Response to

Request for Additional Information No. 106 (1265, 1262), Revision 0

10/28/2008

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 10.02 - Turbine Generator
SRP Section: 10.03 - Main Steam Supply System
Application Section: FSAR Ch. 10

QUESTIONS for Balance of Plant Branch 1 (AP1000/EPR Projects) (SBPA)

Question 10.02-5:

I. FSAR Tier 2 Section 10.2A.2.9, "Overspeed Protection," states that two independent electrical over-speed devices are provided, one of which may be a conventional mechanical type device located on the turbine control shaft or an electrical overspeed protection system. The criteria specified in Items 2.C and 2.D of Section III, "Review Procedures," of SRP Section 10.2 states that a mechanical overspeed trip device will actuate the control, stop, and intercept valves at approximately 111 percent of rated speed. If the COL applicant selects the overspeed control system with two electrical over-speed trip devices, instead of one mechanical and one electrical, please address the following in the FSAR:

   a. Justify the diversity of the two electrical over-speed systems.

   b. Justify the utilization of the a second electrical device in lieu of a mechanical device.

   c. Confirm that the two systems do not share any common components or process inputs. If they do, provide an evaluation of the impact of failures of any such components.

   d. Describe any software used for the triple processors or performing trip logic actuation.

   e. Explain the diversity and defense-in-depth used to defend against a common cause failure (CCF) of the triple processor functions.

   f. Confirm the objectives of Test #174 are correctly described.

   Also, the reasoning is not clear for describing the two electrical trip devices in this alternate turbine design. With the two electrical trip devices for the emergency overspeed control, describe the differences of this alternate option from the primary design. The staff requests the applicant to clearly define in the FSAR the alternate design, and provide justification to call this an alternate design.

II. SRP Section 10.2, "Turbine Generator, Subsection II, "Acceptance Criteria," Item 1.C, states that the TG should have the capability to permit periodic testing of components important to safety while the unit is operating at rated load.

   FSAR Tier 2, Section 10.2A.2.12, Turbine Inservice Inspection and Testing," states that the main steam stop and control valves, reheat stop and intercept valves, and steam extraction no return valves are exercised on a frequency consistent with turbine manufacturer recommendations. However, the application did not state whether or not valve design is such that monthly exercising can be performed at full load per the SRP. Therefore, the staff requests the applicant to clarify in the FSAR the capability of the EPR turbine to be tested for each valve for a full stroke closed at 100 percent full power.

III. In order to meet the GDC 4 criteria, FSAR Tier 2 Section 10.2A.2.12, states that TG valves are exercised periodically and observed for valve motion. Tier 1 Figure 2.8.1-1 indicates that exercising a single control or stop valve would result in the isolation of flow from a steam line and steam generator.

   However, it is not clear from the FSAR, whether the TG stop or control valve in each of the main steam lines are arranged such that by closing a valve will allow diverting its steam flow to the other three. Therefore, the staff requests the applicant to describe in the FSAR, the details on the steam flow path during stop and control valve testing. Also, state in the FSAR, whether normal operation will utilize either full or partial arc control.

Response to Question 10.02-5:

I. A response to this question will be provided by March 31, 2009.

II. A response to this question will be provided by March 31, 2009.

III. A response to this question will be provided by March 31, 2009.

Question 10.03-1:

I. GDC 4 requires that the main steam supply system (MSSS) design need to have capability to withstand the effects of steam and water hammer and relief valve discharge loading. FSAR Tier 2 Section 10.3.3 states that the MSSS design considers steam and water hammer loads due to rapid valve closure, and relief valve thrust loads. Furthermore, the MSSS design includes protection against water entrainment by sloping the MSSS piping to drain low points. However, the FSAR does not describe the application of these loads to the MSSS design. Also, the FSAR states procedures should be implemented to preclude steam hammer loads; but, the FSAR does not address any COL information item for the COL applicants to develop and implement these procedures. Therefore, the staff requests the applicant to provide additional MSSS design details in the FSAR for accommoding hammer and thrust loads. Also, the staff requests the applicant to provide a COL information item in the FSAR to assure procedures are established to preclude steam hammer.

II. GDC-34 requires main steam supply system (MSSS) capability to transfer residual and sensible heat from the reactor coolant system (RCS). Also, the acceptance of the MSSS is abased on meeting the guidance of Branch Technical Position 5-4, “Design Requirements of the Residual Heat Removal System,” Issue 1 of NUREG-0138, “Staff Discussion of Fifteen Technical Issues Listed in ….Issue 1 of NUREG-0138 relative to utilizing the turbine ...”

    The failure Modes and Effects Analyses related to the main steam relief control valves (MSRCVs) are provided in FSAR Tier 2 Table 10.3-4, “Main Steam Supply System Single Active Failure Analysis,” and Tier 2 Table 7.3-2, “FMEA Summary for ESF Actuations.” However, it is not clear whether a single-failure analysis has been performed on the controls for the MSRCVs. FSAR Tier 2 Table 10.3-4 discusses power failures associated with MSRCVs and Tier 2 Table 7.3-2 evaluates emergency safety features (ESF) control failures. However, it is not clear whether an evaluation is performed to conclude that single control failures will not impact more than one MSRCV at a time. Therefore, the staff requests the applicant to provide in the FSAR clarification in this regard to ensure that a single control failure will not impact more than one MSRCV.

