3.9.3 ASME Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures

This section describes the structural integrity of pressure-retaining components, component supports, and core support structures. These components and supports are designed in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Division 1 (Reference 1) and GDC 1, 2, 4, 14, and 15. Compliance with the GDC is described below:

- GDC 1 requires that structures, systems, and components (SSC) be designed to quality standards commensurate with the importance of the safety function that they perform. RG 1.26 and 10 CFR 50.55a define the use of ASME Code Classes 1, 2, and 3 based on quality groups for plant pressure retaining components. Quality Groups A, B, and C are safety-related groups that are designed to meet the requirements of ASME Code Classes 1, 2, and 3, respectively. This section describes the application of the ASME Code, Section III, Division 1 and ASME Code, Subsection NF to the design of Class 1, 2, and 3 pressure-retaining components, their support structures, and core support structures. As noted in Section 3.1, this design is in accordance with the applicable codes required in 10 CFR 50.55a. Further information on quality group classifications is provided in Section 3.2.

- GDC 2 requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena (e.g., earthquakes) combined with the effects of normal or accident conditions. The loading combinations described in this section include consideration of the effects of expected natural phenomena combined with the appropriate effects of normal and accident conditions. SSC are designed so that the stresses are within ASME Code-mandated limits in order to withstand these conditions without loss of their intended functions.

- GDC 4 requires that SSC important to safety be designed to accommodate the effects of, and be compatible with, the environmental conditions of normal and accident conditions. The loading combinations described in this section include consideration of the loading effects and the resulting stresses associated with normal operation, maintenance, testing, and postulated accidents, including a loss-of-coolant accident (LOCA).

- GDC 14 requires that the reactor coolant pressure boundary (RCPB) be designed, fabricated, erected, and tested to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. GDC 15 requires that the reactor coolant system (RCS) and associated auxiliary, control, and protection systems be designed with sufficient margin to assure that the design conditions of the RCPB are not exceeded during conditions of normal operation, including anticipated operational occurrences. Compliance with these GDCs is achieved through compliance with the ASME Code requirements for determining stresses and stress limits that are based on the loads and load combinations described in this section. Compliance with these requirements demonstrates that RCPB components are designed to have an extremely low probability of abnormal leakage, rapidly propagating failure, and gross rupture.

This section refers to U.S. EPR Piping Analysis and Pipe Support Design Topical Report (References 2 and 7) for information related to the design and analysis of safety-related piping. This topical report presents the U.S. EPR code requirements, acceptance criteria, analysis methods, and modeling techniques for ASME Class 1, 2, and 3 piping and pipe supports. Applicable COL action items in the topical report are identified in the applicable portions of this section. The U.S. EPR design is based on the 2004 ASME Code, Section III, Division 1, with no addenda subject to the limitations and modification identified in 10 CFR 50.55a(b)(1) and the piping analysis criteria and methods, modeling techniques, and pipe support criteria described in References 2 and 7.

A design specification is required by Section III of the ASME Code for Class 1, 2, and 3 components, piping, supports, and core support structures. In addition, the ASME Code requires design reports for all Class 1, 2, and 3 components, piping, supports and core support structures documenting that the as-designed and as-built configurations adhere to the requirements of the design specification. A COL applicant that references the U.S. EPR design certification will prepare the design specifications and design reports for ASME Class 1, 2, and 3 components, piping, supports and core support structures that comply with and are certified to the requirements of Section III of the ASME Code. The COL applicant will address the results and conclusions from the reactor internals material reliability programs applicable to the U.S. EPR reactor internals with regard to known aging degradation mechanisms such as irradiation-assisted stress corrosion cracking and void swelling addressed in Section 4.5.2.1.

Other sections that relate to this section are described below:

- Section 3.9.6 describes the snubber inspection and test program.
- Section 3.10 describes the methods and criteria for seismic qualification testing of Seismic Category I mechanical equipment and a description of their seismic operability criteria.
- Section 3.12 describes the design of systems and components that interface with the RCS with regard to intersystem LOCAs.
- Section 3.13 describes bolting and threaded fastener adequacy and integrity.
- Section 5.2.2 describes the pressure-relieving capacity of the valves specified for RCPB.
- Section 10.3 describes the pressure-relieving capacity of the valves specified for the steam and feedwater systems.

3.9.3.1 Loading Combinations, System Operating Transients, and Stress Limits

Section 3.9.3.1.1 describes the design and service level loadings used for the design of ASME Class 1, 2, and 3 components, piping, supports, and core support structures, including the appropriate system operating transients. Sections 3.9.3.1.2 through 3.9.3.1.8 define the loading combinations for the ASME Code Class 1, 2, and 3 components, piping, supports, and core support structures; these sections also define the stress limits applicable to the various load combinations. The loading combinations and corresponding stress limits for ASME Code design are defined for the Design Condition, Service Levels A, B, C and D (also known as normal, upset, emergency, and faulted conditions), and test conditions.

Internal parts of components, such as valve discs, seats, and pump shafts, comply with the applicable ASME Code or Code Case criteria. In those instances where no ASME Code criteria exist, these components are designed so that no safety-related functions are impaired.

Calculation methods used to evaluate RCS components and their supports for faulted loading are provided in Appendix 3C. Calculation methods used to evaluate piping and supports are described in Sections 4 and 6 of Reference 2.

