10.3 Main Steam Supply System

The main steam supply system (MSSS) conveys steam from the steam generators (SG) to the high pressure (HP) turbine. The MSSS also provides steam to the second stage reheaters, deaerator pegging steam and backup auxiliary steam.

10.3.1 Design Bases

The MSSS provides the following safety-related functions:

- Isolate main steam lines in the event of excessive steam flow to prevent over cooling of the reactor coolant.
- During accident conditions, provide initial residual heat removal by venting steam to the atmosphere via the main steam safety valves (MSSV) and main steam relief trains (MSRT).
- In the event of a steam generator tube rupture (SGTR), retain activity by steam side isolation.

The MSSS has the following design basis requirements and criteria:

- Safety-related portions of the MSSS are designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, tsunamis and seiches without loss of capability to perform its safety functions (GDC 2).
- Safety-related portions of the MSSS are designed to withstand the effects of external missiles and internally generated missiles, pipe whip and jet impingement forces associated with pipe breaks (GDC 4).
- Safety-related portions of the MSSS are not shared among nuclear power units (GDC 5).
- Safety-related portions of the MSSS are designed to maintain fuel and reactor coolant pressure boundary (RCPB) design limits by providing sufficient cooldown capacity and suitable power supply and redundancy to assure functionality during a loss of offsite power (LOOP) (GDC 34).
- Safety-related portions of the MSSS are designed to provide decay heat removal capability necessary for core cooling and safe shutdown during a station blackout (SBO) event (beyond design basis accident) (10 CFR 50.63).

The MSSS is designed to meet the following functional criteria:

- Convey steam from the SGs to the HP turbine and second stage reheaters at the flow rates and steam conditions required by the turbine-generator (TG) supplier.
- Provide backup supply to the auxiliary steam system.
- Supply deaerator pegging steam during startup and shutdown.

10.3.2 System Description

10.3.2.1 General Description

A flow diagram of the MSSS is provided in Figure 10.3-1—Main Steam Supply System. The system conveys steam from the SGs to the TG. The system consists of main steam piping, MSRTs, MSSVs and main steam isolation valves (MSIV). Table 10.3-1—Main Steam Supply System Design Data, provides design data for the MSSS.

Safety-related portions of the MSSS include piping between each SG outlet nozzle and its respective main steam isolation valve, inclusive of the following components and associated branch piping:

- MSIVs.
- Main steam warming control valves (MSWCV).
- Main steam warming isolation valves (MSWIV).
- Main steam relief isolation valves (MSRIV).
- Main steam relief control valves (MSRCV).
- MSSVs.

Each of the four SGs has its own main steam line. Each main steam line connects to its SG outlet nozzle, exits the Reactor Building (RB) through penetrations and enters a valve room related to each division. The divisionally separated main steam lines are located in a two-by-two arrangement in valve rooms on top of Safeguard Buildings 1 and 4 and on opposite sides of the RB.

Outside the valve rooms, the main steam lines are routed across a pipe bridge to the Turbine Building (TB) and connect to the four turbine stop valves. Drain pots are provided at the turbine inlet for condensate removal. Branch piping inside the TB supplies second stage reheater steam, deaerator pegging steam, backup auxiliary steam and turbine bypass to the main condenser.

Auxiliary steam from the MSSS is used to supply turbine gland steam during startup and shutdown, and heating steam for the feedwater storage tank during startup. Pressure reducing valves are provided as needed to reduce the header pressure to the pressure required for proper operation of the equipment. The normal supply of auxiliary steam is from the extraction of the moisture separator reheaters (MSR). Backup auxiliary steam is supplied via the MSSS upstream of the HP turbine stop valves and by the auxiliary boilers. The backup sources of auxiliary steam are used during startup and low-load operation.

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 overpressurization. The auxiliary boiler system does not perform any safety-related functions.

10.3.2.2 Component Description

Table 3.2.2-1 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 Table 6.2.4-1—Containment Isolation Valve and Actuator Data.

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.

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.

Controls for the MSRTs are described in 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.

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 $5x10^6$ lb_m/hr and a differential pressure of 1320 psid in either direction. 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.

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.

Instrumentation and Controls

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 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.

During normal power operation above 60 percent power, main steam flow is a function of turbine load; steam pressure is not controlled, but varies with turbine load.

In the case of an imbalance between core power and turbine load, excess steam is dumped to the main condenser via the turbine bypass.

10.3.2.3.3 Plant Shutdown

MSSS shutdown coincides with unit shutdown. Unit load is reduced to no-load and the turbine and reactor are shut down. During shutdown, all four main steam trains are in operation with steam generated in the SGs either dumped to the main condenser via the turbine bypass, or to the atmosphere via the MSRTs or MSSVs (or both). Steam flow is a function of the power supplied by the RCPs and core decay heat. The SG water inventories are maintained by the startup and shutdown feedwater system.

Cooldown from no-load to the point of residual heat removal (RHR) connection is performed by gradually reducing the main steam pressure. If the turbine bypass is available, the process is automatic. Refer to Section 10.4.4 for a description of the TBS. If the MSRIVs are used, the setpoint is reduced manually by the operator in accordance with the primary side cooldown curves.

Once the residual heat removal system (RHRS) is connected, heat transfer from the reactor is via the RHRS. The turbine bypass or MSRTs, feedwater system and MSSS can be taken out of service and the SGs isolated. If desired, the SGs may be placed in wet lay up.

