RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**314-8378**
SRP Section:	**10.03.06 – Steam and Feedwater System Materials**
Application Section:	**10.3.6**
Date of RAI Issue:	**11/16/2015**

Question No. 10.03.06-1

Title 10 of the Code of Federal Regulations (10 CFR) Part 50, Appendix A, General Design Criteria 1 and 30; and 10 CFR Part 50.55a contain provisions regarding quality standards for material specifications that are met by compliance with the applicable provisions of the ASME Boiler and Pressure Vessel Code (ASME Code) and by acceptable application of materials Code Cases as described in Regulatory Guide (RG) 1.84, “Design, Fabrication, and Materials Code Case Acceptability, ASME Section III.” Specifications for permitted materials are identified in the ASME Code, Section III, Appendix I, or described in detail in the ASME Code, Section II.

In FSAR Section 10.3.6.2, on page 10.3-25, the applicant states:

a. The materials that are used are included in Appendix I of the ASME Section III and conform with Parts A, Parts B, and Parts C of ASME Section II (Reference 11) and NRC RG 1.84 (Reference 12).

The NRC staff has three concerns about this section:

1. RG 1.84 contains a list of ASME Code Cases that the NRC finds acceptable or Code Cases that the NRC accepts with conditions. FSAR Section 10.3.6, including Tables 10.3.2-2, 10.3.2-3, and 10.3.2-4, does not provide information on which Code Cases the applicant intends to utilize.

   Provide the Code Cases specified in RG 1.84 that will apply to the APR1400 design, and include whether all the conditions for conditionally approved Code Cases in RG 1.84 will be utilized.

2. The statement above only requires the materials to meet the requirements of the fatigue table in ASME Code Section III and the requirements of ASME Code Section II. This statement does not meet 10 CFR 50.55a(d) and 50.55a(e) which requires that Quality Group B and C components meet the requirements of the ASME Code,

including Article NC/ND-2000. The staff recommends the following modification to the paragraph above as follows:

a. The materials that are used conform to ASME Section III including Appendix I and Part A, Part B, and Part C of ASME Section II (Reference 11) and NRC RG 1.84 (Reference 12).

3. The statement that materials conform to "…Part B… of ASME Section II" is not consistent with Tables 10.3.2-2, 10.3.2-3, and 10.3.2-4 because the tables contain only ferritic materials. ASME Code Section II, Part B addresses nonferrous material specifications. Provide a list of components that are fabricated with material specifications contained in ASME Code Section II-B or delete "Part B" from the FSAR paragraph above.

Response

1. Code Cases in RG 1.84 are not applicable for steam and feedwater system materials.

2. DCD Tier 2, Subsection 10.3.6.2 will be revised as follows:

Current description: a. The materials that are used are included in Appendix I of the ASME Section III and conform with Parts A, Parts B, and Parts C of ASME Section II (Reference 11) and NRC RG 1.84 (Reference 12).

Revised description: a. The materials that are used conform to ASME Section III including Appendix I and Part A, Part B, and Part C of ASME Section II (Reference 11) and NRC RG 1.84 (Reference 12).

3. ASME Sec. III, Part B will be deleted in DCD Tier 2, Subsection 10.3.6.2.

Impact on DCD

DCD Tier 2, Subsection 10.3.6.2 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**314-8378**
SRP Section:	**10.03.06 – Steam and Feedwater System Materials**
Application Section:	**10.3.6**
Date of RAI Issue:	**11/16/2015**

Question No. 10.03.06-2

Title 10 of the Code of Federal Regulations (10 CFR) Part 50.65 requires monitoring of the condition and operation of Structures, Systems, and Components (SSCs) to ensure that they are capable of maintaining their intended function. The functions are established from design goals which are based on operating experience. The requirements of 10 CFR 50.65 are applicable to non-safety systems “whose failure could cause a reactor scram or actuation of a safety-related system;” a main steam-line or feed-line break would result in an Engineered Safety Feature (ESF) actuation. Generic Letter (GL) 89-08. “Erosion/Corrosion-Induced Pipe Wall Thinning,” defined a Flow Accelerated Corrosion (FAC) program that would meet the requirements of 10 CFR 50.65 for secondary, non-safety related systems.

In FSAR Section 10.3.6.2, on page 10.3-25, the applicant states:

> Oxygen-induced corrosion is minimized by providing the following component materials:
>
> a. Steam reheater tubes are ferritic stainless steel or equivalent.
>
> b. Feedwater heater tubes are type 304L stainless steel with carbon steel tube sheets.
>
> c. Main steam piping, hot reheat piping, condensate piping, feedwater piping, and heater drain piping upstream of the drain control valves are carbon steel or equivalent.

The use of carbon steel in a piping system is not an effective tool in minimizing oxygen-induced corrosion. Therefore, delete item c.

In addition, for FSAR Section 10.3.6.2 a., the provision “or equivalent” is vague and not acceptable. The overall design of the APR1400 must be complete in order for the staff to make a reasonable assurance requirement. Provide additional information defining the scope of what materials may be deemed “equivalent” and the basis of how equivalency would be defined or

revise the FSAR Section 10.3.6.2 to remove the “or equivalent” provision from the last sentence as noted below:

a. Steam reheater tubes are ferritic stainless steel.

b. Feedwater heater tubes are type 304L stainless steel.

Response

DCD Tier 2, Subsection 10.3.6.2 will be revised as follows:

Current description:

a. Steam reheater tubes are ferritic stainless steel or equivalent.

b. Feedwater heater tubes are type 304L stainless steel with carbon steel tube sheets.

c. Main steam piping, hot reheat piping, condensate piping, feedwater piping, and heater drain piping upstream of the drain control valves are carbon steel or equivalent.”

Revised description:

a. Steam reheater tubes are ferritic stainless steel.

b. Feedwater heater tubes are type 304L stainless steel.

c. Deleted

Impact on DCD

DCD Tier 2, Subsections 10.3.6.2 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**314-8378**
SRP Section:	**10.03.06 – Steam and Feedwater System Materials**
Application Section:	**10.3.6**
Date of RAI Issue:	**11/16/2015**

Question No. 10.03.06-3

In FSAR Section 10.3.6.3, on page 10.3-27, the applicant states:

> "Most of the piping on the steam and feedwater systems is made of carbon steel. Materials for the piping portions that are extremely susceptible to FAC are installed using an FAC-resistant alloy such as Cr-Mo steel."