A COL applicant that references the U.S. EPR design certification will provide a summary of the maximum total stress, deformation (where applicable), and cumulative usage factor values for each of the component operating conditions for ASME Code Class 1 components. For those values that differ from the allowable limits by less than 10 percent, the COL applicant will provide the contribution of each of the loading categories (e.g., seismic, pipe rupture, dead weight, pressure, and thermal) to the total stress for each maximum stress value identified in this range.

The COL applicant will also provide the maximum total stress and deformation values for each operating condition for Class 2 & 3 components required for safe shutdown of the reactor, or mitigation of consequences of a postulated piping failure without offsite power. Identification of those values that differ from the allowable limits by less than 10 percent will also be provided.

3.9.3.1.1 Loads for Components, Component Supports, and Core Support Structures

The following sections describe the loadings considered in the design of the components, piping, and support structures. Piping analysis methods are described in Appendix 3C and the Piping Analysis Topical Report (Reference 2). Section 3.9.1 lists the design transients and number of events used in fatigue analyses.

Pressure

Design pressure is described in Section 3.3 of Reference 2 and applies to ASME Code Class 1, 2, and 3 components and piping. The criteria for incorporating the effects of both internal and external pressures for components are described in the ASME Code, Section III, Articles NB-3000, NC-3000, and ND-3000.

Deadweight

Deadweight analyses consider the weight of the component, piping, or structure being analyzed and the additional weight of contained fluid, external insulation, and other appurtenances. For piping and components, the deadweight present during hydrostatic test loadings is also considered where such loadings exceed the normal operational deadweights. Static and dynamic heads of liquid are also included in the deadweight analyses of components. Deadweight loads are further described in Sections 3.3.1.2 and 6.3.1 of Reference 2.

Thermal Expansion

The effects of restrained thermal expansion and contraction on piping and supports are described in Section 3.3.1.3 and Section 6.3.2 of Reference 2.

Seismic

Analyses of seismic inertial loads and anchor movements on piping systems and the RCS are described in Sections 3, 4, and 6 of Reference 2 and Appendix 3C, respectively. In addition to the inertia and anchor movement stress effects due to a seismic event, the fatigue effects of such cyclic events are considered in the design of Class 1 components and piping. The number of safe shutdown earthquake (SSE) stress cycles included in the fatigue analysis is identified in FSAR Section 3.7.3 and in Section 3.4.1 of Reference 2.

System Operating Transients

Analyses of system operating transients, including fluid transient loadings, on piping systems and the RCS are discussed in Sections 3.3.1.5 and 6.3.4 of Reference 2 and Appendix 3C, respectively. Thermal and pressure transients are described in Section 3.3.1.8 of Reference 2. Section 3.3.1.5 of Reference 2 also describes water and steam hammer loads. The analysis of these transients results in force time histories for application in the piping analyses.

Wind and Tornado

Wind and tornado loads are discussed in Sections 3.3.1.6, 6.3.5, and 6.3.6 of Reference 2. As noted in ANP-10264NP-A, should a COL applicant that references the U.S. EPR design certification find it necessary to route Class 1, 2, and 3 piping not included in the U.S. EPR design certification so that it is exposed to wind and tornadoes, the design must withstand the plant design-basis loads for this event.

Pipe Break

Loads due to pipe breaks are described in Section 3.3.1.7 of Reference 2. Additionally, the leak-before-break methodology is used to eliminate the dynamic effects of pipe rupture for the main coolant loop, pressurizer surge line, and portions of the main steam line piping (see Section 3.6.3).

Pipe break load design condition and service level evaluations are described in Sections 6.3.7, 6.3.8, and 6.3.9 of Reference 2. Design basis pipe breaks are categorized as Level C. Main steam and main feedwater pipe breaks and LOCA are categorized as Level D.

Friction

Friction loads are described in Section 6.10 of Reference 2.

Minimum Pipe Support Design Loads

Minimum design loads are described in Section 6.3.11 of Reference 2. Normal condition allowable stresses are applicable to the stresses resulting from the described applied loads. Use of this criterion does not eliminate the requirement to analyze supports for applicable service conditions.

Thermal Stratification, Cycling, and Striping

Thermal stratification, cycling, and striping (including applicable NRC Bulletins 79-13, 88-08, and 88-11) are described in Section 3.7 of Reference 2. The pressurizer surge line is analyzed with the main coolant loop piping and supports as described in Appendix 3C. As noted in ANP-10264NP-A, a COL applicant that references the U.S. EPR design certification will confirm that thermal deflections do not create adverse conditions during hot functional testing.

A COL applicant that references the U.S. EPR design certification will examine the feedwater line welds after hot functional testing prior to fuel loading and at the first refueling outage, in accordance with NRC Bulletin 79-13. A COL applicant that references the U.S. EPR design certification will report the results of inspections to the NRC, in accordance with NRC Bulletin 79-13.

Environmental Fatigue

The effects of the environment on fatigue for Class 1 piping and components are addressed in FSAR Section 3.12 and in Section 3.4 of Reference 2.

3.9.3.1.2 Load Combinations and Stress Limits for Class 1 Components

Table 3.9.3-1—Load Combinations and Acceptance Criteria for ASME Class 1 Components provides the loading combinations and corresponding stress design criteria per ASME Service Level for ASME Class 1 components.

3.9.3.1.3 Load Combinations and Stress Limits for Class 2 and 3 Components

Table 3.9.3-2—Load Combinations and Acceptance Criteria for ASME Class 2 and 3 Components provides the loading combinations and corresponding stress design criteria per ASME Service Level for ASME Class 2 and 3 components.