10.3.2.3.4 Abnormal Operation

Section 15.0 describes the evaluation of anticipated operational occurrences (AOO). This includes the following:

- Increased steam flow with failure of MSIV to close.
- Inadvertent opening of one MSRIV.
- Inadvertent opening of an MSSV.
- Loss of external load.
- Turbine trip (TT).
- Loss of condenser vacuum.
- Inadvertent closure of one MSIV.
- Loss of offsite power (LOOP).
- Anticipated transient without scram (ATWS).
- Station blackout (SBO).

10.3.2.3.5 Accident Conditions

Refer to Section 15.0 for a description of accident analyses. This includes an evaluation of a main steam line break (MSLB) and steam generator tube rupture (SGTR).

10.3.3 Safety Evaluation

The design of the safety-related portions of the MSSS satisfies GDC 2 regarding the effects of natural phenomena.

- Safety-related portions of the MSSS are located in the RB and valve rooms, which are part of the Safeguard Buildings. These buildings are designed to withstand the effects of natural phenomena, such as earthquakes, tornadoes, hurricanes, floods, tsunamis and seiches. Section 3.3, Section 3.4, Section 3.5, Section 3.7 and Section 3.8 provide the bases for the adequacy of the structural design of these buildings.

- Safety-related portions of the MSSS are designed to remain functional during and after a safe shutdown earthquake (SSE). Section 3.7 provides the design loading conditions that are considered.

- Consistent with the guidance in RG 1.29, Position C.1.f, main steam piping and components 2.5 inches and larger, upstream of and including the MSIVs, are classified Seismic Category I. Also, consistent with RG 1.29, Position C.3, Seismic Category I design requirements extend to the first seismic restraint downstream of each MSIV.

- Safety-related portions of the MSSS inside containment are located at sufficient elevation to be protected from flooding events inside containment.

- Safety-related portions of the MSSS outside of containment are located within the valve rooms inside the Safeguard Buildings and are protected from internal flooding as described in Section 3.4.3.4.

The design of the safety-related portions of the MSSS satisfies GDC 4 regarding potential dynamic effects, such as pipe whip, jet impingement, and missile impacts caused by equipment failure or events outside the plant. The analysis of a postulated high-energy line failure is provided in Section 3.6.1 and Section 3.6.2. The analysis for missiles is provided in Section 3.5.

- Safety-related portions of the MSSS inside containment are partially protected from the effects of pipe break of other systems inside containment by partial separation in the SG bunkers. Otherwise, protection is provided by anti-whip pipe restraints as described in Section 3.6.2.

- 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.

- 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 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 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.

- 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 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.

The design of the safety-related portions of the MSSS satisfies 10 CFR 50.63 regarding SBO.

- Safety-related portions of the MSSS are designed to perform their safety functions during an SBO event and are capable of recovering from an SBO event. MSRTs are available for decay heat removal using power from the electrical uninterruptible power supply. A discussion of the SBO event and conformance with the guidance in RG 1.155 is provided in Section 8.4.2. The MSSS does not supply steam to power safety-related auxiliaries.

The design of the safety-related portions of the MSSS satisfies single failure considerations. The MSSS has four divisionally separated MSRTs. MSRT redundancy is such that at least two MSRTs are available for decay heat removal with one MSRT train failed. Table 10.3-4—Main Steam Supply System Single Active Failure Analysis, provides the results of a single active failure analysis for the MSSS. These results demonstrate that no single failure, coincident with a LOOP event, compromises the ability to fulfill the system safety functions.

- MSRIV controls have sufficient redundancy that a single failure cannot cause spurious opening, failure to open when required to open, or failure to close when required to close. Each MSRIV has four pilot valves; two pilots in series in each of the two redundant control lines. This arrangement prevents a failure in any pilot valve from causing either a spurious opening or a failure to open.

- MSIV controls have sufficient redundancy that a single failure cannot cause spurious closure, or failure to close when required to close. Each MSIV actuator has redundant dump lines to close the valve. On each dump line there is a pilot-operated dump valve actuated by two solenoid valves in series. It is necessary to open the two pilots in series to open the dump valve and close the MSIV. This arrangement prevents a failure of any pilot valve from causing either spurious closure or failure to close of the MSIV.

- Redundancy is provided in the overpressure protection devices such that failure of one device cannot result in the loss of the overpressure protection function. Each SG is protected by two safety valves and one MSRT. With consideration of RT, either the MSRT or the two safety valves are sufficient to prevent pressure from increasing to more than 110 percent of design.

10.3.4 Inspection and Testing Requirements

The MSSS components are inspected and tested as part of the initial test program. Refer to Section 14.2 (test abstracts #061, #062, #063, #148, #152, #196, #198, #199, #200 and #201) for initial plant startup test program.

Safety-related active components in the MSSS are designed to be tested during plant operation. Provisions are made to allow for inservice inspection of components at times consistent with those specified in the ASME BPV Code, Section XI (Reference 6). Section 3.9.6 describes inservice testing and Section 6.6 describes the inservice inspection program. Periodic testing to demonstrate operability of the MSSS and components is performed as specified in the Technical Specifications in Chapter 16.

10.3.5 Secondary Side Water Chemistry Program

Control of the secondary side water chemistry and proper feedwater conditioning are required to maintain the operational capability of the U.S. EPR steam generators. Good water quality minimizes both fouling of the steam generators that can result in heat transfer losses and also the potential for environments that can cause degradation of steam generator materials. The secondary water chemistry program is based on the EPRI PWR Secondary Water Chemistry Guidelines (Reference 9).

A COL applicant that references the U.S. EPR design certification will identify the authority responsible for implementation and management of the secondary side water chemistry program.

