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: 412-374-6206
Direct fax: 724-940-8505
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: DCP_NRC_002867

May 10, 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-EMB1-05 R1

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-EMB1-05
Revision: 1

Question: (Revision 0)

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.

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

$$Spalg = K1C1PoDo/2t + K2C2\ Do/2I\ (Mx + My + Mz) - K3E.\alpha\alpha\ \Delta T_1/(2*(1-\nu)) - K3C3Eab.(\alpha aTa - \alpha bTb.) - E.\alpha\alpha\ \Delta T_2/(1-\nu))$$

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

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.**

Additional Question: (Revision 1)

In the response of OI-SRP3.9.1-EMB1-05, Westinghouse stated that " 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."

The staff requests Westinghouse to define proper and improper use of the algebraic summation of three orthogonal vectors and provide above mentioned instruction.

References:

1. ADAMS "Chapter 3 SER," ML092150664.
2. WESTEMS™ User's Manual Version 4.5, Volume 2, Rev. 0, "Design Analysis," Westinghouse Electric Company, 2007.

Additional Westinghouse Response: (Revision 1)

This open item response has been revised to respond to the follow-up request by the NRC to the Rev. 0 response

The draft user instruction for proper use of the peak selection options with respect to NB-3600 detailed moment inputs is provided in a separate document ("WESTEMS™ 4.5.2 NB3600 Moment Loading and Peak Selection Instructions for User"). The instructions define how to prevent improper algebraic summation of moment stresses using the program settings for peak selection. They also describe where the algebraic summation of moment stress inputs (not moment components) is appropriate and the associate program settings. This instruction will be included in the analysis plan for the AP1000 piping analyses and will also be incorporated in the next revision of the WESTEMS™ User Manual.

The above mentioned draft user instruction has been made available for staff review at the Westinghouse Twinbrook office.

Westinghouse Response: (Revision 0)

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 2) 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.

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.

Design Control Document (DCD) Revision: None

PRA Revision: None

Technical Report (TR) Revision: None