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Your ref: Docket No. 52-006
Our ref: DCP/NRC2114

April 4, 2008

Subject: AP1000 COL Response to Request for Additional Information (SRP6.5.2)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on Standard Review Plan (SRP) Section 6.5.2. 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-SRP-6.5.2-CIB1-01 as sent in an email from Bill Gleaves to Sam Adams dated February 14, 2008. This response completes all requests received to date for SRP Section 6.5.2.

Pursuant to 10 CFR 50.30(b), the response to the request for additional information on SRP Section 6.5.2, is submitted as Enclosure 1 under the attached Oath of Affirmation.

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

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NRO

/Attachment

1. "Oath of Affirmation," dated April 4, 2008

/Enclosure

1. Response to Request for Additional Information on SRP Section 6.5.2

cc:	B. Gleaves	- U.S. NRC		1E	1A
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	P. Ray	- TVA		1E	1A
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	G. Zinke	- NuStart/Entergy		1E	1A
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ATTACHMENT 1

"Oath of Affirmation"

ATTACHMENT 1

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of:)

AP1000 Design Certification Amendment Application)

NRC Docket Number 52-006)

APPLICATION FOR REVIEW OF
"AP1000 GENERAL INFORMATION"
FOR DESIGN CERTIFICATION AMENDMENT 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 4th day
of April 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 SRP Section 6.5.2

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.5.2-CIB1-01
Revision: 0

Question:

By letter dated April 13, 2007 (ADAMS Accession No. ML071060332) Westinghouse Electric Company, LLC (Westinghouse) submitted for staff review AP1000 Standard Combined License (COL) Technical Report 74A, Supplement 1, "AP1000 Generic Technical Specifications Completion, Update on Open Items," APP GW GLR 064, Revision 1, which was submitted to address open items in the Technical Specifications (TS) and TS Bases. The staff of the Component Integrity, Performance, and Testing Branch 1 (CIB1) is reviewing the quantity of trisodium phosphate (TSP) specified for pH control in the containment sump following a postulated loss-of-coolant accident (LOCA). According to TR 74A, the preliminary TSP quantity in earlier TS proposals "has been replaced with the final information and is based on system design specifications, approved engineering calculation notes and/or verified analysis input assumptions." The affected TS sections are, Limiting Condition for Operation (LCO) 3.6.9, Surveillance Requirement (SR) 3.6.9.1, and Bases section B 3.6.9.

On December 3, 2007, the staff visited the Westinghouse office in Rockville, Maryland to examine Calculation Note APP-PXS-M3C-021, Rev. 0, dated November 16, 2007, which documents the calculations for the TSP requirement. The document concludes that 560 cubic feet of TSP (Na3PO4 – 12H20) should be stored in containment in order to maintain the pH of the water in the sump between 7.0 and 9.5 for 30 days following a postulated LOCA.

In order to complete its review, the staff needs the following information:

1. TR 74A finalizes the preliminary technical specification requirement of 560 cubic feet of TSP stored in containment. Describe the additional evaluation performed to determine that the preliminary value is correct.

2. Calculations for sump pH control require assumptions about the plant configuration, such as the amount and location of cable insulation in containment. Describe the controls in place to ensure the amount of TSP stored in containment will be adequate for the as-built configuration. How are these assumptions and controls documented in the DCD?

3. It appears that in order to determine the amounts of strong acids generated in the AP1000 containment after a postulated LOCA, modified values of cable insulation and containment size for the AP600 were assumed. This assumption was justified based on the similarity between the two plant designs. According to NUREG/CR-5950, the generation of these acids in the sump fluid is also dependent on radiation dose, which should therefore be included in the calculation. Please discuss in more detail the procedure used and the calculated amounts of strong acids generated after a LOCA in the AP1000.

4. Was cesium hydroxide (CsOH) assumed to be present in the calculations of the amount of TSP required in containment? If it was, describe its effect on sump pH.

5. Clarify how the specified amount (560 cubic feet) of TSP was determined for maintaining the pH of the sump water at or above 7 for the 30-day post-LOCA period in the presence of all anticipated acid and base sources.

6. Describe the type of inservice TSP degradation assumed in the sump pH analysis and the basis for selecting a margin of 14 percent to account for this degradation.

Westinghouse Response:

1. The total minimum TSP volume in the pH adjustment baskets for AP1000 has remained consistent among the Tier 1 (DCD 2.2.3) and Tier 2 (DCD Section 6.3 and Technical Specification 3.6.9) sections since Revision 1 of the AP1000 DCD provided in 2002.

