Westinghouse

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_002589

August 7, 2009

Subject: AP1000 Response to Request for Additional Information (SRP 3)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 15. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response 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 RAI(s):

RAI-SRP3.9.1-EMB1-04
RAI-SRP3.9.1-EMB1-05
RAI-SRP3.9.1-EMB1-06
RAI-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 Request for Additional Information on SRP Section 3

DO63
NRO

cc:	D. Jaffe	-	U.S. NRC	1E
	E. McKenna	-	U.S. NRC	1E
	B. Gleaves	-	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

Response to Request for Additional Information on SRP Section 3

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

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

Question:

The transfer function stress database input to WESTEMS program was developed applying unit temperature step increase with a specific temperature's material property to the component model. However, the design/operating transient temperatures may vary significantly in a wide range. 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 is requesting the applicant to provide the technical justification for the variation of material properties when applying the unit step transfer function database in a wide range of temperatures, and document guideline/criteria for developing / benchmarking transfer function stress database.

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 Request For Additional Information (RAI)

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

Question:

The staff reviewed the basis documents for WESTEMS during 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.

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

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

$$S13alg = C1PoDo/2t + C2\ Do/2I\ (Mx + My + Mz) - C3\text{prine}\ Eab.(\alpha aTa - \alpha bTb)$$

The staff notes that the algebraic summation of three orthogonal vectors does not appear to be mathematically correct and physically meaningful. The staff is requesting the applicant to provide technical justification for this option in selecting peak and valley times for the fatigue evaluation.

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. <u>These are not intended to represent physical stress quantities in the component</u> (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

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 Request For Additional Information (RAI)

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

Question:

The staff reviewed WESTEMS validation package CN-PAFM-06-161. The applicant's validation package used WESTEMS result to compare with result of MAXTRAN79 and THERST. The applicant stated that in the comparison the analysis results are different with different programs since slightly different material properties were used. However, the applicant considered that the validation is 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 calculation or hand calculation. The staff also noted that use slightly different model and different material properties to compare the results with approximation may not be appropriate and sometimes miss-leading in demonstrating and benchmarking a computer program. The staff is requesting the applicant to provide benchmark acceptance criteria to validate computer code calculation.

Westinghouse Response:

Westinghouse will provide a benchmark problem for WESTEMS™ NB-3600 analysis using consistent inputs. The results of the benchmark comparisons will be available by the end of December, 2009.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

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

Question:

WESTEMS program provided option to eliminate peak/valley points during calculation. The staff noted that the computer output shall not be modified after executing the program. The staff is requesting the applicant to provide the configuration control and limitation of the program for these type options allowing alter results.

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.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None