MCB Issue List for APR1400 Section 5.4.2.1

Issue #1

Final Safety Analysis Report (FSAR) Section 5.4.2 refers to no cavitation in steam generators that are "identical to the APR 1400 steam generators." The ability to meet Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix G, General Design Criteria (GDC) 14, 15, 31, and 32 for steam generator tubes is based, in part, on an understanding of operating experience with degradation mechanisms.

Provide more information about degradation from cavitation in steam generators and operating experience with the APR1400 design.

a. Where are the identical steam generators in operation?
b. What is the operating experience with respect to cavitation?
c. What is the operating experience with other degradation mechanisms?
d. Is the documentation of this experience available to the NRC staff?

Response

a. Based on the design concept and configuration of the reactor coolant system, the steam generators of the APR1400 are almost the same as the OPR1000's. Therefore, Section 5.4.2.1 will be revised as follows:

   From - "No cavitation has been reported to date in steam generators that are identical to the APR1400 steam generator"
   To - "No cavitation has been reported to date in the OPR1000 steam generators which are almost the same in the design concept and configuration to the APR1400 steam generators."

b. There has been no cavitation degradation in steam generators of the OPR 1000 plants. It is unlikely to occur because the primary side operating pressure (2250 psi) is much higher than the saturation pressure (1723 psi @ 615°F) inside the steam generator tubes and the secondary side flow path is smooth.

c. There are no other degradation mechanisms experienced in the components of the steam generators of the OPR 1000 plants except for the steam generator tubes. For the tubes, the OPR1000 steam generators have experienced PWSCC, ODSCC, and wear. However, SCCs would not be of further concern for the APR1400 steam generator tubes because the tubes are fabricated with Alloy 690. Wear would also not be an impacting degradation mechanism because there has been a design modification to the steam generator internals to mitigate the wear. The number of affected tubes due to wear in recently built OPR1000 plants has been reduced dramatically after the design change (See the response to issue 6).

d. There is no documentation of cavitation experience. For the tubes, the OPR1000 steam generators experience PWSCC, ODSCC, and wear. The staff may review the ISI examination results for the steam generator tubes of the OPR1000 plants.

Issue #2

FSAR Section 5.4.2 has a short paragraph on degradation mechanisms and states that pinholes in tubes and cracks in tubes and tube-to-tubesheet welds are "the more probable modes of tube failure." Industry experience in the U.S. with Alloy 690 tubing is that wear is the predominant degradation mechanism, and no cracking has been observed. A small pinhole leak occurred in one SG as the result of damage from packaging and shipping (NRC Information Notice 2004-16).

Revise FSAR Section 5.4.2 to provide additional justification for the assertion regarding the "more probable modes of tube failure." This additional justification should address:

a. The operating experience with pinhole leaks and small cracks in tubes and tubesheet welds, including any "failures" that occurred.

b. Why these mechanisms are considered "more probable" than wear and other mechanisms.

c. How the materials, design, and inspection of the APR 1400 steam generators address this degradation.

Response

a. There has been no experience with pinhole leaks and small cracks in Alloy 690 steam generator tubes and tubesheet welds in nuclear power plants in Korea. The only degradation found for Alloy 690 tubes is wear.

b. The definition of "more probable modes" in the fifth paragraph of FSAR 5.4.2 will be modified by adding wear, because the OPR1000 steam generators with Alloy 600 have experienced PWSCC, ODSCC, and wear. The revised sentence of the FSAR 5.4.2 will be:

   "The more probable modes of tube failure, which may result in break areas, are the results from involving the occurrence of pinholes, small cracks or wear in the tubes and of cracks in the seal welds between the tubes and tubesheet."

c. The following process and examinations for steam generator tube fabrications will address the more probable modes of tube failure in APR 1400.

   Tubes are made of Alloy 690, and their tube to tubesheet welds are produced with Alloy 152/52/52M. Those materials are resistant to the various degradations due to corrosion. For the concern of wear, the steam generator design of the APR1400 has been modified to address this issue. (Please see the response to the issue 6 for the design changes against wear.)

During the tube fabrication, all the tubes are examined by UT (Ultrasonic Test) and ECT (Eddy Current Test) in accordance with ASME B&PV Code Section III NB-2550 ("Examination and Repair of Seamless and Welded Tubular Products and Fittings"). In addition, inservice inspection type and signal to noise ECT are performed. Also, all the tubes are visually and tactilely inspected to detect surface flaws.

There is a procedure to prevent the tube damage during packing and transportation. In general, tubes with different row numbers are separated by vertical plywood spacers wrapped with a polyethylene sleeve. In each row, tubes are prevented from contacting each other by using polyethylene clips. Tube load vertical locking is assured by a foam type spacer (Polyethylene) inserted into a space between the upper tube and the wooden spacer of the comb fixture.

After the tube expansion and tube-to-tubesheet seal weld in the steam generator manufacturing, all the tubes are inspected by profilometry ECT through the tubesheet thickness (including tube expansion, transition, and unexpanded zone) and examined by liquid penetrant method for seal weld joints to ensure the integrity of tube and seal weld. The requirement for liquid penetrant test is free of any indication.