And,

b. "As shown in Table 10.3.2-4, the main feedwater piping from the main feedwater isolation valve (MFIV) in the MSVH to SGs and the piping downstream of downcomer feedwater control valves are made of high-content chrome-moly materials. This portion of the feedwater system is potentially susceptible to FAC, and the design specifications require FAC-resistant piping materials as described above. Other feedwater system piping is generally made of carbon steel with 1.524 mm (0.06 in) additional margin in design."

The material specifications for the piping systems are contained in FSAR Tables 10.3.2-2, 10.3.2-3, and 10.3.2-4. The staff notes that there are no components with material specifications and grades consistent with Cr-Mo steels in FSAR Tables 10.3.2-2 and 10.3.2-3.

Confirm that FSAR Table 10.3.2-4 contains the only components susceptible to FAC.

Response

DCD Tier 2, Table 10.3.2-2, 10.3.2-3, and 10.3.2-4 will be revised.

Impact on DCD

DCD Tier 2, Table 10.3.2-2, 10.3.2-3, and 10.3.2-4 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**314-8378**
SRP Section:	**10.03.06 – Steam and Feedwater System Materials**
Application Section:	**10.3.6**
Date of RAI Issue:	**11/16/2015**

Question No. 10.03.06-4

In FSAR Section 10.3.6.3, on page 10.3-27, the applicant states:

> "The following piping portions with potential for FAC are generally based on NSAC-202L-R3 (Reference 17) and NUREG-1344 (Reference 18) attached to GL 89-08 (References 19).
>
> a. For other safety/non-safety carbon steel piping with relatively mild FAC degradation identified in NUREG-1344 attached to GL 89-08, NSAC-202L-R3, and through experience, the average thinning rates of 2.54 × 10-6 mm/hr (0.1 × 10^{-6} in/hr) in steam system and 4.35 × 10^{-6} mm/hr (0.17 × 10^{-6} in/hr) in the water system are given based on the actual measurement records from Korea standard nuclear plants. The additional thickness of 0.889 mm (0.035 in) for the portion of steam system piping, and 1.524 mm (0.06 in) for the portion of water system piping in design are applied in consideration of the 40 years of design life."

The NRC staff seeks information on the FAC program that is "generally based on NSAC-202L-R3" and FAC measurements on Korean standard nuclear power plants.

Specifically, the applicant should address the following:

- Describe the Korea Hydro and Nuclear Power (KHNP) FAC program and how the procedure deviates from NSAC-202L.
- How are the actual measurement records from the standard nuclear power plants representative and bounding of the APR1400 design?
- What are the differences in coolant conditions between the APR1400 and the "Korean standard design plants" in terms of material specifications, steam/feedwater flow, water chemistry, and temperatures? If there are differences in the coolant conditions for the APR1400 as built condition compared to the existing Korean standard design plants,

discuss the impact of the different coolant conditions on the erosion rate described above in FSAR Section 10.3.6.3 a.

Response

The difference between KHNP FAC program and NSAC-202L is minor. The added items are as follows:

a. Application of SMART-S program or CHECWORKS program for pipe management in sites

b. Setting up the management basis thickness for wall thinning (the absolute replacement thicknesses are 0.3Tnom for safety-related piping and 0.2Tnom for non-safety-related piping)

c. Wear rate decision method, such as LSPTP, LSSM, and NAM (Near Area of Minimum), for the piping inspected repeatedly over twice

d. Using method of UT inspection instrument

e. Decision method for follow-up inspection timing

f. Detailed evaluation method based on ASME Code Case N-597-2 for the pipe below Tcrit or 0.3Tnom and below 1 operating cycle of remaining life

g. Correspondence method for regulatory body, etc.

The wear for 5 systems of 4 units typed of KSNP was determined based on UT data of the components inspected over twice during past 10 years. The number of used components by system is 53 of CD, 98 of FW, 37 of MS, 43 of Drain Tank of RHDT & MSDT (DT DRN), and 30 of HP HTRs Drain (HP DRN) systems.

The PTP (Point-to-Point) method for UT analysis (UTA) was applied based on the available UT data. As shown in the Figure 1, the wear trends by system were developed based on the Curve Fitting method by operating year and assumed the wear after 9.33 years is same.

