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Your ref: Project Number 740
Our ref: DCP/NRC2081

January 29, 2008

52-6
52-15
52-14

Subject: AP1000 COL Response to Request for Additional Information (TR 106)

In support of Combined License application pre-application activities, Westinghouse is submitting aresponse to the NRC request for additional information (RAI) on AP1000 Standard Combined License Technical Report 106, APP-GW-GLN-106, "Mechanical System and Component Design Updates". This RAI response is submitted as part of the NuStart Bellefonte COL Project (NRC Project Number 740). The information included in the response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification.

A response is provided for RAI-TR106-CIB1-04 as sent in an email from Dave Jaffe to Sam Adams dated December 14, 2007. This response completes all requests received to date for Technical Report 106. Responses to RAI-TR106-CIB1-01 through -03 were submitted under Westinghouse letter DCP/NRC2019 dated October 5, 2007. Responses for RAI-TR106-SEB1-01 through -04 were submitted under Westinghouse letter DCP/NRC2000 on September 19, 2007.

Pursuant to 10 CFR 50.30(b), the response to the request for additional information on Technical Report 106 is submitted as Enclosure 1 under the attached Oath of Affirmation.

Questions or requests for additional information related to the content and preparation of these responses 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,

A. Sterdis, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization



D063
D085
NRO

/Attachment

1. "Oath of Affirmation," dated January 29, 2008

/Enclosure

1. Response to Request for Additional Information on Technical Report No. 106

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

ATTACHMENT 1

"Oath of Affirmation"

ATTACHMENT 1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

| | |
|---|---|
| In the Matter of: | ) |
| NuStart Bellefonte COL Project | ) |
| NRC Project Number 740 | ) |

APPLICATION FOR REVIEW OF
"AP1000 GENERAL COMBINED LICENSE INFORMATION"
FOR COL APPLICATION PRE-APPLICATION REVIEW

W. E. Cummins, being duly sworn, states that he is Vice President, Regulatory Affairs & Standardization, for Westinghouse Electric Company; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission this document; that all statements made and matters set forth therein are true and correct to the best of his knowledge, information and belief.

W. E. Cummins
Vice President
Regulatory Affairs & Standardization

Subscribed and sworn to
before me this 29th day
of January 2008.

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Patricia S. Aston, Notary Public
Murrysville Boro, Westmoreland County
My Commission Expires July 11, 2011
Member, Pennsylvania Association of Notaries

Notary Public

ENCLOSURE 1

Response to Request for Additional Information on Technical Report No. 106

# AP1000 TECHNICAL REPORT REVIEW

## Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR106-CIB1-04
Revision: 0

***Question:***

In NRC RAI-TR106-CIB1-01, dated September 10, 2007, the staff requested that Westinghouse provide a justification for its selection of weld filler metals 2304 and 2209 to weld LDX 2101®. The staff also requested that the applicant state if corrosion testing of LDX 2101® and the proposed weld filler materials has been performed, taking into account the expected water chemistry. In addition, the staff requested that Westinghouse provide the results of testing that shows the suitability of this material for the intended application. By letter dated October 5, 2007, Westinghouse responded by stating the following:

> Published industry guidelines indicate that acceptable strength and corrosion properties of welds can be achieved using highly alloyed duplex fillers such as 2304 or 2209. The selection of 2304 and 2209 fillers will provide corrosion resistance in the as-welded condition that is at least equal to the LDX 2101® base metal. To ensure the corrosion resistance is maintained in borated water environments, corrosion tests of welded coupons using both the 2304 and 2209 fillers will be initiated.

1. It appears, from the applicant's response, that corrosion testing of LDX 2101® and weld filler metals 2304 and 2209 has not been performed to justify the use of these materials in a borated water environment. In addition, the applicant did not provide a technical justification for the use of these materials in the intended application, therefore, the staff requests that the applicant provide a technical justification for the use of the aforementioned materials. In addition, provide a description of the corrosion testing plan that will be used and discuss why the testing plan is adequate to ensure that the materials will not be subject to general corrosion, stress corrosion cracking or other forms material degradation due to corrosion for the life of the plant.

2. The staff notes that weld filler materials 2304 and 2209 are not matching filler materials for LDX 2101® which suggest that these filler metals would have different properties. Given that a matching filler material (Avesta LDX 2101) is currently available, provide a technical justification for using filler materials that are designed to weld duplex stainless steels other than LDX 2101®.

**Westinghouse Response:**

The UNS S32101 (LDX 2101®) duplex stainless steel was chosen to replace the previously specified S24000 (Nitronic 33) austenitic stainless steel for the structural modules of the AP 1000 reactor. The LDX 2101 grade was chosen because of its higher yield strength, superior corrosion resistance, and its availability in the required plate sizes. LDX 2101 is a lean duplex stainless steel with a nominal composition of 21.5% Cr, 5% Mn, 1.5% Ni, and 0.22% N compared to the Nitronic 33 which is an austenitic stainless steel with a nominal composition of 17.5 Cr, 12% Mn, 2.5% Ni, 0.22% N.