During the operation, all tubes are inspected by bobbin ECT in accordance with ISI program.

Issue #3

For compliance with 10 CFR Part 50, Appendix A, GDC 1, GDC 30, and 10 CFR 50.55a, the materials used for the steam generators are acceptable if they are selected, fabricated, tested and inspected (during fabrication and manufacturing) in accordance with the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code). FSAR Section 5.4.2.1 is unclear about processing, testing and inspection of materials used for the steam generator Class 1 and Class 2 pressure boundaries (other than cladding).

Revise the text of FSAR Section 5.4.2.1 to identify that the selection, fabrication, testing, and inspection of all steam generator pressure boundary materials will meet the ASME Code requirements. Subsection 5.4.2.1 should also identify the FSAR Subsections that address these topics.

Following sentence will be added at the end of the first paragraph of FSAR 5.4.2.1.1.

"The selection, fabrication, testing, and inspection of all steam generator pressure boundary materials meet the applicable ASME Code requirements as described in FSAR Section 5.2.3."

Issue #4

The cladding on the primary side of the tubesheet is listed in FSAR Table 5.2-2 as "weld deposited NiCrFe alloy." This material will form part of the reactor coolant pressure boundary since it is joined to the steam generator tube ends. Therefore, the selection, processing, fabrication, and testing of this cladding must meet the requirements of 10 CFR Part 50, Appendix A, GDC 1, GDC 30, and 10 CFR 50.55a.

Revise FSAR Table 5.2-2 to identify the specific cladding alloy (or alloys). In addition, revise FSAR Table 5.2-2 to provide the thickness of the cladding and the total thickness of the tubesheet and cladding.

Response

The cladding materials of tubesheet primary side are Ni-Cr-Fe alloys, whose material specifications are SFA-5.11 [ENiCrFe-7] and SFA-5.14 [ERNiCrFe-7(A), EQNiCrFe-7(A)]. The cladding materials of primary head, stay, and nozzles are stainless steels, whose material specifications are SFA-5.4 [E309L-16, E308L-16], SFA-5.9 [ER309L, ER308L, EQ309L, EQ308L], and SFA-5.22 [E309LT1-1, E308LT1-1].

The thickness of tubesheet cladding and base metal is 0.19 inch and 25.5 inches (minimum), respectively. Therefore, the total thickness of the tubesheet and cladding is 26.69 inches (minimum).

The Table 5.2-2 (2 of 5) of FSAR will be revised to identify the specific cladding material specifications for tubesheet cladding materials of the steam generator. "Tubesheet cladding" row in Table 5.2-2 (2 of 5) will be revised as follows:

From - "Weld-deposited NiCrFe alloy"

To - "SFA-5.11 [ENiCrFe-7] and SFA-5.14 [ERNiCrFe-7(A), EQNiCrFe-7(A)]"

Also, the tubesheet thickness will be added at the end of last paragraph of FSAR 5.4.2.1.1 as follows:

"The thickness of tubesheet cladding and base metal is 0.19 inch and 25.4 inches (minimum), respectively."

Issue #5

The staff does not have a clear understanding of how the design meets 10 CFR Part 50, Appendix A, GDC 14, GDC 15, and GDC 31 with respect to the use of austenitic stainless steel for the steam generators. FSAR Table 5.2-2 lists weld-deposited austenitic stainless steel as one option for the primary head cladding. However, FSAR Subsections 5.4.2.1.1 and 5.4.2.1.4 suggest there could be other applications for austenitic stainless steel.

Revise the FSAR Section 5.4.2.1 to clarify how austenitic stainless steel is used for the steam generators, and identify where it is used for the Class 1 or Class 2 pressure boundary.

Response

There is no austenitic stainless steel used for the primary and secondary side pressure boundary of steam generator in APR 1400. The following sentence will be added at the end of the last paragraph of FSAR 5.4.2.1.1 as follows:

"There is no austenitic stainless steel that is used for the primary and secondary side pressure boundary of steam generators of APR 1400."

Issue #6

The discussion of tube supports in FSAR Subsection 5.4.2.1.2.2 states that this design has been proven to reduce wear in operating reactors.

Revise FSAR Subsection 5.4.2.1.2.2 to provide additional justification for the assertion. If it is based on operating experience outside the United States, provide information on this foreign operating experience to facilitate the staff's review.