3.9.3.1.4 Load Combinations and Stress Limits for Class 1 Piping

Table 3-1 of Reference 2 provides the loading combinations and corresponding stress design criteria per ASME Service Level for ASME Class 1 piping.

3.9.3.1.5 Load Combinations and Stress Limits for Class 2 and 3 Piping

Table 3-2 of Reference 2 provides the loading combinations and corresponding stress design criteria per ASME Service Level for ASME Class 2 and 3 piping.

3.9.3.1.6 Load Combinations and Stress Limits for Core Support Structures

Table 3.9.3-3—Load Combinations and Acceptance Criteria for ASME Core Support Structures provides the loading combinations and corresponding stress design criteria per ASME Service Level for ASME core support structures.

3.9.3.1.7 Load Combinations and Stress Limits for Class 1, 2, and 3 Component Supports

Table 3.9.3-4—Load Combinations and Acceptance Criteria for ASME Class 1, 2, and 3 Component Supports provides the loading combinations and corresponding stress design criteria per ASME Service Level for ASME Class 1, 2, and 3 component supports. In addition to the NF Sections listed in the table, the allowable stress criteria are supplemented by RGs 1.124 and 1.130 for Class 1 linear-type and plate-and-shell-type support structures, respectively.

3.9.3.1.8 Load Combinations and Stress Limits for Class 1, 2, and 3 Pipe Supports

Table 6-1 of Reference 2 provides the loading combinations and corresponding stress design criteria per ASME Service Level for ASME Class 1, 2, and 3 pipe supports. In addition to the NF Sections listed in the table, the allowable stress criteria are supplemented by RGs 1.124 and 1.130 for Class 1 linear-type and plate-and-shell-type support structures, respectively.

3.9.3.1.9 Piping Functionality

Analysis required to establish piping functionality is addressed in Section 3.5 of Reference 2.

3.9.3.2 Design and Installation of Pressure-Relief Devices

The design and installation criteria for pressure-relief devices are described in Section 3.8 of Reference 2. Stress and load combination requirements are provided in Tables 3-1 and 3-2 of Reference 2.

Section 3.3.1.5.1 of Reference 2 discusses relief valve thrust loads. Information on the structural response of the piping and support systems, including dynamic analyses (i.e., response spectrum or time history analyses) or the equivalent static load method is provided in Section 4.2 of Reference 2. Use of snubbers is described in Section 3.9.3.4.5.

3.9.3.2.1 Class 1 Pressurizer Safety Relief Valves

The pressurizer safety relief valves (PSRV) are designed to provide overpressure protection for the RCPB. The PSRVs connect to nozzles on the top head of the pressurizer and discharge through connected piping to the pressurizer relief tank. The PSRVs, in conjunction with the main steam safety valves (MSSV), prevent the RCPB from exceeding 110 percent of its design pressure with only safety classified systems in operation and the failure of the PSRV considered at the lowest set point. The PSRVs and their pilot operators are qualified to operate in saturated steam, water, and steam and water mixtures in hot or cold conditions. They are also designed to operate in hot conditions without electric or instrumentation and controls (I&C) inputs and are designed so that the I&C and power supply to the PSRV pilot operator will operate in the event of a single failure during cold shutdown conditions.

Details on the design of the PSRVs are provided in Sections 5.2.2 and 5.4.13.

3.9.3.2.2 Class 2 Pressure Relief Devices

The MSRIVs and the MSSVs are ASME Code, Section III, Class 2 pressure relief devices. The MSRIVs and the MSSVs provide overpressure protection for the secondary side of the steam generators. These valves are designed to the requirements of Subarticle NC-3500 of the ASME Code and ANSI B16.34 (Reference 3). Additional information on the MSRIVs and the MSSVs is provided in Section 10.3.

3.9.3.2.3 Pressure Relief Device Discharge System Design and Analysis

ASME Code, Section III, Appendix O describes two types of discharge systems for pressure relief devices: open discharge systems and closed discharge systems. An open discharge system discharges fluid directly to the atmosphere or to a vent pipe that is open to the atmosphere. A closed discharge system is hard piped to a distant location or closed tank. ASME Code, Section III, Appendix O also describes the layout considerations and limits for both types of systems, as well as design equations and considerations for analysis of these systems. The U.S. EPR design complies with these requirements.

3.9.3.3 Pump and Valve Operability Assurance

ASME Code Class 1 pump and valve design loadings and stress limits are addressed in Section 3.9.3.1.2. Similarly, ASME Code Class 2 and 3 pump and valve design loadings and stress limits are described in Section 3.9.3.1.3. A list of active safety-related pumps and valves is provided in Section 3.9.6. The design stress limits are described in Section 3.9.3.1. Environmental qualification of safety-related pumps and valves is described in Section 3.11. The functional design and qualification of safety-related pumps, valves, and snubbers is performed in accordance with ASME QME-1-2007 (Reference 8), as endorsed in RG 1.100, Rev. 3, with clarifications as described in Section 3.10.2.

3.9.3.3.1 Pump Operability

Pump operability is established initially by subjecting the pumps to factory tests prior to installation. These factory tests are followed by post-installation testing in the plant. Factory tests include a hydrostatic test for pressure retaining parts, pump seal leakage tests to the hydrostatic test pressure, and performance tests to establish pump head requirements. Post-installation testing includes cold hydrostatic tests and hot functional tests as part of the piping system testing. Section 3.9.6 provides a description of the functional design and qualification provisions and inservice testing (IST) programs for safety-related pumps.