The structural modules will be exposed to borated water that could potentially pick up chloride contaminants. The materials of construction must have a low general corrosion rate and resist pitting and stress corrosion cracking (SCC) in the presence of borides and possible chlorides.

Although corrosion testing with welded LDX 2101 stainless steel samples is just being initiated, there are research data and producers' technical information that show the LDX 2101 will be very resistant in borated water environments. For example, similar duplex stainless steels such as type 2304 and 2205 show very low general corrosion rates in boric acid and bromide salt environments (see Figures 1 and 2), which indicates that duplex stainless steels, in general, perform very well in borated environments.

In waters containing halides the important elements for improved corrosion resistance are Cr, Mo, and N. Because the LDX 2101 contains slightly more Cr and a similar level of N, its pitting and crevice corrosion resistance should be equal to or slightly better than the Nitronic 33 grade that is being replaced.

The relative resistance to pitting and crevice corrosion can estimated from a stainless steel's chemical composition using the "Pitting Resistance Equivalent Number" (PRE number)[1]. The PRE number is calculated from the following empirical relationship:

$$\text{PRE number} = \%Cr + 3.3(\%Mo) + 16(\%N)$$

With this relationship the larger the PRE number the more resistant the stainless steel is to localized corrosive attack. A summary of some common stainless steels and their corresponding PRE numbers is presented in the following table.

| Stainless Steel | PRE number* |
|---|---|
| Type 304 | 20 |
| Type 316L | 23 |
| Nitronic 33 | 22 |
| LDX 2101 Duplex Stainless Steel | 23 |
| 2304 Duplex Stainless Sttel | 24 |
| 2205 Duplex Stainless Steel | 35 |

* based on the nominal composition

This shows that the LDX 2101 grade should have a localized corrosion resistance that is better than 304 and similar to a 316L stainless steel. This is consistent with a recent investigation[2] that measured the corrosion performance of coupons that consist of LDX 2101 sheet material plug welded to 316L base plates. After exposure to ferric chloride test solutions the coupons showed preferential attack of the 316L base plate but little or no attack on the LDX 2101 sheet metal or the 2209 duplex stainless steel plug welds.

Another benefit of the LDX 2101 grade compared to austenitic grades such as 304, 316L, and Nitronic 33 is the improved resistance to chloride stress corrosion cracking (SCC). Austenitic stainless steels such as 304L and 316L are very susceptible to SCC in the presence of chlorides and temperatures in excess of 50 °C (see Figure 3). A recent study[3] has shown the LDX 2101 grade to be much more resistant to SCC than 300 series stainless steels and similar to the 2304 and 2205 duplex stainless steels. In simple salt solutions, the LDX 2101 grade is not susceptible to SCC at ambient pressure boiling temperatures. Based on producer's literature[4] the Nitronic 33 grade has similar susceptibility to SCC as 304L and 316L when it is stressed to 25 KSI or higher. The selection of LDX 2101 for structural modules brings the added benefit of increased SCC resistance compared to either Nitronic 33, 304L, or 316L stainless steels.

As Noted in the NRC RAI-TR106-CIB1-01 supplemental request, the proposed 2304 and 2209 fillers are not matching fillers. The Avesta LDX 2101 matching filler material is a relatively new and until recently was not readily available. Because of this, most LDX 2101 projects have been welded using the 2209 filler, which is the matching filler for 2205 duplex stainless steel. As stated in producer's technical literature[5], the LDX 2101 grades can be welded using the Avesta LDX 2101 filler or the matching fillers for the 2304, 2205, or 2507 grades. These over alloyed fillers provide mechanical properties that can meet the LDX 2101 requirements and improved corrosion resistance in the weld. All weld procedures used for structural module fabrication must be qualified per the ASME Section IX requirements, which mandate tensile testing. Hence, any weld procedure/filler combination that is not capable of meeting the LDX 2101 strength and % elongation requirements would not be allowed.

References:

1. High-Performance Stainless Steels, Nickel Development Institute, Reference Book Series No. 11 021, 2000.
2. B. J. Uhlenkamp and J. D. Fritz, The Use of a lean Duplex Stainless Steel, UNS S32101: Thermal Dimple Jackets on Vessels for High Purity Applications, Paper 07218, NACE International, Corrosion 2007, Nashville, TN 2007.
3. E. Johansson and T. Prosek, Stress Corrosion Cracking Properties Of UNS 32101 – A New Duplex Stainless Steel With Low Nickel Content, Paper 07475, NACE International, Corrosion 2007, Nashville, TN 2007.
4. Armco Nitronic 33 Stainless Steel, Product Data Bulletin No. S-79 Armco, Inc., 1986.
5. B. Holmberg, F. Hagg, M. Laren, and Z. Zhou, *Guidelines: How To Weld Outokumpu LDX 2101®*, Avesta Welding.