Response

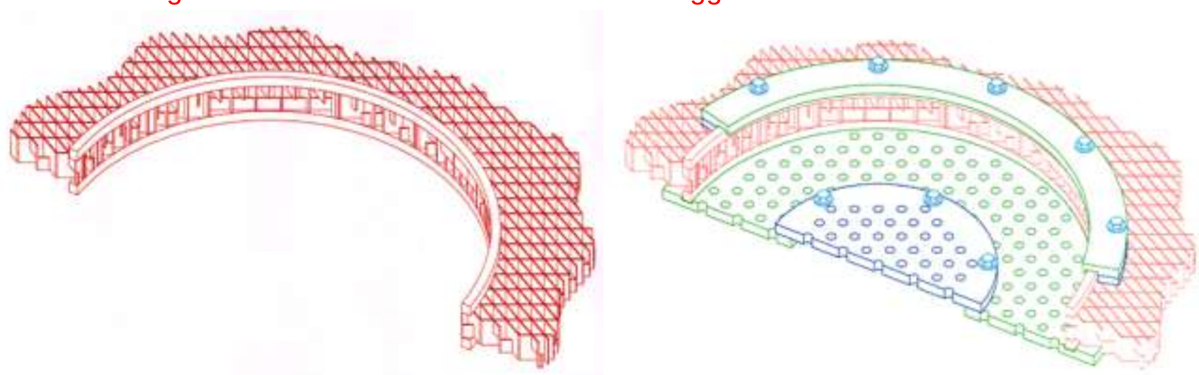
Eggcrate flow distribution plate (EFDP) has been adopted to mitigate the concentrated flow into the central cavity region so as to reduce the localized wear. Up until Han-bit NPP Units 5&6 (OPR1000), there had been no EFDP. Han-ul NPP Units 5&6 (OPR1000) is the first of a kind steam generator to be equipped with the EFDP.

Figure-1 shows the schematics before and after the installation of EFDP.

Comparison of tube wear status at U-bend region between those NPPs provides an additional justification how the EFDP design reduces the tube wear at the central cavity region effectively. Tables 1 & 2 summarize the tube wear status (number of indications and number of tubes with indications) at U-bend region of Han-bit Units 5&6 and Han-ul Units 5&6 based on the recent eddy current test (ECT) results performed during their 6th in-service inspection (ISI).

For the APR1400 steam generator, thermal-hydraulic analysis had been performed to investigate the optimum number of EFDPs to be installed. Figure-2 presents the axial mass flux at the central cavity region according to the number of EFDPs for OPR1000 and APR1400 steam generators. There is no such benefit to have two or more EFDPs. Thus, there is one EFDP at the uppermost full eggcrate for APR1400 steam generator.

Figure-1. Before and After Installation of Eggcrate Flow Distribution Plate



[Before Installation of EFDP] [After Installation of EFDP]

Figure-2. Axial Mass Flux of OPR1000 and APR1400 SG according to Number of EFDPs

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Table-1. Tube Wear Status at U-bend Region of Han-bit Units 5&6[1]

Table-2. Tube Wear Status at U-Bend Region of Han-ul Units 5&6[1]

TS

The statement in Subsection 5.4.2.1.2.2 will be revised as follows:

One set of eggcrate flow distribution plate is installed at the full eggcrate of steam generator to prevent the secondary-side flow from concentrating into central cavity. This design has been proven to effectively reduce localized wear since having been applied to previous nuclear power plants. The flow distribution plate is fixed onto the square-section ring in the full eggcrate with retainer ring segment and hexagon head cap screws. The cover plate is provided in the center of the flow distribution plate for manufacturing process. Lock washers and initial preloads for the cap screws are applied.

[Add] The operating experiences related to the tube wear status at Korean Nuclear Power Plants provide a justification for the assertion.

Steam Generator Tubes ar

Issue #7

FSAR Subsection 5.4.2.1.2.2 has a topic called, “Tube Fastening to Tubesheet,” which states that the fastening methods, “conform to the requirements of ASME Code Sections III and XI.” It describes expansion of the tube into the tubesheet but does not describe the requirements for welding the tube end to the tubesheet cladding.

Revise FSAR Subsection 5.4.2.1.2.2 to state that the welds joining the tube ends to the tubesheet cladding are structural welds that meet all of the requirements of Section NB-3200 of the Section III of the ASME Code.

Response

According to Subsection 5.4.2.1.2.2, tube fastening to tubesheet conforms to the requirements of ASME Code Sections III and IX. The joint classification will be added as follows:

To limit the susceptibility of steam generator tubes to corrosion and to optimize the corrosion resistance of the microstructure, the APR1400 steam generator tubes are made of NiCrFe Alloy 690 that is thermally treated (TT). To reduce residual stresses in the U-bent region of short-radius (less than or equal to 279.4 mm [11 in]) U-bent tubes, the U-bent region of short-radius tubes is stress-relieved after bending. The materials that support the tubes and other materials on the secondary side, such as flow distribution plate and eggcrate flow distribution plate, are stainless steels that are sufficiently resistant to degradation to provide reasonable assurance that the tubes will remain adequately supported and to reduce the potential for the generation of loose parts, which can result in loss of tube integrity.

The tubes are seal welded to the tubesheet cladding after the primary side of the tubesheet is weld clad with nickel−chromium−iron alloy. These fusion welds comply with Sections III and IX of the ASME Code. The tube−to−tubesheet weld is designed to satisfy the allowable limits described in NB−3200 of the Section III of the ASME Code.