III. 10 CFR 52.47(b)(1) requires that a design-certification application contain inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that a plant that incorporates the design certification is built and will operate in accordance with the certification. ITAAC for the main steam supply system (MSSS) is provided in FSAR Tier 1, Table 2.8.2-3 “MSS Inspections, Tests, and Acceptance Criteria.” The staff reviewed these ITAAC requirements and finds them adequate, except that inspection and testing associated with the main steam relief control valves (MSRCVs) do not confirm the throttling and control capabilities required of these valves. For example, Item 7.3 in the above Table 2.8.2-3 provides testing for full-flow capacity of the main steam relief train (MSRT), i.e. with the MSRCV fully open. Similarly, Item 7.1 in the table will test that MSRCVs with positions as shown in Table 2.8.2-2 (i.e., one of which is throttled). However, the FSAR doesn't identify which throttle positions are tested, and ensure the post-accident partial cool-down. Similarly, Test #148 of FSAR Tier 2 Chapter 14.2 (Initial Plant Test Program) provides some testing of valve signals and position indicators, but does not fully test the accident mitigation features. Therefore, the staff requests additional information and/or clarification in the FSAR in this regard.

IV. Please provide additional information, as relates to safety-related function of the following MSRCVs and MSIVs:

1. FSAR Section 10.3.2.2, “Component Description,” states that the MSRCVs provide a safety-related function of controlling MSRT steam flow to prevent over cooling of the reactor coolant system. The MSRCVs allow mitigation of the effects of a stuck open main steam relief isolation valve (MSRIV). Describe in the FSAR the design and operation of the MSRCVs that would achieve the above stated safety-related function.
2. Also, FSAR Section 10.3.2.2 states that the MSSS piping system is designed with a capability to periodically test the operability of the MSIVs and associated apparatus and determine if valve leakage is within acceptable limits. Provide the following clarifications in the FSAR:

    a. The acceptable limits of the leakage through each MSIV from either direction.

    b. Assure these acceptable limits of the leakage through each MSIV are consistent with the assumptions made in main steam line break analyses documented in FSAR Section 15.1.5. Specify the location in the FSAR of these MSIV leakage limits.
3. With respect to safety-related MSIV actuators, provide the methodology for the protection of these actuators from environmental effects and dynamic effects (pipe whip and jet impingement forces) from a main steam line break upstream of the MSIV associated with the broken line.

Response to Question 10.03-1:

I. U.S. EPR FSAR Tier 2, Section 10.3.3 refers to U.S. EPR FSAR Tier 2, Section 3.12 for a description of piping design and piping supports design, including design considerations for accommodating steam and water hammer and thrust loads.

Piping in the MSSS is required to be properly warmed and drained of condensate during startup. System maintenance and operating procedures will include guidance and precautions to be exercised during system and component testing and changing valve alignments to confirm that valves in the MSSS operate properly.

U.S. EPR FSAR Tier 2, Section 10.3.3 will be revised to include a discussion on the need to make sure that piping in the MSSS is properly warmed and drained of condensate during startup, and system maintenance and operating procedures will include guidance and precautions to confirm that valves in the MSSS operate properly.

U.S. EPR FSAR Tier 2, Table 1.8-2—U.S. EPR Combined License Information Items, Item No. 13.5-1, states:

> “A COL applicant that references the U.S. EPR design certification will provide site-specific information for administrative, operating, emergency, maintenance and other operating procedures.”

The revision to U.S. EPR FSAR Tier 2, Section 10.3.3 and the inclusion of Table 1.8-2, Item No. 13.5-1 eliminates the need to add a new COL Information Item in the U.S. EPR FSAR requiring the COL applicant to provide operating and maintenance procedures to address steam hammer issues for the MSSS.

A COL applicant that references the U.S. EPR standard design certification is required to satisfy requirements in the U.S. EPR FSAR or take a departure and provide suitable justification for the departure.

II. A single control failure will not impact more than one MSRCV.

As indicated in U.S. EPR FSAR Tier 2, Figure 7.3-12—MSRCV Control, processing is performed and control orders are generated for each MSRCV in a different division of instrumentation and controls (I&C). Independence between the divisions is implemented so that a single failure in one division does not affect the ability of the remaining divisions to perform their function. Each division uses dedicated sensors as input to the control function processing; a single failure of a sensor is only seen by the associated control division. Signal selection (2^{nd} Max) is then used within each division to prevent a sensor failure from causing erroneous control actions.

The I&C portion of U.S. EPR FSAR Tier 2, Section 10.3.2.2 will be revised to clarify that a single control failure will not impact more than one MSRCV.

III. Additional information will be added to U.S. EPR FSAR Tier 1, Table 2.8.2-1—MSS Equipment Mechanical Design to specify the throttle positions of the MSRCV being tested in ITAAC 2.8.2-7.1. The testing of the MSRCVs will consist of being positioned 40 percent open and a linear variation between 40 percent and 100 percent open. Testing information being added to U.S. EPR FSAR Tier 1, Table 2.8.2-1 is consistent with information in U.S. EPR FSAR Tier 2, Section 10.3.2.2.

