apply, are also shown below. For nonsafety-related (nonrisk-significant) normal power heat sink, nothing applies unless noted below. The safety analysis report (SAR) is reviewed for the overall arrangement and type of normal power heat sink and water makeup to the UHS tank. The reviewer verifies that the normal power heat sink and water makeup to the UHS tank is designed to maintain system function as required in adverse environmental phenomena, including freezing and loss of offsite power. The reviewer evaluates the system for whether:

1. The heat inputs in the normal power heat sink design are conservative. The reviewer makes an independent evaluation of the applicant's calculated heat loads or elects to audit calculations. The normal power heat sink heat loads include heat due to decay of radioactive material, sensible heat, pump work, and the heat load from the operation of the station auxiliary systems serving and dependent upon the normal power heat sink.

   RTNSS B and C: apply since RTNSS B SSCs are considered risk-significant.

   Nonsafety-related (nonrisk significant): may apply. Functions that support achieving and maintaining CSD conditions are reviewed.

2. Operational data from plants of similar design confirm, where possible, the heat input values for sensible heat, pump work, and station auxiliary systems.

   RTNSS B and C: apply since RTNSS B SSCs are considered risk-significant.

3. Programmatic Requirements – In accordance with the guidance in NUREG-0800 “Introduction,” Part 2 as applied to this DSRS Section, the staff will review the programs proposed by the applicant to satisfy the following programmatic requirements. If any of the proposed programs satisfies the acceptance criteria described in Subsection II, it can be used to augment or replace some of the review procedures. It should be noted that the wording of “to augment or replace” applies to nonsafety-related risk-significant SSCs, but “to replace” applies to nonsafety-related nonrisk-significant SSCs according to the “graded approach” discussion in NUREG-0800 “Introduction,” Part 2. Commission regulations and policy mandate programs applicable to SSCs that include:

    A. Maintenance rule, SRP Section 17.6 (DSRS Section 13.4, Table 13.4, Item 17, RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” and RG 1.182, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants.”

    B. Quality Assurance Program, SRP Sections 17.3 and 17.5 (DSRS Section 13.4, Table 13.4, Item 16).

    C. Technical Specifications (DSRS Section 16.0 and SRP Section 16.1) – including brackets value for DC and COL. Brackets are used to identify information or characteristics that are plant specific or are based on preliminary design information.

    D. Reliability Assurance Program (SRP Section 17.4).

    E. Initial Plant Test Program (RG 1.68, “Initial Test Programs for Water-Cooled Nuclear Power Plants,” DSRS Section 14.2, and DSRS Section 13.4, Table 13.4, Item 19).

    F. ITAAC (DSRS Chapter 14).

4. In accordance with 10 CFR 52.47(a)(8),(21), and (22), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues that are identified in the version of NUREG-0933 current on the date 6 months before application and that are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.

5. The reviewer verifies whether:

    A. The total station heat load and system flow requirements are compatible with the normal power heat sink rejection capability.

       RTNSS B and C: apply since RTNSS B SSCs are considered risk-significant.

       Nonsafety-related (nonrisk significant): apply to support CSD.

B. The normal power heat sink can dissipate the maximum possible total heat load, under the expected combination of adverse environmental conditions, even freezing, and can cool the unit (or units) in the post-72 hour period without makeup unless acceptable reliable makeup capabilities can be demonstrated. Long-term cooling and water makeup design features and long term operational programs should be considered to include out past the initial 7 days and out to 30 days. This capability is verified by the staff's audit to check applicable calculations.

RTNSS B and C: applies since RTNSS B SSCs are considered risk-significant.

Nonsafety-related (nonrisk significant): apply to support CSD. Revised paragraph to:

The normal power heat sink can dissipate the maximum possible total heat load with consideration to freezing, and can cool the unit (or units) in the post-72 hour period. Long-term cooling and water makeup design features and long term operational programs should be considered to include out past the initial 7 days and out to 30 days.

C. The single failure of any SSCs will not prevent the normal power heat sink from performing its risk-significant functions.

RTNSS B: applies for functions in the post-72 hour period.

The single failure of any SSCs will not prevent the normal power heat sink from performing its RTNSS B functions.

RTNSS C: does not apply.

Nonsafety-related (nonrisk significant): SSCs that support achieving and maintaining CSD conditions in the post-72 hour period should be design to be reliable.

Note: Regarding consideration of the UHS and normal power heat sink will be considered acceptable if a system can be isolated so the safety function or defense-in-depth function of the system is not compromised.

D. Water makeup is required to the UHS tank associated with the containment heat removal system, post DBA and beyond 7 days. Onsite water sources may vary and maybe supplied from a clean reliable water source, such as the fire protection system or condensate storage.

RTNSS B: applies related to the UHS makeup in the post-72 hour period. The water supply should be designed for single failure. UHS makeup water system is protected from the effects of freezing, floods, hurricanes, tornadoes, and internally- or externally-generated missiles. Flood protection and missile protection criteria are evaluated in detail under the DSRS sections for SAR Chapter 3. The reviewer uses the procedures in these DSRS sections to ensure that the analyses presented are valid. A

statement to the effect that the system is located in a seismic qualified (Category I or II) structure tornado-, missile-, and flood protected or that system components are located in individual cubicles or rooms that withstand both flooding and missiles is acceptable. The location and design of the system, structures, and pump rooms (cubicles) are reviewed for whether the degree of protection is adequate.

