NUREG-0800
(Formerly NUREG-75/087)

U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

10.3 MAIN STEAM SUPPLY SYSTEM

REVIEW RESPONSIBILITIES

Primary - Auxiliary Systems Branch (ASB)
Power Systems Branch (PSB)

Secondary - None

I. AREAS OF REVIEW

The main steam supply system (MSSS) for both boiling water reactor (BWR) and pressurized water reactor (PWR) plants transports steam from the nuclear steam supply system to the power conversion system and various safety-related or non-safety-related auxiliaries. Portions of the MSSS may be used as a part of the heat sink to remove heat from the reactor facility during certain operations and may also be used to supply steam to drive engineered safety feature pumps. The MSSS may also include provisions for secondary system pressure relief in PWR plants.

The MSSS for the BWR direct cycle plant extends from the outermost containment isolation valves up to and including the turbine stop valves, and includes connected piping of 2-1/2 inches nominal diameter and larger up to and including the first valve that is either normally closed or is capable of automatic closure during all modes of reactor operation. The MSSS for the PWR indirect cycle plant extends from the connections to the secondary sides of the steam generators up to and including the turbine stop valves, and includes the containment isolation valves, safety and relief valves, connected piping of 2-1/2 inches nominal diameter and larger up to and including the first valve that is either normally closed or capable of automatic closure during all modes of operation and the steam line to the auxiliary feedwater pump turbine. The ASB is responsible for the review of the MSSS from the containment up to and including the outermost isolation valve. The PSB is responsible for the review of the remainder of the MSSS. (The turbine stop valve review is included in SRP Section 10.2.) The PSB also determines the adequacy of the design, installation, inspection, and testing of the electrical power supplies for essential components required for proper operation of the MSSS. The design of the MSSS must be in accordance with General Design Criteria 2, 4, 5, and 34.

USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

1. The ASB and PSB review the MSSS to determine which, if any, portions of the system are essential for safe shutdown of the reactor or for preventing or mitigating the consequences of accidents. The system is reviewed to verify that:

   a. A single malfunction or failure of an active component would not preclude safety-related portions of the system from functioning as required during normal operations, adverse environmental occurrences, and accident conditions, including loss of offsite power.

   b. Appropriate quality group and seismic design classification are met for safety-related portions of the system.

   c. Failures of nonseismic Category I equipment or structures, or pipe cracks or breaks in high- and moderate-energy piping will not preclude essential functions of safety-related portions of the system.

   d. The system is capable of performing multiple functions such as transporting steam to the power conversion system, providing heat sink capacity or pressure relief capability, or supplying steam to drive safety system pumps (e.g., turbine-driven auxiliary feedwater pumps), as may be specified for a particular design.

   e. The design of the MSSS includes the capability to operate the atmospheric dump valves remotely from the control room following a safe shutdown earthquake coincident with the loss of offsite power so that a cold shutdown can be achieved with dependence upon safety-grade components only.

   f. The system design capability can withstand adverse dynamic loads, such as steam hammer resulting from rapid valve closure and relief valve fluid discharge loads.

2. The ASB reviews the MSSS with regard to measures provided to limit blowdown of the system in the event of a steam line break.

3. The ASB and PSB also review the design of the MSSS with respect to the following:

   a. The functional capability of the system to transport steam from the nuclear steam supply system as required during all operating conditions.

   b. The capability to detect and control system leakage, and to isolate portions of the system in case of excessive leakage or component malfunctions.

   c. The capability to preclude accidental releases to the environment.

   d. Provisions for functional testing for safety-related portions of the system.

4. ASB also performs the following reviews under the SRP sections indicated:

a. Review for flood protection is performed under SRP Section 3.4.1.

b. Review of the protection against internally generated missiles is performed under SRP Section 3.5.1.1.

c. Review of the structures, systems, and components to be protected against externally generated missiles is performed under SRP Section 3.5.2.

d. Review of high- and moderate-energy pipe breaks is performed under SRP Section 3.6.1.