U.S. EPR FSAR Tier 2, Section 14.2.12, Test #148 verifies proper operation of the MSRT valves prior to testing with steam during hot functional testing (HFT). The valves must be verified to be operating correctly to prevent over-cooling during operation. This is described in U.S. EPR FSAR Tier 2, Section 10.3.2.2 and results in the MSRCVs being automatically positioned, based on thermal power:

- From zero to 20 percent thermal power - 40 percent open.
- From 20 to 50 percent thermal power - linear variation between 40 and 100 percent open.
- For greater than 50 percent thermal power - 100 percent open.

U.S. EPR FSAR Tier 2, Section 14.2.12, Test #148 will be revised to specify the throttle positions described in U.S. EPR FSAR Tier 2, Section 10.3.2.2.

After the MSRT valves are demonstrated to be functional in U.S. EPR FSAR Tier 2, Section 14.2.12, Test #148, they will be tested during HFT in U.S. EPR FSAR Tier 2, Section 14.2.12, Test #152, which is a dynamic test performed until satisfactory results are obtained. Operating experience from current plants indicates that dynamic testing is required to prevent over-cooling. U.S. EPR FSAR Tier 2, Section 14.2.12, Test #152 will also be revised to specify the throttle position being tested.

MSRCV throttling addressed in U.S. EPR FSAR Tier 2, Section 15.1.4.1 will also be revised to be consistent with the information in U.S. EPR FSAR Tier 2, Section 10.3.2.2.

IV.

1. The MSRCV are globe type control valves. During power operation greater than 50 percent thermal power, the MSRCVs are 100 percent open. Each MSRCV is designed for a maximum capacity sufficient to pass the rated relieving capacity of the MSRT. As indicated in the component description of the MSRT in U.S. EPR FSAR Tier 2, Section 10.3.2.2, the MSRCVs are automatically positioned at intermediate positions depending on thermal power. As indicated in U.S. EPR FSAR Tier 2, Section 7.3.1.2.4 and Section 7.3.1.2.5, MSRCVs control MSRT steam flow during partial cooldown if turbine bypass is not available. As indicated in U.S. EPR FSAR Tier 2, Section 7.3.1.2.6, in the event of low steam generator pressure, MSRT isolation is completed by closing both the MSRIV and MSRCV. Each MSRT can also be isolated by manual controls. Should the MSRIV fail to close in a MSRT, the MSRT can be isolated by closing its MSRCV.

U.S. EPR FSAR Tier 2, Section 10.3.2.2 will be revised to include references to U.S. EPR FSAR Tier 2, Section 7.3.1.2.4, Section 7.3.1.2.5 and Section 7.3.1.2.6.

2. The following are clarifications of MSIV leakage limits:

   a. Allowable leakage of MSIVs is based on the capability of metal seated gate valves.

      Each MSIV is seat leakage tested in forward and reverse flow directions by the valve supplier.

      Data related to containment isolation for main steam system valves are listed in U.S. EPR FSAR Tier 2, Table 6.2.4-1—Containment Isolation Valve and Actuator Data.

      As indicated in U.S. EPR FSAR Tier 2, Section 10.3.4, inservice testing is described in U.S. EPR FSAR Tier 2, Section 3.9.6. Inservice testing requirements of main steam system valves are listed in U.S. EPR FSAR Tier 2, Table 3.9.6-2—Inservice Valve Testing Program Requirements.

      Inservice leak testing of each MSIV is tested by pressurizing the valve cavity between the disks.

   b. No seat leakage through a closed MSIV is an assumption made in main steam line break analyses described in U.S. EPR FSAR Tier 2, Section 15.1.5, "Steam System Piping Failures Inside and Outside of Containment (PWR)." The effects of the small amount of seat leakage of a MSIV are negligible compared to the effects of the large steam flow through a line break.

3. The U.S. EPR utilizes Leak-Before-Break (LBB) methodology to eliminate from consideration breaks in the piping from the steam generator outlet nozzle to the containment penetration; thus, there are no breaks considered in the main steam line upstream of the MSIV. LBB is described in U.S. EPR FSAR Tier 2, Section 10.3.3 with reference to U.S. EPR FSAR Tier 2, Section 3.6.3. The piping through the penetration up to the MSIV meets the requirements of Subarticle NE 1120 in Section III of the ASME Boiler and Pressure Vessel Code and the maximum stress criteria as required in Branch Technical Position BTP 3-4, Rev. 2 for precluding breaks in the containment penetration

area. The break exclusion for the containment penetration area is described in U.S. EPR FSAR Tier 2, Section 3.6.2.1.1.1.

FSAR Impact:

I. U.S. EPR FSAR Tier 2, Section 10.3.3 will be revised as described in the response and indicated on the enclosed markup.

II. U.S. EPR FSAR Tier 2, Section 10.3.2.2 will be revised as described in the response and indicated on the enclosed markup.

III. U.S. EPR FSAR Tier 1, Section 2.8.2 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR FSAR Tier 2, Section 14.2.12 (Test #148 and Test #152) and Section 15.1.4.1 will be revised as described in the response and indicated on the enclosed markup.

IV.

1. U.S. EPR FSAR Tier 2, Section 10.3.2.2 will be revised as described in the response and indicated on the enclosed markup.