Seismic testing of safety-related active pumps is in accordance with IEEE Std 344[1] (Reference 4) or by an analysis that demonstrates that seismic deflections do not cause the rotor to bind or cause other unacceptable damage to critical pump parts. Section 3.10 provides the details of seismic qualification.

3.9.3.3.2 Active Valve Operability

Active valve operability is established initially by subjecting the valves to factory tests prior to installation. These tests are followed by post-installation testing in the plant. Factory tests include a shell hydrostatic test, a valve closure test, and a performance test to verify correct opening and closing of the valve. In addition to the factory tests,

1. Section 3.11 provides the justification for the use of the latest version of the IEEE standards referenced in this section that have not been endorsed by existing Regulatory Guides. AREVA NP maintains the option to use current NRC-endorsed versions of the IEEE standards.

other post-installation tests are performed on these valves, including cold hydrostatic tests, hot functional tests, periodic inservice inspections, and periodic inservice operational tests.

In addition to the valve qualifications noted above, a representative sample of each valve type is tested for operability during a simulated plant condition event. The valve is mounted so that it conservatively bounds possible plant mounting orientations. The valve includes operators, limit switches, and pilot valves that are normally attached to the valve in the plant. Section 3.10 provides the details of seismic qualification.

An equivalent static load representing the faulted load is applied to the top of the bonnet, and the pressure is increased until the valve actuates. A successful actuation within the design setpoint requirements verifies its operational overpressurization capabilities during a condition event.

The above methods demonstrate that active plant valves perform their safety-related functions during postulated events. Section 3.9.6 also provides a description of the functional design and qualification provisions and IST programs for safety-related valves.

3.9.3.4 Component Supports

Load combinations, system operating transients, stress limits, and deformation limits for component supports are described in Section 3.9.3.1. Section 3.9.3.1 also describes the design and structural integrity of Class 1 linear-type and plate-and-shell-type support structures, in accordance with the criteria in RGs 1.124 and 1.130.

3.9.3.4.1 Component, Piping and Instrumentation Line Support Design

As described in Sections 3.9.3.1.6 through 3.9.3.1.8, core support structures and ASME Code Class 1, 2, and 3 component and piping supports meet the stress criteria of the ASME Code, using the loadings and combinations outlined in the corresponding tables for each of those sections. Additional information regarding these criteria is provided in Section 6 of Reference 2.

3.9.3.4.2 Jurisdictional Boundaries

The jurisdictional boundaries for pipe supports, including piping analyzed to ANSI B31.1 (Reference 5), are described in Section 6.2 of Reference 2.

3.9.3.4.3 Pipe Support Baseplate and Anchor Bolt Design

Pipe support baseplate and anchor bolt design is described in Section 6.4 of Reference 2.

3.9.3.4.4 Use of Energy Absorbers and Limit Stops

The use of energy absorbers and gapped rigid supports (limit stops) is addressed in Section 6.5 of Reference 2.

3.9.3.4.5 Use of Snubbers

Snubber supports for piping systems are described in Section 6.6 of Reference 2. Section 3.9.6 provides a description of the functional design and qualification provisions and IST programs for snubbers. For large bore snubbers of greater than 50 kip capacity, the snubber design verification testing recommendations provided in NUREG/CR-5416 (Reference 6) are followed.

3.9.3.4.6 Pipe Support Stiffness

Support stiffness used in piping analysis models is described in Section 6.7 of Reference 2. Deflection checks are performed as described in Section 6.7 of Reference 2.

3.9.3.4.7 Seismic Self-Weight Excitation

Seismic self-weight excitation, including the response of the support structure to SSE loadings, is described in Section 6.8 of Reference 2.

3.9.3.4.8 Design of Supplemental Steel

The design of supplemental steel is described in Section 6.9 of Reference 2.

3.9.3.4.9 Pipe Support Gaps and Clearances

The use of pipe support gaps in the piping analysis is described in Section 6.11 of Reference 2.

3.9.3.4.10 Instrumentation Line Support Criteria

Instrumentation line support criteria are described in Section 6.12 of Reference 2.

3.9.3.4.11 Pipe Deflection Limits

Pipe deflection limits are described in Section 6.13 of Reference 2.

3.9.3.4.12 Load Combinations and Stress Limits for Buried Piping

As noted in Section 3.10 of Reference 2, Code Class 2 and 3 Seismic Category I buried piping systems are analyzed for pressure, weight, thermal expansion, and seismic loads using dynamic or equivalent static load methods. Further information on this analysis is provided in Section 3.10 of Reference 2. Table 3-4 of Reference 2 provides the design conditions, load combinations, and stress criteria for the qualification of buried piping.

3.9.3.4.13 Model Isolation Methods

The overlap region and influence zone model isolation methods are used to divide large seismic piping systems that cannot be separated by structural methods or decoupling criteria. These methods are similar, in that a section of the piping system is used as the boundary of the models. These methods are further described in Section 5.4.3 and Figure 5-3 of Reference 2.

3.9.3.5 References

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

2. ANP-10264NP-A, Revision 0, "U.S. EPR Piping Analysis and Pipe Support Design Topical Report," AREVA NP Inc., November 2008.

3. ANSI Standard B16.34, "Valves-Flanged, Threaded, and Welding End," American National Standards Institute, 2004.

4. IEEE Standard 344-2004, "IEEE Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers, June 2005.

5. ANSI Standard B31.1, "Power Piping," American National Standards Institute, 2004.

6. NUREG/CR-5416, (EGG-2571), "Technical Evaluation of Generic Issue 113: Dynamic Qualification and Testing of Large Bore Hydraulic Snubbers," U.S. Nuclear Regulatory Commission, September 1992.