Tube Fastening to Tubesheet

The method of fastening tubes to the tubesheet conforms to the requirements of ASME Sections III and IX. Tube expansion into the tubesheet is such that no voids or crevices occur along the length of the tube in the tubesheet. The tube is expanded into the

Issue #8

To meet the requirements of 10 CFR Part 50, Appendix A, GDC 14, GDC 15, and GDC 31 with respect to steam generator design, the design should limit the potential for tube degradation and thermal treatment for stress relief of "tight-radius" tube U-bends should be performed. The discussion of "Steam Generator Tubes and other Secondary Non-Pressure Boundary Material," in FSAR Subsection 5.4.2.1.2.2, states that for the APR 1400 this applies to tubes with a bend radius of less than or equal to 11 inches. The figures in FSAR Section 5.4.2 indicate that most of the tubes are square-bends rather than U-bends, so it is unclear how the stated 11 inch bend radius limit applies.

Revise FSAR Section 5.4.2.1.2.2 to clearly explain which rows of steam generator tubes are U-bends, which rows are square-bends, and which rows are thermally treated for stress relief.

Response

The following paragraph about steam generator tube bending and thermal treatment for stress relief will be added at the end of first paragraph of FSAR Section 5.4.2.1.2.2:

> "There are 13,102 tubes installed in an APR1400 steam generator. Tube bundle has 175 rows and 207 lines (columns). Tubes in row number 1 through 17 are U-bends and tubes in row number 18 through 175 are square-bends. Maximum bend radius of U-bend tube is 11 inches for row number 17. The bend radius of all square-bend tubes is 10 inches. All the U-bend tubes (row number 1 through 17) are thermally treated for stress relief."

Issue #9

FSAR Subsection 5.4.2.1.2.2 states, "One set of eggcrate flow distribution plate is installed at the full eggcrate of steam generator to prevent the secondary-side flow from concentrating into central cavity." In Figure 5.4.2-1, the flow distribution plate (FDP) appears to be the central portion of the uppermost full eggcrate support. If this is correct, it is not clear how this eggcrate FDP is different than the rest of the eggcrate at that level. It is also unclear whether tubes pass through the FDP, or only fluid passes through the FDP.

Revise the statement above from FSAR Subsection 5.4.2.1.2.2 to explain the function of the eggcrate FDP and how the design is different than the rest of the eggcrate at that level.

Response

Eggcrate flow distribution plate (EFDP) has been adopted to mitigate the concentrated flow into the central cavity region installed at the uppermost full eggcrate. The EFDP is a stainless steel (SA-240 Type 405) perforated plate with Φ0.75 inch circular flow holes in a triangular array (the pitch is 1.875 inches). No tubes pass through the EFDP and only secondary side fluid passes through the EFDP. The eggcrates (including the one at that level) are composed of strips intersecting at an angle of 60 degrees as shown in Figure 5.4.2-4 in the DCD Tier 2.

TS

The statement in Subsection 5.4.2.1.2.2 will be revised as follows:

[Add] uppermost

mitigate

t of eggcrate flow distribution plate is installed at the full eggcrate of steam generator to ~~prevent~~ the secondary-side flow from concentrating into central cavity. This design has been proven to effectively reduce localized wear since having been applied to previous nuclear power plants. The flow distribution plate is fixed onto the square-section

[Add] eggcrate

full ~~eggcrate~~ with retainer ring segment and hexagon head cap screws. The cover plate is provided in the center of the flow distribution plate for manufacturing process. Lock w

[Add] eggcrate

loads for the cap screws are applied.

Steam Gen

[Add] Eggcrate flow distribution plate is a stainless steel perforated plate with circular flow holes. No tubes pass through the eggcrate flow distribution plate and only secondary side fluid passes through the eggcrate flow distribution plate.

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Issue #10

In order for the staff to evaluate the effect of design features on tube integrity, revise FSAR Section 5.4.2.1 to describe the SG tube pattern and spacing.

Response

The statement in Section 5.4.2.1 will be revised as follows:

The steam generator tube material is thermally treated NiCrFe Alloy 690 (ASME SB-163). The outside diameter is 19.05 mm (0.75 in) with 1.0668 mm (0.042 in) nominal wall thickness. An analysis is performed to establish the maximum allowable tube wall degradation for the steam generator tubes in accordance with the requirements of NRC RG 1.121 (Reference 8). Load conditions considered are maximum tube differential pressures during normal operation and faulted load conditions. The margin of safety against tube rupture under normal operating condition is not less than 3.0, and the margin of safety agair

[Add] Straight portion of tube is triangular array with 25.4 mm (1.00 in) pitch. U−bend portion of tube is rotated square array with 31.27 mm (1.231 in) pitch.

stean

margin of safety determined by the stress limits specified in the ASME Code.

Please note that the tube array and pitch for OPR1000 and APR1400 steam generators are identical.

Issue #11

Compliance with ASME Code Section III (NB-2160, NB-3121, NC-2160, and NC-3121) requires an appropriate allowance for corrosion and other forms of degradation. FSAR Subsection 5.4.2.1.2.2 states that the corrosion allowance for carbon and low alloy steels is 1/16 inch and that other materials have "sufficiently high corrosion resistance."

Revise FSAR Subsection 5.4.2.1.2.2. to explain the meaning of "sufficiently high corrosion resistance," identify the corrosion allowance for the materials deemed to have "sufficiently high corrosion resistance," and provide the basis for the corrosion allowance specified for each of these materials for the design life of the plant.

