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: 43-374-6206
Direct fax: 724-940-8505
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: DCP_NRC_002813

March 5, 2010

Subject: AP1000 Response to Proposed Open Item (Chapter 3)

Westinghouse is submitting the following responses to the NRC open item (OI) on Chapter 3. These proposed open item responses are submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in these responses is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following proposed Open Item(s):

OI-SRP3.9.1-EMB1-03
OI-SRP3.9.1-EMB1-04
OI-SRP3.9.1-EMB1-05
OI-SRP3.9.1-EMB1-06
OI-SRP3.9.1-EMB1-07

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 Proposed Open Item (Chapter 3)

D063
NRO

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

ENCLOSURE 1

AP1000 Response to Proposed Open Item (Chapter 3)

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

OI Response Number: OI-SRP3.9.1-EMB1-03
Revision: 0

Question:

As a result of the on-site technical review on October 20, 2008, the NRC staff found that the fatigue analyses for the design of AP1000 Seismic Category I components and supports were performed using a computer program called WESTEMS, which is not discussed in the AP1000 DCD Subsection 3.9.1.2, "Computer Code Used in Analyses," nor listed in Table 3.9-15, "Computer Programs for Seismic Category I Components." In its March 5, 2008, response to the staff's RAI-SRP3.9.1-EMB1-03 Revision 2, Westinghouse indicated that the DCD will be revised to add WESTEMS computer program to Table 3.9-15. It also stated that the WESTEMS computer program was not previously reviewed and approved by the NRC staff. However, Westinghouse failed to provide the staff with evidence of the computer code verification and validation documentation for design of the ASME Class 1, 2 and 3 components and piping in accordance with Appendix B to 10CFR 50.55a or ASME Code NQA-1. Instead, it stated that the WESTEMS documentation package will be made available for additional NRC review. On May 26 - 28, 2009, the staff conducted an audit of WESTEMS at Westinghouse headquarters in Monroeville, Pennsylvania. The audit was not completed because not all the documents requested were available at the time of the audit. A follow-up audit will be performed in the Westinghouse Twinbrook Office in Rockville, Maryland to allow review of the remaining documents as they relate to WESTEMS. **This concern is identified as Open Item OI-SRP3.9.1-EMB1-03**.

Westinghouse Response:

In response to the staff's request, and following the audit on WESTEMS held at Monroeville on May 26-28, 2009, WEC delivered the following documents to the WEC Twinbrook Office for NRC review and audit.

The staff's technical reviewers reviewed the following documentation at the WEC Twinbrook Office on July 16-17, 2009.

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

The following documents were delivered to the WEC Twinbook office for NRC review on 6/3/2009:

Document No.	Subject
WCAP-12315, Rev. 1	Transfer Function Method for Thermal Stress and Fatigue Analysis
CN-PAFM-07-65	WESTEMS™ 4.5.1 Change Specification
CN-PAFM-07-153	WESTEMS™ 4.5.1 Validation
LTR-PAFM-07-163	WESTEMS™ 4.5.1 User Manual Addendum
CN-PAFM-06-159	WESTEMS™ 4.5 Change Specification
CN-PAFM-06-161	WESTEMS™ 4.5 Validation
LTR-PAFM-07-11	WESTEMS™ 4.5 User Manual Volume 2 – Design Analysis
CN-PAFM-05-23	WESTEMS™ 4.4 Change Specification
CN-PAFM-05-33	WESTEMS™ 4.4 Validation
LTR-PAFM-05-49	WESTEMS™ 4.4 User Manual
CN-PAFM-04-24	WESTEMS™ 4.3 Change Specification
CN-PAFM-04-25	WESTEMS™ 4.3 Validation
LTR-PAFM-04-72	WESTEMS™ 4.3 User Manual
CN-SMT-02-47	WESTEMS™ 4.2 Change Specification
CN-SMT-02-74	WESTEMS™ 4.2 Validation
LTR-PAFM-03-20	WESTEMS™ 4.2 User Manual
CN-SMT-01-89	WESTEMS™ 4.1.2 Change Specification
CN-SMT-01-60	WESTEMS™ 4.1.2 Validation
WESTEMS USERS MANUAL 4.1 (applies to WESTEMS™ 4.1 and WESTEMS™ 4.1.2)	WESTEMS™ 4.1 User Manual
W-SMT-99-119	WESTEMS™ 4.1 Change Specification
W-SMT-99-120	WESTEMS™ 4.1 Validation
W-SMT-97-014	WESTEMS™ 3.0 Design Analysis Validation
ICE-ICAT(97)-201	WESTEMS™ 3.0 User Manual

The following documents were delivered to the WEC Twinbrook office for NRC review on 6/24-6/25/2009:

Document No.	Subject
CN-STD-94-182	Verification / Validation for THERST Version 1.1
CN-STD-94-095	Validation Package for FATCON Version 3.1
CN-SGDA-02-34	Software Validation Package for WECEVAL Version 8
WCAP-9376 Rev. 2	WECEVAL User's Manual
CN-STD-95-033	Installation Test of MAXTRAN Version 2.1

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

OI Response Number: OI-SRP3.9.1-EMB1-04
Revision: 0

Question:

The transfer function stress database input of WESTEMS program was developed by applying unit temperature step increase with a specific temperature's material property to the component model. However, the design/operating transients temperatures may vary significantly. The staff noted that transfer function stress database has to be properly benchmarked to avoid stress result deviation due to inadequate temperature selection for every component problem to be used in WESTEMS transfer function method. The staff requested that the applicant provide and document guideline/criteria for developing/benchmarking transfer function stress database. This concern is identified as **Open Item OI-SRP3.9.1-EMB1-04**.

References:

1. ADAMS "Chapter 3 SER," ML092150664.

Westinghouse Response:

Section 22.0 of the WESTEMS™ User's Manual (reference 1) refers the user to the transfer function creation guidelines document (reference 2). Section 2.4.2 of the guidelines document, "Limitations and Constraints on the Transfer Function Method," discusses this limitation of the transfer function approach and provides specific recommendations to users considering the selection of representative material properties for application to the range of temperatures for the intended application, and also the selection of appropriate loading parameters both in the finite element analyses used to create the transfer functions and in the WESTEMS™ analysis. To justify the use of the transfer function model over the range of temperatures for the application, the user is instructed to ensure that the stress ranges obtained from the transfer function model compare appropriately or conservatively to a benchmark finite element analysis of a transient spanning the applicable temperature range. The program also includes a user input scaling factor on the transfer function stresses to allow adjustment based on the benchmark comparison. Section 4.0 of the guidelines document provides instructions and considerations for benchmarking transfer functions and provides an example. Numerous models have been created and benchmarked using this methodology in Westinghouse component analyses. Each transfer function application documented according to these guidelines provides the necessary technical justification.

References:

1. WESTEMS™ User's Manual Version 4.5, Volume 2, Rev. 0, "Design Analysis," Westinghouse Electric Company, 2007.

2. Westinghouse letter LTR-PAFM-03-42, Rev. 0, Procedures for Transfer Function Database Creation and Guidelines for the Associated Finite Element Analyses, C. Y. Yang.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

OI Response Number: OI-SRP3.9.1-EMB1-05
Revision: 0

Question:

The staff reviewed the basis documents for WESTEMS during the on-site review. In CN-PAFM-06-159, "WESTEMS Software Change Specification for Version 4.5," the applicant generated an algebraic stress histories option to be used in selection of peak and valley times. The option used the following equations to calculate time vs. stress in selecting peak and valley times.

$$Snalg = C1PoDo/2t + C2\ Do/2I\ (Mx + My + Mz) + C3Eab\,(\alpha aTa - \alpha bTb$$

$$Spalg = K1C1PoDo/2t + K2C2\ Do/2I\ (Mx + My + Mz) - K3Ea\alpha a\ \Delta T_1\ /(2*(1-\nu))- K3C3Eab\,(\alpha aTa - \alpha bTb\,) - Ea\alpha a\ \Delta T_2\ /(1-\nu))$$

$$S13alg = C1PoDo/2t + C2\ Do/2I\ (Mx + My + Mz) - C3prine\ Eab\,(\alpha aTa - \alpha bTb$$

The staff noted that the algebraic summation of three orthogonal vectors is mathematically incorrect and physically meaningless. The staff requested the applicant to provide technical justification for this option in selecting peak and valley times for the fatigue evaluation. This concern is identified as **Open Item OI-SRP3.9.1-EMB1-05**.

In its response to RAI-SRP3.9.1-EMB1-05, the applicant noted that WESTEMS uses the algebraic sums of three orthogonal moments to permit the influence of moment and temperature solution reversals to produce a "signed stress intensity", to be used for the selection of peaks and valleys. It also noted that after the peak and valley times are selected, the fatigue evaluation uses the individual moment values from the time history inputs for each transient at the peak and valley times to determine the moment ranges of each moment component, and then the ranges are combined by the square root sum of squares (SRSS) method according to the ASME Code NB-3600 equations to determine the resultant moment range, Mi. The applicant is requested to discuss the technical basis that the use of the algebraic summation of three orthogonal vectors would not lead to erroneous moment stresses that is misleading for the selection of the peaks and valleys. **This is related to OI-SRP3.9.1-EMB1-05.**