10.3.5.1 Chemistry Control Basis

The objectives of the U.S. EPR secondary water chemistry program are:

- To protect the steam generators, turbine and supporting feedwater systems from general and localized corrosion caused by the ingress of oxygen and other chemical contaminants.
- To minimize the metal release rate from the steam-water cycle materials in order to reduce the transport of corrosion products into the steam generators.

Water chemistry recommendations for secondary systems invoke plant and operational philosophies which address the control of corrosion products and dissolved impurities by minimizing potential sources and by implementing effective monitoring. Secondary system components and piping are all-ferrous materials with the exception of the steam generator tubing. Elimination of copper alloys from the steam-water cycle allows the secondary system pH to be set at a higher value, which significantly reduces both erosion-corrosion and the corrosion of the carbon steel and low-alloy steel materials and directly reduces the transport and deposition of their corrosion products into the steam generators. Steam generator tubing is fabricated from thermally treated Alloy 690, which has been shown by both testing and operating experience to be more resistant to intergranular corrosion than Alloy 600. Alloy 690 remains, however, susceptible to stress corrosion cracking in some environments, including those with lead and low-valence sulfur species at both low and high pH. Therefore, emphasis is placed on excluding lead and lead compounds from the secondary chemistry environment.

Condensate polishing is used in the recirculation cleanup system during plant startup and shutdown evolutions to remove both dissolved and particulate contaminants prior to admitting feedwater to the steam generators. During power operation, continuous blowdown and cleanup of steam generator water limits the concentration of ionic species in the steam generator to acceptable levels.

10.3.5.2 Chemistry Control Program

U.S. EPR steam generator water and feedwater quality requirements are based on current water chemistry technology and the EPRI PWR Secondary Water Chemistry Guidelines (Reference 9) and include both control and diagnostic parameters and associated action limits. Additional control and diagnostic parameters have been included as appropriate based on AREVA NP experience and information available in the literature.

The Secondary Water Chemistry Control Program is implemented by plant operating procedures, which control the recording and management of data and require appropriate corrective actions in response to abnormal chemistry conditions. Records of chemistry program data are maintained as part of the plant records management system.

10.3.5.2.1 Control and Diagnostic Parameters

EPRI Reference 9 water chemistry guidelines place chemical parameters into two categories:

- Control Parameters are those chemistry parameters that have a demonstrated relationship to steam generator or turbine degradation and must be maintained within specified values. Control parameters have action levels, hold values and monitoring requirements associated with them.
- Diagnostic Parameters are those chemistry parameters that may affect the corrosion performance of system materials but do not impose restrictions on plant operation. They are used to monitor program effectiveness, identify programmatic problems, assist in problem diagnosis and provide early detection of a parameter that may be trending toward an action level value.

Each Control Parameter has an associated action or actions to be taken within a specified time frame when its value is outside the defined operating range. These Action Level responses are intended to prevent steam generator or secondary system materials degradation caused by abnormal chemistry conditions.

10.3.5.2.2 U.S. EPR Water Chemistry Guidelines

The overall objective of the water treatment program is to minimize the risk of general and flow-accelerated corrosion of the steam-water cycle materials. An all-volatile treatment (AVT) amine, such as ammonium hydroxide or morpholine, or an organic amine such as ethanolamine (ETA), dimethylamine (DMA), or methoxypropylamine (MPA), is added to the feedwater to establish an optimum pH level ≥9.5 at 77°F. Hydrazine is also added to control the residual dissolved oxygen concentration and to maintain a passive protective film of magnetite on carbon steel surfaces. These treatment chemicals are injected into the condensate pump discharge header.

Descriptions of the U.S. EPR chemistry guidelines for the plant operating modes are provided in the following paragraphs.

Cold Shutdown/Wet Layup (Modes 5 and 6)

Wet layup is the preferred storage method after the steam generators have been placed in service. During normal plant cooldown, the steam generators are used for heat removal until the RCS is sufficiently cooled to place the RHRS in service. If not used for additional cooling to supplement the RHRS, the steam generators are filled as full as possible with water containing ≤100 ppb oxygen while maintaining a positive nitrogen overpressure. Chemistry parameters and monitoring requirements for blowdown and the steam generator fill source during this mode of operation are specified in Table 10.3-5—Cold Shutdown/Wet Layup–Steam Generator Sample.

Heatup/Hot Shutdown/Hot Standby (Modes 2, 3 and 4)

As power and reactor coolant temperature are increased from hot shutdown to hot standby conditions, the concentration of dissolved solids will increase in the steam generator bulk water, but “hideout” will be minimal due to the low heat flux at this time. The objective during this period and prior to steaming is to reduce impurity levels to near-operating chemistry conditions. This is accomplished by minimizing the inventory of corrosion products and contaminants in the feedwater system by recirculating the water from the effluent of the highest pressure feedwater heater to the condenser while providing purification by the condensate polishers. The recirculated feedwater is heated to promote the conversion of hematite to magnetite and to promote the oxygen-hydrazine reaction. Prior to feeding the steam generators, the water quality of the feed source is confirmed via chemistry samples.

Feedwater chemistry parameters and monitoring requirements during heatup/hot shutdown/hot standby and startup, along with specific diagnostic parameters, are given in Table 10.3-6—Heatup/Hot Shutdown/Hot Standby – Feedwater Sample (from SG Feed Source). Blowdown chemistry parameters and monitoring requirements are listed in Table 10.3-7—Heatup/Hot Shutdown/Hot Standby – Blowdown Sample.