**Design Control Document (DCD) Revision:**
None

**PRA Revision:**
None

**Technical Report (TR) Revision:**
None

**Boric Acid**

$B(OH)_3$

| **Conc.[1]%:** | **4** | **20** |
|---|---|---|
| **Temp. °C:** | **BP** | **BP** |
| Carbon Steel : | 2 | 2 |
| 13% Cr-steel : | 0 | 1 |
| 18-2 : | 0 | 0 |
| Standard Cr-Ni : | 0 | 0 |
| Standard Cr-Ni-Mo : | 0 | 0 |
| 4438 : | 0 | 0 |
| 4439 : | 0 | 0 |
| 904L : | 0 | 0 |
| Sanicro28 : | 0 | 0 |
| 254SMO : | 0 | 0 |
| 654SMO : | 0 | 0 |
| SAF2304 : | 0 | 0 |
| 2205 : | 0 | 0 |
| SAF2507 : | 0 | 0 |
| Ti : | 0 | 0 |

Rating of "0" designates a corrosion rate less than 0.1 mm/year;
Rating of "1" designates a corrosion rate between 0.1 - 1.0 mm/year
Rating of "2" designtes a corrosion rate greater than 1.0 mm/year

**Figure 1.** Corrosion performance of various stainless steels in boric acid environments. (source – Corrosion Handbook, Ninth Edition, Outokumpu Stainless Oy, 2004)

**Sodium Bromide**

NaBr

| **Conc.[1]%:** | **5-10** | **20** |
|---|---|---|
| **Temp. °C:** | **20** | **80** |
| Carbon Steel : | 2 | |
| 13% Cr-steel : | | |
| 18-2 : | Op | Op |
| Standard Cr-Ni : | Op | Ops |
| Standard Cr-Ni-Mo : | Op | Ops |
| 4438 : | Op | Ops |
| 4439 : | Op | Ops |
| 904L : | Op | Ops |
| Sanicro28 : | O | O |
| 254SMO : | O | O |
| 654SMO : | O | O |
| SAF2304 : | O | O |
| 2205 : | O | O |
| SAF2507 : | O | O |
| Ti : | O | O |

Rating of "0" designates a corrosion rate less than 0.1 mm/year;
Rating of "1" designates a corrosion rate between 0.1 - 1.0 mm/year
Rating of "2" designates a corrosion rate greater than 1.0 mm/year
The "p" designates possibility of pitting
The "s" designates possibility of stress corrosion cracking

**Figure 2.** Corrosion performance of various stainless steels in boric acid environments. (source – Corrosion Handbook, Ninth Edition, Outokumpu Stainless Oy, 2004)

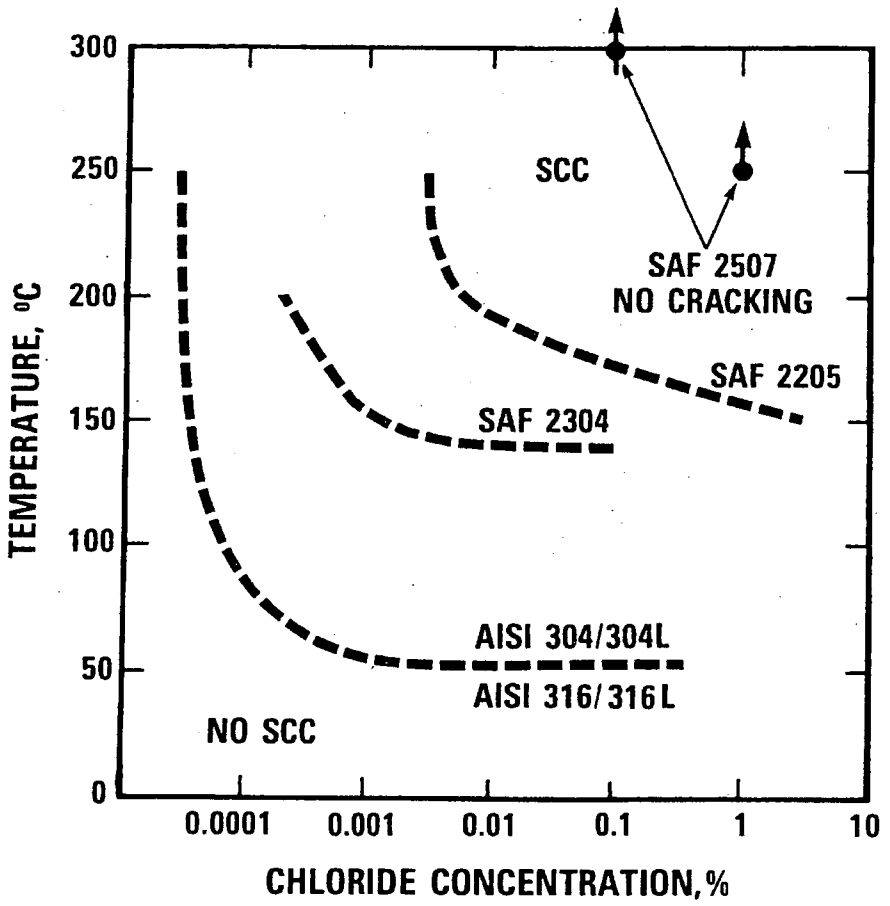


**Figure 3.** The SCC threshold for various austenitic and duplex stainless steels (from Sandvik SAF – 2507 Duplex Stainless Steel Data Sheet)