References:

1. ADAMS "Chapter 3 SER," ML092150664.

Westinghouse Response:

WESTEMS™ provides the user with various options to control the selection of peak and valley times in each transient to be used in the fatigue calculations, using general algebraic stress equations. However, the moment stress terms in the algebraic equations used for the peak and

valley time selection are not equivalent to the resultant moment stress used in the later actual fatigue stress range calculation per ASME Code. After the peak and valley times are selected, the fatigue evaluation uses the individual moment values from the time history inputs for each transient at the peak and valley times to determine the moment ranges of each moment component, and then the ranges are combined by the square root sum of squares (SRSS) method according to the ASME Code NB-3600 equations to determine the resultant moment range, Mi. Therefore, the moment stress term (e.g., in Equation 10) is calculated by:

$$C2*Mi*Do/(2*I)$$

Where Mi is the resultant moment range between the peak or valley times in the fatigue pair (from WESTEMS™ User's Manual Section 10.1):

$$Mi = [(\Delta M1)^2 + (\Delta M2)^2 + \ldots + (\Delta Mm)^2)]^{0.5}$$

Where:

Δ defines the range (difference) between the associated terms for each peak time in the pair;

m = number of moment histories defined by the user. Note that the ranges between each of the signed moment stress terms are first calculated before squaring them.

The fatigue evaluation must correctly consider the moment stress ranges in the NB-3600 equations. One option available for moment inputs is to use moment history inputs via "tagnames" (data point labels) specified for the model. It is the responsibility of the user to provide the moment histories in a manner that reflects appropriate moment stresses coincident with the thermal and pressure stresses with respect to the selection of peaks and valleys, as well as appropriate maximum stress ranges in the evaluation. The moment tagname input approach allows the user to input as many tagnames as needed to represent the moment stress ranges in the model.

When using this approach, the user needs the ability to account for the possibility of sign reversals in the moment histories. For example, in a piping system that is normally hot but experiences a transient where cold water is injected, the components in or adjacent to that section may experience reversals in one or more moment component signs. To allow the user to account for sign reversals, the moment terms in the general algebraic stress history equations are inserted independently. These are not intended to represent physical stress quantities in the component (as assumed in the question posed), but rather are provided as a manipulative tool for the user to combine the appropriate influence of moments in the stress histories to make the automated process select the peaks and valleys determined to be appropriate.

This intention is indicated in Section 10.1.2 of the WESTEMS™ 4.5 User's Manual (Reference 1) as quoted below:

"Algebraic stress histories are created for use only in the selection of peak and valley times. For the selected times, the parameters for the actual fatigue evaluation are saved, corresponding to: Pressure, Moments, ΔT1, ΔT2, Ta, Tb. The stress histories simulate the equation stress intensities in a way to account for stress reversals:

Snalg = C1*Po*Do/(2*tnom) + C2*Mx*Do/(2*I) + C2*My*Do/(2*I) + C2*Mz*Do/(2*I) - C3*Eab*(αa *Ta – αb*Tb)

Spalg = K1*C1*Po*Do/(2*tnom) + K2*C2*Mx*Do/(2*I) + K2*C2*My*Do/(2*I) + K2*C2*Mz*Do/(2*I) - K3*Ea*αa*ΔT1/(2*(1-v)) - Ea*αa*ΔT2/(1-v) - K3*C3*Eab*(αa *Ta – αb*Tb)

S13alg = C1*Po*Do/(2*tnom) + C2*Mx13*Do/(2*I) + C2*My13*Do/(2*I) + C2*Mz13*Do/(2*I) - C3prime*Eab*(αa *Ta – αb*Tb)

Where terms are as defined in NB-3653 (note that material properties are all taken at reference (stress free) temperature; and:

Mx, My, Mz = moment components whose resultant is Mi in NB-3653; (*Note: in this discussion, moments are designated as Mx, My, Mz as typical examples. The user may specify the number of moment components, Mi, desired.*)

The algebraic sums of these terms permit the influence of moment and temperature solution reversals to produce a "signed stress intensity", to be used for the selection of peaks and valleys. Note that in the basic application of this technique, the thermal stress terms are subtracted to account for the algebraic signs resulting from the temperature solutions, compared to the standard convention of tensile and compressive stress signs (i.e., tensile stress is positive). It is noted that the sum of the moment stress terms here is not equivalent to the resultant moment stress used in the later actual fatigue stress range calculation."