Power Operation (Mode 1)

Control of feedwater pH and dissolved oxygen has a direct impact on the formation and transport of corrosion products from the condensate and feedwater systems into the steam generators. The presence of ionic species in the blowdown greater than the specified control values indicates the ingress of contaminants, either from condenser cooling water in-leakage, poor quality makeup water or improperly regenerated condensate polishers. Corrective action must be taken by the plant to identify and remedy the source of contaminants.

Feedwater chemistry parameters and monitoring requirements during power operation are specified in Table 10.3-8—Power Operation (>25% Reactor Power) – Feedwater Sample.

Blowdown chemistry control parameters and monitoring requirements during power operation are listed in Table 10.3-9—Power Operation (>25% Reactor Power) – Blowdown Sample. In general, these chemistry parameters are achieved by maintaining feedwater chemistry within the specified limits (see Table 10.3-8) and by maintaining a sufficiently high blowdown flow rate. A continuous blowdown rate of up to one percent of the steam flow is used to minimize the concentration of dissolved contaminants in the steam generators.

Dissolved oxygen in the condensate is maintained at less than 10 ppb during power operation. See Table 10.3-10—Power Operation (>5% Reactor Power) – Condensate Sample. Air ingress into the condenser is monitored during plant operations and corrective action is taken by the operators to locate and remedy the source of excessive air ingress, which increases dissolved oxygen above the control parameters.

10.3.5.2.3 Chemistry Sampling

The secondary sampling system provides chemistry sampling and analysis, both continuous and grab samples, from selected locations in the secondary system to monitor water quality. Analyses of the chemistry samples are used to control the secondary side water chemistry and to permit corrective actions to be taken in the event of contaminant ingress or other chemistry excursion.

Design of the U.S. EPR secondary sampling system considers sampling flow velocities, sample tubing length, and routing of the sample tubing to prevent impurities from settling out in the tubing and to obtain representative samples for analysis. Continuous sampling flows have bypass flow provisions to maintain flow velocities to prevent settling of suspended solids in the sample lines. A description of the secondary sampling system and specific sampling locations are found in Section 9.3.2. Sample frequencies are specified in Tables 10.3-5 through 10.3-10.

10.3.5.3 Contaminant Ingress

There are five sources that may introduce contaminants into the secondary system during operation. These are condenser cooling water in-leakage, poor quality makeup water, improperly regenerated condensate polishers, atmospheric leaks at the condenser or pump seals, and contaminated water treatment chemicals. The latter source of contaminants is controlled by the COL applicant's chemical use and control program which is responsible for certification of all on-site chemicals.

The remaining sources of contaminants, described below, are detected by continuous monitoring or sample analysis, and appropriate action is taken following detection to locate and to correct the problem.

- Contaminants that enter the system through condenser tube leaks are detected by continuous process monitoring of the condensate pump discharge, condenser hotwells, feedwater pump discharge, reheater drains and steam generator blowdown.
- The condensate polisher discharge is continuously monitored for cation conductivity, dissolved oxygen and sodium when in use.
- Demineralized water is continuously monitored as it is being produced and the demineralized water storage is routinely sampled to verify makeup water quality.
- Air inleakage is detected by monitoring the condensate pump discharge for excessive dissolved oxygen and by monitoring the condenser air removal rate.

10.3.5.4 Condensate Polishing

Condensate polishers are used in the recirculation cleanup system during plant startup and shutdown to remove both dissolved and particulate contaminants prior to admitting feedwater to the steam generators. This practice achieves the required water purity in a shorter time and prevents these contaminants from entering the steam generators.

Condensate polishers are used during power operation in the event of an upset in chemistry conditions, for example, during periods of condenser cooling water leakage or when inadequate performance of the makeup water system would introduce impurities to the steam generators. Additional information on the condensate polishing system may be found in Section 10.4.6.

10.3.5.5 Primary to Secondary Leakage

Leakage of primary water into the steam generator via through-wall tube defects provides a source of radioactive iodine to the secondary system. The volatility of radioactive iodine is increased by acidic and oxidizing solutions. As described in Section 10.3.5.2, the U.S. EPR secondary side AVT chemistry is both basic and reducing. These conditions suppress the volatility of radioactive iodine species and any release via the air ejector will be minimized.

10.3.5.6 Chemical Addition System

Equipment is provided to inject controlled quantities of treatment chemicals as part of the secondary water chemistry program. These treatment chemicals are injected into the condensate pump discharge header.

10.3.6 Steam and Feedwater System Materials

10.3.6.1 Material Selection and Fabrication

Table 10.3-11—Main Steam Supply System and Main Feedwater System Material Data provides material data for the MSSS and main feedwater system. The MSSS and main feedwater system do not use copper or copper alloy materials.

As required by GDC 1, material selection and fabrication requirements for Class 2 and 3 components per Reference 1 in safety-related portions of the MSSS and feedwater system are consistent with the quality group and seismic design classifications provided in Table 3.2.2-1. RG 1.84 describes acceptable code cases that may be used in conjunction with the above specifications.

Cleaning and handling of Class 2 and Class 3 components of the MSSS and feedwater system is in accordance with the acceptable procedures described in RG 1.37.

The guidance in RG 1.71 for additional welder qualification is applied for welds on ASME Class 2 and 3 components of the MSSS and feedwater system in locations of restricted direct physical and visual accessibility.

The MSSS and feedwater system piping material is not low-alloy steel; therefore, control preheat temperatures for welding low-alloy steel as described in RG 1.50 is not applicable to these systems.