2. U.S. EPR FSAR Tier 2, Section 10.3.2.2 will be revised as described in the response and indicated on the enclosed markup.

3. U.S. EPR FSAR Tier 2, Section 10.3.3 will be revised as described in the response and indicated on the enclosed markup.

U.S. EPR Final Safety Analysis Report Markups

walls and roofs of the structures containing these portions of the system, as described in Section 3.5.

- Load drops on safety-related portions of the MSSS are precluded during operations, requiring the MSSS to be operable by administrative controls implemented in plant procedures. The controls include the use of handling devices suitable for the load being lifted and limitations on lift heights and lift paths over safety-related components.

10.03-1 (Part I)

- The MSSS design considers steam hammer and relief valve discharge loads to make sure system safety functions can be performed. Refer to Section 3.12 for a description of piping design and piping supports design. Loads from relief valve thrusts and sudden closure of valves (hammer) is included in the piping analyses. Operating and maintenance procedures ~~should~~will include precautions to prevent steam hammer and relief valve discharge loads. Piping in the MSSS is required to be properly warmed and drained of condensate during startup. System maintenance and operating procedures will include guidance and precautions to be exercised during system and component testing and changing valve alignments to confirm that valves in the MSSS operate properly.

- The MSSS design includes protection against water entrainment by sloping the main steam piping to drained low points.

The design of the safety-related portions of the MSSS satisfies GDC 5 regarding sharing of systems. Safety-related portions of the MSSS are not shared among nuclear power units.

The design of the safety-related portions of the MSSS satisfies GDC 34 regarding residual heat removal from the reactor coolant system.

- The MSSS provides residual heat removal by venting steam from the SGs via the MSRTs to the atmosphere and cooling down the reactor coolant system to the point of placing the RHRS in operation.

- The design of the safety related portions of the MSSS is consistent with the positions in BTP 5-4 (Reference 4), as it relates to the design requirements for residual heat removal. The MSRTs are safety-grade with safety-grade actuators, operable from the MCR and capable of using either only onsite or offsite power. MSRT capacity is such that with only two of the four trains available, the reactor can be cooled to the point of RHRS operation within 36 hours.

- The MSSS design conforms to NUREG-0138, Issue Number 1, (Reference 5) regarding credit being taken for non-safety-related valves downstream of the MSIV to limit blowdown of a second SG in the event of a main steam line break upstream of the MSIV. Table 10.3-3—Main Steam Branch Piping (2.5 Inches and Larger), Downstream of MSIV, identifies the MSSS valves that are credited for this event. Consistent with Reference 5, the only non-safety-related valves that are credited are the HP turbine stop valves.

Main Steam Warming Valves

Each MSIV includes a bypass line for pressure equalization and warming. Each bypass line features both a motor-operated MSWIV and a downstream MSWCV. The isolation and control valves are normally closed and are part of the Reference 1 pressure boundary. The MSWIV is Class 2 and the MSWCV is Class 3. During startup, the control valves are positioned to regulate the warming rate.

MSIV Low Point Drain Valves

Each bypass line has three low point drains; one upstream of the MSWIV, one between the MSWIV and MSWCV, and one downstream of the MSWCV. During startup and hot standby, these drains are opened to route condensate to the clean drain system. These drains are closed during normal operation.

Turbine Valves

The turbine stop valves, turbine control valves and valves in the steam supply to the second stage reheaters are described in Section 10.2.

Condensate Drains

Drains are provided at the turbine inlet and turbine bypass header to continuously and automatically remove condensate.

Main Steam Sample

An isokinetic sampler is provided in each of the four turbine steam inlets. The sampler provides main steam samples to the secondary side sample panel. Process sampling systems are described in Section 9.3.2.

Main Steam Piping

Each of the four SGs has its own main steam line. Each main steam line connects to its SG outlet nozzle, exits the RB through containment penetrations and enters the associated Valve Room related to each division in the Safeguard Buildings. Branch piping inside the TB supplies second stage reheater steam, deaerator pegging steam, backup auxiliary steam and turbine bypass to the main condenser.

10.03-1 (Part II)

Instrumentation and Controls

~~Instrumentation and controls (I&C) for the safety-related portions of the MSSS are part of the engineered safety feature actuation system (ESFAS) as described in Section 7.3. The ability to manually initiate ESF systems at the system level is provided in the main control room (MCR).~~ Safety-related instrumentation and controls (I&C) are provided for the safety-related portions of the MSSS as described in U.S. EPR Tier 2, Section 7.3. The safety-related I&C satisfy the single failure criterion

10.03-1 (Part II)

as described in U.S. EPR Tier 2, Section 7.1. The ability to manually initiate MSSS control actions is available in the main control room (MCR).

10.3.2.3 System Operation

10.3.2.3.1 Plant Startup

MSSS startup coincides with unit startup. Initially, using reactor coolant pump (RCP) and decay core heat, the MSSS piping and components are slowly warmed and pressurized in preparation of supplying steam to the turbine. Once no-load conditions (i.e., hot standby) are achieved and the reactor is critical, steam is admitted to the turbine and unit load is increased. During plant startup, large amounts of condensate are generated in the main steam piping and are removed to prevent water hammer and turbine damage. Low point drains are opened prior to startup for condensate removal and are closed after the turbine is loaded.