These aspects of the peak and valley selection tool enable control of the NB-3600 analysis peak and valley times selection in a manner that the user justifies. As with any analysis tool that provides such flexibility, the final inputs and results must be verified by the user to be applicable for the problem being analyzed. The user manual provides the details of how the inputs and options switches are used to calculate the stresses so that the user can adequately manage the analysis. The ultimate peak and valley inputs selected for the fatigue evaluation are printed in the fatigue analysis output files, and are verified independently as part of the quality assurance (QA) process. No additional information is needed to satisfy the QA requirements.

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

Response to follow-up question:

The WESTEMS™ NB-3600 peak selection options include a switch for using the SRSS combination of moments when detailed individual moment components are input. Westinghouse has prepared a detailed user instruction for the proper use of the peak selection options in the NB-3600 module, to avoid the improper use of the algebraic summation of three orthogonal vectors that could lead to erroneous results. This instruction will be incorporated into the user documentation and in project analysis plans.

References:

1. WESTEMS™ User's Manual Version 4.5, Volume 2, Rev. 0, "Design Analysis," Westinghouse Electric Company, 2007.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

OI Response Number: OI-SRP3.9.1-EMB1-06
Revision: 0

Question:

The staff reviewed WESTEMS validation package CN-PAFM-06-161. The applicant's validation package compared WESTEMS results with results of MAXTRAN79 and THERST. The applicant stated that the comparison used slightly different material properties. The comparison also showed the results are different with different programs. However, the applicant considered that the validation was acceptable even with a significant difference in ΔT calculation and stress result comparison. The staff noted that computer program benchmark must use the same input model in alternate calculations or hand calculations. The staff noted that use of a slightly different model and different material properties to compare the results with approximation may not be adequate to benchmark a computer program. The staff requested the applicant to provide benchmark acceptance criteria to validate the computer code calculation. This concern is identified as **Open Item OI-SRP3.9.1-EMB1-06**.

References:

1. ADAMS "Chapter 3 SER," ML092150664.

Westinghouse Response:

Westinghouse has benchmarked WESTEMS™ NB-3600 analysis using consistent inputs and defined acceptance criteria. The documentation can be made available for review at the request of the staff.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

OI Response Number: OI-SRP3.9.1-EMB1-07
Revision: 0

Question:

WESTEMS program provided an option to eliminate peak/valley points during calculation. The staff noted that the computer output should not be modified after executing the program. The staff requested the applicant to provide the configuration control and limitations of the program for this option. This concern is identified as **Open Item OI-SRP3.9.1-EMB1-07**.

In its response to RAI-SRP3.9.1-EMB1-07, the applicant indicated that WESTEMS provides various tools and options for the user to select the appropriate peak and valley points for the fatigue evaluation. It noted that the use of the WESTEMS peak time selection tools and options, as well as the interactive peaks editor, does not involve user modification of the fatigue analysis results output files. The applicant also noted that these tools allow the user to modify parameters of the peak time selection process and/or ultimately the peak and valley times/stresses used in the final analysis. The modifications are saved as revised inputs to the interactive fatigue analysis or in a file for fatigue reanalysis. The applicant is requested to discuss how the interactive WESTEMS allowing the user to manually modify the peak and valley times/stresses without the configuration control and documentation changes record satisfies the quality assurance requirements in accordance with 10 CFR 50 Appendix B and ASME NQA-1. **This is related to OI-SRP3.9.1-EMB1-07.**

References:

1. ADAMS "Chapter 3 SER," ML092150664.

Westinghouse Response:

Although WESTEMS™ provides various tools and options for the user to select the appropriate peak and valley points for the fatigue evaluation, it is important to note that the use of the WESTEMS™ peak time selection tools and options, as well as the interactive peaks editor, does not involve user modification of the fatigue analysis results output files. These tools allow the user to modify parameters of the peak time selection process and/or ultimately the peak and valley times used in the final analysis. The modifications are saved as revised inputs to the interactive fatigue analysis or in a file for fatigue reanalysis. These user modifications are reflected in the echo of inputs in fatigue analysis results files and/or in an intermediate fatigue analysis input file that is saved for use in reanalysis. When the fatigue analysis is run or re-run in the program, a separate set of analysis output files is created with the configuration control information, the echo of inputs, including the peak and valley time and stress information, and

the fatigue stress range and usage factor calculation outputs. These analysis results output files constitute the quality assurance (QA) record for the analysis and include the program configuration control information, an echo of all of the analysis inputs, including time histories, selected peak and valley times and stress quantities, and details of the stress range and usage factor calculations. These analysis records, together with the program user's documentation, provide sufficient documentation for independent verification of the fatigue analysis inputs and results, as required by the Westinghouse QA process. No additional information is needed to satisfy the QA requirements.

Response to follow-up question:

The user does not modify peak and valley times/stresses without configuration control. All peak and valley selection is recorded in the final configured output files so that inputs and outputs can be verified according to the QA process.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None