5.2.3.3.6 *Threaded Fasteners*

DCD Tier 2 Section 5.2.3.6, expands on the discussion in DCD Tier 2 Section 3.13 regarding threaded fasteners in the context of RCPB applications. The staff confirmed that the information provided in DCD Tier 2 Section 5.2.3.6 is consistent with DCD Tier 2 Section 3.13. The staff evaluation of this information is found in Section 3.13 of this SER.

5.2.3.3.7 *Reactor Coolant Chemistry*

It is essential that coolant purity be maintained carefully, since many dissolved species can enhance material corrosion or otherwise damage internal components. One way of meeting this is by having RCS chemical parameters that are consistent with the limiting values presented in the EPRI PWR Primary Water Chemistry Guidelines (here after "EPRI Guidelines"). Although the staff does not formally review or issue a safety evaluation for the various EPRI water chemistry guidelines, these guidelines are recognized as representing the industries' best practices in water chemistry control. Extensive experience in operating reactors has demonstrated that following the EPRI Guidelines minimizes the occurrence of corrosion-related failures. Further, the EPRI Guidelines are periodically revised to reflect evolving knowledge with respect to best practices in chemistry control. Therefore the staff accepts the use of the latest version of the EPRI guidelines as an acceptable basis for reactor coolant chemistry considerations (for example as stated in SRP Section 9.4.3).

The applicant addressed the EPRI guidelines through two COL items. These COL items ensure that the COL applicant references the latest edition of the EPRI guidelines (COL 5.2(5)) and provides threshold values and operator actions for primary water chemistry that are in compliance with the latest version of the EPRI Guidelines (COL 9.3(7)). These COL Items ensure the APR1400 primary water chemistry will conform to the latest EPRI Guidelines and thus will follow industry best practices, and the staff therefore determined that the APR1400 RCS water chemistry values, are acceptable.

fluoride

EPRI Guidelines also specify certain water chemistry concentrations as control parameters, which require strict adherence to limits in order to achieve material protection. In APR1400 DCD Tier 2 Section 5.2.3.2.1, "Reactor Coolant Chemistry," the applicant provided a detailed discussion of the control parameters for dissolved oxygen, ammonia, lithium, dissolved hydrogen, fluoride and sulfate. For each of these chemical species, except Li, the applicant provided limiting values equal to, or more stringent than, the Action Level 2 values from the EPRI Guidelines. (For chloride and ~~fluoride~~ ion concentrations, these values are also mentioned in RG 1.44 as strict limits.) For Li concentration, no exact limits are provided in the EPRI Guidelines, as this component is determined by the pH control. The EPRI Guidelines only state Action Level 1 limits for H_2 and O_2, and ~~DCD Tier 2 Table 5.2-55, "Reactor Coolant Design Specification,"~~ standard values are consistent with, or more stringent than, these limits. The EPRI Guidelines stipulate sampling three times/week for all but sulfate (once/week) and dissolved O (as stipulated in plant TS). However, they note that sampling frequencies may vary and that they will be determined in the plant TS. The staff concluded that the applicant has provided appropriate limits for the RCS water chemistry control parameters since the limits are the same, or more stringent that the limits recommended by the EPRI Guidelines.

EPRI Guidelines specify certain water chemistry parameters as "diagnostic", which do not have mandated limits, but which should nevertheless be monitored as they provide an additional level of protection from corrosion, radiation protection and other failures. These are listed as

DCD Tier 2 Table 5.2-8, "Reactor Coolant Detailed Power Operation Specifications,"

b. The pump and valve IST program.

c. The hydrostatic testing program.

The following sections of the SER document the staff's review of the ISI and testing program. As stated in the introduction, the staff's review of the pump and valve IST program is documented in Section 3.9, "Mechanical Systems and Components," of this SER.