Preheat temperatures for carbon steel piping in the ASME Code Section III, Division 1, Class 2 and 3 portions of the MSSS and main feedwater system will follow the guidance provided in ASME Section III, Appendix D, Article D-1000. Preheat temperatures for carbon steel piping in the non-ASME Section III portions of the MSSS and main feedwater system are in accordance with ASME B31.1.

Non-destructive examination (NDE) for tubular products in the ASME Code, Class 2 and 3 portions of MSSS and main feedwater system is in accordance with ASME Section III, Division 1, Sections NC-5000 and ND-5000.

Examination of tubular products in the ASME Code Class 2 and 3 portions of the main steam supply and main feedwater systems are in accordance with ASME Section III, Division 1, sub-articles NC-2550/ND-2550 through NC-2560/NC-2560.

Preservice and inservice inspection of Class 2 and 3 components per Reference 1 in the MSSS and feedwater system are addressed in Section 6.6. The following requirements apply to the non-safety-related portions of the MSSS and feedwater system:

- Components are carbon steel.
- Piping is ASME B36.10 (Reference 10).

- Fittings are ASME B16.9 and B16.11 (Reference 11).
- Flanges are ASME B16.5 (Reference 11).

10.3.6.2 Fracture Toughness

The material specifications for pressure retaining materials in safety-related portions of the MSSS and feedwater system meet the fracture toughness requirements specified in the following for Quality Group B and Quality Group C components, respectively:

- ASME BPV Code, Section III, Class 2, Article NC-2300, (Reference 12).
- ASME BPV Code, Section III, Class 3, Article ND-2300, (Reference 13).

10.3.6.3 Flow-Accelerated Corrosion

The design of the piping systems in the MSSS and main feedwater system, including applicable material standards and inspection programs, incorporates considerations to prevent the occurrence of erosion and corrosion in these systems. Industry guidance and requirements for inspection and monitoring programs is found in Generic Letter 89-08 (Reference 14) and NSAC-202L-R3 (Reference 15).

The design includes material selection, limits on flow velocity and limits on water chemistry to reduce flow accelerated corrosion (FAC), and erosion and corrosion of piping and piping components. The design meets the guidance contained in GL 89-08 (Reference 14) and NSAC-202L (Reference 15) concerning acceptable inspection programs.

MSSS and main feedwater system piping, valves and fittings are FAC resistant, unless the application is specifically evaluated and found to be non-susceptible to FAC degradation. Piping material resistant to FAC is constructed of carbon steel containing a minimum of 0.10 percent chromium. Chrome-molybdenum or stainless steel piping may be used in other systems that are non-safety related, such as feedwater heater drains or cold reheat to prevent erosion and corrosion.

A design phase evaluation will be performed to identify portions of the main steam and main feedwater systems that are potentially susceptible to service-induced degradation mechanisms. The design phase evaluation provides reasonable assurance that piping material selections are appropriate for the operating conditions and that the systems are resistant to FAC, erosion, corrosion, and cavitation.

During the design phase, an evaluation of FAC will be performed for the main steam supply system, main feedwater system, condensate system, steam generator blowdown system, and the non-safety-related power conversion systems. In addition to main pipe lines, the evaluation will include drains, vents, and bypass piping in the aforementioned systems.

The minimum design wall thicknesses will be determined in the design phase by the process previously described in order to allow for a minimum lifetime of the affected piping systems of at least 40 years.

The COL applicant that references the U.S. EPR design certification will develop and implement a FAC condition monitoring program that is consistent with Generic Letter 89-08 and NSAC-202L-R3 for the carbon steel portions of the steam and power conversion systems that contain water or wet steam prior to initial fuel loading.

10.3.7 References

1. ASME Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components," The American Society of Mechanical Engineers, 2004.

2. ANSI/ASME B31.1-2004, "Power Piping," The American Society of Mechanical Engineers, 2004.

3. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NC including Article NC-7000:"Overpressure Protection," The American Society of Mechanical Engineers, 2004.

4. NUREG-0800, BTP 5-4, "Design Requirements of the Residual Heat Removal System," Nuclear Regulatory Commission, Rev. 3, March 2007.

5. NUREG-0138, Issue 1, "Staff Discussion of Fifteen Technical Issues," Nuclear Regulatory Commission, November 1976.

6. ASME Boiler and Pressure Vessel Code, Section XI: "Rules for Inservice Inspection of Nuclear Power Plant Components," The American Society of Mechanical Engineers, 2004.

7. NEI 97-06, "Steam Generator Program Guidelines," Nuclear Energy Institute, 1997.

8. NEI 03-08,"Guideline for the Management of Materials Issues," Nuclear Energy Institute, 2003.

9. EPRI Report 1008224, "Pressurized Water Reactor Secondary Water Chemistry Guidelines," Revision 6, Electric Power Research Institute, December 2004.

10. ASME/ANSI B36.10M-2000, "Welded and Seamless Wrought Steel Pipe," The American Society of Mechanical Engineers/American National Standards Institute.

11. ASME/ANSI B16.5a-1998, "Pipe Flanges and Flanged Fittings", B16.9-2001, "Factory-Made Wrought Buttwelding Fittings" and B16.11-2001, "Forged Steel Fittings, Socket Welding and Threaded," The American Society of Mechanical Engineers/American National Standards Institute.

12. ASME Boiler and Pressure Vessel Code, Section III, Class 2, Article NC-2300: "Fracture Toughness Requirements for Material," The American Society of Mechanical Engineers, 2004.

