

3.13 Threaded Fasteners (ASME Code Class 1, 2, and 3)

This section addresses the application of the ASME Boiler and Pressure Vessel Code (BPV), Section III, Division 1 (Reference 1) to the design of Class 1, 2, and 3 pressure-retaining threaded fasteners.

10 CFR 50.55a and NRC Regulatory Guide 1.26 define the use of ASME Code Classes 1, 2, and 3 based on Quality Groups associated with specific plant systems and parameters. Quality Groups A, B, and C are safety-related groups associated respectively with ASME Code Classes 1, 2, and 3. Additional information on the U.S. EPR System Quality Group Classification is provided in Section 3.2.2.

The following General Design Criteria (GDC) of 10 CFR 50, Appendix A apply to this section:

- GDCs 1 and 30 require that structures, systems, and components (SSC) be designed to quality standards commensurate with the importance of the safety function to be performed. These criteria are met by conformance with the criteria of Reference 1, and Regulatory Guide 1.65.
- GDC 4 requires that SSC accommodate the effects of, and that they are compatible with, the environmental conditions of normal and accident conditions. This criterion is met by protecting the threaded fasteners against the detrimental effects of certain lubricants and sealants that promote corrosion and by protecting the threaded fasteners from boric acid corrosion.
- GDC 14 requires that the reactor coolant system (RCS) and the RCS pressure boundary are designed with sufficient margins. These criteria are met by the use of ASME Class 1 criteria for the RCS system.
- GDC 31 requires that the reactor coolant pressure boundary (RCPB) be designed with sufficient margin, so that when stressed under operating, maintenance, testing, and postulated accident conditions the boundary behaves in a nonbrittle manner, minimizing the probability of rapidly propagating fracture. This criterion is met by application of the requirements of 10 CFR 50, Appendix G, which demonstrates that threaded fasteners in the RCPB will behave in a nonbrittle manner, thereby minimizing the probability of rapidly propagating fracture and satisfying the requirements of GDC 31.

Additionally, 10 CFR 50, Appendix B, Criterion XIII, requires that measures be established to control the cleaning of material and equipment to prevent damage or deterioration. Regulatory Guide 1.37 provides quality assurance criteria for cleaning fluid systems and associated components that comply with Appendix B. The cleaning criteria in RG 1.37 is applied to threaded fasteners, so that contaminants that they could be exposed to will not damage or deteriorate the materials, alter their properties, accelerate effects associated with aging, or increase the susceptibility to failure mechanisms such as stress corrosion cracking.

3.13.1 Design Considerations

The design and analysis of pressure boundary threaded fasteners complies with ASME Class 1, 2, and 3 requirements. Proven threaded fastener designs, materials, and fabrication techniques are used in the U.S. EPR. Class 1 pressure boundary threaded fasteners are designed in accordance with Reference 1, Subsection NB. Class 2 and Class 3 pressure boundary threaded fasteners are designed in accordance with the applicable Reference 1, Subsection NC and ND requirements.

3.13.1.1 Materials Selection

ASME Code Section III provides acceptable standards for selecting threaded fastener materials identified in ASME Code, Section II (Reference 2). Section II provides the material properties for threaded fasteners used in mechanical joints for ASME Code Class 1, 2 and 3 applications. Table 3.13-1 lists the applicable criteria in Reference 1 that pertain to the material selection for threaded fasteners in Class 1, 2, and 3 systems. Materials used in threaded fasteners are selected for their compatibility with the environmental conditions they are exposed to. Only proven materials for the specific application and environment are used after evaluation of the potential for degradation.

Reactor Vessel

Regulatory Guide 1.65 defines acceptable materials and testing procedures for the reactor vessel (RV) closure stud bolting. The RV closure studs are SA-540, Grade 24V Class 3. Conformance with the recommendations of Regulatory Guide 1.65 provides the integrity of RV studs and fasteners.

3.13.1.2 Special Materials Fabrication Processes and Special Controls

The criteria for mechanical property testing of threaded fasteners complies with the requirements of Reference 2, Part A as noted in Table 3.13-1. Threaded fastener materials are chosen from proven materials for the specific application and environment and are used after evaluation of the potential for degradation, including galvanic corrosion and stress corrosion cracking. Conformance with RG 1.65 for RV studs and RG 1.37 for threaded fasteners minimizes the potential for stress corrosion cracking of threaded fasteners.

The lubricants and sealants used on the following threaded fasteners types have been selected based on experience:

- Threaded fasteners that maintain pressure boundary integrity in the reactor coolant and related systems.
- Threaded fasteners used inside those systems.
- Threaded fasteners used in component structural support for those systems.

Experience has shown that the selected lubricants and sealants are effective and that they do not cause or accelerate corrosion of the fastener. Field selection of thread lubricants and sealants is not permitted.

Lubricants are selected in accordance with the guidance provided in NUREG-1339 (Reference 3). Fabrication and examination of threaded fasteners will be performed on a site basis in accordance with the criteria in Table 3.13-1 for ASME Code Class 1, 2, and 3 systems.