7. ANP-10264NP, Revision 1, "U.S. EPR Piping Analysis and Pipe Support Design Topical Report," AREVA NP Inc., May 2010.

8. ASME QME-1-2007 Edition, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," 2007 Edition.

Table 3.9.3-1—Load Combinations and Acceptance Criteria for ASME Class 1 Components[1,18]
Sheet 1 of 3

Service Condition	Service Level	Category	Loading or Stress Component	Acceptance Criteria[2]
Design	-	General Primary Membrane Stress Intensity (SI)[3]	Design Pressure, Design Mechanical Load[4]	NB-3221.1
		Local Membrane SI[3]	Design Pressure, Design Mechanical Load[4]	NB-3221.2
		Primary Membrane Plus Primary Bending SI[3]	Design Pressure, Design Mechanical Load[4]	NB-3221.3
		External Pressure	Design Pressure - External	NB-3221.4
		Special Stress Limits[5]	Design Pressure, Design Mechanical Load[4]	NB-3227
Normal	A	Primary Plus Secondary SI	Coincident Level A Service Pressure, Applied Mechanical Load[6], General Thermal Stresses	NB-3222.2
		Alternating SI (Fatigue Usage)[7,8,9]	Range of Level A: Service Pressure, Applied Mechanical Load[6], General and Local Thermal Stresses, Gross and Local Structural Discontinuity Stresses	NB-3222.4
		Thermal Stress Ratchet	Cyclic Thermal Stress	NB-3222.5
		Special Stress Limits[5]	Coincident Level A Service Pressure, Applied Mechanical Load[6]	NB-3221
		Deformation Limits	As Set Forth in the Design Specification	NB-3222.6[10]

Table 3.9.3-1—Load Combinations and Acceptance Criteria for ASME Class 1 Components[1,18]
Sheet 2 of 3

Service Condition	Service Level	Category	Loading or Stress Component	Acceptance Criteria[2]
Upset	B	General Primary Membrane SI[3]	Coincident Level B Service Pressure, Applied Mechanical Load[6]	NB-3223(a)(1)
		Local Membrane SI[3]	Coincident Level B Service Pressure, Applied Mechanical Load[6]	NB-3223(a)(1)
		Primary Membrane Plus Primary Bending SI[3]	Coincident Level B Service Pressure, Applied Mechanical Load[6]	NB-3223(a)(1)
		Primary Plus Secondary SI	Coincident Level B Service Pressure, Applied Mechanical Load[6], General Thermal Stresses	NB-3223(a)(1)
		Alternating SI (Fatigue Usage)[7,8,9]	Range of Level B: Service Pressure, Applied Mechanical Load[6,11], Earthquake Inertial Load[11,12,13], General and Local Thermal Stresses, Gross and Local Structural Discontinuity Stresses	NB-3223(a)(1)
		Thermal Stress Ratchet	Cyclic Thermal Stress	NB-3223(a)(1)
		Special Stress Limits[5]	Coincident Level B Service Pressure, Applied Mechanical Load[6]	NB-3227
		Deformation Limits	As Set Forth in the Design Specification	NB-3223(a)(3)[10]
Emergency[14]	C	General Primary Membrane SI[3]	Coincident Level C Service Pressure, Applied Mechanical Load[6]	NB-3224.1
		Local Membrane SI[3]	Coincident Level C Service Pressure, Applied Mechanical Load[6]	NB-3224.1

Table 3.9.3-1—Load Combinations and Acceptance Criteria for ASME Class 1 Components[1,18]
Sheet 3 of 3

Service Condition	Service Level	Category	Loading or Stress Component	Acceptance Criteria[2]
Emergency[14]	C	Primary Membrane Plus Primary Bending SI[3]	Coincident Level C Service Pressure, Applied Mechanical Load[6]	NB-3224.1
		External Pressure	Design Pressure – External	NB-3224.2
		Special Stress Limits[5]	Coincident Level C Service Pressure, Applied Mechanical Load[6]	NB-3224.3
		Deformation Limits	As Set Forth in the Design Specification	NB-3224.6[10]
Faulted[15]	D	Primary SI[3]	Coincident Level D Service Pressure, Applied Mechanical Load[6,11], Earthquake Inertial Load[11,13], Loss-of-Coolant Accident[11,13] and Secondary Side Pipe Rupture[11,13] loads (due to Internal Decompression Wave, Thrust, Jet Impingement, Asymmetric Cavity Pressure, Pipe Impact), Internal Hazard (Missile Impact) Load[11]	NB-3225(a)
		Special Stress Limits[5]	Coincident Level D Service Pressure, Applied Mechanical Load[6]	NB-3227
Pressure Testing [16,17]	N/A	General Primary Membrane SI[3]	Coincident Test Pressure, Applied Mechanical Load[6]	NB-3226(b)
		Primary Membrane Plus Primary Bending SI[3]	Coincident Test Pressure, Applied Mechanical Load[6]	NB-3226(c)
		External Pressure	Test Pressure - External	NB-3226(d)
		Special Stress Limits[5]	Coincident Test Pressure, Applied Mechanical Load[6]	NB-3227

Notes:

1. The information in this table pertains to the analysis of Class 1 components. Analysis of Class 1 bolting is not explicitly addressed in this table, except that the loading to be considered in the analysis of the bolting is as shown in the table. In addition to these loads, bolt preload is considered in the stress analysis of the bolting, as appropriate. Acceptance criteria for bolting are given in Subsubarticle NB-3230 of Section III of the ASME Boiler and Pressure Vessel Code.

