Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, D.C. 20555

Direct tel: 412-374-6206
Direct fax: 412-374-5005
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: DCP/NRC2148

May 30, 2008

Subject: AP1000 Response to Request for Additional Information (SRP4.5.1)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 4.5.1. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in the response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

A response is provided for RAI-SRP4.5.1-CIB1-01, as sent in an email from Phyllis Clark to Sam Adams dated March 26, 2008. This response completes all requests received to date for SRP Section 4.5.1.

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on SRP Section 4.5.1

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cc:	D. Jaffe	-	U.S. NRC	1E
	E. McKenna	-	U.S. NRC	1E
	P. Clark	-	U.S. NRC	1E
	P. Ray	-	TVA	1E
	P. Hastings	-	Duke Power	1E
	R. Kitchen	-	Progress Energy	1E
	A. Monroe	-	SCANA	1E
	J. Wilkinson	-	Florida Power & Light	1E
	C. Pierce	-	Southern Company	1E
	E. Schmiech	-	Westinghouse	1E
	G. Zinke	-	NuStart/Entergy	1E
	R. Grumbir	-	NuStart	1E
	T. Malota	-	Westinghouse	1E

ENCLOSURE 1

Response to Request for Additional Information on SRP Section 4.5.1

RAI Response Number: RAI-SRP4.5.1-CIB1-01
Revision: 0

Question:

DCD Tier 2, Section 4.5.1, describes the materials used to fabricate components of the control rod drive mechanism (CRDM). The parts of the CRDM exposed to reactor coolant are made of materials designed to resist the degradation mechanisms of the reactor environment. Currently, AP1000 DCD, Section 4.5.1.1 and the corresponding Table 5.2-1 in Section 5.2.3, includes Types 304LN and 316LN stainless steels, which have high resistance to sensitization, and therefore are more resistant to stress corrosion cracking due to its low carbon content. DCD Tier 2, Section 4.5.1 was revised to include austenitic stainless steel Types 304, 304L, 316 and 316L as discussed in the Westinghouse Technical Report APP-GW-GL-009 (TR-33), Revision 1 submitted by Westinghouse letter dated May 24, 2007. TR-33, which provides the basis for the change, states that the addition of these materials will enhance manufacturing flexibility, reduce costs, and reduce risk relative to material availability. The changes to the AP1000 DCD as proposed in TR-33 was submitted pursuant to 10 CFR 52.63(a)(1)(vii) on the basis that the proposed changes contribute to increased standardization of the certification information.

Types 304 and 316 stainless steel material (higher carbon content) are less resistance to sensitization due to heat treatment or welding. In addition, there are emerging issues involving Types 304 and 316 stainless steels that are discussed in NRC Information Notice 2006-27, "Circumferential Cracking in Stainless Steel Pressurizer Heater Sleeves of Pressurized Water Reactors" and numerous requests for relief from the ASME Code concerning repairs to leaking CRDM canopy seal welds. These instances of stress corrosion cracking are occurring in stagnant or dead-end PWR coolant environments. Since the proposed use of Types 304 and 316 stainless steel materials are more susceptible to intergranular stress corrosion cracking and transganular stress corrosion cracking than the low carbon Types 304L, 304LN, 316L and 316LN stainless steel material, the use of Types 304 and 316 materials may affect the integrity of the CRD components (including the reactor coolant pressure boundary portions of the latch housing and rod travel housing). Specifically, it can affect the structural integrity of these CRD components which are subjected to stagnant water (trapped oxygen), dead legs or areas prone to increased levels of oxygen.

Therefore, the NRC staff requests that Westinghouse delete the proposed addition of these materials from the AP1000 DCD or provide further justification addressing the acceptability of the proposed addition of Types 304 and 316 stainless steel. As currently proposed, the staff finds the proposed addition of the materials does not meet NRC regulations on the basis that the changes (1) unacceptability decrease the overall safety and reliability of the facility design and (2) contribute to a decreased standardization of the certification information contrary to 10 CFR 52.63(a)(1)(vi) and (vii).

Westinghouse Response:

While Types 304 and 316 stainless steel may be more susceptible to sensitization, controls are established in Section 5.2.3.4 to avoid sensitization due to heat treatment or welding and prevent susceptibility to intergranular attack as addressed by Regulatory Guide 1.44. Cleaning procedures and contamination preventions measures are implemented to prevent the presence of detrimental impurities that could contribute to intergranular cracking or transgranular stress corrosion cracking. All austenitic stainless steels are procured in the solution annealed condition. Welding procedures are reviewed for control of preheat and interpass temperatures during welding. The application of these measures to control the fabrication and processing of austenitic stainless steels has been reviewed and approved as acceptable by the staff.