13. ASME Boiler and Pressure Vessel Code, Section III, Class 3, Article ND-2300: "Fracture Toughness Requirements for Material," The American Society of Mechanical Engineers, 2004.

14. NRC Generic Letter 89-08, "Erosion/Corrosion-Induced Pipe Wall Thinning," Nuclear Regulatory Commission, May 2, 1989.

15. NSAC-202L-R3, "Recommendations for an Effective Flow-Accelerated Corrosion Program," Electric Power Research Institute, 2006.

16. ASME Boiler Pressure Vessel Code, Section VIII, Division 1: "Rules for Construction of Pressures Vessels", The American Society of Mechanical Engineers, 2004.

Table 10.3-1—Main Steam Supply System Design Data

Steam Flow	Rated Conditions
Per steam generator	5.17×10^6 lb/hr
Total	20.68×10^6 lb/hr
Design Conditions	
Design pressure	1435 psig
Design temperature	592°F
Operating Conditions	
Full plant load pressure	1110.9 psia
Full plant load temperature	557.58°F (99.75% quality)
Main Steam Piping: See Table 10.3-11	
Main Steam Relief Isolation Valve (MSRIV)	
Number per main steam line	1
Normal set pressure	1370 psig
Rated capacity	2,844,146 lb/hr
Code	ASME Code, Section III, Class 2, Seismic Category I
Actuator	Solenoid/Pilot, System Medium Powered, Open/Closed

Table 10.3-2—Design Data for Main Steam Safety Valves

Number per main steam line	2
Set pressure, first MSSV	1460 psig
Set pressure, second MSSV	1490 psig
Rated relieving capacity per valve	1,422,073 lb/hr
Relieving capacity per steam line	2,844,146 lb/hr
Valve size	8 x 10 minimum
Design code	ASME Code, Section III, Class 2, seismic Category I

Table 10.3-3—Main Steam Branch Piping (2.5 Inches and Larger), Downstream of MSIV

Description	Maximum Steam Flow	Shutoff Valve	Valve Closure Time	Actuator	Comments
Turbine bypass lines to condenser; six lines total	2.2×10^6 lb/hr each valve	18 in globe (turbine bypass valve)	5 seconds or less when tripped closed	Automatic operator, fail close	Valves are normally closed during power operation.
Reheating steam 2nd stage to MSRs, One or more lines.	1.2×10^6 lb/hr total	See Comment.	See Comment.	See Comment.	Flow ceases following HP turbine stop valve closure on a turbine trip due to lack of heat transfer in the MSRs. The 2nd stage reheaters, their drain tanks and piping are designed to main steam design pressure and temperature.
Backup main steam supply to auxiliary steam system - one line.	See Comment	4-in (isolation valve)	20 seconds or less	Automatic operator	This line is not normally open during power operation. It is open during startup. The capacity of the 4-inch line is small relative to the MSS capacity.
High pressure turbine steam supply lines; 4 lines total	5×10^6 lb/hr each line	27.5 in. ID inlet to stop valve in each line	0.3 seconds or less	Hydraulically operated from electro-hydraulic turbine control system	Main steam flow to high pressure turbine ceases following stop valve closure on a turbine trip. Each HP stop valve has a downstream control valve that also automatically closes.
Deaerator Pegging Steam -Two lines	See comment.	12-in. (isolation valve)	60 seconds or less	Automatic operator	This line is not normally open during power operation. It is open during startup.

Table 10.3-4—Main Steam Supply System Single Active Failure Analysis
Sheet 1 of 3

	Component	Failure	Comments
1	Main steam isolation valves (MSIV)	Loss of power from one power supply	Loss of one power supply has no effect on ability of valve to close. Valve fails closed on loss of electrical signals or loss of hydraulic pressure. Valve actuator has 2 redundant closure systems. Valve closure is controlled by 4 cross-division power supplies provided to the actuator closing systems.
		Valve fails to close upon receipt of automatic signal	Closure of three of four MSIVs adequate to meet safety requirements.
2	Main steam relief isolation valves (MSRIV)	Loss of power from one power supply	Loss of one power supply has no effect on ability of valve to open or close. Valve fails closed upon loss of electrical signals. Valve actuator system has 2 redundant opening / closing systems. Valve closure is controlled by 4 cross-division power supplies provided to the actuator opening/closing systems.
		Valve fails to close upon receipt of automatic signal	Each valve has 2 redundant opening/closing systems. A single failure in the opening/ closing system will not cause failure of valve to close. Backup isolation valve MSRCV provided in each main steam relief train.
		Valve fails to open upon receipt of automatic signal	Each valve has 2 redundant opening/closing systems. A single failure in the opening/ closing system will not cause failure of valve to open. If MSRT is not available, 2 MSSVs on each main steam line provide adequate overpressure protection and provide adequate residual heat removal.

Table 10.3-4—Main Steam Supply System Single Active Failure Analysis
Sheet 2 of 3

	Component	Failure	Comments
3	Main steam relief control valves (MSRCV)	Loss of power from one power supply	Valve is fully open during power operation for thermal power greater than 50% and remains fully open upon loss of power supply. Valve is 40% open from 0% to 20% thermal power. Valve is between 40% to 100% open from 20% to 50% thermal power. Valve fails as-is upon loss of power. Redundant power supply provided.
		Valve fails to close upon receipt of automatic signal	Second isolation valve MSRIV provided in each main steam relief train.
4	Main steam warming isolation valves (MSRWIV)	Loss of power from one power supply	Valve remains closed. Valve is closed during power operation. Valve fails as-is upon loss of power. Redundant power supply provided.
		Valve fails to close upon receipt of automatic signal	See above. Second isolation valve MSRWCV provided in each main steam warming line.
5	Main steam warming isolation valves (MSRCV)	Loss of power from one power supply	Valve remains closed. Valve is closed during power operation. Valve fails as-is upon loss of power. Redundant power supply provided.
		Valve fails to close upon receipt of automatic signal	See above. Second isolation valve MSRWIV provided in each main steam warming line.
6	Main steam line pressure sensors	No signal generated for protection logic	Refer to Chapter 7, Section 7.3.

