UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 1, 2011

MEMORANDUM TO: Eileen McKenna, Chief
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SUBJECT: SUMMARY OF THE AP1000 DESIGN CERTIFICATION – REGULATORY ON SITE AND OFF-SITE REVIEWS OF OPEN ITEMS FOR THE WESTEMS COMPUTER CODE

During the time period between June 23, 2010, and September 2, 2010, the U.S. Nuclear Regulatory Commission's (NRC) staff conducted on-site and off-site reviews of WESTEMS computer code issues related to Open Items (OI)-SRP3.9.1-EMB-05, 06, and 07 identified in the staff's Safety Evaluation Report Section 3.9.1 associated with the AP1000 Design Control Document (DCD) review of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code Class 1, 2, and 3 Components, Component Supports, and Core Support Structures. The purpose of the on-site review was to verify that the WESTEMS computer code (WESTEMS) was implemented in accordance with the methodology and design criteria in ASME Code Section III and the AP1000 DCD. Specifically, OIs SRP3.9.1-EMB-05, 06, and 07 were discussed during the review.

Westinghouse provided documents to support the use of WESTEMS and the closure of the OIs. Based on the information reviewed, the staff found that the design documents for the reviewed components reflected the methodology and criteria contained in the DCD. Based on on-site and off-site reviews conducted by the NRC staff, the staff found that the proposed use of WESTEMS

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for AP1000 analysis is not acceptable. As implemented by the applicant, WESTEMS is not in compliance with ASME code requirements and the applicant does not have adequate procedures to control use of the code or to compensate for the options it allows. A detailed discussion of the findings is contained in the enclosure, "On-Site and Off-Site Review Summary Report."

Docket No. 52-006

Enclosure:
As stated

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Docket No. 52-006

Enclosure:
As stated

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On-Site and Off-Site Review Summary Report

Information submitted previously by Westinghouse in support of its AP1000 Design Certification Amendment application is used in this enclosure. Westinghouse considers some of the information "proprietary" within the meaning of the definition provided in Title 10, Code of Federal Regulations, Section 2.390(b)(5). Westinghouse has requested that this information be withheld from public disclosure and the NRC staff agrees that the submitted information sought to be withheld contains proprietary commercial information and should be withheld from public disclosure. This enclosure documents the NRC staff's review of the WESTEMS Computer Code which contains proprietary information that has been redacted in order to make the evaluation available to the public. The redacted information will appear as a blank space surrounded by "square brackets" as follows:

[ ]

The complete text of this WESTEMS Computer Code review, containing proprietary information can be found at Agencywide Documents Access and Management System (ADAMS) Accession Number ML102880708 (Summary of the AP1000 Design Certification – Regulatory On-Site and Off-Site Reviews of Open Items for the WESTEMS Computer Code). This document can be accessed by those who have specific authorization to access Westinghouse proprietary information.

Subject: WESTEMS Computer Code On-Site Review

In the response to the AP1000 design control document (DCD) open item (OI)-SRP3.9.1-EMB-03, Westinghouse Electric Company (Westinghouse) added the WESTEMS computer code to Table 3.9-15 in the DCD. The staff performed several on-site reviews to discuss and resolve WESTEMS issues related to OI-SRP3.9.1-EMB-05, 06, and 07.

On June 23 and 24, 2010, U.S. Nuclear Regulatory Commission (NRC) staff (K. Hsu, C. Wu, P. Clark, and J. Dixon-Herrity) conducted an on-site (Westinghouse's Cranberry, Pennsylvania office) review of the AP1000 WESTEMS computer code based on the requirements of Standard Review Plan (SRP) Section 3.9.1. The purpose of the on-site review was to verify that WESTEMS was implemented in accordance with the methodology and design criteria in ASME Code Section III and the AP1000 DCD. Specifically, OI-SRP3.9.1-EMB-05, 06, and 07 were discussed during the review.

Westinghouse presented a sample problem operation using WESTEMS. During the WESTEMS operation presentation, the staff identified that the piping thermal stress calculation was not correct because thermal stresses for inside surface and outside surface should have a different mathematical sign. Westinghouse engineers confirmed that the outside surface thermal stress

calculation was not correct and agreed to issue an error report. The staff concluded that this issue will be considered as part of OI-SRP3.9.1-EMB-06. Therefore, OI-SRP3.9.1-EMB-06 cannot be resolved. The staff also determined that additional information is required to resolve OI-SRP3.9.1-EMB-05, and 07.