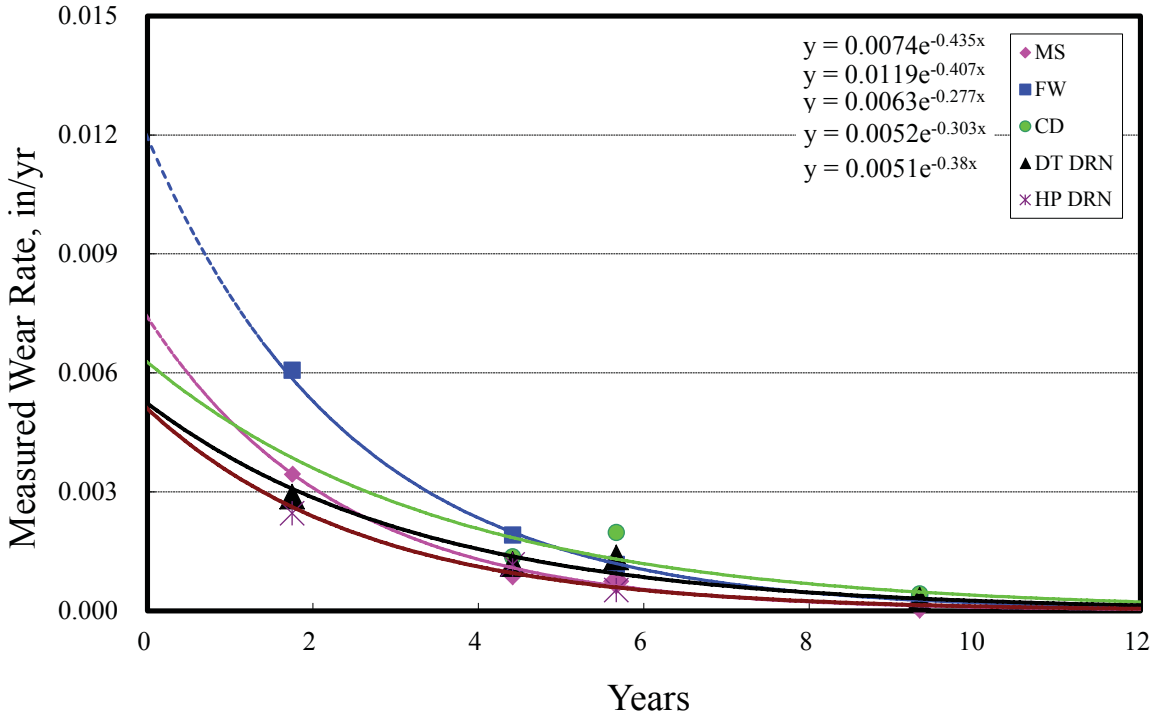

Figure 1. Wear rate trend by system of KSNPs

The wear trends calculated by below equation (1) are shown in Figure 2.

$$W = \int_0^{9.33} f(x)dx + y(40 - 9.33) \quad (1)$$

Where, W: wear

f(x): wear trend as shown in Figure 1

y: wear rate at 9.33 year

40: design life

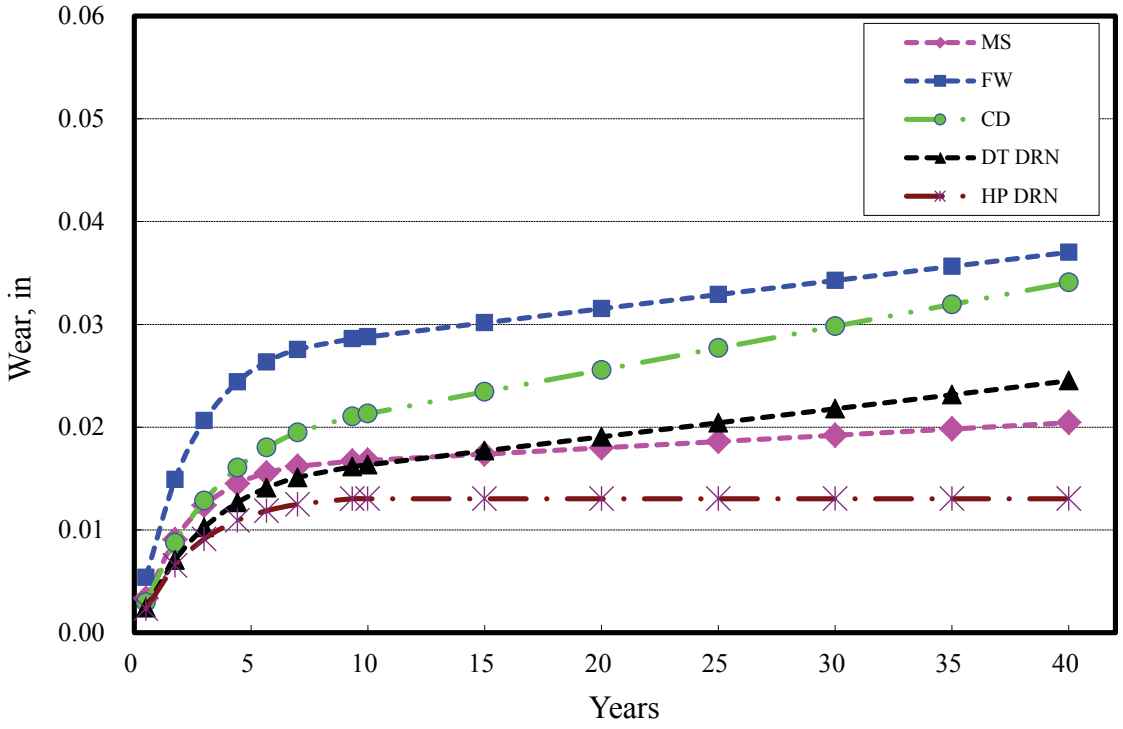

Figure 2. Wear trend by system of KSNPs

The corrosion allowance of 0.06 in reflected the safety factor of 1.7 was determined at FW system which was shown the maximum wear among water systems. And, the corrosion allowance of 0.035 in reflected the safety factor of 1.7 was determined at MS system which was only steam system.

Table 1 describes the operating condition of FW and MS systems in OPR1000 (KSNP) and APR1400. The flow velocities of FW and MS systems were calculated based on the density of 2.22 lb/ft^3 for steam and 51.75 lb/ft^3 for water, which were equally applied. It does not mean to compare pH because the two types of units are similarly operated.

Table 1. Operating condition of FW and MS systems in OPR1000 (KSNP) and APR1400

No.	System	Items	Units	OPR1000	APR1400
1	MS	OP at SG outlet nozzle	psia	1070	992
2	MS	OT at SG outlet nozzle	^{o}F	548.8	544
3	MS	Flow Rate	lb/hr	12.72 x 10^{6}	17.95 x 10^{6}
4	MS	Pipe Size at SG1 MS Outlet	in	26.375	30.938
5	MS	Flow Velocity	ft/s	209.7763	215.1464
6	FW	OP at SG FW inlet	psig	1020.304	1085
7	FW	OT at SG FW inlet	^{o}F	450	450
8	FW	Flow Rate	lb/hr	12.72 x 10^{6}	18.13 x 10^{6}
9	FW	Pipe Size at SG1 FW Inlet	in	12.75	14
10	FW	Flow Velocity	ft/s	38.5058	31.9367
11	FW	pH	-	9.0~10.0	9.0~10.0

Here, the affecting parameters to FAC are flow velocity and temperature, and pH. As described in Table 1, the temperature and pH are similar between OPR1000 and APR1400. So, the corrosion allowances determined in KSNP was used in APR1400.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.: **314-8378**

SRP Section: **10.03.06 – Steam and Feedwater System Materials**

Application Section: **10.3.6**

Date of RAI Issue: **11/16/2015**

Question No. 10.03.06-5

Title 10 of the Code of Federal Regulations (10 CFR) Part 50.65 requires monitoring of the condition and operation of Structures, Systems, and Components (SSCs) to ensure that they are capable of maintaining their intended function. The functions are established from design goals which are based on operating experience. The requirements of 10 CFR 50.65 are applicable to non-safety systems “whose failure could cause a reactor scram or actuation of a safety-related system;” a main steam-line or feed-line break would result in an Engineered Safety Feature (ESF) actuation. Generic Letter (GL) 89-08. “Erosion/Corrosion-Induced Pipe Wall Thinning,” defined a Flow Accelerated Corrosion (FAC) program that would meet the requirements of 10 CFR 50.65 for secondary, non-safety related systems.