Table 10.3-4—Main Steam Supply System Single Active Failure Analysis
Sheet 3 of 3

	Component	Failure	Comments
7	Main steam line activity sensors	No signal generated for protection logic	Refer to Chapter 7, Section 7.3.

Table 10.3-5—Cold Shutdown/Wet Layup–Steam Generator Sample

Control Parameters		
Parameter	**Sample Frequency**	**Normal Limit or Control Value**
pH @ 77°F	3X/wk until stable, then weekly	≥9.5 pH
Hydrazine[1]	3X/wk until stable, then weekly	≥75 ppm
Sodium	3X/wk until stable, then weekly	≤1000 ppb(2)
Chloride	3X/wk until stable, then weekly	≤1000 ppb(2)
Sulfate	3X/wk until stable, then weekly	≤1000 ppb(2)
Diagnostic Parameters		
Parameter	**Consideration**	
Sludge Analysis	When sludge is available as a result of sludge lancing or other maintenance activities.	
Control Parameters for Steam Generator Fill Source		
Parameter	**Frequency**	**Initiate Action**
Dissolved O_2	Prior to and/or During Fill	>100 ppb[3]

Notes:

1. Alternatives to hydrazine may be used if qualified. Appropriate limits for any hydrazine alternative will be substituted.
2. These values are to be reduced to ≤100 ppb prior to heatup above 200°F.
3. Contingent on having control of O_2 in fill source. If control is not achievable, then measures are initiated to minimize oxygen, such as sparging with N_2 or by adding N_2H_4.

Table 10.3-6—Heatup/Hot Shutdown/Hot Standby – Feedwater Sample (from SG Feed Source)

Control Parameters			
Parameter	**Sample Frequency**	**Value Prior to Feeding Steam Generators**	**Value Prior to Power Escalation >5%**
pH @ 77°F	daily/continuous	≥9.5 pH	≥9.5 pH
Dissolved O_2	daily/continuous (>5% Power)	≤100 ppb	≤10 ppb
Hydrazine[1]	daily	≥8x[O2] and ≥20 ppb	≥ 8x[O2] and ≥20 ppb
Cation Conductivity	continuous	≤0.2 mS/cm	≤0.2 mS/cm
Iron	daily	≤5 ppb	≤5 ppb
Lead[2]	prior to >5% power	≤0.050 ppb	≤0.050 ppb

Diagnostic Parameters		
Parameter	**Sample Frequency**	**Normal Value**
Suspended Solids		
• Startup	daily	≤100 ppb
• Hot Standby/Reactor Critical <5% Power	daily	≤10 ppb
Silica	daily	--[3]

Notes:

1. Alternatives to hydrazine may be used if qualified. Appropriate limits for any hydrazine alternative will be substituted.

2. Lead is highly undesirable for the secondary side. It is recommended that transport of lead be limited to less than two pounds per year, which relates to a level of 0.050 ppb in the feedwater.

3. Silica can be released from anion resin by pH changes and by impurities present during startup. Monitoring feedwater silica provides an indication of polisher performance. A value is not given since silica transport to the steam generators will be low because of the low flow rates and limited time spent during these modes.

Table 10.3-7—Heatup/Hot Shutdown/Hot Standby – Blowdown Sample

Control Parameters			
Parameter	**Sample Frequency**	**Value Prior to Power Escalation >5%**	**Value Prior to Power Escalation >25%**
Sodium	continuous(1)	≤100 ppb	≤10 ppb
Chloride	daily	≤100 ppb	≤20 ppb
Sulfate	daily	≤100 ppb	≤20 ppb
If Sodium, Chloride, or Sulfate: Exceeds 250 ppb or Exceeds 50 ppb for an interval of 100 hours while the plant is >5% Reactor Power, then the plant must return to <5% Reactor Power as quickly as safe plant operation permits.			

Diagnostic Parameters		
Parameter	**Sample Frequency**	**Normal Value**
Cation Conductivity @ 77°F	continuous	≤2.0 μS/cm
Silica	daily	≤300 ppb
pH @ 77°F	continuous	≥9.0 pH
Hydrazine(2)	daily	Detectable

Notes:

1. If continuous monitoring instrumentation is out of service, grab sampling may be used until continuous monitoring is reestablished.

2. Alternatives to hydrazine may be used if qualified. Appropriate limits for any hydrazine alternative will be substituted.

Table 10.3-8—Power Operation (>25% Reactor Power) – Feedwater Sample

Control Parameters		
Parameter	**Sample Frequency**	**Normal Limit or Control Value**
pH @77°F	continuous	≥9.5 pH
Hydrazine(1)	continuous	< 8 x CPD (O_2)(2) or <20 ppb, whichever is greater
Total Iron(3)	weekly	≤5 ppb
Total Copper(3),(4)	weekly	≤1 ppb
Total Lead(5)	weekly	<0.05 ppb
Oxygen	continuous(6)	≤5 ppb

Diagnostic Parameters	
Parameter	**Consideration**
Cation Conductivity @77°F	Semi-quantitative indicator of organic acid concentrations (product of amine decomposition). Normal value is ≤0.2 μS/cm
Metal Oxide Species (ECP)	Assessment of corrosion product impact on SG tubing.
Integrated Corrosion Product Transport	Periodic assessment of corrosion product mass transport to the SG using integrated samples.

