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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 R2
OI-SRP3.9.1-EMB1-06 R1
OI-SRP3.9.1-EMB1-07 R2

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,

D. A. Lindgren / For

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Proposed Open Item (Chapter 3)

D063
NRO

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ENCLOSURE 1

AP1000 Response to Proposed Open Item (Chapter 3)

OI Response Number: OI-SRP3.9.1-EMB1-05
Revision: 2

Question:

Revision 2:

Follow-up question #1 (WEC Response provided in Rev. 2 of this Open Item):

Westinghouse failed to address the staff's RAI regarding the use of the algebraic summation of three orthogonal vectors as discussed in WESTEMS user manual and user instructions.

Follow-up question #2 (WEC Response provided in Rev. 2 of this Open Item):

The WESTEMS methodology for stress combination is not correct in that it adds the thermal stresses absolutely. ASME NB-3600 requires using the full stress range. Adding thermal stress absolutely decreases the stress range and therefore does not meet ASME NB-3600 requirements.

Follow-up question #3 (WEC Response provided in Rev. 2 of this Open Item):

The thermal stress due to discontinuity item is subtracted in WESTEMS algebraic stress histories calculation as shown below:

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

$$Spalg = K1C1PoDo/2t + K2C2\ Do/2I\ (Mx + My + Mz) - K3Ea\ \alpha a\ \Delta T1 /(2^*(1-v)) - \mathbf{K3C3Eab\ (\alpha aTa - \alpha bTb)} - Ea\alpha a\ \Delta T2 /(1-v))$$

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

ASME Code Section III NB-3653 identified an absolute value is required for this item. The staff is requesting the applicant to provide justification to ensure that WESTEMS method using negative sign for this item meets ASME Code requirements.

Follow-up question #4 (WEC Response provided in Rev. 2 of this Open Item):

In the response of OI-SRP3.9.1-EMB1-05, the applicant provided the following description:

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.

ASME Code identified that Mi is the range of moment which is occurs when the systems goes from one service load set to another. WESTEMS defines Mi as SRSS for m set of moment ranges. The staff is requesting the applicant to justify the difference.

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.

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.

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

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

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

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.
2. WESTEMS™ User's Manual Version 4.5, Volume 2, Rev. 0, "Design Analysis," Westinghouse Electric Company, 2007.
3. LTR-PAFM-10-99, "WESTEMS Version 4.5.2 User's Manual Addendum 2: NB-3600 Moment Loading and Peak Selection Instructions."

Westinghouse Response:

Revision 2:

This open item response has been revised to respond to four (4) follow-up questions by the NRC following staff review of the submitted Rev. 1 response and related documentation provided to the WEC Twinbrook Office. The follow-up questions are labeled as 1 thru 4 above and are answered in succession below.

The user instruction referred to in Rev. 1 of this open item response (and made available at the WEC Twinbrook Office for staff review) has been approved as an addendum to the WESTEMS User's Manual Version 4.5 (Reference 2) and has been added as Reference 3 to this response. This document is proprietary and will be submitted on the docket at the request of the NRC separate from this response.

Response to follow-up question #1:

It is first noteworthy to reiterate that the intended use of moment inputs is not to algebraically sum three orthogonal vectors. The intent of multiple moment inputs is to allow users flexibility in specifying moment stress inputs for selection of peaks and valleys. The supplemental user instruction (Reference 3) documents the possible uses of the moment inputs and associated options, and clearly instructs users to use the SRSS option when the moment inputs represent orthogonal vectors. It also provides instruction for review and verification of the peaks and valleys selected. When a single moment input is used, already representing the resultant moment, the instructions provide guidance for the user to account for moment reversals in the resultant moment input to properly account for the moment ranges between transients.

It is important to recognize that WESTEMS™ uses a two step process for fatigue evaluation. The first step creates stresses for the selection of peak and valley times from each transient history, and saves only the inputs at those times. The second step uses the inputs at each selected time in all transients to form the fatigue stress range pairs and calculate usage factors according to ASME Code.

A more thorough explanation of this process including examples, if determined to be necessary, will be provided at the audit scheduled for 6/23-6/24/10 at WEC Cranberry HQ.

Response to follow-up question #2:

WESTEMS™ meets the requirements of Subsection NB-3600 of the ASME Code as explained below.