System Boundary Subject to Inspection. The definition of the system boundary subject to inspection is acceptable if it is in agreement with the definition of the RCPB provided in 10 CFR 50.2. Per 10 CFR 50.2, the RCPB includes all pressure-retaining components of boiling and PWRs, such as pressure vessels, piping, pumps, and valves, which are part of the RCS, or connected to the RCS, up to and including any and all of the following: (a) the outermost containment isolation valve in system piping that penetrates the primary reactor containment; (b) the second of two valves normally closed during normal reactor operation in system piping that does not penetrate primary reactor containment; (c) the RCS safety and relief valves. The examination requirements of ASME Section XI, Subsection IWB, apply to all Class 1 pressure retaining components and their welded attachments.

DCD Tier 2 Section 5.2.4.1.1 states that the RPV, pressurizer, primary side of the SG, and associated piping, pumps, valves, bolting, and component supports are subject to inspection. The applicant further stated that all ASME Code Class 1 pressure-retaining components are subject to inspection. The staff confirmed that the applicant appropriately enumerated all components subject to inspection compliant with 10 CFR 50.55a and ASME Section XI.

Arrangement of Systems and Components to Provide Accessibility. The design and arrangement of system components are acceptable if an adequate clearance is provided in accordance with ASME Section XI, Subarticle IWA-1500, "~~ccessibility~~ Accessibility." 10 CFR 50.55a(g)(3)(i) requires Class 1 components, including supports, to be designed and be provided with access to enable the performance of inservice examination of these components, in addition to meeting the preservice examination requirements set forth in the editions and addenda of Section III or XI of the ASME Code of record.

DCD Section 5.2.4.1.2 states that the layout and arrangement of the APR1400 plant provides adequate working space and access for inspection, maintenance, and repair of the Class 1 components of the RCPB in accordance with ASME Section XI, Subarticle IWA-1500. The applicant also stated that all Class 1 components shall be designed for and provided with access to enable the performance of ASME Section XI inspections in the installed condition. The applicant also described the provisions provided in the APR1400 design to allow access for to perform the required examinations of the RPV, reactor coolant piping, RCPs, the pressurizer, the SGs, and other RCPB components. In addition, the application states that provisions are made for removable insulation, removable shielding, the installation of handling machinery, adequate personnel and equipment access space, and laydown space for all temporarily removed or serviced components. Storage space for the removable insulation panels is also provided as well as working room adjacent to each piping system weld to allow for manual examination. Relevant to this, DCD Tier 2 Section 5.2.4.1, states that dissimilar metal welds and austenitic welds in piping will be examined from both sides. It is further stated that when ultrasonic examination from both sides is not possible, then single-sided ultrasonic examination will be performed in accordance with ASME Section XI, Appendix VIII. The staff determined that the applicant's approach is acceptable because it is in accordance with ASME Section XI.

approximately 350 °F (176.7 °C) and 450 psia (31.6 kg/cm2A). Also, the SCS is operated while the plant is shutdown during reduced inventory, such as mid-loop operation. Additionally, the SCS is used to cooldown the RCS following a small break LOCA (SBLOCA) (refer to Section 6.3). The SCS is designed with two independent trains that can operate in both single and two loop operation. Each train has its own suction and discharge connections to the RCS.

This section of the DCD describes the design basis, system operation, instrumentation and testing requirements of the SCS. DCD Tier 2 Section 6.3, "Emergency Core Cooling System," provides additional information of the SCS as it relates to the interface with the ~~SIT~~. SIS

5.4.7.2 *Summary of Application*

After the reactor coolant temperature and pressure have been reduced to below their designed values for SCS operation, as shown in the table below, the SCS is placed into shutdown cooling service to maintain or reduce the RCS temperature to the temperature defined by the SCS mode of operation: (1) Normal Shutdown, (2) Safety Shutdown, and (3) Refueling Shutdown. In the safety shutdown mode, the SCS will be used for accidents such as SBLOCA, steam and feedwater line breaks, and SG tube ruptures. In addition, the SCS is used for plant heatup operations that bring the RCS from cold shutdown to hot standby. The SCS operational modes are summarized in the table below with approximate initial and final reactor conditions.