Response

The water contacting materials of construction for primary-side and secondary side components of the APR1400 steam generator include: 1) austenitic stainless steel cladding, Alloy 690 base metal and Alloy 52(M)/ 152 weld metals (divider bar, its welds, and tubesheet cladding) and martensitic stainless steel type 410S (divider plate) for primary-side components, and 2) low alloy steel (shells, large diameter nozzles, etc.), ferritic stainless steels, types 409 (tube supports) and type 405 (flow distribution plate), carbon steel (top head, large diameter safe ends), and Alloy 690 (tubes and small nozzles) for secondary-side components.

According to the experiments done by Combustion Engineering[1)], the following general corrosion rates were determined after exposure to AVT chemistry faulted with concentrated, acidified fresh water for 249 days:

For type 347 stainless steel: 0.013 - 0.048 mils per year (mpy)
For type 405 and 409 ferritic stainless steel: 0.028 - 0.061 mpy
For 1010 carbon steel: 0.135 - 0.524 mpy
For A508 class 2 low ally steel: 0.122 - 0.380 mpy

For primary water condition with or without zinc, the following general corrosion rates were determined by the Westinghouse[2)]:

Approximate Corrosion Rate at 3.5 Months (mg/dm^2/mo (MDM))

Material	Corrosion	
	with Zn	without Zn
304SS	1.1	3.5
316SS	1.3	3.5
600MA	1.5	2.6
600TT	0.5	2.1
690TT	0.2	1.3

1mdm ≈ 5×10^{-4} mpy

That is, for primary water conditions, the severity of general corrosion is austenitic stainless steel > Alloy 600 > Alloy 690.

The general corrosion rate is more sever in the secondary-side rather than in the primary side from the above experimental data. The highest corrosion rate of stainless steels in the secondary-side low level faulted condition is only 0.061 mpy (3.7 mils or 0.1 mm for 60 years). Also, Alloy 690 is more corrosion resistant than stainless steels. Therefore, the 300 and 400-series stainless steels and Alloy 690 have sufficiently high corrosion resistance and general corrosion is not a concern.

For carbon steels and low alloy steels, the corrosion allowance of 1.0 mpy is reasonable because the highest corrosion rate is 0.524 mpy in the secondary-side low level faulted condition. Thus, an overall corrosion allowance of 1/16 inch (62.5 mils) will be sufficient for the 60 year design life of the APR1400 steam generator.

Note: 1. J.J. Krupowicz, “Corrosion of Support Materials”, paper presented to the EPRI proceedings (EPRI NP-2791, Proceedings: Support-Structure Corrosion in Steam Generator),” Jan. 1983, page 2-7.
2. J.N. Esposito, et al., “The Addition of Zinc to Primary Reactor Coolant for Enhanced PWSCC Resistance,” paper presented at the symposium (International Symposium on Environmental Degradation of Materials in Nuclear Power Systems- Water Reactors),” 1991, page 497.

Issue #12

The paragraph on “Tube Supports” in FSAR Subsection 5.4.2.1.2.2 states that the tube supports contact the tubes with a flat surface except for the flow distribution plate above the economizer section entrance. The method of contact with the tubes is important with respect to 10 CFR Part 50, Appendix A, GDC 14, 15, and 31 because of the potential for mechanical and chemical effects on tube integrity.

Revise FSAR Subsection 5.4.2.1.2.2 to describe how the flow distribution plate contacts the tubes.

Response
The statement in Subsection 5.4.2.1.2.2 will be revised as follows:

Tube Supports

[Add] Flow distribution plate is a stainless steel perforated plate with circular flow holes, where the tube and secondary side fluid pass. The diameter of flow hole is 19.685 mm (0.775 in).

The three types of structures in the APR1400 steam generators that support the tubes are horizontal grid or eggcrate, vertical, and diagonal. All three types are fabricated from Stainless Steel Type 409. A design consideration for the supports is the prevention of dryout at support locations. With one exception, all tube supports in the APR1400 steam generator are constructed of flat strips that present a flat surface to the tube. The exception is the flow distribution plate just above the entrance to the economizer section of the tube bundle. At this location, secondary water is subcooled, and dryout will therefore not occur.

Fabrication and Processing of Ferritic Materials

Issue #13

To meet the requirements of 10 CFR Part 50, Appendix A, GDC 14, 15, and 31, the ferritic materials used to form the primary and secondary pressure boundaries must: (1) comply with Appendix G to 10 CFR Part 50, 10 CFR 50.55a(c), (d), and (e), and (2) follow the provisions of Appendix G to Section III of the ASME Code. For Class 1 and Class 2 steam generator components, the regulations cited above require the use of Section III of the ASME Code. Article NB-2300, Article NC-2300, and Appendix G of Section III of the ASME Code address fracture toughness requirements for Class 1 and Class 2 components. FSAR Subsection 5.4.2.1.3 states that Class 1 components meet the fracture toughness requirements of the ASME Code but does not address Class 2 components.

