April 11, 2003

MEMORANDUM TO: Marsha Gamberoni, Deputy Director
New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation

FROM: Joseph Colaccino, Senior Project Manager ***/RA/***
New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation

SUBJECT: FEBRUARY 25, 2003, TELEPHONE CONFERENCE CALL SUMMARY

On Tuesday, February 25, 2003, a telephone conference call was held with Westinghouse Electric Company (Westinghouse) representatives and Nuclear Regulatory Commission (NRC) staff to discuss several requests for additional information (RAIs). The following RAIs were discussed: 251.001, 251.002, 251.024, 251.025, 251.026, 251.027, 251.028 and 251.029. Westinghouse submitted responses to these RAIs on November 15 (ADAMS Accession No. ML023360097) and December 2, 2002 (ADAMS Accession No. ML023400058). A list of call participants is included in Attachment 1. Attachment 2 contains NRC staff comments regarding the subject RAIs that were sent to Mr. Michael Corletti of Westinghouse via electronic mail on February 11, 2003. These comments were used to facilitate discussions during the telephone conference call. Additional information was transmitted to Westinghouse via electronic mail on March 14, 2003, related to RAI 251.028 to facilitate any future discussions.

Following is a brief summary of the discussions regarding the identified RAIs (see comments in Attachment 2):

RAI 251.001

Westinghouse stated that the insights from the AP600 review could not be used for the AP1000 review because the turbine vendor for the AP1000 is Mitsubishi whereas the turbine vendor for the AP600 was Siemens. Additional information may be required if the staff needs to consider the AP1000 review as completely stand-alone.

RAI 251.002

Westinghouse stated that they would revise the RAI response to address Items a and c of this RAI. With respect to Item d, Westinghouse stated that this was related to RAI 251.001 and that insights from the AP600 review could not be used for the AP1000 review. Therefore, no additional information is required for Item d at this time.

RAI 251.024

Westinghouse stated that they would revise their RAI response to address how the turbine vendor determines K_{IC} values when they determine the specification.

RAI 251.025

Westinghouse stated that they would verify the values for K_{IC} and revise the RAI response. In addition, they would revise the design control document (DCD) if necessary.

RAI 251.026

Westinghouse stated that they would revise their RAI response to address the issues raised by the NRC staff. In addition, if this information is already included in WCAP-15783, “Analysis of the Probability of the Generation of Missiles from Fully Integral Nuclear Low Pressure Turbines,” they would provide a pointer in the DCD to the WCAP.

RAI 251.027

After a discussion of this RAI, the NRC staff concluded that no additional information was required.

RAI 251.028

Westinghouse stated that this RAI was related to RAI 251.024 and they would also revise this RAI response to address this issue.

After the conference call, the staff requested additional information related to this RAI. This information was transmitted to Westinghouse via an e-mail dated March 14, 2003, and is included below:

> The staff's RAI was intended to have a validation of the MHI test results so that at least the staff can use the information in the public domain (in this case, an ASME paper) to make sure that the AP1000 disk materials can meet Westinghouse's fracture toughness requirement of 200 ksi square root of inch for the rotor. Please provide how results from the material tests on each rotor will be used to derive the K_{Ic} for that rotor. Please state if K_{Ic} is derived from the FATT curves by MHI or using the Rolfe-Novak-Barsom's approach. In either case, provide a justification for the margin used in determining the K_{Ic} to reflect uncertainties associated with using an empirical equation.

RAI 251.029

Westinghouse stated that the control systems and valves for the turbine main stop and governor valves referenced in the DCD were similar to previous Westinghouse turbine control system designs. Westinghouse agreed to revise the RAI response to further address the NRC staff’s issue.

Docket No. 52-006

Attachments: As stated

cc w/atts: See next page

RAI 251.025

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cc w/atts: See next page

ACCESSION NUMBER: ML030730711

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February 25, 2003

TELEPHONE CONFERENCE CALLS SUMMARY

LIST OF PARTICIPANTS

Nuclear Regulatory Commission	Westinghouse
Joseph Colaccino	Mike Corletti
Simon Shung	Don Hutchings
	Ed Cummins
	Takahiro Imamura (MHI)

Attachment 1

NUCLEAR REGULATORY COMMISSION STAFF

COMMENTS THAT WERE SENT TO WESTINGHOUSE TO FACILITATE

DISCUSSIONS OF THE REQUESTS FOR ADDITIONAL INFORMATION (RAIs)

RESPONSES FOR CALL HELD

ON FEBRUARY 25, 2003

(Note: Provided below is the original RAI followed in italics by a discussion of the remaining unresolved issues that were discussed on the phone call.)