Mode Of Operation	**Initial Conditions**			**Final Conditions**		
	Pressure (kg/cm2A) / (psia)	**Temperature (°C) / (°F)**	**Flow Rate (L/min) & (gpm)**	**Time After Shutdown (Hours)**	**Temperature (°C) / (°F)**	**Trains In Service**
Normal S/D	31.6 / 450	~176.7 / ~350	18,927 / (5,000)	24 40	60 / 140 54.4 / 130	2 2
Safety S/D	28.1 / 400	~193.3 / ~380	18,927 / (5,000)	24	93.3 / 200	1
Refueling			18,927 / (5,000)	96	~48.9 / ~120	2
Startup	Variable	Variable	18,927 / (5,000)	Pressure: 31.6 kg/cm^2A / 450 psia	176.7 / 350	2

Prior to fuel loading, the SCS configuration and component operational performance is verified through a series of inspections, tests, and analyses whereupon the results are compared against the acceptance criteria as identified in DCD Tier 1 Section 2.4.4, "Shutdown Cooling System," Table 2.4.4-4, "Shutdown Cooling System ITAAC." During the initial startup following basis demonstrating why the use of such a criteria will provide for an acceptable level of safety against flywheel failure. The staff issued follow-up RAI 503-8641, Question 05.04.01.01-9 (ML16188A055), requesting the applicant to revise the APR1400 DC to apply a RCP flywheel stress limit of one-third of the yield strength of the material, or provide a technical justification regarding why the use of one-third of the ultimate strength as the design stress limit will provide an acceptable level of safety against potential failure of the flywheels. Examples of an acceptable approach discussed in the June 29, 2016, public meeting included specifying a yield strength of 800 N/mm^2 (116 ksi) that was in original flywheel analysis (dated August 13, 2014) in lieu of the current specified yield strength of 640 N/mm^2 (92.825 ksi) or providing sufficient analytical basis to demonstrate that the change in the probability of creating a missile by using ultimate strength as the design stress limit, in lieu of the yield strength, is small. The staff issued follow-up RAI 503-8641, Question 05.04.01.01-9 (ML16188A055), requesting the applicant to address this issue. If the use of the one-third ultimate strength criteria is to be justified, as noted above, the acceptance criteria in the APR1400-A-M-NR-14001, "KHNP APR1400 Flywheel Integrity Report," Revision 0, dated November 24, 2014, needs to be revised. Therefore, RAI 503-8641, Question 05.04.01.01-9, was being tracked as an open item.

In its responses to RAI 503-8641, Question 05.04.01.01-9(ML17233A366 and ML17240A437), the applicant stated thatAPR1400-A-M-NR-14001, was revised to apply a flywheel stress limit of one-third of the material's yield strength, which is 640 N/mm^2 (92.825 ksi), which supersedes the previous RAI response (ML16256A805). In addition, in its revised response to RAI 503-8641, Question 05.04.01.01-9 (ML17240A437), the applicant revised APR1400 DCD, Section 5.4.18 to include Revision 3 of APR1400-A-M-NR-14001, issued July 2017, which supersedes Revision 0 of APR1400-A-M-NR-14001, dated November 24, 2014. Upon reviewing Revision 3 of APR1400-A-M-NR-14001, issued July 2017, the staff notes that the design specification for the flywheel was modified by optimizing the shrink-fit stresses to meet the normal operating stress limit of one-third of yield strength. Based on this redesign, APR1400-A-M-NR-14001 was modified extensively to demonstrate that the design stress of the flywheel at design speed does not exceed one-third of the yield strength of the material, consistent with Section 5.4.1.1 of NUREG-0800. The staff found APR1400-A-M-NR-14001, Revision 3, issued July 2017, which was submitted by the applicant in its letter dated August 28, 2017, acceptable and is discussed below. Therefore, RAI 503-~~8640~~ 8641, Question 05.04.01.01-9, is resolved and closed.

