3.3 Piping Design

Design Description

Piping associated with fluid systems is categorized as either nuclear safety-related (i.e., Seismic Category I) or non-nuclear safety (NNS) related (i.e., non-Seismic Category I). The piping shall be designed for a design life of 60 years. Piping systems that must remain functional during and following a safe shutdown earthquake (SSE) are designated as Seismic Category I and are further classified as American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (ASME Code) Class 1, 2 or 3. The piping design requirements identified in this section encompass piping systems classified as nuclear safety-related and unless otherwise specified in this description, piping systems means nuclear safety-related piping systems. Piping systems and their components are designed and constructed in accordance with the ASME Code requirements identified in the individual system Design Descriptions.

Piping systems shall be designed to meet their ASME Code class and Seismic Category I requirements. The ASME Code Class 1, 2 and 3 piping systems shall be designed to retain their pressure integrity and functional capability under internal design and operating pressures and design basis loads. Piping stresses due to static and dynamic loads shall be combined and calculated in accordance with the ASME Code and shall be shown to be less than the ASME Code allowables for each service level.

For ASME Code Class 1 piping systems, a fatigue analysis shall be performed in accordance with the ASME Code Class 1 piping requirements. Environmental effects shall be included in the fatigue analysis. The Class 1 piping fatigue analysis shall show that the ASME Code Class 1 piping fatigue requirements have been met.

For ASME Code Class 2 and 3 piping systems, piping stress ranges due to thermal expansion shall be calculated in accordance with the ASME Code Class 2 and 3 piping requirements. The piping stress analysis shall show that the ASME Code Class 2 and 3 piping thermal expansion stress range requirements have been met. For the ASME Code Class 2 and 3 piping systems and their components which will be subjected to severe thermal transients, the effects of these transients shall be included in the design.

Feedwater lines shall be designed for thermal stratification loads.

Piping systems shall be designed to minimize the effects of erosion/corrosion.

For those piping systems using ferritic materials as permitted by the design specification, the ferritic materials and fabrication processes shall be selected to ensure that the piping system is not susceptible to brittle fracture under the expected service conditions.

For those piping systems using austenitic stainless steel materials as permitted by the design specification, the stainless steel piping material and fabrication process shall be selected to

reduce the possibility of cracking during service. Chemical, fabrication, handling, welding, and examination requirements that reduce cracking shall be met.

Piping system supports shall be designed to meet the requirements of ASME Code Subsection NF.

For piping systems, the pipe applied loads on attached equipment shall be calculated and shown to be less than the equipment allowable loads.

Analytical methods and load combinations used for analysis of piping systems shall be referenced or specified in the ASME Code Certified Stress Report. Piping systems and their supports shall be mathematically modeled to provide results for piping system frequencies up to the analysis cutoff frequency. Computer programs used for piping system dynamic analysis shall be benchmarked.

Systems, structures and components that shall be required to be functional during and following an SSE shall be protected against the dynamic effects associated with postulated high energy pipe breaks in Seismic Category I and NNS piping systems. In addition, structures, systems, and components that shall be required to be functional during and following an SSE shall be protected against or qualified to withstand the environmental effects of spraying, flooding, pressure and temperature due to postulated pipe breaks and cracks in Seismic Category I and NNS piping systems. Each postulated piping failure shall be documented in a Pipe Break Analysis Report which concludes the reactor can be shut down safely and maintained in a safe, cold shutdown condition without offsite power. The Pipe Break Analyses Report shall specify the criteria used to postulate breaks and the analytical methods used to perform the pipe break analysis. For postulated pipe breaks, the Pipe Break Analysis Report shall confirm: (1) piping stresses in the containment penetration area shall be within their allowable stress limits, (2) pipe whip restraints and jet shield designs shall be capable of mitigating pipe break loads, (3) loads on safety-related systems, structures and components shall be within their design loads limits, and (4) safety-related piping required to be functional during and following an SSE are protected against or qualified to withstand the environmental conditions that would exist without loss of it’s safety function for the time needed to be functional. Piping systems that are qualified for leak-before-break design may exclude design features to mitigate the dynamic effects from postulated high energy pipe breaks.

Piping systems shall be designed to provide clearance from structures, systems, and components where necessary for the accomplishment of the structure, system, or component's safety function as specified in the respective structure or system Design Description.

The as-built piping shall be reconciled with the piping design required by this section.

Inspections, Tests, Analyses and Acceptance Criteria

Table 3.3 provides a definition of the inspections, tests, analyses, and associated acceptance criteria, which will be performed for Advanced Boiling Water Reactor (ABWR) nuclear safety-related and NNS related piping systems, as specified in this design description. Piping classification information is provided in the individual Certified Design Material (CDM) entry for each of the piping systems. Furthermore, Table 3.3 may be completed on an individual system basis.

Table 3.3 Piping Design

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
1. The piping system shall be designed to meet its ASME Code Class and Seismic Category I requirements. The ASME Code Class 1, 2, and 3 piping system shall be designed to retain its pressure integrity and functional capability under internal design and operating pressures and design basis loads. Piping and piping components shall be designed to show compliance with the requirements of ASME Code Section III.	1. Inspections of ASME Code required documents will be conducted.	1. An ASME Code Certified Stress Report exists for the piping system and concludes that the design complies with the requirements of ASME Code, Section III.
2. Systems, structures, and components, that are required to be functional during and following an SSE, shall be protected against or qualified to withstand the dynamic and environmental effects associated with postulated failures in Seismic Category I and NNS piping systems. Each postulated piping failure shall be documented in a Pipe Break Analysis Report. Piping systems that are qualified for leak-before-break design may exclude design features to mitigate the dynamic effects from postulated high energy pipe breaks.	2. Inspections of the Pipe Break Analysis Report, or Leak-Before-Break Report (if applicable), will be conducted. An inspection of the as-built high and moderate energy pipe break mitigation features (including spatial separation) will be performed.	2. A Pipe Break Analysis Report and Leak-Before-Break Report (if applicable) exist for the as-built plant and concludes that for each postulated piping failure, the reactor can be shut down safely and maintained in a safe, cold shutdown condition without offsite power. The Pipe Break Analysis Report includes the results of inspections of high and moderate energy pipe break mitigation features including spatial separation.

Table 3.3 Piping Design (Continued)

Inspections, Tests, Analyses and Acceptance Criteria		
Design Commitment	**Inspections, Tests, Analyses**	**Acceptance Criteria**
3. The as-built piping shall be reconciled with the piping design required in Section 3.3.	3. A reconciliation analysis using the as-designed and as-built information will be performed.	3. An as-built stress report exists and concludes that the as-built piping has been reconciled with the design documents used for design analysis. For ASME Code Class piping, the as-built stress report includes the ASME Code Certified Stress Report and documentation of the results of the as-built reconciliation analysis.