Revise FSAR Subsection 5.4.2.1.3 to state the requirements for both Class 1 and Class 2 components. This can be accomplished with a reference to FSAR Subsection 5.2.3.3 with additional information to address the requirements for the Class 2 steam generator components.

Response

Tier 1, page 2.4-6 defines the ASME Section III Class used for designing APR1400 RCS Components. The Safety Class in Table 3.2-1 in Tier 2 shows the Safety Class that ASME requires in designing Nuclear Power Plants. In the APR1400, the steam generators are entirely designed in accordance with ASME Section III Class 1.

The pressure boundary components of the APR1400 steam generators are entirely ASME Section III Class 1 components even though the secondary side of the steam generator is classified as Safety Class 2 (See Tier 1, Page 2.4-6 and Tier 2, Table 3.2-1). Therefore, for clarification, the first sentence of Subsection “Fracture Toughness” of FSAR Section 5.4.2.1.3 will be revised as follows:

"The primary and secondary side pressure boundary components of the steam generator meet the fracture toughness requirements of the ASME Code, Section III NB."

Issue #14

To meet the requirements of 10 CFR Part 50, Appendix A, GDC 1, welding of ferritic Class 1 and Class 2 pressure-boundary steam generator components must comply with 10 CFR 50.55a(c), (d), and (e). FSAR Subsection 5.4.2.1.3 lists appropriate Regulatory Guides (RGs) and refers to Subsection 5.2.3.3 for welding controls; however, Subsection 5.2.3.3 states that the requirements are for reactor coolant pressure boundary components (Class 1) only.

Revise FSAR Subsection 5.4.2.1 to state that the welding requirements for ferritic Class 1 components described in Subsection 5.2.3 also apply to Class 2 steam generator components or revise FSAR Subsection 5.4.2.1 to identify specific welding requirements for ferritic Class 2 components.

FSAR Subsection 5.4.2.1 does not list conformance with RG 1.34, "Control of Electroslag Weld Properties," nor does this subsection state that electroslag welding is not used for the steam generator Class 2 components. Revise Subsection 5.4.2.1 to, (a) state that electroslag welding is not used for steam generator components, or, (b) state that electroslag welding conforms to the guidance in RG 1.34.

Response

Regarding welding requirements, there is no difference in the application of the ASME Code and/or regulatory requirements between the primary and secondary side pressure boundary components of the APR1400 steam generator. Therefore, the following sentence will be added in front of the first sentence of Subsection "Welding" of FSAR Section 5.4.2.1.3:

"The primary and secondary side pressure boundary components of the steam generator meet the welding requirements as described in Subsection 5.2.3.3.

Electroslag welding (ESW) is not used in the primary or secondary side pressure boundary components of the steam generator"

Issue #15

Controls are needed in the fabrication and processing of austenitic stainless steel Class 1 and Class 2 pressure boundary components in order to meet 10 CFR Part 50, Appendix A, GDC 14, GDC 15, and GDC 31. FSAR Subsection 5.4.2.1.4 provides these requirements. However, the staff notes that since this topic is complex and addressed elsewhere in the FSAR, it would be appropriate to remove the details from FSAR Subsection 5.4.2.1.4 and refer to Subsection

5.2.3.4. The staff will address the documentation of controls on the fabrication and processing of austenitic stainless steel materials further in its Issue List for FSAR Section 5.2.3.

Revise FSAR Section 5.4.2.1.4 to delete statements regarding controls on the fabrication and processing of austenitic stainless steel materials and instead insert a reference to FSAR Section 5.2.3.4.

Response

The fabrication and processing requirements for austenitic stainless steel materials described in FSAR Section 5.4.2.1.4 are the same as those of FSAR Section 5.2.3.4. The statements regarding controls on the fabrication and processing of austenitic stainless steel materials will be deleted and replaced with the following sentence in FSAR 5.4.2.1.4, Fabrication and Processing of Ferritic Materials.

> "The austenitic stainless steel materials that form the primary and secondary side pressure boundary of the steam generator, if any, meet the fabrication and processing requirements as described in Subsection 5.2.3.4."

Issue #16

The steam generator components that form the reactor coolant pressure boundary (RCPB) and the supporting structural components must be compatible with the reactor coolant and secondary coolant in order to meet the requirements of 10 CFR Part 50, Appendix A, GDC 4. However, FSAR Subsection 5.4.2.1.5 addresses only the secondary water chemistry.

Revise FSAR Subsection 5.4.2.1.5 to include a description of primary water chemistry and compatibility with the steam generator materials, or include a reference to a section in which this is addressed.

For the description of the primary water chemistry of the steam generator, the following sentence will be incorporated into the FSAR 5.4.2.1.5 "Compatibility of Materials with the Primary and Secondary Coolant and Cleanliness Control:"

> "The primary water chemistry is controlled at a level comparable to the EPRI guidelines as stated in FSAR Section 5.2.3.2.1 to minimize corrosion in the steam generators. The materials of the primary side steam generators are selected to minimize corrosion and have demonstrated satisfactory performance in existing operating reactor plants. A detailed description is provided in FSAR Section 5.2.3.2.2."