On July 27 to 28, 2010, the NRC staff (K. Hsu, C. Wu) conducted an on-site (Westinghouse's Twinbrook Office in Rockville, Maryland) review of thirteen Westinghouse proprietary documents (see Attachment) addressing WESTEMS open items. On August 24, 2010, NRC staff (K. Hsu, C. Wu) conducted an on-site (Westinghouse's Twinbrook Office in Rockville, Maryland) review of the document, "Westinghouse Level 3 Quality procedure for WESTEMS NB-3600 Fatigue Analysis and Verification, draft version," which had been identified in Reference 1 by Westinghouse to address OI-SRP3.9.1-EMB-07.

On September 2, 2010, NRC staff (Kaihwa Hsu, Cheng-Ih Wu, Anthony Hsia, Jennifer Dixon-Herrity) conducted an on-site (Westinghouse's Twinbrook Office in Rockville, Maryland) review of the thirteen Westinghouse proprietary documents addressing WESTEMS and the Level 3 Quality Procedure for WESTEMS to make the final safety determination on the implementation of WESTEMS for the AP1000 piping fatigue analyses.

On-site Reviews findings:

The proposed use of WESTEMS for the AP1000 to perform NB-3600 fatigue analysis is not acceptable - this usage is not in compliance with ASME code requirements and the applicant does not have adequate procedures to control use of the code or to compensate for the options it allows.

Safety Significance: WESTEMS is used in Westinghouse fatigue analysis for all Class 1 analyses. These analyses are performed to prevent fatigue cracking during operation.

The following provides a list of the documents reviewed and a summary of the OIs for WESTEMS and observations from a September 2, 2010, on site staff audit of:

- WESTEMS NB-3600 Fatigue Analysis and Verification Procedure draft dated August 20, 2010
- Primary Systems Design and Repair Level 3 Quality Procedure
- AP1000 Piping and Fatigue Analysis General Methods and Inputs Calculation Note APP-GW-POC-020, Revision C
- Other attachments made available to support NRC review of applicant actions to address WESTEMS concerns

OI-SRP3.9.1-EMB1-05 Use of Algebraic Sum Method

WESTEMS allowed use of algebraic summation of three orthogonal moment vectors to generate stress histories for selection of peak and valley times. Using this methodology is mathematically incorrect and has the potential to lead to erroneous results.

NB-3600 defines resultant range of moment as follows:

> "Mi= resultant range of moment which occurs when the system goes from one service load set to another, in.-lb (N-mm). Service loads and combinations thereof shall be provided in the Design Specification. In the combination of moments from load sets, all directional moment components in the same direction shall be combined before determining the resultant moment (i.e., resultant moments from different load sets shall not be used in calculating the moment range Mi)."

WESTEMS approach: In order to resolve the issue related to algebraic summation of three orthogonal vectors, WESTEMS Level 3 quality procedure allows the user to use resultant moments from different load sets in calculating the moment range Mi, which does not comply with the above ASME Sect. III NB-3600 requirement.

Observations from audit of "Westinghouse Level 3 Quality procedure for WESTEMS NB-3600 Fatigue Analysis and Verification":

- 5.1.4.2 – [

  ].

- ASME code NB-3652 explicitly states that resultant moments from different load sets shall not be used to calculate the range.

- WESTEMS applied in this fashion is not in compliance with this ASME code requirement.

- The WESTEMS procedure still allows the use of algebraic summation in that it is controlled through a user option and is the methodology used if no action is taken by the user.

WESTEMS does not contain a basis for the use of algebraic summation of three orthogonal moments, which is mathematically incorrect. In addition, WESTEMS is not in compliance with ASME code requirements with either option selected. Based on this, the staff determined that OI-SRP3.9.1-EMB-05 is not resolved.

OI-SRP3.9.1-EMB1-07 Configuration Control of WESTEMS

To show compliance with NRC regulations, the staff must find that the program is demonstrated to be accurate and repeatable. With the WESTEMS program, the output contains false peaks which must be identified and removed by an analyst before the data is input into WESTEMS again to continue the analysis. As a result, when different analysts run the same problem, they may get different answers.

AP1000 DCD Chapter 17 states "Each organization maintains ....quality assurance program that meets the NQA-1 criteria that apply to its work scope." ASME Code NQA-1 Paragraph 401, "Use of Computer Programs," requires that to "the extent required in Paragraphs 401(a) and (b) of this Requirement, computer program acceptability shall be preverified or the results verified with the design analysis for each application. Preverified computer programs shall be controlled in accordance with the requirements of this Standard.

(a) The computer program shall be verified to show that it produces correct solutions for the encoded mathematical model within defined limits for each parameter employed.