WESTEMS™ correctly calculates the stress range for a fatigue pair by determining the pressure stress range, moment stress range, and thermal stress range between the two load case peak times in the pair, and adds these stress ranges absolutely as described in ASME NB-3600 equations. This is documented in Section 10.1 of the WESTEMS™ User's Manual Version 4.5 Volume 2 (Reference 2). The thermal stress input terms ΔT1, ΔT2, Ta, and Tb retained for each load case peak time include their algebraic signs appropriately so that the range calculated between the two load sets is correct. Once the ranges are determined, the stress ranges for each term are correctly added absolutely.

If the statement in the follow-up question is meant to refer to the algebraic stress due to one transient, which is used only for the selection of peak and valley times, the statement is incorrect. The algebraic equations employed in the peak and valley selection allow addition of the thermal stress to the other stresses in the history based on sign consistent with the loading from temperature, pressure and moment inputs, and do not simply add thermal stress absolutely. The peaks and valleys within one transient must be determined considering the signs of the load inputs and their influence on the stress history. For this reason, the user can set the relative sign of the thermal stress history to be consistent with the signs of the pressure and moment stress histories input.

Response to follow-up question #3:

The equations for Snalg, Spalg, and S13alg provided in the Rev. 0 response of this Open Item were in the context of algebraic stress quantities used by WESTEMS™ peak and valley selection, taken from Section 10.1.2 (NB-3600 Peak and Valley Selection) of the WESTEMS™ 4.5 User's Manual Volume 2 (Reference 2). These are not the same as the equations for Sn and Sp in Section 10.1 (Application of ASME Code Criteria Using NB-3600 Models) of the Manual. The Sn and Sp in Section 10.1 represent the same stress range quantities as Sn and Sp in NB-3653, and therefore the absolute values of the stress range terms are added.

As explained in Section 10.1.2 of the Manual, the algebraic stress quantities Snalg, Spalg, and S13alg are used in the first step of the evaluation to determine stress peak and valley times for each transient. The context of the algebraic stress equations referred to above is in step (e) of Section 10.1.2 discussing peak and valley selection. Since the stress is for only one transient, it does not represent a range. The algebraic quantities must be used to account for temperature sign reversals in the transient response, so that the correct range may be calculated in the second step of the analysis process where fatigue usage is calculated.

Since the temperature terms from the 1D analysis solution are calculated with signs conforming to a legacy convention used in previous Westinghouse fatigue analyses, they result in signs on the thermal stress terms that are opposite the conventional positive sign for tension and negative for compression. This is explained in the paragraphs below the algebraic equations in step e of Section 10.1.2. Therefore, when the option is used to determine peaks and valleys based on the combined algebraic stress equations, it is necessary to switch the signs on the thermal stress terms to conform to the conventional sign of the pressure stress term (tension is positive). This is the reason for the negative sign on the thermal stress terms in the Snalg, Spalg, and S13alg equations, so that the algebraic stresses are combined appropriately to provide a stress history from which to determine peak and valley times consistently.

After the algebraic stress quantities Snalg, Spalg, and S13alg are used to determine the peak and valley times in each individual transient, the input values of $\Delta T1$, $\Delta T2$, Ta, and Tb are saved, with their respective signs, for each time selected. These signed values are then used in step 2 of the fatigue evaluation to form the stress pairs between load sets, so that the correct ranges are calculated in the actual Sn, Sp, and S13 stress ranges used for the fatigue calculation.

Response to follow-up question #4:

The Mi range defined by ASME Code NB-3653.1 is determined by taking the range of the individual directional moment components and then determining the resultant. This is represented by the equation above. The ASME Code explicitly states that resultant moments from different load sets shall not be used to calculate the range. This is because the effect of sign reversals in individual directional moment components would be lost if the resultants are taken before the range is calculated. If the user supplies the directional moment components, e.g., as M1, M2, M3, WESTEMS™ calculates the ranges and the resultant according to the ASME Code using the equation provided in this question. If the user chooses to supply one resultant moment input, e.g., as M1, the user must supply the M1 inputs for each load case so that the ranges between load cases conservatively account for any sign reversals in any of the individual directional moment components. This latter methodology has been classically employed in piping fatigue analyses to simplify inputs, so the variable number of moment histories allowed accommodates this approach. Application of this approach is illustrated in examples included in the user instructions previously provided in response to this OI, "WESTEMS™ 4.5.2 NB-3600 Moment Loading and Peak Selection Instructions for User," which has been incorporated as WESTEMS™ Version 4.5.2 User's Manual Addendum 2 (Reference 3).