In FSAR Section 10.3.6.3, page 10.3-28, the applicant states:

f. The entire portion of extraction steam piping is made of chrome-moly materials

Item f is prefaced by: “the following piping portions with potential for FAC are generally based on NSAC-202L-R3 and NUREG-1344 attached to GL 89-08.” As such, the staff interprets that a chrome-moly steel is necessary to prevent FAC in this system.

In FSAR Table 10.3.2-3 the applicant states:

Main steam piping to moisture separator reheater	A 106 Gr. B (seamless)	250 (10), 300 (12)	B 31.1
Fittings	ASTM A-234, WPB	250 (10), 300 (12)	
Flanges	ASTM A-105	80 (3) and lager	
Valves (globe, gate, check)	ASTM A-216, WCB or WCC	65 (2.5) ~ 650 (26)	
HP turbine to moisture separator reheater	A588 Gr. C (welded)	1,050 (42)	B 31.1
moisture separator reheater to LP turbine	A588 Gr. C (welded)	1,050 (42)	B 31.1
Fittings	ASTM A-234, WPB	1,050 (42)	

In Section 10.3.6.3, the DCD states that the extraction steam system is fabricated from chrome-moly steel. Table 10.3.2-3 has the extraction steam system made from “weathering steel” (A-588 Gr C) which contains no molybdenum.

Revise FSAR Section 10.3.6.3 and/or Table 10.3.2-3 to be consistent.

Response

The pipe made of A-588 is a non safety related item provided by the turbine generator (TG) vendor. Therefore, the content related to A-588 will be deleted in DCD Tier 2, Table 10.3.2-3.

Impact on DCD

DCD Tier 2, Table 10.3.2-3 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**314-8378**
SRP Section:	**10.03.06 – Steam and Feedwater System Materials**
Application Section:	**10.3.6**
Date of RAI Issue:	**11/16/2015**

Question No. 10.03.06-6

In FSAR Section 10.3.6.3, on page 10.3-27, the applicant states:

> "Most of the piping on steam and feedwater systems is made of carbon steel. Materials for the piping portions that are extremely susceptible to FAC are installed using an FAC-resistant alloy such as Cr-Mo steel."

And,

c. "SG blowdown piping from SG to the blowdown flash tank is made of chrome-moly materials. FAC-susceptible portions are made of stainless steel;"

Provide the staff with a justification why "extremely susceptible" portions of steam and feedwater piping use Cr-Mo steel, while FAC-susceptible portions of the SG blowdown piping use stainless steel, which is more resistant to FAC than Cr-Mo steel.

Response

The steam generator blowdown system should not be described in this chapter dealing with steam and power conversion system. The stainless steel in wet lay-up pipelines, which are not to be used during normal operation, was not applied for FAC prevention but for preventing corrosion and protecting the performance of other components such as filters. So, the written contents will be deleted in DCD Tier 2, Subsection 10.3.6.3.

DCD Tier 2, Subsection 10.3.6.3 will be revised as follows:

Current description:

"Most of the piping on steam and feedwater systems is made of carbon steel. Materials for the piping portions that are extremely susceptible to FAC are installed using an FAC-resistant alloy such as Cr-Mo steel."

c. SG blowdown piping from SG to the blowdown flash tank is made of chrome-moly materials. FAC-susceptible portions are made of stainless steel.

Revised description:

"Most of the piping on steam and feedwater systems is made of carbon steel. Materials for the piping portions that are susceptible to FAC are installed using an FAC- resistant alloy such as Cr-Mo steel."

c. Delete

Impact on DCD

DCD Tier 2, Subsection 10.3.6.3 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.: **314-8378**

SRP Section: **10.03.06 – Steam and Feedwater System Materials**

Application Section: **10.3.6**

Date of RAI Issue: **11/16/2015**

Question No. 10.03.06-7

Title 10 of the Code of Federal Regulations (10 CFR) Part 52.6 requires that information submitted as part of a standard design certification under 10 CFR Part 52 shall be complete and accurate in all material respects.

Title 10 of the Code of Federal Regulations (10 CFR) Part 50.65 requires monitoring of the condition and operation of Structures, Systems, and Components (SSCs) to ensure that they are capable of maintaining their intended function. The functions are established from design goals which are based on operating experience. The requirements of 10 CFR 50.65 are applicable to nonsafety systems “whose failure could cause a reactor scram or actuation of a safety-related system;” a main steam-line or feed-line break would result in an Engineered Safety Feature (ESF) actuation. Generic Letter (GL) 89-08. “Erosion/Corrosion-Induced Pipe Wall Thinning,” defined a Flow Accelerated Corrosion (FAC) program that would meet the requirements of 10 CFR 50.65 for secondary, non-safety related systems.

In FSAR Table 10.3.2-3 the applicant states:

HP turbine to moisture separator regeater	A588 GR. C(welded)	1,050 (42)	B31.1
Moisture separator reheater to LP turbine	A588 Gr. C (welded)	1,050 (42)	B31.1

ASME Code B31.1 (2014), “Power Piping” Subsection 123.1 states that materials used for construction must be listed in Mandatory Appendix A of B31.1. Additionally, ASME Code B31.1 subparagraph 123.2.2 states that “Boiler External Piping” may be constructed out of materials that are acceptable per Mandatory Appendix A or ASME Code Section I as long as the material is also listed in ASME Code Section II-D.