Notes:

1. Alternatives to hydrazine may be used if qualified. In this case, appropriate limits for the alternate chemical will be used.

2. As measured at the outlet of the deaerator tank.

3. These limits apply to steady-state operation after a stabilization period. Integrated sampling shall be initiated at approximately 25% power. The action level response time when the analyzed data becomes available; e.g., shall be within one to two weeks of sample collection.

4. If feedwater copper concentrations are routinely less than 20 parts per trillion (ppt), the sampling frequency may be reduced to a plant specific routine (i.e., copper analysis on a quarterly basis).

5. Lead is highly undesirable for the secondary side. It is recommended that transport of lead be limited to less than two pounds per year, which relates to <0.05 ppb in the feedwater.

6. If the monitor is out of service, dissolved oxygen shall be analyzed once per shift.

Table 10.3-9—Power Operation (>25% Reactor Power) – Blowdown Sample

Control Parameters		
Parameter	**Sample Frequency**	**Normal Limit or Control Value**
Cation Conductivity @77°F	continuous	--[1]
Sodium	continuous	≤5 ppb
Chloride	daily	≤10 ppb
Sulfate	daily	≤10 ppb
Lead	weekly	≤1 ppb
Diagnostic Parameters		
Parameter	**Consideration**	
Silica	daily	To minimize transport to the steam cycle. If the value is >300 ppb, the source shall be identified and action taken to reduce the concentration of silica.
pH @ 77°F	Continuous indicator of pH additive concentrations.	
Specific Conductivity and pH agent	Reasonable consistencies between values of pH, ammonia, conductivity, etc. are to be achieved.	
Hideout Return Evaluation	Perform for each shutdown.	

Notes:

1. The baseline cation conductivity for blowdown will depend on the amine selected for feedwater pH control.

Table 10.3-10—Power Operation (>5% Reactor Power) – Condensate Sample

Control Parameters		
Parameter	**Sample Frequency**	**Normal Limit or Control Value**
Dissolved O_2[1]	continuous	≤10 ppb

Notes:

1. Measured at the deaerator outlet.

Table 10.3-11—Main Steam Supply System and Main Feedwater System Material Data

Segment	Material Specification		
Main Steam Line	**Pipe (2)**	**Fittings (2) (5)**	**Valves (3)**
Steam generator outlet to fixed restraint downstream of MSIV	ASME SA-106 Grade C	ASME SA-234 Grade WPC	ASME SA-216 Grade WCC or SA-105
Fixed restraint to high pressure turbine (1) (3)	ASTM A-106 Grade B	ASTM A-234 Grade WPB	ASTM A-216 Grade WCB or A-105
Main Feedwater Line			
Feedwater pump outlet to fixed restraint (1)	ASTM A-106 Grade B	ASTM A-234 Grade WPB	ASTM A-216 Grade WCB or A-105
Fixed restraint to steam generator	ASME SA-106 Grade B	ASME SA-234 Grade WPB	ASME SA-216 Grade WCB or SA-105

Notes:

1. Outside of the ASME Section III boundary.

2. The minimum chromium content of carbon steel piping, fittings, valves, and weld filler metals in the main steam supply system and main feedwater system shall be 0.10% for resistance to flow accelerated corrosion, unless exempted by the system design engineer. Portions of the main steam supply system and the main feedwater system that are not susceptible to flow accelerated corrosion degradation may be exempted.

3. Does not include the turbine stop and control valves or the turbine bypass valves.

4. The weld filler metal classifications used in the ASME Code Class 2 and 3 portions of the main steam supply system and main feedwater system are given in detailed specifications provided to the Certificate of Authorization Holder performing the welding on behalf of the owner. The Certificate of Authorization Holder is responsible for meeting the requirements of the detailed specifications, and the ASME code for weld filler metals. This includes requirements for strength, toughness, and other mechanical properties, service compatibility with the materials being joined, and other design criteria. The Certificate of Authorization Holder is an organization holding an ASME N certificate, NA certificate, or an NPT certificate to design and/or construct nuclear class 1, 2 or 3 components, install said components, or produce sub-assembly components.

   For carbon steel piping in the ASME Code Class 2 and 3 portions of the main steam supply and main feedwater systems, which is evaluated and found not susceptible to flow accelerated corrosion (FAC), the applicable welding material specifications include: ASME Section II, Part C, SFA-5.17, SFA-5.18 and SFA-5.20. If the welding processes used during fabrication or construction are required to vary from the aforementioned, then the welding materials will be consistent to that of the connecting piping and similar to the aforementioned welding materials.

For carbon steel piping in the ASME Code Class 2 and 3 portions of the main steam supply and main feedwater systems, which is evaluated and determined to require resistance to FAC, the applicable welding material specifications include: ASME Section II, Part C, SFA-5.18 and SFA-5.20 with a minimum chromium content of 0.10 percent. If the welding processes used during fabrication or construction are required to vary from the aforementioned, then the welding materials will be consistent to that of the connecting piping and similar to the aforementioned welding materials with a minimum chromium content of 0.10 percent.

5. Fittings include the pipe fittings furnished in accordance with ASME B16.9, such as tees, reducers, and laterals.

Next File