In the review of the main steam supply system, the ASB and PSB will coordinate other branches' evaluations that interface with the overall review of the system as follows: The Reactor Systems Branch (RSB) identifies essential components associated with the portion of the MSSS inside the primary containment that are required for normal operations and accident conditions, establishes shutdown cooling load requirements versus time, and verifies the design transient used in establishing the flow capacity and setpoint(s) of steam generator relief and safety valves as part of its primary review responsibility for SRP Section 5.2. The Structural and Geotechnical Engineering Branch (SGEB) determines the acceptability of the design analyses, 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 the 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 Equipment Qualification Branch (EQB) reviews the seismic and environmental qualification of components under SRP Sections 3.10 and 3.11. The Mechanical Engineering Branch (MEB) determines that the components, piping, and supports are designed in accordance with applicable codes and standards as part of its primary review responsibility for SRP Sections 3.9.1 through 3.9.3. The MEB 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. The MEB also reviews the adequacy of the inservice testing program of the system valves as part of its primary review responsibility for SRP Section 3.9.6. The Materials Engineering Branch (MTEB) verifies, upon request, the compatibility of the materials of construction with service conditions. The Instrumentation and Control Systms Branch (ICSB) reviews portions of the MSSS with respect to the adequacy of design, installation, inspection, and testing of essential components necessary for instrumentation and control functions as part of its primary review responsibility for SRP Sections 7.1, 7.4, 7.5, and 7.7. The Procedures and Systems Review Branch (PSRB) determines the acceptability of the preoperational and startup tests as part of its primary review responsibility for SRP Section 14.0. The reviews for fire protection, technical specifications, and quality assurance are coordinated and performed by the Chemical Engineering Branch, Standardization and Special Projects Branch (SSPB), and Quality Assurance Branch as part of their primary review responsibility for SRP Sections 9.5.1, 16.0, and 17.0, respectively.

For those areas of review identified above as being part of the primary review responsiblity of other branches, the acceptance criteria necessary for the review and their methods of application are contained in the referenced SRP sections of the corresponding primary branches.

II. ACCEPTANCE CRITERIA

Acceptability of the design of the MSSS, as described in the applicant's safety analysis report (SAR), is based on specific general design criteria and regulatory guides.

The design of the MSSS is acceptable if the integrated design of the system is in accordance with the following criteria:

1. General Design Criterion 2, as related to safety-related portions of the system being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods, and the positions of the following:

    a. Regulatory Guide 1.29, as related to the seismic design classification of system components, Positions C.1.a, C.1.e, C.1.f, C.2, and C.3.

    b. Regulatory Guide 1.117, as related to the protection of structures, systems, and components important to safety from the effects of tornado missiles, Appendix Positions 2 and 4.

2. General Design Criterion 4, with respect to safety-related portions of the system being capable of withstanding the effects of external missiles and internally generated missiles, pipe whip, and jet impingement forces associated with pipe breaks, and the position of Regulatory Guide 1.115 as related to the protection of structures, systems, and components important to safety from the effects of turbine missiles, Position C.1.

    The system design should adequately consider steam hammer and relief valve discharge loads to assure that system safety functions can be achieved and should assure that operating and maintenance procedures include adequate precautions to avoid steam hammer and relief valve discharge loads. The system design should also include protection against water entrainment.

3. General Design Criterion 5, as related to the capability of shared systems and components important to safety to perform required safety functions.

4. General Design Criterion 34, as related to the system function of transferring residual and sensible heat from the reactor system in indirect cycle plants, and the following:

    a. The positions in Branch Technical Position RSB 5-1 as related to the design requirements for residual heat removal.

    b. Issue Number 1 of NUREG-0138 as related to credit being taken for all valves downstream of the main steam isolation valves (MSIV) to limit blowdown of a second steam generator in the event of a steam line break upstream of the MSIV.

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to determine that the design criteria and bases and the preliminary design as set

forth in the preliminary safety analysis report meet the acceptance criteria given in subsection II of this SRP section. For review of operating license (OL) applications, the procedures are used 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 procedures for OL applications include a determination that the content and intent of the technical specifications prepared by the applicant are in agreement with the requirements for system testing, minimum performance, and surveillance, developed as a result of the SSPB review, as indicated in subsection I of this SRP section.

The primary reviewers, will coordinate this review with the other branches' areas of review as stated in subsection I of this SRP section. The primary reviewers obtain and use such input as required to assure that this review procedure is complete.

The review procedures below are written for typical MSSSs for both direct and indirect cycle plants. The reviewer will select and emphasize material from this SRP section, as may be appropriate for a particular case.