Normally, piping and components upstream of the MSIVs are warmed first, followed by piping and components downstream of the MSIVs. However, if so desired the process can begin with the MSIVs open and the entire system warmed at once. In either case, the TG manufacturer heat-up limitations are observed.

For warm up with the MSIVs initially closed, pressurization of the downstream piping can be initiated once adequate SG pressure is attained. The MSWIV is fully opened and the warm up rate is manually-adjusted by setting the position of the MSWCV. Once pressure has equalized, the warm up line is closed and the MSIVs are opened.

Once the MSIVs are open, further heat up is controlled by turbine bypass to the main condenser.

10.3.2.3.2 Normal Operation

During normal power operation, the electric generator is connected to the grid with core power and turbine load in equilibrium. The reactor and turbine control systems operate automatically and the turbine bypass is not in use. All four main steam trains are in operation discharging steam from the SG to the turbine. The state of major system components is as follows:

- The MSIVs are held open by hydraulic oil pressure in the lower piston chambers. The pilot solenoid valves are closed and energized.
- The MSRIVs are closed.
- The MSRCVs are open.
- The MSWIVs and MSWCVs are closed. These valves are in the MSIV bypass lines.
- The three drain line motor-operated valves are closed.

Table 2.8.2-1—MSS Equipment Mechanical Design (2 Sheets)

Equipment Description	Equipment Tag Number (1)	Equipment Location	ASME Code Section III	Function	Seismic Category
MSSVs	30LBA11AA191 30LBA12AA191 30LBA21AA191 30LBA22AA191 30LBA31AA191 30LBA32AA191 30LBA41AA191 30LBA42AA191	Safeguard Building 1 Safeguard Building 1 Safeguard Building 1 Safeguard Building 1 Safeguard Building 4 Safeguard Building 4 Safeguard Building 4 Safeguard Building 4	Yes	Open, Close	I
Main Steam Relief Isolation Valves	30LBA13AA001 30LBA23AA001 30LBA33AA001 30LBA43AA001	Safeguard Building 1 Safeguard Building 1 Safeguard Building 4 Safeguard Building 4	Yes	Open, Close	I
Main Steam Relief Control Valves	30LBA13AA101 30LBA23AA101 30LBA33AA101 30LBA43AA101	Safeguard Building 1 Safeguard Building 1 Safeguard Building 4 Safeguard Building 4	Yes	Open, Throttle(2), Close	I
MSIVs	30LBA10AA002 30LBA20AA002 30LBA30AA002 30LBA40AA002	Safeguard Building 1 Safeguard Building 1 Safeguard Building 4 Safeguard Building 4	Yes	Close	I
Main Steam Warming Isolation Valves	30LBA14AA001 30LBA24AA001 30LBA34AA001 30LBA44AA001	Safeguard Building 1 Safeguard Building 1 Safeguard Building 4 Safeguard Building 4	Yes	Close	I
Main Steam Warming Control Valves	30LBA14AA101	Safeguard Building 1	Yes	Close	I

10.03-1 (Part III)

Table 2.8.2-1—MSS Equipment Mechanical Design (2 Sheets)

Equipment Description	Equipment Tag Number [(1)]	Equipment Location	ASME Code Section III	Function	Seismic Category
	30LBA24AA101 30LBA34AA101 30LBA44AA101	Safeguard Building 1 Safeguard Building 4 Safeguard Building 4			
Turbine Bypass Valves	30MAN11AA051 30MAN13AA051 30MAN21AA051 30MAN23AA051 30MAN31AA051 30MAN33AA051	Turbine Building	N/A	Close	N/A

1) Equipment tag numbers are provided for information only and are not part of the certified design.

2) The main steam relief control valves are capable of being positioned 40 percent open and capable of a linear variation between 40 and 100 percent open.

10.03-1 (Part III)

5.2 Safety-related components meet electrical independence and redundancy requirements.

14.2.12.12.2 Main Steam Relief Trains (Test #148)

10.03-1 (Part III)

1.0 OBJECTIVE

1.1 To demonstrate the proper operation of the MSRT.

1.2 To verify electrical independence and redundancy of safety-related power supplies.

2.0 PREREQUISITES

2.1 Construction activities on the MSRT (MSRCV and MSRIV) and interfacing equipment have been completed.

2.2 The ~~MSRT~~MSRIV pilot valves have been calibrated and are operating satisfactorily prior to performing the following test.

2.3 External test equipment has been calibrated and is functional.

2.4 Support systems required for operation of the MSRT are functional.

2.5 Verify that factory acceptance testing has been completed.

2.6 Verify proper operation of alarm, control, and indication functions.

3.0 TEST METHOD

3.1 Simulate inputs to the MSRT and observe receipt of these signals as follows:~~.~~

3.1.1 Verify that the MSRCV responds as follows to simulated levels of thermal power:

- From zero to 20 percent thermal power-40 percent open.
- From 20 to 50 percent thermal power-linear variation between 40 and 100 percent open.
- For greater than 50 percent thermal power-100 percent open.