Revision 3 of APR1400-A-M-NR-14001, issued July 2017, specified that the design specification was revised to optimize the shrink-fit stresses, deleted the requirement of total stresses at joint release since it is not applicable, and used yield strength of the material as the design stress limit in lieu of the ultimate strength of the flywheel material. The staff verified that the calculated stresses of the flywheel during normal operating conditions are below one-third of the yield strength, and that the stresses during design overspeed conditions are less than the two-thirds of the yield strength of the flywheel material.

For the ductile fracture analysis, APR1400-A-M-NR-14001, Revision 3, uses the elastic stress analysis method of the ASME Code, Section III, Article F-1330 to predict the critical speed based on the ductile fracture of the flywheel. The ASME Code states that the stress limits for the general primary membrane stress intensity should be equal to 0.7 of the minimum specified ultimate tensile strength of the flywheel material. The staff verified that the minimum calculated limiting speed (2748 rpm) assuming a 13 mm (0.50-inch) crack is at least twice the normal operating speed (1200 rpm). The staff determined that the critical speed for ductile fracture meets the criterion in RG 1.14. In addition, the staff confirmed that the critical speed for ductile fracture (2748 rpm) is greater than the LOCA overspeed of 1500 rpm. Therefore, the staff pressurization downstream of the low pressure system. The staff concludes that the charging line pathway pressure detection and manual isolation terminates a potential ISLOCA transient. .

Therefore, the staff finds the design response to this pathway satisfies the ISLOCA acceptance criteria in Section 5.A(C) of this SER based on the following:

- System integrity is preserved since the portion of the ~~letdown~~ charging line pressurized by the ISLOCA is designed to full RCS design pressure.

- The ~~letdown line downstream of the letdown control valves~~ charging line upstream of the charging pumps and all other downstream interfacing systems are designed to be protected from an ISLOCA by manual action of the isolation valves. Therefore, the low pressure systems integrity is ensured.

- The RCS pressurization pathway is isolated, which prevents primary coolant loss and no increase in offsite dose.

The staff reviewed the impact of the difference between the letdown line and the charging line. In the letdown line, the pressurization pathway is in the direction of normal flow. Therefore, the "letdown line has been designed to reduce and control the fluid pressure under normal and ISLOCA operating conditions." Besides isolation, a backup relief valve is provided which is sized to provide reasonable assurance that the design pressure, in the low pressure sections, is not exceeded. However, for the charging line, the pressurization pathway direction in the charging line is opposite to the flow. To remedy this condition, the charging line has three check valves in series to prevent overpressurization of the CVCS. This check valve configuration has a high probability of not failing when the charging pump and auxiliary charging pump (ACP) are not in operation. The applicant noted that a pressure indicator upstream of the charging pumps provides MCR indication upon sensing high pressure to initiate an operator manual isolation of the charging line by the containment isolation valves. To further improve over-pressurization protection, the applicant stated that there will be installed relief valves "in the volume control tank [VCT] discharge line, charging pump mini-flow line, charging pump discharge line, and ACP discharge line." The staff determined that this pathway configuration is acceptable because it is consistent with the guidance in SECY-90-016, meets the ISLOCA acceptance criteria in Section 5.A(C) of this SER, and additional relief valves provide additional assurance that the design pressure, in the low pressure sections, is not exceeded.

Reactor Coolant Pump Seal Injection Line

The seal injection line is a primary pathway system connected directly to the RCS through which an ISLOCA event can start. Pressurization is composed of two separate pathways: (1) from the charging nozzle through the shell side of the regenerative HX to the seal injection line and (2) from the RCP seals through the tube side of the high pressure seal cooler to the discharge side of the charging pump. As noted in Table 5A-1 of this SER, the applicant identified the boron recovery system and atmospheric system as low-pressure interfacing systems with RCP seal injection line which presents a potential over-pressurization transient event.

The design pressure of the seal injection line is 212.7 kg/cm^{2}G (3,025 psig), which is greater than normal RCS pressure. Therefore, the staff finds that the seal injection line meets the acceptance criteria in Section 5.A(C) of this SER