The fire protection system is one example of a UHS makeup source, which is manually aligned in the post-72 hour period. For example, the UHS makeup source should include, fire protection water tank(s), motor driven pump, diesel driven pumps (and support for fuel oil), piping interconnections, associated electrical power/diesel generators, instrumentation and controls, and dedicated associated valves and piping system. In addition, offsite water sources should also be considered such as water connections, flanges, or hose connections so that local fire truck pumpers can be utilized. The Short-Term Availability Controls should include this UHS tank makeup source.

The passive containment cooling ancillary water storage and associated pumps and piping system is also one other example of a UHS tank makeup source, which is manually aligned in the post-72 hour period.

The UHS tank makeup source many be shared between reactors at a multiple reactor site.

RTNSS C: apply related to the UHS makeup in order to meet NRC safety goal guidelines. UHS makeup water system should be protected from the effects of freezing.

The fire protection system is one example of a UHS makeup source, which is manually aligned to support defense-in-depth functions. For example, the UHS makeup source should include, fire protection water tank(s), motor driven pump, diesel driven pumps (and support for fuel oil), piping interconnections, associated electrical power/diesel generators, instrumentation and controls, and dedicated associated valves and piping system. In addition, offsite water sources should also be considered such as water connections, flanges, or hose connections so that local fire truck pumpers can be utilized. The Short-Term Availability Controls should include this UHS tank makeup source.

The passive containment cooling ancillary water storage and associated pumps and piping system is also one other example of a UHS tank makeup source, which is manually to support defense-in-depth functions.

The UHS tank makeup source many be shared between reactors at a multiple reactor site.

6. For a reactor site that may utilize mechanical chillers for the design of the normal heat sink, guidance is provided in DSRS Section 9.2.2, III.4.K.

7. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and

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

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

RTNSS B: applies for functions for normal power heat sink and functions that support UHS tank make up in the post-72 hour period.

RTNSS C: applies for defense-in-depth functions for normal power heat sink and functions that support UHS tank makeup in order to meet NRC safety goal guidelines.

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

   RTNSS B: applies for functions for normal power heat sink and functions that support UHS tank make up in the post-72 hour period.

   RTNSS C: applies for defense-in-depth functions for normal power heat sink and functions that support UHS tank makeup in order to meet NRC safety goal guidelines.

9. 10 CFR 20.1406(a) requires that the applicant describe how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste.

   10 CFR 20.1406(a) applies to this DSRS section because the possibility of leakage of radioactive water into the UHS exists

   RTNSS B and C and nonsafety-related: apply.

IV. <u>EVALUATION FINDINGS</u>

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's SER. The reviewer also states the bases for those conclusions.

The review has determined the adequacy of the applicant's proposed water makeup to the UHS tank and normal power heat sink design criteria, design bases, and safety classification and the requirements for cooling water delivery for a safe-shutdown during normal and accident conditions. The staff concludes that the design is acceptable and meets the requirements of GDCs 1, 2, 4, 44, 45, and 46. The specific areas of review for the safety-related UHS are as listed below. Additionally, the nonsafety-related evaluation findings are shown in ***bold-italics***. RTNSS B and C functions, if they apply, are also shown below. For nonsafety-related (nonrisk-significant) normal power heat sink, nothing applies unless noted below.

1. The applicant meets GDC 1 requirements for the UHS. Acceptance is bases on the SSCs important to safety as being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Recognized codes and standards shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product. Appropriate records of the design, fabrication, erection, and testing of SSCs important to safety shall be maintained by or under the control of the nuclear power unit licensee throughout the life of the unit.

2. The applicant meets GDC 2 requirements for capability to withstand the effects of natural phenomena such as earthquake, tornado, hurricane, flood, tsunami and seiche. Acceptance is based on RG 1.27, Positions C.2 and C.3.

   Note: RTNSS B SSCs are designed to withstand the effects of natural phenomena without loss of function. RTNSS C SSCs are evaluated, utilizing the "graded approach philosophy", against the effects of the most probable hazards (e.g. floods, winds, missiles, seismic events). As a result of this evaluation, RTNSS C maybe designed against the effects of natural phenomena. SRP Section 19.3 provides further guidance related to the reliability and availability missions of RTNSS B and C SSCs.

3. The applicant meets GDC 4 requirements for the effects of missiles inside and outside of containment, effects of pipe whip, jets, and environmental conditions from high and moderate energy line breaks, and dynamic effects of flow instabilities (i.e., water hammer loads) as to impairment of required functions during normal plant operations and under upset or accident conditions. Acceptance for water hammer effects is based on the following:

   A. Vents are provided at high points for liquid-filled, but normally idle, piping (or systems) where voiding can occur. These vents should be designed for ease of periodic operational testing.

