Response to Action Item 5-6 Section 5.4.2.1

MCB Issue List Regarding APR-1400, FSAR Section 5.4.2.1

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_Rev.01

The materials of primary and secondary side Code class 1,2 and 3 parts 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.), carbon steel (top head, large diameter safe ends and small nozzles), and Alloy 690 (tubes) 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 general corrosion rates in Table 1 were determined by the Westinghouse[2)]:

Table 1. Approximate Corrosion Rate at 3.5 Months

Material	Corrosion			
	with Zn		without Zn (mdm)	
	mdm	mpy [1)]	mdm	mpy [1)]
304SS	1.1	0.00638	3.5	0.02030
316SS	1.3	0.00754	3.5	0.02030
600MA	1.5	0.00870	2.6	0.01508
600TT	0.5	0.00290	2.1	0.01218
690TT	0.2	0.00116	1.3	0.00754

Response to Action Item 5-6 Section 5.4.2.1

Note 1): Please note that the mpy values are not reported by the Westinghouse. They are just converted with the approximate conversion factor of 1 mdm ≈ 5.8×10^{-3} mpy.

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

However, please note that carbon or low alloy steels, or Alloy 690 are only materials used for the primary or secondary pressure boundary and there is no austenitic stainless steel which is used for the primary and secondary side pressure boundary of steam generator in APR 1400. The low alloy steel components which consist of primary side primary boundary are covered with austenitic stainless steel or nickel base alloy.

For the primary side, we consider the corrosion allowance of 2 mils or 0.03 mpy (0.053 mm or 0.0008 mm/year) for austenitic stainless steel and nickel base alloy cladding. It is a conservative value because the reported maximum corrosion rate of austenitic stainless steel is 0.02030 mpy (5.2×10^{-4} mm/year), which is measured in primary water environment without zinc addition (See Table 1).

For carbon steels and low alloy steels of secondary side of steam generator, the corrosion allowance of 1.0 mpy (0.025 mm/year) is reasonable because the highest corrosion rate is 0.524 mpy (0.01 mm/year) in the secondary-side low level faulted condition. Thus, an overall corrosion allowance of 1/16 inch (62.5 mils or 1.6 mm) 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.

Based above evaluation, FSAR 5.4.2.1.2 will be revised as follow:

“<u>Corrosion Allowance</u>

Carbon or low allow steel materials, which compose the pressure boundary of secondary side, have the corrosion allowance of 1.6 mm (1/16 in). For the primary side pressure boundary materials which are low alloy steel, they are protected against general corrosion with the austenitic stainless steel or Ni-base alloy deposited cladding which has the corrosion allowance of 0.053 mm (0.002 in). These corrosion allowances for the primary and secondary side pressure boundary materials are selected based on the test data. Therefore, there is no expectation of general corrosion problem in the APR1400 steam generators.”

Response to Action Item 5-6 Section 5.4.2.1

Impact on DCD
DCD 5.4.2.1.2.2 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 Specification.

Impact on Technical/Topical/Environmental Reports
There is no impact on any Technical, Topical or Environmental Reports.

reapplied, and controlled inside the tube so that the crevice between the tube and tubesheet is as small as possible. Expansion of tubes creates residual stresses in the transition zone between the expanded and the unexpanded regions of the tube. Residual stress measurements have been taken on the transition zone. The residual stress measurements verify the absence of any high residual tensile stress in the transition zone. Material specifications such as the use of TT tubing, welding procedures and fabrication procedures preclude the need for complete-bundle stress relief after assembly.

Corrosion Allowance

The markup in the response is already reflected in DCD Rev.2.

Carbon or low allow steel materials, which comprise the pressure boundary of the secondary side, have a corrosion allowance of 1.6 mm (1/16 in). For the primary side pressure boundary materials which are low alloy steel, they are protected against general corrosion with austenitic stainless steel or Ni-base alloy deposited cladding which has a corrosion allowance of 0.053 mm (0.002 in). These corrosion allowances for the primary and secondary side pressure boundary materials are selected based on test data. Therefore, there is no expectation of a general corrosion problem in the APR1400 steam generators.

Bolting Materials

Primary studs and nuts of the APR1400 steam generators are SB-637 N07718, and secondary studs and nuts are SA-540 Grade B24, or SA-193 Grade B7. These studs and nuts have performed adequately under service conditions and have not shown stress-corrosion cracking. The yield strength of ferritic fastener materials is limited to a maximum of 10,546 kg/cm^2 (150 ksi).

5.4.2.1.3 Fabrication and Processing of Ferritic Materials

Fracture Toughness

The primary and secondary side pressure boundary components of the steam generator meet the fracture toughness requirements of the ASME Code Section III NB. Fracture toughness testing is described further in Subsection 5.2.3.3.

Welding

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