3.1.2 Verify that the MSRIV responds to simulated steam pressure changes.

3.2 Verify that the MSRT (MSRCV and MSRIV) operates over the design range using actual or simulated signals.

3.3 Simulate varying system inputs and observe output responses at the MSRT and at interfacing equipment.

3.4 Verify response of the MSRT valves and position indicators.

3.5 Demonstrate dynamic operation of the MSRT valves during HFT, using Test #152.

4.4 PRT temperature, pressure, and level.

4.5 Reactors drain tank temperature, pressure, and level.

4.6 IRWST temperature, pressure, and level.

4.7 Position response of valves to loss of motive power.

5.0 ACCEPTANCE CRITERIA

5.1 The RCS allows venting of the pressurizer and reactor vessel through designed flow paths, as shown on the plant layout drawings~~described in Section 5.4~~.

5.2 The primary depressurization system provides a depressurization path through designed flow paths.

5.3 The primary depressurization piping systems vibration and displacement data has been collected and is being evaluated.

5.4 The primary depressurization system functions as designed, refer to Section 5.4.

5.5 Safety-related components meet electrical independence and redundancy requirements.

14.2.12.12.6 ~~Rapid Depressurization~~Partial Cooldown (Test #152)

1.0 OBJECTIVE

1.1 To verify the flow path~~s~~ of the MSRT during partial cooldown~~rapid depressurization system~~.

1.2 To verify ~~that MSRT and associated piping perform as designed~~the MSRT setpoint is reduced upon receipt of a safety injection signal.

1.3 To verify electrical independence and redundancy of safety-related power supplies.

1.4 To verify response of the MSRT (MSRCV and MSRIV) to simulated signals.

10.03-1 (Part III)

2.0 PREREQUISITES

2.1 Construction activities on the MSRT and main steam system ~~to be tested~~ are essentially complete.

2.2 Plant is at HZP (pressure and temperature) conditions during HFT.

2.3 Plant systems required to support testing are functional.~~ or temporary systems are installed and functional.~~

2.4 Permanently installed instrumentation is ~~functional and~~ calibrated and ~~is~~ functional for performance of the following test.

2.5 Verify that factory acceptance testing has been completed.

2.6 Verify proper operation of alarm, control and indication functions.

3.0 TEST METHOD

3.1 Verify the performance of the MSRT by simulating a safety injection signal and verifying that the MSRT setpoint is reduced.

3.2 Verify power-operated valves fail upon loss of motive power as designed.

3.3 Verify electrical independence and redundancy of power supplies for safety-related functions.

10.03-1 (Part III)

3.4 Verify that the MSRCV postions to 40 percent open based on a thermal power level of 0 percent.

4.0 DATA REQUIRED

4.1 Valve position indications as a function of time.

4.2 RCS temperature and pressures as a function of time.

4.3 RCS depressurization rates as a function of time.

4.4 SG pressure and level as a function of time.

4.5 Position response of MSRT valves to loss of motive power.

5.0 ACCEPTANCE CRITERIA

5.1 The ~~rapid depressurization~~main steam system provides a depressurization path through ~~designed flow paths~~the MSRT valves and associated silencers to atmosphere, as described in Section 10.3.2.2.

5.2 The MSRT setpoint is reduced upon receipt of a safety injection signal, as described in Sections 6.3.3.1, 10.3.2.2, and 16 B 3.3.1.

5.3 Safety-related components meet electrical power supply independence and redundancy requirements, as described in Section 8.1.4.2.

10.03-1 (Part III)

5.4 The MSRCV positions to 40 percent based on a thermal power of 0 percent, as described in Section 10.3.2.2.

5.5 The MSRIV positions as required to control the rate of steam pressure reduction with minimal overshoot.

14.2.12.12.7 Integrated Engineered Safety Features/Loss of Power (Test #153)

For the U.S. EPR design, the sequencer is not a stand alone component and this function is accomplished in the protection system. This test is not intended to be a comprehensive test of the sequencer.

1.0 OBJECTIVE

1.1 To verify the full functional sequence of the ESFs (protection system).

1.2 ~~To demonstrate electrical redundancy, independence, and load group assignment.~~

steam flow. If the power increase is sufficiently large, a low DNBR RT or high LPD RT is initiated.

Overpressure protection is provided on each of the four main steam lines by an MSRT and two main steam safety valves (MSSVs). Each MSRT consists of a single-failure proof main steam relief isolation valve (MSRIV) and a downstream main steam relief control valve (MSRCV). The discharge capacity of each MSRT is approximately 50 percent of the full load steam flow of the SG. The discharge capacity of each MSSV is approximately 25 percent. Although the inadvertent opening of a relief valve occurs in one SG, the four SGs pick up and share the extra load within a few seconds because their steam lines are connected at the turbine bypass header. Consequently, conditions in the RCS remain symmetric until RT and closure of the MSIVs.

10.03-1 (Part III)

The MSRIVs are fast opening valves that are normally closed. ~~The MSRCVs are normally open control valves. They are fully open at HFP and close to 40 percent as core thermal power decreases to 40 percent, below which they remain 40 percent open.~~ The MSRCVs are control valves that are fully open above 50 percent thermal power. They close linearly from full open to 40 percent open as thermal power decreases from 50 percent to 20 percent. Below 20 percent thermal power they remain 40 percent open. The opening of the MSRIV automatically switches the MSRCV to control SG pressure to a high relief valve setpoint. It closes when SG pressure falls below that setpoint.