1. There are significant differences in the design of the MSSS for an indirect cycle (PWR) plant as compared to that for a direct cycle (BWR) plant. Further, different portions of the MSSS are safety-related in different plant designs, although the safety functions of the system are much the same in all PWR plants, and also in all BWR plants. The first step in the review of the MSSS, then, is to determine which portions are designed to perform a safety function. For this purpose, the system is evaluated to determine the components and subsystems necessary for achieving safe reactor shutdown in all conditions or for performing accident prevention or mitigation functions.

2. The reviewer determines that essential (safety-related) portions of the MSSS are correctly identified and are isolable to the extent required from nonessential portions of the system. The system description and piping and instrumentation diagrams (P&IDs) are reviewed to verify that they clearly indicate the physical division between each portion. System arrangement drawings are reviewed to identify the means provided for accomplishing system isolation.

3. The SGEB reviews the seismic design bases and MEB reviews the quality and seismic classification as indicated in subsection I of this SRP section. The SAR is reviewed by ASB and PSB to verify that essential portions of the MSSS are designed to Quality Group B and/or seismic Category I requirements, and to verify that the design classifications specified meet the acceptance criteria specified in subsection II of this SRP section. In general:

   a. The main steam lines from the steam generators to the containment isolation valves in PWR plants are classified seismic Category I and Quality Group B.

   b. The main steam lines in BWR plants extending from the outermost containment isolation valve and connected piping up to and including the

first valve that is either normally closed or capable of automatic closure during all modes of normal reactor operations but not including the turbine stop and bypass valves are classified seismic Category I and a quality group classification in accordance with BTP RSB 3-1.

Alternatively, for BWRs containing a shutoff valve (in addition to the two containment isolation valves) in the MSSS, seismic Category I and a quality group classification in accordance with BTP RSB 3-2 should be applied to that portion of the MSSS extending from the outermost containment isolation valves up to and including the shutoff valve.

4. The SAR is reviewed to assure that design provisions have been made to permit appropriate functional testing of system components important to safety. It is acceptable if the SAR delineates a testing and inspection program and the system drawings show any test recirculation loops or special connections around isolation valves that would be required by this program.

5. The system description, safety evaluation, component table, and P&IDs are reviewed to verify that the system has been designed to:

   a. Provide the necessary quantity of steam to any turbine-driven safety system pumps. The reviewer verifies that the design is capable of providing the required steam flow to the turbine so that an adequate supply of water can be pumped. (OL)

   b. Assure safe plant operation by including appropriate design margins for pressure relief capacity and setpoints for the secondary system, and for removal of decay heat during various accident conditions, as may be applicable in a particular case. The review is done on a case-by-case basis, and system acceptability is based on a comparison of system flow rates, heat loads, maximum temperatures, and heat removal capabilities to those of similarly designed systems for previously reviewed plants. For PWRs the design is reviewed to verify system capability for controlled cooldown to about 350°F to allow actuation of RHR system.

   c. Provide leakage detection means for steam leakage from the system in the event of a steam line break. Temperature or pressure sensors are acceptable means for initiating signals to close the main steam line isolation valves and/or turbine stop valves to limit the release of steam during a steam line break accident.

   d. Assure that in the event of a postulated break in a main steam line in a PWR plant, the design will preclude the blowdown of more than one steam generator, assuming a concurrent single active component failure. In this regard, all main steam shut-off valves downstream of the MSIVs, the turbine stop valves, and the control valves are considered to be functional. The reviewer should verify that the main steam isolation valves, shut-off valves in connecting piping, turbine stop valves, and bypass valves can close against maximum steam flow. The reviewer verifies that the SAR provides a tabulation

and descriptive text of all flow paths that branch off the main steam lines between the MSIVs and the turbine stop valves. The descriptive information shall include the following for each flow path:

(1) System identification

(2) Maximum steam flow in pounds per hour

(3) Type of shut-off valve(s)

(4) Size of valve(s)

(5) Quality of the valve(s)

(6) Design code of the valve(s)

(7) Closure time of the valve(s)

(8) Actuation mechanism of the valve(s) (i.e., solenoid operated, motor operated, air operated diaphragm valve, etc.)