Contrary to requirements of ASME B31.1, materials meeting the specification of ASTM A588 “Standard Specification For High-Strength Low-Alloy Structural Steel, Up to 50 ksi [345 Mpa] Minimum Yield Point, With Atmospheric Corrosion Resistance” are not listed in Appendix A of

ASME B31.1 and are not listed in ASME Section II-D. Revise FSAR Table 10.3.2-3 to use material that is listed in Appendix A of ASME B31.1 or ASME Code Section II-D or provide more information on the selection of this material.

The information should include a justification for using commercial structural steel for power plant applications, operating experience with this material in power plant applications, deterioration mechanisms of this material in steam power conversions systems, information on the quality assurance that will be associated with this component. It is important to note that the steam in these systems will not be "high quality" and FAC will need to be addressed.

Response

The pipe made of A-588 is belonging to the portion of the TG vendor and a non-safety-related item. Therefore, the items related to A-588 will be deleted in DCD Tier 2, Table 10.3.2-3.

Impact on DCD

DCD Tier 2, Table 10.3.2-3 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.: **314-8378**

SRP Section: **10.03.06 – Steam and Feedwater System Materials**

Application Section: **10.3.6**

Date of RAI Issue: **11/16/2015**

Question No. 10.03.06-8

Title 10 of the Code of Federal Regulations (10 CFR) Part 52.6 requires that information submitted as part of a standard design certification under 10 CFR Part 52 shall be complete and accurate in all material respects.

Table 10.3.2-1, on page 10.3-32, states:

Main Steam Isolation Valves (MSIVs)	
Valve type	EH (electro-hydraulic)
Valve size, mm (in)	813 (32)
Number of MSSVs per main steam line	1
Total number of MSSVs	4

Revise this table to state “MSIV” instead of “MSSV” where appropriate to correct the typographical error.

Response

Table 10.3.2-1 will be revised to correct the typographical error.

Impact on DCD

DCD Tier 2, Table 10.3.2-1 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.: **314-8378**

SRP Section: **10.03.06 – Steam and Feedwater System Materials**

Application Section: **10.3.6**

Date of RAI Issue: **11/16/2015**

Question No. 10.03.06-9

Title 10 of the Code of Federal Regulations (10 CFR) Part 50.65 requires monitoring of the condition and operation of Structures, Systems, and Components (SSCs) to ensure that they are capable of maintaining their intended function. The functions are established from design goals which are based on operating experience. The requirements of 10 CFR 50.65 are applicable to nonsafety systems “whose failure could cause a reactor scram or actuation of a safety-related system;” a main steam-line or feed-line break would result in an Engineered Safety Feature (ESF) actuation. Generic Letter (GL) 89-08. “Erosion/Corrosion-Induced Pipe

Wall Thinning,” defined a Flow Accelerated Corrosion (FAC) program that would meet the requirements of 10 CFR 50.65 for secondary, non-safety related systems.

In FSAR Section 10.3.6.3, on page 10.3-27, the applicant states:

> As shown in Table 10.3.2-4, the main feedwater piping from the main feedwater isolation valve (MFIV) in the MSVH to SGs and the piping downstream of downcomer feedwater control valves are made of high-content chrome-moly materials. In FSAR Section 10.3.6.3 the applicant describes the FAC program as being based on NSAC-202L-R3, but modified by operating experience from Korean standard design nuclear power plants.

In FSAR Table 10.3.2-4 the applicant has the following information on this material:

MFIC to SG	SA-335 Gr. 922 (seamless)	150 (6), 250 (10), 350 (14), 600 (24)	Section III, Class 2
Fittings	SA-420 WPL6, SA-234 WP22	150 (6), 250 (10), 350 (14), 600 (24)	
Flanges	SA-350 LF2, SA-182 F22	150 (6) ~ 600 (24)	
Valves (globe, gate check)	SA-182 F22 or SA-217 WCp, SA-350 LF2	150 (6) ~ 600 (24)	

Material specifications ASME SA-420 WPL6 and SA-350 LF2 are not chrome-moly steels. Material specifications ASME SA-182 F22 and SA-217 WC9 are chrome-moly steels. As written, Table 10.3.2-4 allows for fittings and flanges to be used that are not consistent with the paragraph on FSAR page 10.3-27.

Revise FSAR to address this inconsistency.

Response

DCD Tier 2, Table 10.3.2-4 will be revised.

Impact on DCD

DCD Tier 2, Table 10.3.2-4 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**314-8378**
SRP Section:	**10.03.06 – Steam and Feedwater System Materials**
Application Section:	**10.3.6**
Date of RAI Issue:	**11/16/2015**

Question No. 10.03.06-10

Title 10 of the Code of Federal Regulations (10 CFR) Part 50.65 requires monitoring of the condition and operation of Structures, Systems, and Components (SSCs) to ensure that they are capable of maintaining their intended function. The functions are established from design goals which are based on operating experience. The requirements of 10 CFR 50.65 are applicable to nonsafety systems “whose failure could cause a reactor scram or actuation of a safety-related system;” a main steam-line or feed-line break would result in an Engineered Safety Feature (ESF) actuation. Generic Letter (GL) 89-08. “Erosion/Corrosion-Induced Pipe

Wall Thinning,” defined a Flow Accelerated Corrosion (FAC) program that would meet the requirements of 10 CFR 50.65 for secondary, non-safety related systems.

In FSAR Section 10.3.7, on page 10.3-29, the applicant states:

> COL 10.3(3) The COL applicant is to provide a description of the FAC monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam and are susceptible to erosion-corrosion damage. The description is to address consistency with GL 89-08 and NSAC-202LR3 and provide a milestone schedule for implementation of the program.

In FSAR Section 10.3.6.3 the applicant describes the FAC program as being based on NSAC-202L-R3, but modified by operating experience from Korean standard design nuclear power plants.

1. The statement “monitoring program for carbon steel portions of the steam and power conversation systems…” inappropriately narrows the scope of the FAC program. NSAC-202L, Section 4.2.2 provides recommendations for excluding lines; the guidance states that it is inappropriate to exclude stainless steel or chrome-moly lines under certain conditions (the line contains some carbon steel piping or components or a wear

mechanism has not been identified). The staff recommends that the statement “carbon steel portions of” be removed from the COL items. Otherwise, provide an explanation on how the APR-1400 design meets all the provisions of NSAC-202L, Section 4.2.2.