When the low SG pressure or high SG pressure decrease setpoint is reached, the PS initiates RT and closes the MSIVs. This isolates the affected SG from the other three unaffected SGs. When the low-low SG pressure or high-high SG pressure drop setpoint is reached, the PS isolates the MSRIV and the low-load feedwater line in the affected SG.

Should an MSRIV inadvertently open as postulated, the associated MSRCV terminates steam flow through the affected MSRT automatically when SG pressure decreases below its setpoint. The MSRCV requires 40 seconds to close. The automatic closure of the MSRCV in the affected MSRT terminates the event, but is postulated to fail open as the most severe single failure. This allows the blowdown of the affected SG to continue until dryout or closure of the MSRIV on the low-low SG pressure PS signal. The MSRIV might cycle between its opening and closing setpoints until the operator initiates a cool down in the unaffected SGs to transition to RHR cooling. Once RCS temperature decreases, the MSRIV in the affected SG remains closed.

The evolution of the stuck open MSSV scenario is similar to that of the inadvertent opening of MSRIV except for two differences: the capacity of the MSSV is half that of the MSRT and the MSSV cannot be isolated.

The auxiliary boiler system consists of feedwater supply equipment, deaerator, sampling system, water chemistry control equipment and automatic control equipment. Safety relief valves are in accordance with the ASME Boiler and Pressure Vessel (BPV) Code, Section VIII (Reference 16) to protect the system from overpressuration. The auxiliary boiler system does not perform any safety-related functions.

10.3.2.2 Component Description

Table 3.2-1 provides the quality group and seismic design classification of components and equipment in the MSSS. Section 3.2 also describes how the guidance in RG 1.26 is implemented for the U.S. EPR. The main steam lines, from the SGs up to and including the fixed restraint downstream of the MSIVs, are designed and constructed in accordance with Quality Group B and Seismic Category I. The remaining piping out to the TG stop valve and second stage reheaters meets ASME Power Piping Code B31.1 (Reference 2). Data related to containment isolation for MSSS valves are listed in U.S. EPR FSAR Tier 2, Table 6.2.4-1—Containment Isolation Valve and Actuator Data.

10.03-1 (Part IV)

Main Steam Safety Valves

Each main steam line has two Reference 1 safety valves, located upstream of the main steam isolation valve (MSIV). The main steam safety valves (MSSV), along with the main steam relief trains (MSRT), provide overpressure protection of the main steam piping and SGs. The safety valves discharge to the atmosphere via directly connected vent stacks. Low-point drains in the vent stacks route any accumulated water to the TB drains.

MSSV setpoint and capacity are such that with consideration of reactor trip (RT), the MSSVs alone prevent system pressure from rising above 110 percent of design value upon full loss of load.

Table 10.3-2—Design Data for Main Steam Safety Valves, provides design data for the MSSVs.

Main Steam Relief Trains

Each main steam line has one MSRT located upstream of its MSIV. Each MSRT consists of a Reference 1 normally closed, fast opening MSRIV and a downstream, normally open MSRCV. The MSRIVs are designed in accordance with ASME BPV Code, Section III, Division 1, Subsection NC including Article NC-7000 (Reference 3).

The MSRTs are part of the SG secondary side overpressure protection. MSRT setpoint and capacity are such that with consideration of RT, the MSRTs alone prevent system pressure from increasing above 110 percent of design pressure upon full loss of load.

The MSRTs discharge to the atmosphere via silencers and have low-point drains in the discharge piping to minimize condensate accumulation.

During mild pressure transients, the MSRIVs automatically open to prevent opening of the MSSVs. If the turbine bypass is unavailable, the MSRIVs vent steam to the atmosphere to remove residual heat.

10.03-1 (Part IV)

Controls for the MSRTs are described in U.S. EPR FSAR Tier 2, Section 7.3.1.2.4, Section 7.3.1.2.5, and Section 7.3.1.2.6.

Each MSRIV is an angle globe valve with a motive steam-operated piston actuator. Each actuator has a piston in the main valve and pilot valves also actuated by the motive steam. The valve is closed by balancing the main piston with steam on both sides. A spring is implemented above the main piston to assist in keeping the valve closed. The valve is rapidly opened by venting steam from above the main piston. The valve is maintained open by keeping both solenoid pilot valves open (energized) in one or both control lines.

The actuator is pilot operated for fast opening with high reliability (redundancy of pilots). There is one set of four solenoid-driven pilot valves (two pilots in series on each of the two redundant control lines, also called manifolds). This arrangement prevents a failure in any pilot valve from causing either a spurious opening (two pilots in series) or a failure to open (two redundant control lines) of the MSRIV. Figure 10.3-2—Main Steam Isolation and Main Steam Relief Isolation Valve Actuators, illustrates MSRIV actuation.

Functional tests of pilot valves may be performed individually during normal operation without impairing power generation.

The MSRCVs provide a safety-related function of controlling MSRT steam flow to prevent over cooling the reactor coolant. The MSRCVs allow mitigation of the effects of a stuck open MSRIV.