   The removal of the Technical Specification 3.6.9 bracket for the TSP volume in TR-74A resulted from an update of the preliminary calculation of the original DCD design value. The TSP calculation was updated based on evolving plant design details, however, no significant changes were made to the current AP1000 design parameters that required changing the original value in the bracket.

2. The DCD identifies the total TSP volume needed to maintain the containment sump pH following an accident and the DCD also documents design assumptions and controls needed to confirm that the TSP stored in containment will be adequate for the as-built plant configuration.

   While much of the specific information used to calculate the required TSP volume for the plant is appropriately contained in the detailed design documents and calculations that support the TSP volume calculation, the DCD documents and controls key aspects of the AP1000 design that most significantly impact the TSP volume calculation.

There are three principle groups of AP1000 plant design characteristics controlled by the DCD that help to control both the amount of electrical cable in containment and the consequential hydrochloric acid (HCl) formation process from radiolytic decomposition of electric cable jacket insulation following an accident, which include:

- Containment diameter and associated containment system and equipment layout / locations (controlled by DCD plant layout drawings)
  - Major system layout within containment
  - The number and location of major equipment, and associated piping or ducting routing and locations, within containment (which control process sensing instrument cabling and component control or power cabling starting-point locations)
  - The instrumentation channels for various systems in containment that are controlled within DCD Technical Specifications 3.3.1 (reactor trip instrumentation) and 3.3.2 (safeguards actuation instrumentation), as well as DCD Subsection 7.5 (post-accident monitoring instrumentation)

- Containment cable penetration locations and associated cable routing factors controlled by DCD layout drawings that include:
  - Containment penetration locations (which control cabling end-point routing to their containment exit locations and potential cable tray bundling)
  - Containment fire zone configuration (DCD Appendix 9A) layout
  - Cable routing separation requirements for safety-related, nonsafety-related, and defense-in-depth equipment location / separation (to help satisfy regulatory requirements related to Class 1E criteria, fire protection criteria, and plant reliability and potential cable tray bundling)

- Core power and associated core fission product inventories and post-accident radiolytic flux levels
  - Core power rating
  - Fission product source terms

While the specific DCD controls over the important design aspects impact total electrical cabling length and limit cable length variation, the overall plant simplification itself also helps to significantly reduce the absolute total length of electrical cabling in the plant by more than 80 percent over conventional plants. Therefore, relatively minor changes in individual containment plant equipment, equipment sizing, or cable routing that are beyond these identified DCD controls are not expected to significantly impact total cable lengths due to this reduced absolute volume of AP1000 plant cabling, which includes the containment cabling and associated insulation mass.

While the plant I&C system design, architecture, and layout can control I&C cabling between components and I&C input / output cabinets, and also between the I&C cabinets themselves, there are relatively few I&C cabinets in containment. Therefore I&C architecture, which is controlled within the DCD Chapter 7, is not expected to have any significant impact on total containment cabling and the consequential electrical cabling effects on long-term containment sump pH.

Therefore, the DCD controls over the AP1000 plant design significantly limit the impact of individual changes on the plant cabling and consequential effects on TSP volume. In addition, the conservative TSP margin as part of the AP1000 helps to assure that the pH impact of any cable routing changes are minimal.

3. The calculation of the required TSP volume is based taking the volume of TSP required to control the pH of the total water inventory that mixes within containment following an accident (which includes the RCS, core makeup tanks, accumulators, and IRWST) and increasing this volume by a fractional margin to account for the long-term formation of strong acids and bases generated in containment following an accident.

This water-inventory-only TSP volume is adjusted for the TSP volume addition to account for three specific post-accident, long-term acid and base formation phenomena which include:

- Contributions that <u>decrease</u> pH from hydrochloric acid produced by radiolytic decomposition of electric cable jackets
- Contributions that <u>decrease</u> pH from nitric acid produced by radiolytic formation from air dissolved in the containment sump water
- Contributions that <u>increase</u> pH by the strong base cesium hydroxide formed from fission products released from the reactor core fission

The water-inventory-only sump pH calculation provides the majority of the TSP volume calculated and the cesium hydroxide contribution helps to counteract the adjustment needed for the two acid formation phenomena.

The approach taken in the TSP volume calculation for both AP600 and AP1000 was to evaluate the long-term contribution from acids and bases for these post-accident phenomena and to calculate a long-term TSP adjustment margin to be added to the water-inventory-only TSP volume.