2. Would a COL applicant using the APR1400 design have a FAC program that is consistent with the KHNP FAC program or the EPRI program without modifications? Revise COL 10.3 (3) accordingly.

Response

1. The difference between KHNP FAC program and NSAC-202L is minor. COL 10.3(3) was already revised like below.

   ″The COL applicant is to provide a description of the FAC monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam and are susceptible to erosion-corrosion damage. The description is to address consistency with GL 89-08 and NSAC-202L-R3 and provide a milestone schedule for implementation of the program.”

2. First paragraph on page 10.3-29 will be revised.

Impact on DCD

DCD Tier 2, Section 10.3.6.3 page 10.3-29 will be revised as indicated on the attached markup.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

10.3.6 Steam and Feedwater System Materials

10.3.6.1 Fracture Toughness

The material specifications for pressure retaining components in the safety-related portion of the main steam and feedwater system meet the fracture toughness requirements of the ASME Section III, Articles NC-2300 (Class 2) for Quality Group B and ND-2300 (Class 3) for Quality Group C components.

10.3.6.2 Materials Selection and Fabrication

MSS and feedwater system piping materials used for ASME Section III, Class 2 and 3 components defined in NRC RG 1.26 are provided in Tables 10.3.2-2, 10.3.2-3, and 10.3.2-4. The APR1400 meets the regulatory requirements of 10 CFR 50.55a, GDC 1 of Appendix A to 10 CFR 50, and Appendix B to 10 CFR 50.

The material selection and fabrication methods used for Class 2 and 3 components conform with the following:

Q. 10.03.06-1

a. The materials that are used ~~are included in Appendix I of the~~ ASME Section III and ~~conform with~~ Parts A, Parts B, and Parts C of ASME Section II (Reference 11) and NRC RG 1.84 (Reference 12).

conform to

including Appendix I

b. No austenitic stainless steel piping material is used in the main steam and feedwater systems.

c. The secondary system piping is designed to allow cleaning to remove foreign material and rust prior to operation and to prevent introduction of this material into the SG. Cleaning and acceptance criteria are based on the requirements of ASME NQA-1 (Reference 13) and recommendations of NRC RG 1.28 (Reference 14).

d. The control preheats temperatures for welding of low-alloy materials conform with the NRC RG 1.50 (Reference 15) for the MSS and feedwater system. Preheat temperature for carbon steel piping of the ASME Section III, Division 1,

Class 2, and 3 portions of the MSS and feedwater system conform with the ASME Section III, Appendix D, Article D-1000.

e. Welder performance qualification for areas of limited accessibility conforms with the recommendations of NRC RG 1.71 (Reference 16) (i.e., assurance of the integrity of welds in locations of restricted direct physical and visual accessibility).

f. The nondestructive examination procedures and acceptance criteria for the examination of Class 2 and Class 3 materials of tubular products conform with the requirements of ASME Section III, NC/ND-2550 through NC/ND-2570.

g. A description of periodic inservice inspection and inservice testing of ASME Section III, Class 2 and 3 components is provided in Section 6.6 and Subsection 3.9.6. Preservice and inservice testing and inspection are addressed further in Chapter 14.

h. No copper alloys are used for components that are in contact with feedwater, steam, or condensate.

Oxygen-induced corrosion is minimized by providing the following component materials:

Q. 10.03.06-2

a. Steam reheater tubes are ferritic stainless steel ~~or equivalent.~~

b. Feedwater heater tubes are type 304L stainless steel ~~with carbon steel tube sheets~~.

c. ~~Main steam piping, hot reheat piping, condensate piping, feedwater piping, and heater drain piping upstream of the drain control valves are carbon steel or equivalent~~.

10.3.6.3 Flow-Accelerated Corrosion

FAC-resistant materials are used for the FAC-susceptible piping in steam and power conversion systems. The water chemistry conditions of the secondary system are controlled to minimize corrosion. The additional pipe thickness are applied for the carbon

Table 10.3.2-2

Main Steam Piping Design Data

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
SG to containment penetration	SA-106 Gr. C (seamless)	785.0 (30.907)	Section III, Class 2
Containment penetration to MSVH	SA-106 Gr. C (seamless)	785.0 (30.907) 820.7 (32.311)	Section III, Class 2
Fittings	SA-234 WPC	785.0 (30.907), 820.7 (32.311)	Section III, Class 2
Valves (gate)	SA-352 LCC	820.7 (32.311)	Section III, Class 2
MSVH to MS pipe enclosure	A-106 Gr. C (seamless)	802.8 (31.607)	B31.1
Fittings	A-234 WPC	Larger than 600 (24)	B31.1
MS pipe enclosure to main steam header	A-106 Gr. C (seamless)	802.8 (31.607)	B31.1
Main steam header	A-234 WPC	1517.7 (59.75)	
Main steam header to MSV	A-106 Gr. C (seamless)	732.8 (28.85)	
Fittings	A-234 WPC	Larger than 600 (24)	
Flanges	ASTM A-105	80 (3) and larger	
Valves (globe, gate, check)	ASTM A-105 or ASTM A-216 WCB	65 (2.5) ~ 650 (26)	

Q. 10.03.06-3

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Table 10.3.2-2

Main Steam Piping Design Data

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
SG to containment penetration	SA-106 Gr.C (seamless)	785.0 (30.907)	Section III, Class 2
Containment penetration to MSVH	SA-106 Gr.C (seamless)	785.0 (30.907) 820.7 (32.311)	Section III, Class 2
Fittings	SA-234 WPC	785.0 (30.907) 820.7 (32.311)	Section III, Class 2
MSVH to MS pipe enclosure	A-106 Gr.C (seamless)	802.8 (31.607)	B31.1
Fittings	A-234 WPC	Larger than 600 (24)	B31.1
MS pipe enclosure to main stream header	A-106 Gr.C (seamless)	802.8 (31.607)	B31.1
Main steam header	A-672 Gr.B70 (welded)	1517.7 (59.75)	B31.1
Main steam header to MSV	A-106 Gr.C (seamless)	732.8 (28.85)	B31.1
Fittings	A-234 WPC	Larger than 600 (24)	B31.1