3.5.1.3 Turbine Missiles

251.001

It was stated in Section 10.2.2 that "(t)he rotor design, manufacturing, and material specification and the inspections recommended for the AP1000 provide an acceptable very low probability of missile generation." Section 10.2.2 further explains that "(t)he probability of destructive overspeed condition and missile generation, assuming the recommended inspection and test frequencies, is less than 1 x 10^{-5} per year."

Provide the source of the assessment of this low probability value (e.g., from WCAP-15783, "Analysis of the Probability of the Generation of Missiles from Fully Integral Nuclear Low Pressure Turbines)." List all modifications that Westinghouse has made to the Monte-Carlo simulation methodology since 1984, the year when an early version of the methodology described in WSTG-3-P, "Analysis of the Probability of a Nuclear Turbine Reaching Destructive Overspeed," was approved by the Nuclear Regulatory Commission (NRC). (Design Control Document [DCD] Section 3.5.1.3)

> *The applicant has answered this question partially. NRC approved Westinghouse's turbine missile methodology on February 2, 1987. WSTG-1-p, "Procedures for Estimating the Probability of Steam Turbine Disk Rupture from Stress Corrosion Cracking," is one of the four topical reports reviewed in that effort. The methodology in this report can be considered as a Monte Carlo simulation with only one random variable with uniform distribution. This variable is related to the flaw shape factor, Q, and the crack branching effect. WCAP-15783 changed the methodology completely. Now the only random variable is related to the crack growth rate with a normal distribution. Westinghouse needs to explain why the WCAP-15783 methodology is an acceptable replacement of the WSTG-1-p methodology and justify its choice of the mean and standard deviation for this new random variable. Confirm that the WCAP-15783 methodology is the same as the underlying methodology, the WSTG-4-p methodology, for the AP600. Even if WCAP-15783 is the same as WSTG-4-p, the above mentioned concern has to be addressed because WSTG-4-p was provided only as a reference to facilitate the AP-600 review.*

251.002

Address Questions 2.a to 2.f if the modifications mentioned in Question 251.001 affect the subject of each of these six questions/comments. (DCD Section 3.5.1.3)

a. Provide the probability distributions for both undetected and reported indications for the probabilistic burst and missile analysis and the bases for the selection. How are they used in the Monte-Carlo simulations?

   Substantiate the statement that the inspection procedures, equipment, and personnel will allow the owner to reliably detect a flaw with a length of 1.5 mm and a depth of 0.375 mm.

b. No additional information needed

c. Was the stress corrosion crack growth rate independent of the level of stress intensity factor? Plot data from tests and operating plants to support your conclusion. If any variables related to stress corrosion crack initiation were included in your current turbine missile probability analysis, please provide detailed information regarding the use of the stress corrosion crack initiation parameters in your analysis.

   The applicant has answered this question partially. The crack growth rate that was approved in 1987 was based on a database of 60 keyway cracks and 9 bore cracks. What is the basis for the new corrosion crack growth rate in WCAP-15783? Does the mean and the standard deviation of the error term, ε, which appeared in the crack growth equation, reflect the statistical characteristics of the new database?

d. Provide all random variables, their distributions, and suggested number of standard deviations that were used in your Monte-Carlo simulations. Explain the need for distributions other than the normal distribution for any of the variables, and justify the use of the suggested number of standard deviations for all variables. Comment on the convergence of the calculated P_1 value for your Monte-Carlo simulation involving this many random variables. Further, how were the mean values for these variables determined, especially for the mass of bladed disk fragments and fragments from other rotating parts? How do they correlate with industry experience on turbine missile events? Are values for these variables dependent upon the specific design or model of a turbine? Please use a typical turbine model to be used in the AP1000 application as an example and illustrate how these values were established. How was the degree of blade crushing, blade bending, and deformation of stationary blades considered in your calculation of the probability of casing penetration?

   See comments under 251.001.

e. Assess the contributions due to these modifications to the turbine missile probability reported in the submittal.

   See comments under 251.001.