For AP600, the water-inventory-only TSP volume was increased by 35% to account for long-term effects. The cable decomposition effects are about 85% of the acid contribution and the air radiolysis accounts for the remaining 15%. The cesium hydroxide formation compensates for about 14% of the acid production, essentially countering the air radiolysis effects.

As part of the AP600 design certification process, the NRC staff reviewed the AP600 long-term phenomena calculation (PXS-M3C-036, Rev. 0) that calculated the TSP adjustment factor for these three processes to be added to the AP600 water-inventory-only TSP volume calculation (PXS-M3C-021, Rev. 0). The AP600 long-term sump pH effects calculation included an appendix with the key sections of the water-inventory-only AP600 TSP volume calculation.

The AP600 approach for long-term sump phenomena was found to be satisfactory as documented in the evaluation in Chapter 15.3 under Post-Accident Containment Water Chemistry Management discussion for both the AP600 and AP1000 FSER's (NUREG-1512 and NUREG-1793, respectively).

This same approach was followed for the AP1000 TSP volume calculation (APP-PXS-M3C-021, Revision 0) that was recently reviewed by the NRC staff.

Containment Sump pH Analysis FSER Evaluation

The staff review of the AP600 calculation helped to support the basis for the finding in the AP600 FSER evaluation of the adequacy of the post-accident containment water chemistry evaluation and the consistency of the long-term pH effect calculation that "...used the methods and models described in NUREG/CR-5950, 'Iodine Evolution and pH Control,' to determine the formation of hydrochloric and nitric acids."

As discussed in Section 15.3 of the AP600 FSER under Post-Accident Water Chemistry Management, "...in the analyses of these accident sequences, Westinghouse considered the following factors:

(1) the water mass and its boric acid concentrations in the reactor coolant system and the passive core cooling system injection lines
(2) the addition of trisodium phosphate (TSP)
(3) hydrochloric acid generated from electrical cable degradation
(4) cesium hydroxide formed from the fission products released from the core
(5) nitric acid produced by irradiation of water and air

Westinghouse used the methods and models described in NUREG/CR-5950, 'Iodine Evolution and pH Control,' to determine the formation of hydrochloric and nitric acids."

As discussed in the AP600 FSER, the calculated water-inventory-only TSP volume for AP600 was increased to compensate for long-term acid and base buildup. With the cesium-hydroxide formed from fission product release providing a strong base, cesium hydroxide will contribute to the increase of the pH that helps to counteract the long-term acid formation.

AP1000 TSP Volume Calculation

This same approach was followed for the AP1000 TSP calculation and increased long-term margins were included for the TSP volume added to the water-inventory-only volume for the AP1000 design.

Since the fundamental long-term phenomena are similar for AP1000 and the effects are also expected to be relatively similar, the AP1000 approach was to appropriately revise the fractional adjustment factor for long-term phenomena (35% calculated TSP addition for AP600, with additional 13% margin for conservatism, for a total of 48%) based on the AP1000 design differences, which include the core power increase and the increase in containment volume.

Table 1 provides a summary of the key factors that affect the long-term TSP adjustment factor and a comparison of the changes from AP600 to AP1000 that are accounted for in the long-term TSP adjustment factor.

Each of these long-term effects are accounted for in the TSP volume calculation for AP1000 since appropriate long-term effects margin is added to the water-inventory-only TSP volume in calculating the required total TSP volume in the DCD.

For AP1000, the air radiolysis factor increases by the increased containment volume (~1.19), but the cesium hydroxide contribution increases by a larger amount due to the core power ratio (~1.76, which increases post-accident radiation flux and fission product inventories), effectively canceling the air radiolysis acid effects and counteracting some of the cable insulation radiolysis acid effects.

Relative to cable insulation radiolysis effects and as discussed in the response to Question 2), due to the extensive similarities in plant, equipment, and electrical cabling routing and overall layout, the AP600 and AP1000 designs are expected to have relatively comparable electrical cable routing and total electrical cable insulation mass.