(b) The encoded mathematical model shall be shown to produce a valid solution to the physical problem associated with the particular application."

WESTEMS Code methodology has demonstrated that false/fake/redundant stress peaks are created when the program is run. As such, absent appropriate procedures to account for these peaks, it fails to meet NQA-1. The procedures for WESTEMS allow the user to modify its output to eliminate unwanted results such as false/fake/redundant peaks. The staff found that the use of procedures to address the errors is acceptable if the results are accurate and repeatable.

Observations from the audit of "Westinghouse Level 3 Quality procedure for WESTEMS NB-3600 Fatigue Analysis and Verification" – these are examples of procedure inadequacies and lack of guidance and are not meant to be all inclusive of problems with the procedure:

- 5.2.1 – Regarding moment stress range input, [

  ]. WESTEMS procedure does not comply with this ASME requirement since it does not consider T plus M load sets.

- 5.2.2 Moment History Input – [

]. This guidance is subject to the user's judgment as to whether an inflection point is "intermediate and insignificant." There is no clear guidance and it may result in different peak selection by users.

- 5.4.3 Peak Selection Documentation: [

].
- 5.5 - STEP 5 (Optional) Refine Inputs with Peak Editing and Reanalyze. There is no guidance on when STEP 5 should be used – including what the acceptance criteria are and why and when use of the step would be valid. Why does WESTEMS generate redundant and false peaks that the user needs to justify, eliminate and document? Why is it acceptable to have the analyst compensate for this aspect of the program or "conservatism in the algorithm"?

The staff found that the Level 3 Quality Procedure does not provide assurance of a repeatable valid result to the physical problem. Therefore, OI-SRP3.9.1-EMB-07 is not resolved.

The staff determined the following options exist to address the above concerns with the use of WESTEMS for the AP1000:

- Correct the issues described above regarding WESTEMS' creation of stress peaks and develop a new version.
- Perform spreadsheet calculations using the appropriate ASME equations documented in the DCD.
- Perform a significant revision of the WESTEMS NB-3600 Fatigue Analysis and Verification Procedure to consolidate all user instructions in one document and upgrade the procedure to provide detailed and clear user guidance that will generate repeatable and correct results that are not user-dependent.

Reference:

1. AP1000 response to open item (SRP3), DCP_NRC_003018, August 20, 2010 (ADAMS, Accession Number ML1023504400)

- The Westinghouse Procedure NSNP 3.2.6, Revision 3 "Design Analysis" which controls the documentation of a calculation note and controls the documentation of input and output of program WESTEMS™ NB-3600 model fatigue analysis.

- The Westinghouse Procedure NSNP 3.3.3, Revision 2 "Design Verification by Independent Review or Alternate Calculations" which controls the verification process for WESTEMS™ NB-3600 model fatigue analysis.

- The Westinghouse Procedure NSNP 3.6.2, Revision 2 "Validation of Computer Software", which controls the validation of the WESTEMS™ computer program. The validation procedure ensures that the computer program produces correct results.

- The Westinghouse Procedure NSNP 3.6.3, Revision 1 "Configuration control of Computer Programs and Systems" which controls changes to computer software and ensures that changes are documented, approved, and controlled by authorized personnel in accordance with established procedures. According to Westinghouse, this procedure ensures that the computer program will generate correct results.

- An internal letter LTR-PAFM-10-132 that identifies personnel trained in WESTEMS™ NB-3600 model analysis, and identifies those who are qualified to perform or verify WESTEMS™ NB-3600 model analysis. This letter will be revised as training or qualifications change or at least once yearly as required by Westinghouse Procedure WESTINGHOUSE 2.6.

- The internal letter LTR-PAFM-10-99, "WESTEMS™ Version 4.5.2 User's Manual Addendum 2: NB-3600 Moment Loading and Peak Selection Instructions", which explains the moment selection options. It is the user and verifier responsibility to ensure that options in the manual are selected correctly.

- The internal letter LTR-PAFM-10-100, "WESTEMS™ Version 4.5.2 User's Manual Addendum 3: Peak and Valley Selection and Documentation Guidelines", which explains the peak and valley selection options. It is the user and verifier responsibility to ensure that specific analyses performed with the WESTEMS™ program are performed correctly.

- The internal letter LTR-PAFM-10-118, "WESTEMS™ 4.5.2 Category A Software Problem Report – NB-3600 OD Stress Calculation," which is an error report generated in response to an NRC audit finding for NB-3600 calculation of Sp-alg-OD for peak selection in WESTEMS™.

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