2. Acceptance Criteria are taken from the referenced section or appendix in Section III of the ASME Code. Per Paragraph NB-3228 in Section III of the ASME Code, where certain of the design/normal/upset/emergency service condition or special stress limit criteria are not met, plastic analysis methods may be used to qualify the component in question.

3. The general primary membrane, local membrane, and primary membrane plus primary bending stress intensities (i.e., the primary stress intensities) exclude secondary and peak stresses.

4. Design mechanical loads are Service Level A applied mechanical loads (see Note 6) which are selected such that when they are combined with the effects of Design Pressure, they produce the highest primary stresses of any coincident combination of loadings for which Level A service limits are designated. This is an important consideration when design pressure and applied mechanical load produce stresses of opposite sign.

5. Special stress limits are considered for design condition, all service levels, and test conditions. These limits apply to bearing loads, pure shear, progressive distortion of non-integral connections, triaxial stress, nozzle-piping transitions, application of elastic analysis for stresses beyond the yield strength, and to requirements for specially designed welded seals. See Paragraph NB-3227 of Section III of the ASME Code.

6. Applied mechanical loads are loads applied to the component at supports, restraints, and component nozzles. Component nozzle loads consist of deadweight load, thermal expansion load, steady state flow load and dynamic fluid load imposed by the attached piping. Loads on the components at their interfaces with supports and restraints consist of deadweight load, thermal expansion load, steady state flow load, and dynamic fluid load imposed by the supports and restraints. Thermal expansion loads applied to the component nozzles by the attached piping are considered to produce primary stresses within the limits of reinforcement of a nozzle, and secondary stresses outside the limits of reinforcement.

7. If the requirements of Subsubparagraph NB-3222.4(d) in Section III of the ASME Code are met, the component in question may be exempted from fatigue analysis. When evaluating exemption from fatigue for Service Level B, Service Level A limits are used (see Subsubparagraph NB-3223(a)(2) in Section III of the ASME Code.

8. Ranges of Level A and Level B service pressure, general and local thermal stresses, as well as gross and local structural discontinuity stresses, which result from system operating transients (i.e., pressure and thermal transients) are considered in the fatigue calculations. Cyclic loading due to applied mechanical load and earthquake inertial load is also considered in the fatigue calculations.

9. The cumulative fatigue usage factor is calculated by summing the Level A and Level B fatigue usage. If applicable, fatigue usage from Level C and pressure testing conditions are also included in the calculation of the cumulative usage factor (see Notes 14 and 17).

10. Limits on deformation, if any, are given in the component design specification.

11. Loads due to dynamic events are combined considering the time phasing of the events (i.e., whether the loads are coincident in time). When the time phasing relationship can be established, dynamic loads may be combined by the square-root-sum-of-the-squares (SRSS) method, provided it is demonstrated that the non-exceedance criteria given in NUREG-0484 are met. When the time phasing relationship cannot be established, or when the non-exceedance criteria in NUREG-0484 are not met, dynamic loads are combined by absolute sum. SSE and high energy line break (loss-of-coolant accident (LOCA) and secondary side pipe rupture) loads are always combined using the SRSS method.

12. The earthquake inertial load used in the Level B Alternating stress intensity calculations is taken as 1/3 of the peak SSE inertial load or as the peak SSE inertial load. If the earthquake inertial load is taken as the peak SSE inertial load, then 20 cycles of earthquake loading shall be considered. If the earthquake inertial load is taken as 1/3 of the peak SSE inertial load, then the number of cycles to be considered for earthquake loading shall be 300 (the equivalent number of 20 full SSE cycles as derived in accordance with IEEE Std 344).

13. Earthquake inertial load and high energy line break load (LOCA and secondary side pipe rupture load) include both the load applied to the component by external attachments (piping, supports, restraints) and any load induced by the acceleration of the component itself.

14. If a component is subjected to more than 25 emergency condition transient cycles which result in an alternating stress intensity (S_a) value greater than that for 10^6 cycles, as determined from the applicable fatigue design curves of Figures I-9.0 in Section III of the ASME Code, then those cycles in excess of 25 are included in the fatigue calculation that determines the cumulative usage factor. See Paragraph NB-3113 in Section III of the ASME Code.

15. The rules given in Appendix F of Section III of the ASME Code are used for analysis of faulted service condition loading (see Paragraph NB-3225(a) in Section III of the ASME Code).

16. If the calculated pressure (including static head) at any point within a component exceeds 1.06 times the required test pressure, as calculated per Paragraph NB-6221 of Section III of the ASME Code, stress intensities are calculated using all loadings that exist during the test. See Paragraph NB-3226(a) in Section III of the ASME Code.

17. If a component is subjected to more than 10 pressure testing cycles which result in an alternating stress intensity (Sa) value greater than that for 10^6 cycles, as determined from the applicable fatigue design curves of Figures I-9.0 in Section III of the ASME Code, then those cycles in excess of 10 are included in the fatigue calculation that determines the cumulative usage factor. See Paragraph NB-3226(e) in Section III of the ASME Code.

18. Large valves (i.e., those valves with inlet piping connections larger than 4-inch NPS) in the Class 1 piping systems are designed according to the standard design rules given in Subparagraph NB-3512.1 or the alternate design rules given in Subparagraph NB-3512.2. Small valves (i.e., those valves with inlet piping connections 4-inch NPS or smaller) in the Class 1 piping systems are designed according to the standard design rules given in Subparagraph NB-3513.1 or the alternate design rules given in Subparagraph NB-3513.2.