The emerging issue involving Types 304 and 316 stainless steels discussed in NRC Information Notice 2006-27, "Circumferential Cracking in Stainless Steel Pressurizer Heater Sleeves of Pressurized Water Reactors" has not been attributed to a unique set of material or fabrication parameters and industry actions are planned to identify similar occurrences. Both Type 304 and 316 stainless steels have been used extensively in numerous PWR component applications. The occurrence of failures or leakage due to cracking in stainless steel components has been limited to a very small number of occurrences when exposed to PWR operating environment conditions. Many incidents have been associated with additional contributing factors for specific applications and are not limited to standard grade austenitic stainless steels associated with sensitization.

Requests for relief from the ASME Code concerned repairs to leaking CRDM canopy seal welds on older CRDM designs. There were three canopy seal locations, the lower canopy seal of the CRDM to the RPV head adapter, a middle canopy seal of the CRDM to the rod travel housing and an upper canopy seal at the top of the rod travel housing. The majority of the leaks have occurred at the lower canopy seal weld location, although some leaks have also occurred at the middle canopy seal weld. The AP1000 CRDM design has eliminated the lower and upper canopy seal welds. These have been replaced with full penetration welded joints. The middle canopy seal weld has been redesigned with a larger radius and thicker wall to reduce stress levels. In addition, a vent and drain path has been included in the design for the canopy seal volume to prevent fully stagnant conditions. While there is no significant flow in this region during normal operation, these features will prevent water from being entrapped in the canopy seal area for multiple cycles and will also eliminate air entrapment to minimize the presence of an oxygenated environment. The combined effect of these design changes minimizes the potential for stress corrosion cracking in the CRDM assembly.

The instances of stress corrosion cracking occurring in stagnant or dead-end PWR coolant environments are not dependent on the carbon content of the austenitic stainless steel. Standard low carbon and stabilized grades of austenitic stainless steels are susceptible to TGSCC under these conditions. TGSCC has been observed in Type 308L weld metal, as well as Type 304 base metal. (Ref. 6) TGSCC also occurred in Type 316L piping and valve leakoff lines using Types 304, 304L and 316. (Refs. 7 and 8) Cracking has also been detected in Type

347 and Type 321 stabilized grades of stainless steel. In the presence of high stresses and adverse environmental conditions, 300 series stainless steels are potentially susceptible to SCC in a non-sensitized condition. Prevention of cracking under these environmental conditions is achieved by changing the environment or modifying the design to reduce stress levels. Steps have been taken in redesigning the AP1000 CRDM assembly to reduce stresses and modify the local environmental conditions to address SCC concerns in the canopy seal region.

Based on the factors described above, the use of Types 304 and 316 stainless steels in the CRDM assembly does not increase the susceptibility to intergranular or transgranular stress corrosion cracking when compared to the low carbon Types 304L, 304LN, 316L and 316LN stainless steel material. The use of Types 304 and 316 materials in AP1000 has been approved on the basis that the fabrication and processing of reactor coolant pressure boundary (RCPB) austenitic stainless steel meets GDC 1 and 4, and 10 CFR Part 50, Appendix B, Criterion XIII, because it conforms to the applicable provisions of the ASME Code and the regulatory positions in, or acceptable alternatives to, RGs 1.31, 1.34, 1.36, 1.37, 1.44, and .1.71. This position and the modifications to the AP1000 CRDM assembly provide the basis for the acceptability of Types 304 and 316 austenitic stainless steels.

Reference(s):

1. 10 CFR 52.63 Finality of design certifications dated January 14, 2004 and August 28, 2007

2. NRC Information Notice 2006-27, "Circumferential Cracking in Stainless Steel Pressurizer Heater Sleeves of Pressurized Water Reactors" dated December 11, 2006

3. United States Energy Commission Regulatory Guide 1.44 dated May 1973, "Control of the Use of Sensitized Stainless Steel"

4. ASTM A262-02A (Re-approved 2008) ,"Standard Practice for Detecting Susceptibility to intergranular attack in Austenitic Stainless Steel.

5. ASME B&PV Code 1998 Edition in including 2000 Addenda

6. C. M. Pezze and I. L. W. Wilson, *"Transgranular Stress Corrosion Cracking of 304 Stainless Steel Canopy Seal Welds in PWR Systems,"* Proceedings of the 4th International Symposium on Environmental Degradation of Materials in Nuclear Power Systems-Water Reactors, NACE, 1990, pp. 4-164 – 4-177.

7. J. M. Boursier, S. Gallet, Y. Rouillon, and P. Bordes, *"Stress Corrosion Cracking of Austenitic Stainless Steels in PWR Primary Water: An Update of Metallurgical Investigations Performed on French Withdrawn Components,"* Presented at the PWR Chemistry and Corrosion Management Conference, Chendu, October 1999.

8. R. Killian, O. Wachter, M. Wideera, G. Brummer. U. Ilg, *"Parameters Influencing the Transgranular Stress Corrosion Cracking Behavior of Austenitic Stainless Steels in Systems Conveying Reactor Coolant,"* Fontevraud 5 Contribution of Materials Investigation to the Resolution of Problems Encountered in Pressurized Water Reactors, SFEN, 2002.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None