Table 10.3.2-3

Main Steam Branch Piping Design Data (2.5 Inches and Larger)

Q. 10.03.06-3
Q. 10.03.06-5
Q. 10.03.06-7

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
Main steam piping to MSADV	SA106 Gr. C (seamless)	500 (20)	Section III, Class 2
MSADV discharge piping to silencer	A106 Gr. B (seamless)	400 (16)	B31.1
Main steam piping to MSSV	SA-105	200 (8)	Section III, Class 2
MSSV discharge piping to vent stack	A106 Gr. B (seamless)	250 (10), 650 (26)	B31.1
Main steam piping to pipe chase	SA-333 Gr. 6 (seamless)	200 (8)	Section III, Class 2
Pipe chase to AF pump turbine steam isolation valve	SA-106 Gr. B (seamless)	200 (8)	Section III, Class 3
Fittings	ASTM (S)A-234 WPB	65 (2.5) and larger	Section III, Class 2
Flanges	SA-350 LF2, ASTM A-105	65 (2.5) ~ 600 (24)	Section III, Class 2
Valves (globe, gate, check)	ASTM (S)A-216, WCB or WCC, A352 LCB	65 (2.5) and larger	Section III, Class 2
Main steam piping to moisture separator reheater	A106 Gr. B (seamless)	250 (10), 300 (12)	B31.1
Fittings	ASTM A-234, WPB	250 (10), 300 (12)	
Flanges	ASTM A-105	80 (3) and larger	
Valves (globe, gate, check)	ASTM A-216, WCB or WCC	65 (2.5) ~ 650 (26)	
HP turbine to moisture separator reheater	A588 Gr. C (welded)	1,050 (42)	B31.1
Moisture separator reheater to LP turbine	A588 Gr. C (welded)	1,050 (42)	B31.1
Fittings	ASTM A-234, WPB	1,050 (42)	

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Table 10.3.2-3

Main Steam Branch Piping Design Data (2.5 Inches and Larger)

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
Main steam piping to MSADV	SA-106 Gr.C (seamless)	500 (20)	Section III, Class 2
MSADB discharge piping to silencer	A-106 Gr.B (seamless)	400 (16)	B31.1
Main steam piping to MSSV	SA-105	150 (6)	Section III, Class 2
MSSV discharge piping to vent stack	A-106 Gr.B (seamless)	250 (10) 650 (26)	B31.1
Main steam piping to pipe chase	SA-333 Gr.6 (seamless)	200 (8)	Section III, Class 2
Pipe chase to AF pump turbine steam isolation valve	SA-106 Gr.B (seamless)	200 (8)	Section III, Class 2
Fittings	ASTM(S)A-234 WPB	65 (2.5) and larger	Section III, Class 2

Table 10.3.2-4 (1 of 2)

Feedwater Piping Design Data

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
Feedwater pump to feedwater pump discharge header	A-106 Gr. B (seamless)	600 (24)	B31.1
Feedwater pump discharge header	A-672 Gr. B60 (welded)	762 (30)	
Feedwater pump discharge header to feedwater heaters 5/6/7	A-672 Gr. B60 (welded)	660.4 (26), 762 (30)	
Feedwater heaters 7 to feedwater heaters 7 discharge header	A-672 Gr. B60 (welded)	660.4 (26)	
Feedwater heaters 7 discharge header	A-672 Gr. B60 (welded)	812.8 (32)	
Fittings	A-234 WPB	600 (24), 660.4 (26), 762 (30), 812.8 (32)	
Flanges	ASTM A-105	80 (3) and larger	
Valves (globe, gate, check)	ASTM A-105 or ASTM A-216 WCB or WCC	65 (2.5) ~ 660.4 (26)	
Feedwater heaters 7 discharge header to MFIV	A-106 Gr. B (seamless, welded)	250 (10), 660.4 (24), 762 (26), 812.8 (32)	B31.1
Fittings	A-234 WPB	250 (10), 660.4 (24), 762 (26), 812.8 (32)	
Flanges	ASTM A-105	80 (3) and larger	
Valves (globe, gate, check)	ASTM A-105 or ASTM A-216 WCB or WCC	65 (2.5) ~ 660.4 (26)	

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Q. 10.03.06-9

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Table 10.3.2-4 (1 of 2)

Feedwater Piping Design Data

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
Feedwater pump to feedwater pump discharge header	A-106 Gr.B (seamless)	600 (24)	B31.1
Feedwater pump discharge header	A-672 Gr.B60 (welded)	762 (30)	B31.1
Feedwater pump discharge header to Feedwater heaters 5/6/7	A-672 Gr.B60 (welded)	650 (26) 812.8 (32)	B31.1
Feedwater heaters 7 to Feedwater heaters 7 outlet header	A-672 Gr.B60 (welded)	650 (26)	B31.1
Feedwater heaters 7 outlet header	A-672 Gr.B60 (welded)	812.8 (32)	B31.1
Fittings	A-234 WPB A-234 WPC	600 (24) 812.8 (32)	B31.1
Feedwater heaters 7 outlet header to MFCVs	A-106 Gr.B (seamless, welded)	250 (10) 600 (24)	B31.1
Fittings	A-234 WPB	250 (10) 600 (24)	B31.1

Table 10.3.2-4 (2 of 2)

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
Downcomer feedwater control valve to main steam valve house (MSVH)	A335 Gr. P22 (seamless)	250 (10)	B31.1
Fittings	A-234 WP22	250 (10)	
Flanges	ASTM A-182 Gr. F22	-	
Valves (globe, gate, check)	ASTM A-182 Gr. F22 or ASTM A-217 Gr. WC9	-	
MFIV to SG	SA-335 Gr. P22 (seamless)	150 (6), 250 (10), 350 (14), 600 (24)	Section III, Class 2
Fittings	SA-420 WPL6, SA-234 WP22	150 (6), 250 (10), 350 (14), 600 (24)	
Flanges	SA-350 LF2, SA-182 F22	150 (6) ~ 600 (24)	
Valves (globe, gate, check)	SA-182 F22 or SA-217 WC9, SA-350 LF2	150 (6) ~ 600 (24)	