The MSRCVs are automatically positioned, based on thermal power, as follows:

- From zero to 20 percent thermal power–40 percent open.
- From 20 to 50 percent thermal power–linear variation between 40 and 100 percent open.
- For greater than 50 percent thermal power–100 percent open.

Main Steam Isolation Valves

Each main steam line includes an MSIV, located in the Valve Room just outside the containment. The MSIVs provide a safety-related function of isolating the main steam lines in the event of excessive steam flow to prevent over cooling the reactor coolant.

10.03-1 (Part IV)

In response to a main steam isolation signal, the MSIVs quickly and automatically close. Each MSIV is capable of closure in five seconds or less against a flow of approximately 5×10^6 lb_m/hr and a differential pressure of 1320 psid in either direction. ~~The piping system~~Each MSIV is designed with a capability to periodically test the operability of the MSIVs and associated apparatus and determine if valve leakage is within acceptable limits. Each MSIV is seat leakage tested in the forward and reverse flow directions by the valve supplier. Periodic leak testing of each MSIV is tested by pressurizing the valve cavity between the disks.

The MSIVs are gate valves with hydraulic-pneumatic actuators and are Reference 1, Class 2, pressure boundary.

The hydraulic-pneumatic actuator is a piston actuator with its upper chamber charged with high pressure nitrogen and its lower chamber connected to a hydraulic oil system. The nitrogen stored in the upper chamber serves as a spring to close the valve without failure. The hydraulic oil supplied to the lower chamber opens the valve.

The actuator upper chamber is closed and continuously maintained at high pressure. In the event of leakage, the upper chamber is equipped with pressure transmitters to alert the operator; in which case the upper chamber is manually connected to a nitrogen gas cylinder to restore the nominal pressure.

Each MSIV actuator has its own hydraulic oil system that pumps hydraulic oil from a tank into the actuator lower chamber. Fast closure is performed by dumping the hydraulic oil back to the oil tank via two redundant lines. Figure 10.3-2 illustrates this subsystem. Only one dump line is shown for clarity. On each dump line there is a dump valve pilot-operated by two solenoid valves in series and operating on the de-energize-to-trip principle. It is necessary to de-energize the two pilots in series to open the dump valve and therefore close the MSIV. This arrangement prevents a failure of any one pilot valve from causing either spurious MSIV closure (two pilots in series) or failure to close (two redundant control lines).

Each dump line also has an exercise dump valve for testing (partial closure) or slow closure. Each exercise dump valve is operated by a solenoid pilot valve. For MSIV testing or slow closure, the main dump valve is in the quick closure position and the exercise pilot is energized to slowly drain hydraulic fluid back to the tank.

Functional testing of pilot valves can be performed individually during normal operation without affecting power generation.

- Safety-related portions of the MSSS are protected from pipe whip and jet forces resulting from breaks in other systems outside of containment by the design layout of the safety related portions of MSSS. The safety-related portions of the MSSS consist of four separated trains, with no other systems present in each valve room. From the valve room to the fixed points, the MSSS is protected from the effects of pipe breaks in other systems by anti-whip pipe restraints as described in Section 3.6.2.

10.03-1 (Part IV)

- Piping ruptures of the safety-related portions of the MSSS inside containment is not postulated by applying leak-before-break analysis as described in Section 3.6.3.

- Piping ruptures of safety-related portions of MSSS piping through the containment penetration up to the MSIV are not postulated by applying the break exclusion for containment penetration area as described in U.S. EPR FSAR Tier 2, Section 3.6.2.1.1.1.

- Safety-related portions of the MSSS are protected from pipe whip and jet forces resulting from breaks in another main steam line outside containment by the system design layout. The MSSS consists of four separated trains with no other systems present in each valve room. From the valve room to the fixed points, each main steam line is protected from pipe breaks in another main steam line by anti-whip pipe restraints. Refer to Section 3.6.2 for additional information.

- Failure of Non-Seismic Category I portions of the MSSS or of other systems located close to essential portions of the system, or of Non-Seismic Category I structures that house, support or are close to essential portions of the MSSS, does not preclude operation of the essential portions of the MSSS. Safety-related portions of the MSSS are inside the Reactor Building and Safeguard Buildings, which are all classified Seismic Category I structures; therefore, Non-Seismic Category I structures are not a concern. Refer to Section 3.12 for a description of the design of piping systems and piping supports used in Seismic Category I, Seismic Category II and non-safety-related systems.

- Safety-related portions (only includes piping and supports) of the MSSS inside containment are partially protected from internal missiles inside containment by partial separation in the SG bunkers. Further information on missile protection is provided in Section 3.5.

- Safety-related portions of the MSSS outside containment are protected from internal missiles by the separated trains in the valve room, so that at most one valve station is affected by missiles. Further information on missile protection is provided in Section 3.5.

- Consistent with the guidance in RG 1.115, Position C.1, the TG location and axis is favorably oriented with respect to the containment such that turbine missile impacts on safety-related portions of the MSSS from a single U.S. EPR plant are precluded. Refer to Section 3.5.1.3 for the evaluation of turbine missiles.

- Consistent with RG 1.117, Appendix Positions 2 and 4, the safety-related portions of the MSSS are protected against the effects of tornado missiles by the external