(9) Motive or power source for the valve actuating mechanism.

e. In the event of a main steam line break, termination of steam flow from all systems identified in d, above, except those that can be used for mitigation of the accident, is required to bring the reactor to a safe cold shutdown. For these systems the reviewer verifies that the SAR describes what design features have been incorporated to assure closure of the steam shut-off valve(s) and what operator actions, if any, are required. If the systems that can be used for mitigation of the accident are not available, or the decision is made to use other means to shut down the reactor, the reviewer verifies that the SAR decribes how these systems are secured to assure positive steam shut-off and what operator actions, if any, are required.

f. Assure that in the event of a postulated safe shutdown earthquake in a PWR plant, the design includes the capability to operate atmospheric dump valves remotely from the control room so that cold shutdown can be achieved using only safety-grade components, assuming a concurrent loss of offsite power (refer to Branch Technical Position RSB 5-1 attached to SRP Section 5.4.7).

6. The reviewer verifies that the system is designed so that essential functions will be maintained, as required, in the event of adverse environmental phenomena, certain pipe breaks, or loss of offsite power. The reviewer uses engineering judgment and the results of failure modes and effect analyses to determine that:

a. Failure of nonseismic Category I portions of the MSSS or of other systems located close to essential portions of the system, or of nonseismic Catagory I structures that house, support, or are close to essential portions of the MSSS, do not preclude operation of the essential portions of the MSSS. Reference to SAR sections describing

site features and the general arrangement and layout drawings will be necessary, as well as the SAR tabulation of seismic design classifications for structures and systems. Statements in the SAR that confirm that the above conditions are met are acceptable.

b. Essential portions of the MSSS are protected from the effects of floods, hurricanes, tornadoes, and internally and externally generated missiles. Flood protection and missile protection criteria are evaluated under the SRP Section 3 series. The locations and the design of the system and structures are reviewed to determine that the degree of protection provided is adequate. A statement to the effect that the system is located in a seismic Category I structure that is tornado missile and flood protected, or that components of the system will be located in individual cubicles or rooms that will withstand the effects of winds, flooding, and tornado missiles is acceptable.

c. Essential portions of the MSSS are protected from the effects of high and moderate energy line breaks and cracks, including pipe whip, jet forces, and environmental effects. The means of providing such protection will be given in Section 3.6 of the SAR and procedures for reviewing this information are given in SRP Section 3.6.

d. Essential components and subsystems necessary for safe shutdown can function as required in the event of loss of offsite power. The SAR is reviewed to verify that for each MSSS component or subsystem affected by a loss of offsite power, the system functional capability meets or exceeds minimum design requirements. Statements in the SAR and results of failure modes and effects analyses are considered in assuring that the system meets these requirements. This is an acceptable verification of system functional reliability.

7. The descriptive information, P&IDs, MSSS drawings, and failure modes and effects analyses in the SAR are reviewed to assure that essential portions of the system will function following design basis accidents assuming a concurrent single active component failure. The reviewer evaluates the analyses presented in the SAR to assure function of required components, traces the availability of these components on system drawings, and checks that the SAR contains verification that minimum requirements are met for each accident situation for the required time spans. For each case the design is acceptable if minimum system requirements are met.

8. The SAR is reviewed to assure that the applicant has committed to address the potential for steam hammer and relief valve discharge loads, and will take adequate procedures action to minimize such occurrences. Drain pots, line slope and valve operators should be addressed.

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and his review supports conclusions of the following type, to be included in the staff's safety evaluation report:

The main steam supply system (MSSS) includes all components and piping from the outermost containment isolation valves (for BWRs) [from the steam generator connection (for PWRs)] up to and including the turbine stop valves. The essential portions of the MSSS are designed to quality Group B [for PWRs, from the steam generator to the containment isolation valves, and connected piping up to and including the first valve that is normally closed] [for BWRs, from the outermost containment isolation valves and connecting piping up to and including the first valve that is either normally closed or capable of automatic closure during all modes of normal reactor operation, but not including the turbine stop and bypass valves]. Those portions of the MSSS necessary to mitigate the consequences of an accident such as a steam line break are designed to the quality standards commensurate with the importance to its safety function, and are designed to the following standards: _____. The scope of review of the MSSS for the _____ plant included layout drawings, piping and instrumentation diagrams, and descriptive information for the system.