Issue #17

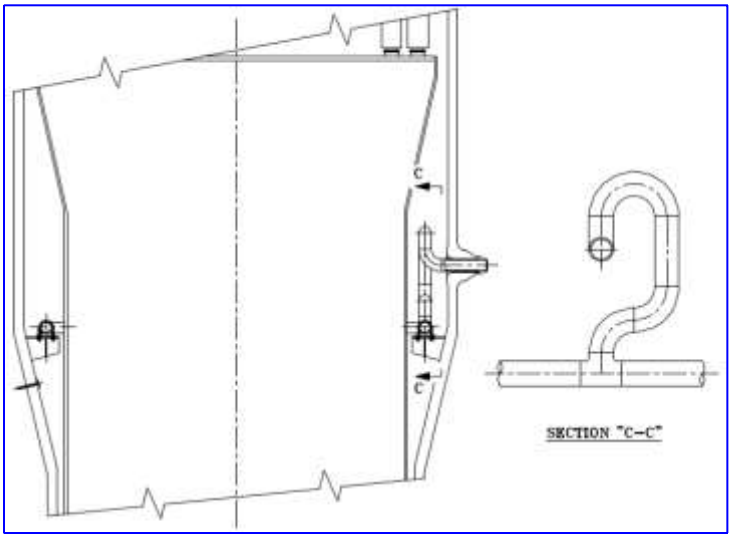
Providing adequate access for corrosion product and foreign object detection and removal is necessary to meet the requirements of 10 CFR Part 50, Appendix A, GDC 14 and GDC 15. Among the sources of loose parts are the feedwater components.

Revise FSAR Subsection 5.4.2.1.6 to explain the difference between downcomer feedwater and recirculation feedwater rings, and provide the location of the feedwater box.

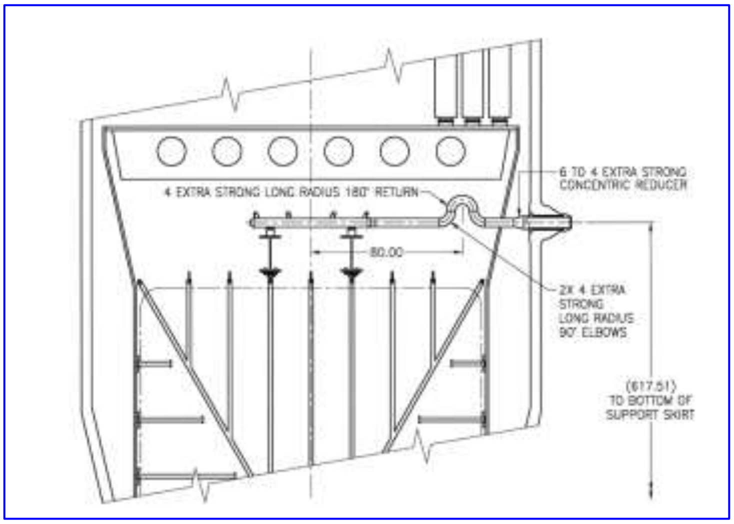
Response

The downcomer feedwater ring inside the steam generator applies the upward bend using a goose-neck design and I-type spray nozzles having small holes (hole diameter is 0.23 inch) and are installed to prevent the foreign object inclusion. Two I-type spray nozzles at each end of the piping is threaded into the piping, thus the two I-type spray nozzles can be detached from the piping to remove any foreign objects.

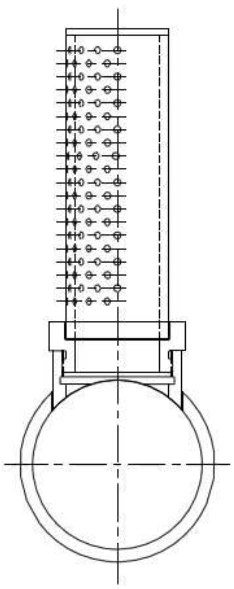
The recirculation feedwater ring provides the circulation of water through the steam generator during wet lay-up and the addition of chemical cleaning agents. There are J-type discharge nozzles on the recirculation piping.



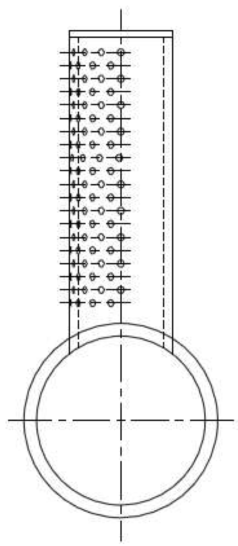
[Downcomer Feedwater Ring]



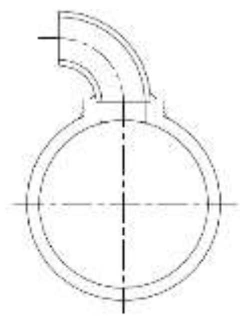
[Recirculation Feedwater Ring]



[Detachable I-Type Spray Nozzle]



[I-Type Spray Nozzle]