Table 3.9.3-2—Load Combinations and Acceptance Criteria for ASME Class 2 and 3 Components

Loading Condition	Service Levels	Loads[3]	Stress Criteria[2,4]
Design/Normal	-/A	Sustained Loads: Pressure, Weight, Other Mechanical Loads	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves
Upset	B	Occasional Loads: Pressure, Weight, Thermal Effects, Dynamic Fluid Loads[1], Wind[5]	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves
Emergency	C	Occasional Loads: Pressure, Weight, Thermal Effects, Dynamic Fluid Loads[1], Tornado[5]	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves
Faulted	D	Occasional Loads: Pressure, Weight, Thermal Effects, DFL[1], SSE Inertia, Pipe Break	NC/ND-3300, Vessels NC/ND-3400, Pumps NC/ND-3500, Valves

Notes:

1. Dynamic fluid loads (DFL) are occasional loads such as safety and relief valve thrust, steam hammer, water hammer, or other loads associated with plant upset or faulted condition as applicable.

2. ASME Code Section III.

3. Dynamic loads are combined by the SRSS method.

4. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," Paragraph 9, 'Elimination of Operating Basis Earthquake,' Nuclear Regulatory Commission, July 21, 1993.

5. Wind and tornado loads are not combined with earthquake loading.

Table 3.9.3-3—Load Combinations and Acceptance Criteria for ASME Core Support Structures[1]
Sheet 1 of 3

Service Condition	Service Level	Category	Loading or Stress Component	Acceptance Criteria[2]
Design	-	General Primary Membrane Stress Intensity (SI)[3]	Design Pressure Difference, Design Mechanical Load[4]	NG-3221.1
		Primary Membrane Plus Primary Bending SI[3]	Design Pressure Difference, Design Mechanical Load[4]	NG-3221.2
		External Pressure Difference	Design Pressure Difference - External	NG-3221.3
		Special Stress Limits[5]	Design Pressure Difference, Design Mechanical Load[4]	NG-3221
Normal	A	Primary Membrane Plus Primary Bending SI[3]	Coincident Level A Service Pressure Difference, Applied Mechanical Load[6]	NG-3222.1
		Primary Plus Secondary SI	Coincident Level A Service Pressure Difference, Applied Mechanical Load[6], General Thermal Stresses	NG-3222.2
		Expansion SI	Thermal Expansion Load, Thermal Anchor Motion Load	NG-3222.3
		Alternating SI (Fatigue Usage)[7,8,9]	Range of Level A: Service Pressure Difference, Applied Mechanical Load[6], General and Local Thermal Stresses, Gross and Local Structural Discontinuity Stresses	NG-3222.4
		Thermal Stress Ratchet	Coincident Level A Service Pressure Difference, Cyclic Thermal Stress	NG-3222.5
		Special Stress Limits[5]	Coincident Level A Service Pressure Difference, Applied Mechanical Load[6]	NG-3222
		Deformation Limits	As Set Forth in the Design Specification	NG-3222.6[10]

Table 3.9.3-3—Load Combinations and Acceptance Criteria for ASME Core Support Structures[1]
Sheet 2 of 3

Service Condition	Service Level	Category	Loading or Stress Component	Acceptance Criteria[2]
Upset	B	Primary Membrane Plus Primary Bending SI[3]	Coincident Level B Service Pressure Difference, Applied Mechanical Load[6]	NG-3223(a)
		Primary Plus Secondary S.I	Coincident Level B Service Pressure Difference, Applied Mechanical Load[6], General Thermal Stresses	NG-3223(a)
		Expansion SI	Thermal Expansion Load, Thermal Anchor Motion Load	NG-3223(a)
		Alternating SI (Fatigue Usage)[7,8,9]	Range of Level B: Service Pressure Difference, Applied Mechanical Load[6,11], Earthquake Inertial Load[11,12], General and Local Thermal Stresses, Gross and Local Structural Discontinuity Stresses	NG-3223(a)
		Thermal Stress Ratchet	Coincident Level B Service Pressure Difference, Cyclic Thermal Stress	NG-3223(a)
		Special Stress Limits[5]	Coincident Level B Service Pressure Difference, Applied Mechanical Load[6]	NG-3223(a)
		Deformation Limits	As Set Forth in the Design Specification	NG-3223(a)[10]
Emergency	C	Primary Membrane SI[3]	Coincident Level C Service Pressure Difference, Applied Mechanical Load[6]	NG-3224.1 (a)(1)
		Primary Membrane Plus Primary Bending SI[3]	Coincident Level C Service Pressure Difference, Applied Mechanical Load[6]	NG-3224.1 (a)(2)
		External Pressure Difference	Design Pressure Difference - External	NG-3224.2
		Special Stress Limits[5]	Coincident Level C Service Pressure Difference, Applied Mechanical Load[6]	NG-3224.3
		Deformation Limits	As Set Forth in the Design Specification	NG-3224.6[9]

Table 3.9.3-3—Load Combinations and Acceptance Criteria for ASME Core Support Structures[1]
Sheet 3 of 3

Service Condition	Service Level	Category	Loading or Stress Component	Acceptance Criteria[2]
Faulted[13]	D	Primary SI[3]	Coincident Level D Service Pressure Difference, Applied Mechanical Load[6,11], Earthquake Inertial Load[11,14], Loss-of-Coolant Accident[11,14] and Secondary Side Pipe Rupture[11,14] load (due to Internal Decompression Wave, Thrust, Jet Impingement, Asymmetric Cavity Pressure)	NG-3225
		Special Stress Limits[5]	Coincident Level D Service Pressure Difference, Applied Mechanical Load[6]	NG-3225

Notes:

1. The information in this table pertains to the analysis of RPV core support structures. Analysis of threaded structural fasteners within the core support structures is not explicitly addressed in this table, except that the loading to be considered in the analysis of the fasteners is as shown in the table. In addition to these loads, bolt preload is considered in the stress analysis of the fasteners, as appropriate. Acceptance criteria for threaded structural fasteners within the RPV core support structures are given in Subarticle NG-3230 of Section III of the ASME Boiler and Pressure Vessel Code.