The basis for acceptance of the MSSS in our review was conformance of the applicant's design criteria and bases to the Commission's regulations as set forth in the General Design Criteria (GDC) of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDC 2, 4, 5, and 34. This conclusion is based on the following:

1. The applicant has met the requirements of GDC 2, "Design Bases for Protection Against Natural Phenomena," with respect to the ability of structures housing the safety-related portion of the system and the safety-related portions of the system being capable of withstanding the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, and floods and GDC 4 "Environmental and Missile Design Bases" with respect to structures housing the safety-related portions of the system and the safety-related portions of the system being capable of withstanding the effects of external missiles, and internally-generated missiles, pipe whip and jet impingement forces associated with pipe breaks. The essential portions of the MSSS (as identified in the above discussion) are designed Seismic Category I and housed in a Seismic Category I structure which provides protection from the effects of tornadoes, tornado missiles, turbine missiles, and floods. This meets the positions of Regulatory Guide 1.29, "Seismic Design Classification," Position C.1.a, C.1.e, C.2 and C.3 or C.1.f, C.2 and C.3; Regulatory Guide 1.115, "Protection Against Low Trajectory Turbine Missiles," Position C.1; and Regulatory Guide 1.117, "Tornado Design Classification," Appendix Positions 2 and 4.

   In addition, the system design capabilities should include the capability to accommodate steam hammer dynamic loads resulting from rapid closure of systems valves (including turbine bypass and stop valves), and safety/relief valve operation without compromising required safety functions. Water entrainment considerations should include provisions for drain pots, line sloping and valve operation. Operating and maintenance procedures are to be reviewed by the applicant to alert plant personnel to the potential for such occurrences and means to minimize such occurrences. This commitment should be stated in the applicants' SAR.

2. The applicant has met the requirements of GDC 5, "Sharing of Structures, Systems, and Components with Respect to the Capability of Shared Systems and Components," important to safety to perform required safety functions. We have reviewed the interconnections from the MSSS of each unit to _____. The interconnections are designed so that the capability to mitigate the consequences of an accident in either unit and achieve safe shutdown in that unit is retained without reducing the capability of the other unit to achieve safe shutdown.

   or

   Each unit of the _____ plant has its own MSSS with no interconnections between the safety-related and/or nonsafety- related portions.

3. The applicant has met the requirements of GDC 34, "Residual Heat Removal," with respect to the system function of transferring residual and sensible heat from the reactor system in PWR plants. The MSSS is capable of providing heat sink capacity and pressure relief capability and supplying steam to the steam driven safety-related pumps necessary for safe shutdown. The MSSS is also designed to include the capability to operate the atmospheric pump valves remotely from the control room following a safe shutdown earthquake coincident with the loss of offsite power so that a cold shutdown can be achieved with dependence upon safety-grade components only. This meets the positions in Branch Technical Position RSB 5-1, "Design Requirements of Residual Heat Removal System," and in Issue 1 of NUREG-0138.

V. IMPLEMENTATION

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

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.

Implemenation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides, NUREGs and implementation of acceptance criterion subsection II.2, associated with water hammer loads, is as follows:

(a) Operating plants and OL applicants need not comply with the provisions of this revision.

(b) CP applicants will be required to comply with the provisions of this revision.

VI. REFERENCES

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

2. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Missile Design Bases."

3. 10 CFR Part 50, Appendix A, General Design Criterion 5, "Sharing of Structures Systems and Components."

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

5. Regulatory Guide 1.26, "Quality Group Classifications and Standards for Water-, Steam-, and Radioactive-Waste-Containing Components of Nuclear Power Plants."

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

7. Regulatory Guide 1.115, "Protection Against Low-Trajectory Turbine Missiles."

8. Regulatory Guide 1.117, "Tornado Design Classification."

9. Branch Technical Positions ASB 3-1, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," attached to SRP Section 3.6.1, Branch Technical Position MEB 3-1, "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," attached to SRP Section 3.6.2.

10. Branch Technical Position RSB 3-1, "Classification of Main Steam Components Other than the Reactor Coolant Pressure Boundary for BWR Plants," attached to SRP Section 3.2.2.

11. Branch Technical Position RSB 3-2, "Classification of BWR/6 Main Steam and Feedwater Components Other Than the Reactor Coolant Pressure Boundary," attached to SRP Section 3.2.2.

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

13. NUREG-0138, "Staff Discussion of Fifteen Technical Issues Listed in Attachment to November 3, 1976, memorandum from Director NRR to NRR Staff."