Chapter 10

10.2.3.2 Fracture Toughness

251.024

The second paragraph in Section 10.2.3.2 contains the statement, "(t)he ratio of material fracture toughness, K_{IC} (as derived from material tests on each rotor) to the maximum tangential stress for rotors at speeds from normal to design overspeed, will be at least 200 ksi x √in (or at least 2) at minimum operating temperature." This sentence is not clear and should be revised. Confirm that you are trying to suggest that fracture toughness will be at least 200 ksi x √in and the ratio of fracture toughness to the maximum applied stress intensity factor for rotors at speeds from normal to design overspeed will be at least 2. (Section 10.2.3)

Based on the RAI response the following question/concern needs to be addressed. What if the "mechanical properties tests" on material taken from the rotor shows a toughness value (e.g., 170 ksi x √in) less than 200 ksi x √in? Since K_{Ic} is considered a deterministic parameter in the analysis, Westinghouse needs to account for proper uncertainties for any indirectly obtained or derived K_{Ic} values.

251.025

It was mentioned in the third paragraph of Section 10.2.3.2 that conservative factors of safety are included for the size uncertainty of potential or reported ultrasonic indications, rate of flaw growth, and the duty cycle stresses and number. Provide these factors of safety, and comment on how they are determined. (Section 10.2.3)

It was shown on Page 4-7 of WCAP-15783 that K_{Ic} is an order of magnitude greater than the reasonable value for turbine disk material. There must be an error in the units. Provide and justify the correct value that Westinghouse intends to report.

10.2.3.2.1 Brittle Fracture Analysis

251.026

It was mentioned in the first paragraph of Section 10.2.3.2.1 that the maximum rotor stress is determined from rotation, steady-state thermal loads, and transient thermal loads from startup and load change. Provide the operating speed and the first and second critical speeds for the rotor. If any of the rotor critical speeds are below the operating speed, explain why you do not need to consider rotor vibratory stresses when passing through critical speeds during startups and shutdowns. (Section 10.2.3)

The Westinghouse response confirmed that the rotor resonant stresses resulting from rotor passing through critical speeds during startups and shutdowns were not considered in the evaluation of low cycle fatigue. Where have they been considered? If they were considered in the high cycle fatigue evaluation, how much did the resonant stress contribute to each of the alternating stresses listed in Table 4-2 of WCAP-15783?

251.027

Provide the K_{IC} value and the factor of safety that was used to generate the allowable initial flaw area from an initial flaw area. Discuss the appropriateness of the assumption that a crack would originate from the centerline for rotors without bores. (Section 10.2.3)

Additional questions derived from this response were combined with comments related to RAI 251.025.

251.028

It was stated in the last paragraph of Section 10.2.3.2.1 that there is not a separate material toughness (K_{IC}) requirement for the AP1000 rotors. Not having a K_{IC} requirement for the deterministic brittle fracture mechanics analysis is not appropriate. In the AP600 review, the staff accepted the use of the Rolfe-Novak-Barsom correlation of upper shelf Charpy values with K_{IC} in the turbine missile probability analysis. That was because for a missile probability analysis involving more than twenty random variables, the impact of the variability of K_{IC} on the final results is small. It was never the staff's intention to accept the Rolfe-Novak-Barsom correlation for a deterministic brittle fracture mechanics analysis on any components without sufficient safety margin (say 30 percent) to account for the uncertainty in using this empirical formula. Provide a K_{IC} requirement for the AP1000 rotors. (Section 10.2.3)

Is Westinghouse suggesting that the material toughness (K_{Ic}) requirement for the AP1000 rotors is 200 ksi $\sqrt{in}$? Elaborate on the statement that "(t)his minimum allowable is readily achievable based upon MHI tests and experience."How do the MHI ***[Joe-define]*** *test results compare with those analyzed by R. Viswanathan and S. Gehl and published in ASME Journal of Engineering Materials and Technology (April 1991, Vol. 113, pp. 263-270)?*

10.2.3.6 <u>Maintenance and Inspection Program Plan</u>

251.029

It was mentioned in Section 10.2.3.6 that the maintenance and inspection program plan for the turbine assembly and valves is based on turbine missile probability calculations reported in WCAP-15783, operating experience of similar equipment, and inspection results. Provide the calculated turbine missile probability results that were used for this purpose and explain how they were used to determine the inspection intervals of 10 years for low-pressure (LP) turbines and 8 years for high-pressure (HP) turbines, the inspection intervals of 3 years for a variety of valves, and the quarterly testing frequency for valves. (Section 10.2.3)

The methodology of WCAP-15783 is based on the failure rate derived from years of unit and component service in Japanese nuclear power stations. Please comment on the design of the main stop and governing valves and their control systems to be used in the AP1000 plant to justify the use of the above-mentioned information from Japan.

cc:

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