   B. Consideration is given to voiding following pump shutdown or during standby. If in the system design voiding could occur, the design should provide for a slow system fill upon pump start to avoid water hammer, or the design should maintain functions following an inadvertent water hammer occurrence. Keep-fill systems should be considered during standby conditions.

   C. Operating and maintenance procedures are reviewed by the applicant for assurance of sufficient measures for avoiding water hammer (e.g., rapid fill due to pump start, periodic fill and vent checks, avoidance of sudden valve movement or realignment).

   D. Preoperational testing maybe necessary to verify that during various system alignments or train transfers/shutdowns that there is no evidence of water hammer occurrence.

   Note: RTNSS B SSCs are analyzed and designed to withstand adverse effects associated with internal hazards, i.e., those created from conditions inside the plant (e.g., turbine missiles, pipe whip).

4. The applicant meets GDC 5 requirements for sharing of SSCs by demonstrating that such

sharing does not affect the safe-shutdown of any unit in an active or passive failure.

Note: In many cases, the DC addresses a single unit and a COL applicant may address a single unit or a multiple unit site.

GDC 5 is applicable to the mPower^{TM} containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

Note: GDC 5 is not applicable to RTNSS B or C functions. Water makeup to the UHS tank should be reviewed.

5. The applicant meets GDC 44 UHS requirements. Acceptance is based on RG 1.27, Positions C.2 and C.3; RG 1.72, Positions C.1, C.4, C.5, C.6, and C.7; and ANSI/ANS 5.1. GDC 44 is applicable to the mPower^{TM} containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

6. The applicant meets GDC 45 requirements for inservice inspection of the safety-related components and equipment by demonstrating the accessibility of the UHS system for periodic inspections.

   GDC 45 is applicable to the mPower^{TM} containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

7. The applicant meets GDC 46 requirements for periodic pressure and functional testing to ensure structural and leak tight integrity, operability, and performance of its active components, and operability of the system as a whole by demonstrating the capability to operate the system at full capacity during normal startup or shutdown procedures or during normal operation without degrading the system to provide for a safe-shutdown or to mitigate the consequences of an accident.

   GDC 46 is applicable to the mPower^{TM} containment heat removal system and the UHS tank, which is further described in DSRS Section 6.2.2.

8. The applicant meets 10 CFR 20.1406 requirements for minimization of contamination of the facility and the environment, and for avoiding design features that would interfere with eventual decommissioning.

   RTNSS B and C and nonsafety-related nonrisk-significant: apply.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this DSRS section.

RTNSS B and C: apply for the review for ITAAC to the importance of functions in the post-72 hour period or defense-in-depth functions.

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

RTNSS B and C: apply for the review for ITAAC to the importance of functions in the post-72 hour period or defense-in-depth functions.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific DC, or COL, applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower™ and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (Agencywide Documents Access and Management System Accession No. ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor reviews, including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™-specific DC, or COL submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the Standard Review Plan (SRP) revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9), as long as the mPower™ DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47(a)(9). Alternatively, the staff may supplement the DSRS section by adding appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

VI. REFERENCES

1. SECY-94-084, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in the Passive Plant Designs," and SECY-95-132, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems (RTNSS) in the Passive Plant Designs."

2. RG 1.182, "Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants."

3. 10 CFR Part 50, Appendix A, GDC 1, "Quality standards and records."

4. 10 CFR Part 50, Appendix A, GDC 2, "Design Bases for Protection Against Natural Phenomena."

5. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."

6. 10 CFR Part 50, Appendix A, GDC 5, "Sharing of Structures, Systems, and Components."

7. 10 CFR Part 50, Appendix A, GDC 44, “Cooling Water.”

8. 10 CFR Part 50, Appendix A, GDC 45, “Inspection of Cooling Water System.”

9. 10 CFR Part 50, Appendix A, GDC 46, “Testing of Cooling Water System.”

10. RG 1.27, “Ultimate Heat Sink for Nuclear Power Plants.”

11. RG 1.72, “Spray Pond Piping made from Fiberglass-Reinforced Thermosetting Resin.”

12. ANS 5.1, “Decay Heat Power for Light Water Reactors,” October 1979.

13. 10 CFR Part 52.47(b)(1), “Contents of Applications, Technical Information, Inspections, Tests, Analyses, and Acceptance Criteria.”

14. 10 CFR Part 52.80(a), “Contents of Applications, Additional Technical Information, Inspections, Tests, Analyses, and Acceptance Criteria.”

15. RG 1.29, “Seismic Design Classification.”

16. RG 1.153, “Criteria for Power, Instrumentation, and Control Portions of Safety Systems.”

17. RG 1.155, “Station Blackout.”

18. RG 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants.”

19. RG 1.215, “Guidance for ITAAC Closure Under 10 CFR Part 52.”

20. Nuclear Management and Resources Council (NUMARC) Report 87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors."

21. NRC Information Notice 96-36, “Degraded of Cooling Water Systems Due to Icing.”

22. 10 CFR 50.65, “Requirements for monitoring the effectiveness of maintenance at nuclear power plants.”

23. RG 1.174, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant Specific Changes to the Licensing Basis.”

24. RG 1.206, “Combined License Applications for Nuclear Power Plants.”