3.13.1.3 Fracture Toughness Requirements for Threaded Fasteners Made from Ferritic Materials

The pressure-retaining Class 1 components of the pressure boundary that are made of ferritic material meet the requirements of Reference 1, NB-2300 (Table 3.13-1), supplemented by the additional requirements set forth in 10 CFR 50, Appendix G. The fracture toughness properties of ferritic materials of the Class 2 pressure-retaining components meet the requirements of Reference 1, NC-2300 (Table 3.13-1). The fracture toughness properties of ferritic materials of the Class 3 pressure retaining components meet the requirements of Reference 1, ND-2300 (Table 3.13-1).

Integrity of the RV studs and fasteners is addressed by conformance with the recommendations of Regulatory Guide 1.65.

3.13.1.4 Pre-Service Inspection Requirements

Pressure boundary Class 1 threaded fasteners are examined in accordance with ASME Code, Section XI (Reference 4), IWB-2200 for Preservice Inspection. Pressure boundary Class 2 threaded fasteners are examined in accordance with Reference 4, IWC-2200, and pressure boundary Class 3 threaded fasteners are examined in accordance with Reference 4, IWD-2200 for Preservice Inspection.

3.13.1.5 Certified Material Test Reports

Pressure-retaining Class 1, 2, and 3 bolts and studs comply with the requirements for Certified Material Test Reports (CMTRs) in accordance with the criteria of Reference 1:

- NB-2130 for Class 1.
- NC-2130 for Class 2.
- ND-2130 for Class 3.

Material identification is also required for Class 1, 2, and 3 bolts and studs per Reference 1:

- NB-2150 for Class 1.

- NC-2150 for Class 2.
- ND-2150 for Class 3.

The results of material chemistry tests (e.g., alloying elements) and physical property tests will be documented in applicable CMTRs, as required by Reference 1 (see Table 3.13-1). CMTRs will be retained in accordance with 10 CFR 50.71.

3.13.2 Inservice Inspection Requirements

Inservice inspection of ASME Class 1, Class 2, and Class 3 threaded fasteners is performed in accordance with the applicable edition and addenda of Reference 4 (see Table 3.13-2), as required by 10 CFR 50.55a, except where specific written relief has been granted by the NRC.

A COL applicant referencing the U.S. EPR design certification will submit the inservice inspection program for ASME Class 1, Class 2, and Class 3 threaded fasteners to the NRC prior to performing the first inspection. The program will identify the applicable edition and addenda of ASME Section XI and ensure compliance with the requirements of 10CFR50.55a(b)(2)(xxvii).

3.13.3 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. ASME Boiler and Pressure Vessel Code, Section II, "Materials," The American Society of Mechanical Engineers, 2004.
3. NUREG-1339, R.E. Johnson, "Resolution of Generic Safety Issue 29: Bolting Degradation or Failure in Nuclear Power Plants," Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, June 1990.
4. ASME Boiler and Pressure Vessel Code, Section XI, "Rules for Inspection of Nuclear Power Plant Components," The American Society of Mechanical Engineers, 2004.

Table 3.13-1—ASME BPV Code Section III Criteria for Selection and Testing of Bolted Materials

Code Category		ASME Class 1 Criteria	ASME Class 2 Criteria	ASME Class 3 Criteria
Material Selection		NCA-1220 and NB-2128	NCA-1220 and NC-2128	NCA-1220 and ND-2128
Material Test Coupons and Specimens for Ferritic Steel Material (Tensile Test Criteria)	Heat Treatment Criteria	NB-2210	NC-2210	ND-2210
	Test Coupons Requirements Bolting/Stud Materials	NB-2221 NB-2224	NC-2221 NC-2224.3	ND-2221 ND-2224.3
Fracture Toughness Requirements	Material to be Impact Tested	NB-2311	NC-2311	ND-2311
	Types of Impact Test	NB-2321	NC-2321	ND-2321
	Test Coupons	NB-2322	NC-2322	ND-2322
	Acceptance Standards	NB-2333	NC-2332.3	ND-2333
	Number of Impact Tests Necessary	NB-2345	NC-2345	ND-2345
	Retesting	NB-2350	NC-2352	ND-2352
	Calibration of Test Equipment	NB-2360	NC-2360	ND-2360
Examination Criteria for Bolts, Studs, and Nuts		NB-2580	NC-2580	ND-2580
Certified Material Test Report Criteria		NCA-3860	NCA-3860	NCA-3860

**Table 3.13-2—ASME BPV Code Section XI Examination Categories for
Inservice Inspections of Mechanical Joints in ASME Code Class 1, 2, and 3
Systems that are Secured by Threaded Fasteners**

Code Category	ASME Class 1 Criteria	ASME Class 2 Criteria	ASME Class 3 Criteria
Specific Bolting Inspections	Table IWB-2500-1, Exam. Cat. B-G-1 for bolting greater than 2 inches in diameter	Table IWC-2500-1, Exam. Cat. C-D for bolting greater than 2 inches in diameter	Not Applicable - Currently there are no examination categories that correspond to those that exist for ASME Class 1 and 2 bolting.
	Table IWB-2500-1, Exam. Cat. B-G-2 for bolting less than or equal to 2 inches in diameter		
System Pressure Tests	Table IWB-2500-1, Exam. Cat. B-P	Table IWC-2500-1, Exam. Cat. C-H	Table IWD-2500-1, Exam. Cat. D-B