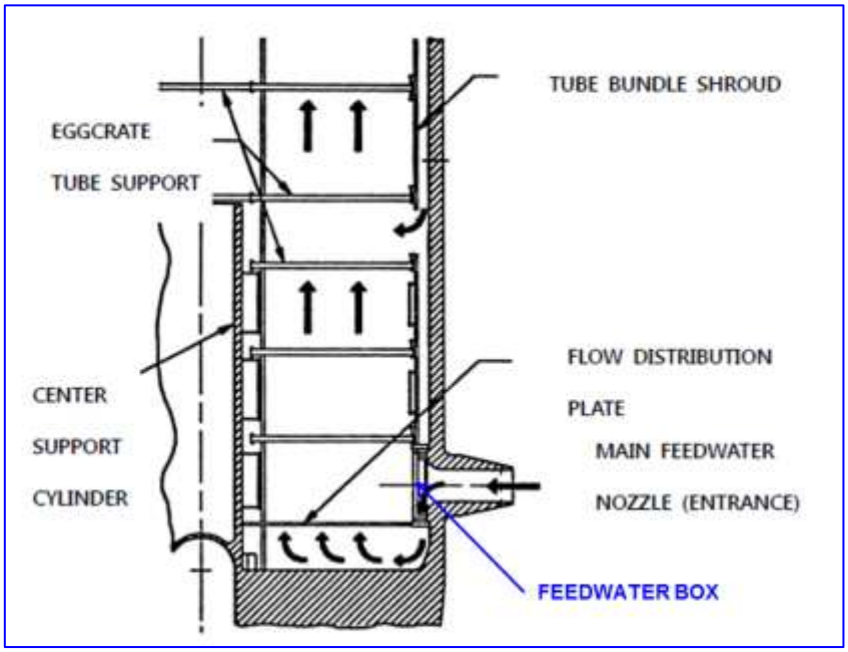


[J-Type Discharge Nozzle]

The feedwater box is installed in the pathway of economizer feedwater nozzle flow as shown in Figure 5.4.2-2.

In the feedwater box bottom plate where all the economizer feedwater inflows, there are clusters of small holes (hole diameter is 0.23 inch) to prevent any foreign objects through the economizer feedwater line. Two 5 inch inspection holes provide access to remove any foreign objects trapped in the feedwater box bottom plate. The hole clusters in the feedwater box bottom plate and two I-type spray nozzles in the downcomer feedwater piping prevent the foreign object inclusion from the feedwater line to the steam generator secondary side.

Figure 5.4.2-2 Steam Generator Economizer and Lower Tube Bundle Region



[Location of Feedwater Box at the Lower Tube Bundle Region]

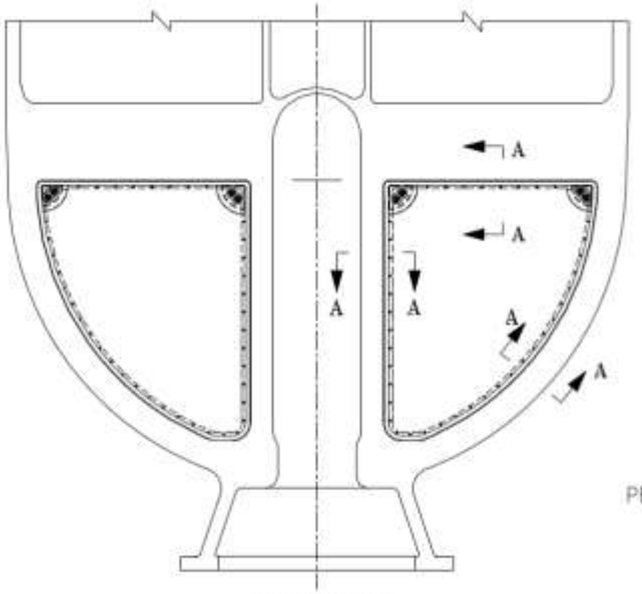
Issue #18

FSAR Table 5.4.2-2 identifies SA240, Type 410S martensitic stainless steel as the divider plate material for the steam generators. If the divider plate provides structural support to pressure boundary components (e.g., tubesheet), then the FSAR needs to provide the fabrication and processing requirements.

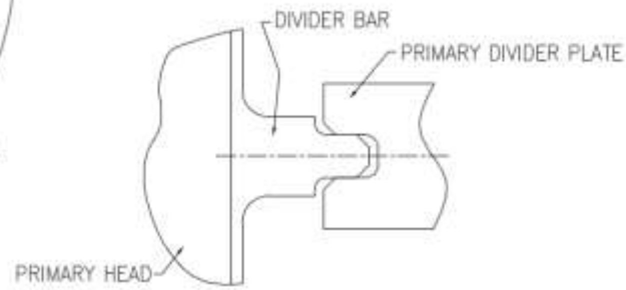
If the divider plate provides structural support, revise FSAR Table 5.4.2-2 to include fabrication and processing requirements for SA240, Type 410S martensitic stainless steel, or include a reference to a section in which such requirements are addressed.

Response

The divider plate in the steam generator primary head applies the tongue-and-groove joint instead of welding to the primary head and tubesheet as shown below. The divider plate is not the structural support to the pressure boundary components.



ELEVATION



SECTION "A-A"