The amount of electrical cabling inside containment is related to the equipment in containment, equipment locations, and routing of cabling from the equipment to the associated containment penetrations. These design aspects were not significantly impacted by the uprating. Cable routing is expected to be more closely related to containment diameter rather than containment height and volume and the containment diameter did not change for AP1000. Therefore, relative to electrical cabling effects, the important physical containment dimensions and layout limitations (equipment locations, elevations, separation arrangements, fire zone arrangements, cable penetration locations, etc.) that help to drive the most important aspects of electrical cable routing are not significantly different for AP1000 from AP600. Therefore, significant cable routing changes are not anticipated. While there may be differences in powered equipment sizing that affects electrical power cable requirements that slightly increase cable sizes, this is also not expected to significantly impact total containment insulation mass.

Cable insulation degradation is also affected by the radiolytic flux, which is affected by the core power change from AP600 to AP1000. The added margin included in AP1000 TSP calculation sufficiently accommodates any flux impact. In addition, the analytical approach in the long-term TSP margin calculation recognizes that there are conservatisms in the calculated cable insulation radiolysis effects. For example, there is self-shielding of cabling bundles within cable trays since the beta radiolysis flux does not effectively penetrate bundled cabling.

One important contribution to the long-term margin comes from the calculation of the water-inventory-only TSP volume. While there was relatively small AP1000 water volume changes from AP600 (~1.07), updated TSP titration curves were used for AP1000 that increased the water-inventory-only volume by a factor of about 1.5.

Applying the long-term adjustment factor to a larger water-inventory-only value inherently results in a relatively larger margin volume for AP1000 to compensate for long-term effects that are relatively similar to those for AP600.

Balancing these various difference effects, the long-term adjustment factor used for AP1000 (65% versus 48%) was conservatively increased and this factor can compensate for a cable mass increase of more than twice the cable mass assumed for AP600 and still have remaining margin. With this conservative AP1000 TSP volume adjustment margin included, the calculated upper pH value of 7.8 for AP1000 (with 560 ft3 of TSP) has significant margin to the upper containment sump pH limit of 9.5 in BTP MTEB 6-1.

Therefore, as a result of the conservative approach for the total TSP volume calculation for AP1000, the calculated TSP volume stored in containment for AP1000 is expected to be adequate for the as-built plant configuration.

Table 1
Comparison of Key Calculation Parameters Affecting Sump pH

Parameter	AP600	AP1000	AP600 to AP1000 Plant Ratios
Relevant Water Inventory pH Factors			
RCS water volume	7297 ft3	8940 ft3	1.26
IRWST (minimum)	70000 ft3	73100 ft3	1.04
CMTs	2000 ft3	2500 ft3	1.25
Accumulators (water)	1700 ft3	1700 ft3	1.0
Total Containment Water Volumes	**84697 ft3**	**90440 ft3**	**1.07**
TSP Volume Summary Water-inventory-only pH volume Long-term acids/bases volume Degradation margin volume	 132 ft3 195 ft3 (48%) 214 ft3 (10%)	 293 ft3 490 ft3 (65%) 560 ft3 (14%)	 **1.56** - -
Max calculated pH (< 9.5 per BTP MTEB 6-1)	7.37	7.8	-
Relevant Long-Term Factors (affects TSP add margins)			
Containment Diameter (affects HCl produced)	130 ft	130 ft	1.0
Core power (affects Cs and HCl / HNO3 flux)	1933 MWt	3400 MWt	1.76
Containment free volume (affects HNO3 produced)	1.73E6	2.06E6	1.19

4. See the response to Question 3 above.

   As discussed in Section 4.2 of the calculation, and as confirmed in Sections 15.3 of both the AP600 and AP1000 FSERs, the formation of strong base cesium hydroxide (CsOH) when core fission products mix with the water in the containment sump helps to mitigate the effects of the acid formation from cable degradation and nitrogen and increase the containment sump pH.

   However, the two acid formation processes dominate the cesium-hydroxide long-term contribution, which is reflected in the overall need to <u>increase</u> the TSP volume calculated for the water-<u>inventory-</u>only pH calculation by a factor of about 35% for the AP600 calculation, which was increased to about 48% to provide additional sump pH control margin. A similar approach was followed for AP1000.

5. See the response to Question 3 above.

6. As Section 4.9 of the governing AP1000 TSP volume calculation (APP-PXS-M3C-021) indicates, the margin added to the calculated TSP minimum volume to account for any TSP degradation was arbitrary and was not attributable to any specific TSP degradation mechanism. This approach simply provided additional TSP volume to assure that the minimum pH requirement will be satisfied even with a slight degradation of the TSP volume for any reason.

Design Control Document (DCD) Revision:

None

PRA Revision:

None

Technical Report (TR) Revision:

None