Q. 10.03.06-3
Q. 10.03.06-9

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Table 10.3.2-4 (2 of 2)

Segment	Material Specification	Nominal OD (mm (in))	ASME Class
Downcomer MFCV to main steam valve house (MSVH)	A-335 Gr.P22 (seamless)	250 (10)	B31.1
Fittings	A-234 WP22	250 (10)	B31.1
MSVH to MFIV	SA-333 Gr.6 (seamless)	250 (10) 600 (24)	Section III, Class 2
MFIV to SG	SA-335 Gr. P22 (seamless)	150 (6) 250 (10) 350 (14) 600 (24)	Section III, Class 2
Fittings	SA-234 WP22	150 (6) 250 (10) 350 (14) 600 (24)	Section III, Class 2

steel steam and water piping in consideration of the 40 years of design life. The piping layout is also considered to minimize the incidence of FAC or erosion/corrosion in piping.

Q. 10.03.06-6 Most of the piping on steam and feedwater systems is made of carbon steel. Materials for the piping portions that are extremely susceptible to FAC are installed using an FAC-resistant alloy such as Cr-Mo steel.

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The following piping portions with potential for FAC are generally based on NSAC-202L-R3 (Reference 17) and NUREG-1344 (Reference 18) attached to GL 89-08 (References 19).

a. For other safety/non-safety carbon steel piping with relatively mild FAC degradation identified in NUREG-1344 attached to GL 89-08, NSAC-202L-R3, and through experience, the average thinning rates of 2.54×10^{-6} mm/hr (0.1×10^{-6} in/hr) in steam system and 4.35×10^{-6} mm/hr (0.17×10^{-6} in/hr) in the water system are given based on the actual measurement records from Korea standard nuclear plants. The additional thickness of 0.889 mm (0.035 in) for the portion of steam system piping, and 1.524 mm (0.06 in) for the portion of water system piping in design are applied in consideration of the 40 years of design life.

b. As shown in Table 10.3.2-4, the main feedwater piping from the main feedwater isolation valve (MFIV) in the MSVH to SGs and the piping downstream of downcomer feedwater control valves are made of high-content chrome-moly materials. This portion of the feedwater system is potentially susceptible to FAC, and the design specifications require FAC-resistant piping materials as described above. Other feedwater system piping is generally made of carbon steel with 1.524 mm (0.06 in) additional margin in design.

Q. 10.03.06-6

c. SG blowdown piping from SG to the blowdown flash tank is made of chrome-moly materials. FAC-susceptible portions are made of stainless steel; FAC-susceptible portions include wet layup recirculation lines, filters on upstream and downstream lines, and mixed-bed demineralizer upstream and downstream lines. Other SG blowdown piping is made of carbon steel with 1.524 mm (0.06 in) additional margin in design.

Delete

Table 10.3.2-1 (1 of 2)

Main Steam System and Component Design Data

Main Steam System Design Data	
Description	Value
MSS design pressure/temperature	84.37 kg/cm^{2}A (1,200 psia) / 298.9 °C (570 °F)
MSS operating pressure/temperature (at SG steam nozzle outlets)	69.74 kg/cm^{2}A (992 psia) / 284.2 °C (543.6 °F)
Total main steam flow (MGR condition)	8.14 × 10^6 kg/hr (17.95 × 10^6 lb/hr)
Component Design Data	
Main Steam Piping	
Number of main steam lines	4
Steam flow, kg/hr (lb/hr)	8.14 × 10^6 (17.95 × 10^6)
Pipe size, ID, m (in)	0.72662 (28.607)
Design pressure, kg/cm^{2}A (psia)	84.37 (1,200)
Pipe material	Carbon steel
Design Code	ASME Section III, Class 2
Seismic Category	I
Main Steam Isolation Valves (MSIVs)	
Valve type	EH (electro-hydraulic)
Valve size, mm (in)	813 (32)
Number of ~~MSSV~~s per main steam line	1
Total number of ~~MSSV~~s	4
Design Code	ASME Section III, Class 2
Seismic Category	I
Main Steam Isolation Valve Bypass Valves (MSIVBVs)	
Valve type	EH (electro-hydraulic)
Valve size, mm (in)	100 (4)
Number of MSIVBV per main steam line	1
Total number of MSIVBVs	4
Design Code	ASME Section III, Class 2
Seismic Category	I

MSIVs

Q. 10.03.06-8

Q. 10.03.06-10

For the safety/non-safety carbon steel piping with relatively mild FAC degradation, the FAC monitoring program is prepared and implemented using knowledge acquired from experience in pipe wall thinning management of the operating nuclear power plants in Korea. The FAC monitoring program includes preservice thickness measurements of as-built piping considered susceptible to FAC and erosion/corrosion. By performing this preservice measurement, the piping thickness margin that is used as a wall thinning margin is known. By combining the measurement with regular inspections, the frequency of the pipe replacement can be predicted. Reasonable assurance of the integrity and safety of plants is provided by conducting inspection and maintenance during the service life of the plant and replacing piping if necessary. The type of fluid, flow rates, fluid temperatures, and pressure of ASME Class 2 and 3 piping for steam and feedwater system are given in Table 10.3.2-5.

Delete

The COL applicant is to provide a description of the FAC monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam and are susceptible to erosion-corrosion damage. The description is to address consistency with GL 89-08 and NSAC-202L-R3 and provide a milestone schedule for implementation of the program (COL 10.3(3)).

10.3.7 Combined License Information

COL 10.3(1) The COL applicant is to provide operating and maintenance procedures including adequate precautions to prevent water (steam) hammer and relief valve discharge loads and water entrainment effects in accordance with NUREG–0927 and a milestone schedule for implementation of the procedure.

COL 10.3(2) The COL applicant is to establish operational procedures and maintenance programs as related to leak detection and contamination control.

COL 10.3(3) The COL applicant is to provide a description of the FAC monitoring program for carbon steel portions of the steam and power conversion systems that contain water or wet steam and are susceptible to erosion-corrosion damage. The description is to address consistency with GL 89-08 and NSAC-202L-R3 and provide a milestone schedule for implementation of the program.