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.

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 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.

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

AP1000 TECHNICAL REPORT REVIEW

Response to SER Open Item (OI)

OI Response Number: OI-SRP3.9.1-EMB1-06
Revision: 1

Question:

Revision 1:

Follow-up question (WEC Response provided in Rev. 1 of this Open Item):

The benchmark for WESTEMS is not acceptable. The WESTEMS validation and verification calculation demonstrates that the stress result is incorrect. he inside surface of the charging piping for temperature cooldown during charging shutdown and return to service transient was noted to be under compression. However, inside surface for temperature cooldown must be under tension based on system conditions – it cannot be in compression as indicated.

Revision 0:

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:

Revision 1:

This open item response has been revised to respond to a follow-up question by the NRC following staff review of the submitted Rev. 0 response and related documentation provided to the WEC Twinbrook Office.

Response to follow-up question:

It is a correct observation that the thermal stress on the inside surface of a pipe subjected to a temperature cooldown will be in tension. This is correctly reflected in the WESTEMS™ results based on the option selected for the run observed in the benchmark case, and the associated sign convention.

The WESTEMS™ NB-3600 module was modeled after the analysis process used for piping fatigue analysis at Westinghouse since the 1970s. The 1-D temperature solution methodology employed in that process (using previous programs THERST, MAXTRAN, and FATCON) used an arbitrary convention that produced NB-3600 ΔT1 and ΔT2 values with signs at the inside surface to match the direction of the temperature excursion. When multiplied by the appropriate NB-3600 factors, the temperature term ranges are converted to stress values. Since the fatigue analysis process considers the range of all parameters between load sets, this convention still produces the correct stress range values for the fatigue analysis pairs. Since the ranges are determined for each stress term using a consistent sign convention for the temperature terms, there is no need for consideration of conventional tension or compression for the signs of the individual thermal stress terms. In WESTEMS™, for analysis using Moment Stress Range inputs, the fatigue analysis process produces the correct stress ranges using the sign convention consistent with THERST.

However, in recognition of the use of the past convention, when the WESTEMS™ peak selection options are used that allow the individual transient stress histories to combine the thermal stress terms with the pressure stress and potentially the moment stress terms, the signs of the thermal stress terms are intentionally reversed to maintain consistency with the pressure stress term, which uses the conventional positive value for tension, which is the expectation described in the review comment above. This is discussed in the WESTEMS™ User's Manual Volume 2, Section 10.1.2. This allows the user to assign the inputs appropriately considering conventional signs on the algebraic stress terms when determining the history to be used for peak and valley selection. The fatigue stress range pair calculations remain correct because the ranges of the individual thermal, pressure, and moment stress terms in Equations 10 and 11 are calculated independently before combining to determine the total stress ranges. Therefore, the fatigue stress ranges are always calculated correctly.

Revision 0:

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: 2

Question:

Revision 2:

Follow-up question #1 (WEC Response provided in Rev. 2 of this Open Item):

The WESTEMS manual does not adequately address manually removing the peak and valley stress points. The manual provides no control over removal so that the results obtained are not predictable and repeatable.

Follow-up question #2 (WEC Response provided in Rev. 2 of this Open Item):

The WESTEMS NB-3600 analysis heavily relies on user determined options and manual selection of the stress peaks and valleys.

Revision 1:

In the response of OI-SRP3.9.1-EMB1-07, Westinghouse stated that "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."

It is noted that the interactive WESTEMS allowing the user to manually modify the peak and valley times/stresses. The echo printout of the stress peak/valley modifications does not provide technical basis to modify the stress result calculated by WESTEMS. The staff requests Westinghouse to explain how to control the user operation for the modification and provide the technical basis for stress modification. Since the modifications are saved as revised inputs to the interactive fatigue analysis or in a file for fatigue reanalysis, the technical justification for modification should be provided by the analyst in the print out or recorded in file. The staff notes that the inclusion of peaks editor may imply that WESTEMS cannot select peak/valley locations adequately. Therefore, the peaks editor is required to modify the WESTEMS peak/valley stress results. The staff requests Westinghouse to discuss why peak editor is required to modify the peak/valley stress calculated by WESTEMS.