2. Acceptance criteria are taken from the referenced section in Section III of the ASME Code. If the criteria in the specified sections is not met, Plastic Analysis methods may be used to qualify the core support structure in question (see Paragraph NG-3228 in Section III of the ASME Code).

3. The general primary membrane and primary membrane plus primary bending stress intensities (i.e., the primary stress intensities) exclude secondary and peak stresses.

4. Design mechanical loads are Service Level A applied mechanical loads (see Note 6) and impact loads which are selected such that when they are combined with the effects of design pressure difference, they produce the highest primary stresses of any coincident combination of loadings for which Level A service limits are designated. This is an important consideration when design pressure difference and applied mechanical load produce stresses of opposite sign.

5. Special stress limits are considered for design condition and all service level conditions. These limits apply to bearing loads, pure shear, progressive distortion of non-integral connections, triaxial stress, nozzle-piping transitions, and for application of elastic analysis for stresses beyond the yield strength. See Paragraph NG-3227 of Section III of the ASME Code.

6. Applied mechanical loads are loads applied to the core support structures at their interfaces with the RPV pressure boundary and internals, as well as those due to pressure drop across the various parts of the core support structures. Loads on the core support structures at their interfaces with the RPV pressure boundary and internals consist of deadweight load, thermal expansion load, steady state flow load, and dynamic fluid load imposed by the pressure boundary and internals.

7. If the requirements of Subsubparagraph NG-3222.4(d) in Section III of the ASME B Code are met, the core support structure in question can be exempted from fatigue analysis.

8. Ranges of Level A and Level B service pressure differences, general and local thermal stresses, as well as gross and local structural discontinuity stresses, which result from system operating transients (i.e., pressure and thermal transients) are considered in the fatigue calculations. Cyclic loading due to applied mechanical load and earthquake inertial load is also considered in the fatigue calculations.

9. The cumulative fatigue usage factor is calculated by summing the Level A and Level B fatigue usage.

10. Limits on deformation, if any, are given in the component design specification.

11. Loads due to dynamic events are combined considering the time phasing of the events (i.e., whether the loads are coincident in time). When the time phasing relationship can be established, dynamic loads may be combined by the SRSS method, provided it is demonstrated that the non-exceedance criteria given in NUREG-0484 is met. When the time phasing relationship cannot be established, or when the non-exceeding criteria in NUREG-0484 are not met, dynamic loads are combined by absolute sum. SSE and high energy line break (LOCA and secondary side pipe rupture) loads are always combined using the SRSS method.

12. The earthquake inertial load used in the Level B alternating stress intensity calculations is taken as 1/3 of the peak SSE inertial load or as the peak SSE inertial load. If the earthquake inertial load is taken as the peak SSE inertial load then 20 cycles of earthquake loading shall be considered. If the earthquake inertial load is taken as 1/3 of the peak SSE inertial load, then the number of cycles to be considered for earthquake loading shall be 300 (the equivalent number of 20 full SSE cycles as derived in accordance with IEEE Std 344).

13. The rules given in Appendix F of Section III of the ASME B Code are used for analysis of Faulted Service Condition loading (see Paragraph NG-3225 in Section III of the ASME Code).

14. Earthquake inertial load and high energy line break load (LOCA and secondary side pipe rupture load) include both the load applied to the RPV core support structures by the RPV pressure boundary and internals as well as any load induced by the acceleration of the core support structures themselves.

Table 3.9.3-4—Load Combinations and Acceptance Criteria for ASME Class 1, 2, and 3 Component Supports

Loading Condition	Service Limits	Loads[3]	Stress Criteria[2,4]
Design/Normal	-/A	Loads: Weight, Thermal Effects, Other Mechanical Loads	Table NF-3131(a)-1
Upset	B	Loads: Weight, Thermal Effects, Dynamic Fluid Loads[1], Wind[5]	Table NF-3131(a)-1
Emergency	C	Loads: Weight, Thermal Effects, Dynamic Fluid Loads[1], Tornado[5]	Table NF-3131(a)-1
Faulted	D	Loads: Weight, Thermal Effects, Dynamic Fluid Loads[1], SSE Inertia, Pipe Break	Table NF-3131(a)-1
Testing	N/A	Loads: Weight	Table NF-3131(a)-1

Notes:

1. DFL are occasional loads such as safety and relief valve thrust, steam hammer, water hammer, or other loads associated with plant upset or faulted condition as applicable.

2. Table NF-3131(a)-1 of the ASME Code, Section III, Subsection NF provides a cross-reference to various sections of NF for stress allowables for specific types of component supports.

3. Dynamic loads are combined by the SRSS method.

4. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," Paragraph 9, 'Elimination of Operating Basis Earthquake,' Nuclear Regulatory Commission, July 21, 1993.

5. Wind and tornado loads are not combined with earthquake loading.

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