Revision 0:

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.
2. WESTEMS™ User's Manual Version 4.5, Volume 2, Rev. 0, "Design Analysis," Westinghouse Electric Company, 2007.
3. LTR-PAFM-10-100, "WESTEMS Version 4.5.2 User's Manual Addendum 3: Peak and Valley Selection and Documentation Guidelines."

Westinghouse Response:

Revision 2:

This open item response has been revised to respond to two (2) follow-up questions by the NRC following staff review of the submitted Rev. 1 response and related documentation provided to the WEC Twinbrook Office. The follow-up questions are labeled as 1 and 2 above and are answered in succession below.

The user instruction referred to in Rev. 1 of this open item response (and made available at the WEC Twinbrook Office for staff review) has been approved as an addendum to the WESTEMS User's Manual Version 4.5 (Reference 2) and has been added as Reference 3 to this response. This document is proprietary and will be submitted on the docket at the request of the NRC separate from this response.

Response to follow-up question #1:

The WESTEMS™ User's Manual Version 4.5 Volume 2 (Reference 2) addresses peak time editing in Section 8.11 for NB-3200 analysis and in Section 10.6 for NB-3600 analysis. The WESTEMS™ analysis output files provide information regarding peak times selected by the program and peak times edited by the user. In Revision 1 of this Open Item response, additional user instructions are provided in a User's Manual Addendum (Reference 3) with explicit instructions for output files and information to be documented with respect to the peak and valley times used in the analyses. This document has been made available for staff review at the WEC Twinbrook Office. Also, as stated above, this addendum will be submitted on the docket in a separate transmittal.

Response to follow-up question #2:

The WESTEMS™ peak and valley selection algorithm is designed to assist the user in selection of peak and valley times, mirroring a process that previously used a combination of automated and manual steps in classic piping fatigue analyses. The method used in the NB-3600 module provides users with options to reflect similar processes used in past Westinghouse evaluations for piping component design fatigue analyses.

Because design fatigue analysis is highly dependent on the transient input histories, and the transient input histories are dependent on users, the nature of NB-3600 stress equations requires user selection of methods to process the user inputs. As stated previously, the automated peak and valley time selection algorithm is designed to select more peak and valley times that would be typically selected using a manual process. This is to protect against missing valid peak and valley times.

As a result, the user is also provided a controlled process to edit peak times for the final analysis run to remove redundant peaks, and to save the results of the entire process along with justification in the analysis documentation. Guidelines for this process are provided in a User's Manual Addendum (Reference 3) with explicit instructions for output files and information to be documented with respect to the peak and valley times used in the analyses. This addendum was referred to in the Revision 1 response to this Open Item and provided to the WEC

Twinbrook Office for Staff Review. As mentioned above, this addendum will also be submitted on the docket in a separate transmittal.

It should also be noted that most piping fatigue analyses may be accomplished using the conservative application of the maximum Moment Stress Range input option, where user interaction and required options are minimal. In the case of some components that require more detailed analysis methods for qualification, typically by using more precise assignment of applicable moment loads to each transient, it is expected that more user involvement should be required in a tool intended for general use. This expectation is consistent with the historical approach to piping fatigue analysis. It is also consistent with other applications of general purpose software, such as the ANSYS fatigue module, where the user is responsible for transient load inputs and definition of event time histories for the selection of peak and valley stress states.

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 ability for the user to edit stress peak and valley times is provided because the total set of peaks and valleys selected by the automated algorithm in WESTEMS™ is somewhat dependent on the user definition of the transient inputs and because the algorithm is designed to be conservative in the selection process. If the user determines that the conservative set of peaks and valleys is acceptable for qualification, no further action is required. On the other hand, the user has the ability to perform a more detailed evaluation by removing conservatism with the editing process and to document the justification for the final set of peaks and valleys for analysis. The revised peaks and valleys may be used in another execution of the program using the new input file to produce the final analysis for documentation.

Guidelines for accomplishing this process and the required analysis documentation are provided in a separate draft document, "WESTEMS™ Peak Selection Guidelines," which has been made available for staff review at the Westinghouse Twinbrook Office. 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.

Revision 0:

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