From: "Limberger, Wayne" <wlimber@entergy.com>
To: <JGR@nrc.gov>
Date: 10/19/2007 4:12:24 PM
Subject: VY License Renewal EAF Audit Q&A Responses

Jonathan,

Attached is a report of the Q&A database open items showing Ken Chang's questions and VY's responses. Note that the database numbered these items sequentially as #387 through #393, and they are the only items we currently show as open. We understand that you will get a copy to Ken Chang. Call me at 802-258-4204 if you have any questions.

<<LR EAF Audit Q&A Responses.pdf>>

Mail Envelope Properties (47190F9C.2CD : 17 : 62157)

Subject: VY License Renewal EAF Audit Q&A Responses
Creation Date 10/19/2007 4:11:32 PM
From: "Limberger, Wayne" <wlimber@entergy.com>

Created By: wlimber@entergy.com

Recipients
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JGR (Jonathan Rowley)

Post Office	**Route**
TWGWPO03.HQGWDO01	nrc.gov

Files	**Size**	**Date & Time**
MESSAGE	393	10/19/2007 4:11:32 PM
TEXT.htm	2824	
LR EAF Audit Q&A Responses.pdf		421626
Mime.822	583159	

Options

Expiration Date:	None
Priority:	Standard
ReplyRequested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

Junk Mail Handling Evaluation Results
Message is eligible for Junk Mail handling
This message was not classified as Junk Mail

Junk Mail settings when this message was delivered
Junk Mail handling disabled by User
Junk Mail handling disabled by Administrator
Junk List is not enabled
Junk Mail using personal address books is not enabled
Block List is not enabled

Item	Request	Response
387	The ASME Code defines that stress intensity (SI) from two temperature transients is calculated from the stress components from the two conditions. Please explain how it could be calculated from stress intensities of the two conditions derived from Greens Functions, especially at locations of geometric discontinuity. Also, please justify the validity of combining the thermal transient stress intensities with the stress intensities from the external loads and pressure loading.	To show that the method whereby the Green's Function (GF) approach used in EAF calculations obtains results comparable to results from standard ASME Code fatigue calculations, a comparison of calculations performed for the VY feedwater nozzle was performed. The current ASME Code design fatigue calculation (VY-10Q-303) which was performed directly using ANSYS, was compared to the EAF calculation (VY-16Q-302) performed using the GF methodology for the turbine roll transient, which is the most severe design basis transient for VY feedwater nozzle. To ensure a consistent comparison between the two calculations, the same stress path locations were selected. The Code fatigue calculation alternating stresses (using Sz-Sx) were extracted from the ANSYS model at the base metal rather than at the cladding as was originally performed in VY-10Q-303 to be consistent with VY-16Q-302. In addition, the Code fatigue calculation ANSYS model was re-run with the same heat transfer coefficients and material properties used for the GF calculation. The comparison showed that the differences in alternating stresses are less than 1% at both the safe end and blend radius locations. Although this comparison was for the feedwater nozzle, the results are considered to be equally applicable to all other nozzle locations based on a BWR Vessel and Internals Project (BWRVIP) study (EPRI Report No. 1003557, "BWRVIP-108: BWR Vessel and Internals Project, Technical Basis for the Reduction of Inspection Requirements for the Boiling Water Reactor Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii," Final Report, October 2002, SIA File No. BWRVIP-01-308P). In BWRVIP-108, 3-D models of four different nozzles were developed and analyzed for the BWR fleet. The results of this study showed that for a range of vessel nozzles, the stress concentration factors for pressure loading are 2.65 +/- 3%, indicating that all different - sized BWR vessel nozzles have the same geometric characteristics for calculating peak stresses in the blend radius regions. The adequacy of the hand calculations used to calculate mechanical load stresses is addressed as follows: For the feedwater nozzle of another BWR plant, SIA performed hand calculations for stresses due to mechanical loads (as was done for VY) and benchmarked those calculations against finite element results obtained from applying the mechanical loads to a finite element model. The hand calculations were performed using the same methodology as used for VY. The finite element model was an axisymmetric two-dimensional (2-D) finite element model. This model was constructed and meshed in a very similar manner to the VY nozzle FEMs. Non-symmetric loading elements were used and the shear, moment, axial, and torsional loads were applied to the model. A comparison of the stresses from the hand calculations vs. the FEM is as follows:

Location: Safe-End - Linearized Membrane + Bending Stress
Stress from Hand Calculations (psi): 8863
Stress from FEM (psi): 5852
Difference, Hand Calc vs. FEM: 51.45%

Location: Safe-End - Total Stress
Stress from Hand Calculations (psi): 8863
Stress from FEM (psi): 7855
Difference, Hand Calc vs. FEM: 12.83%

Location: Nozzle Forging - Linearized Membrane + Bending Stress
Stress from Hand Calculations (psi): 1042
Stress from FEM (psi): 769
Difference, Hand Calc vs. FEM: 35.50%

Location: Nozzle Forging - Total Stress
Stress from Hand Calculations (psi): 1042
Stress from FEM (psi): 554
Difference, Hand Calc vs. FEM: 88.09%

As shown by these results, use of the hand calculations is conservative compared to the FEM results, especially under the assumption that the stresses from the hand calculations are treated entirely as membrane in nature.

The combination of thermal stress intensities with stress intensities from external loads and pressure is addressed as follows:

The stress range for pressure and external loadings range from zero to a finite value. The stress intensities (SI) calculated from external loading are conservatively added to the maximum calculated thermal transient SI using the same sign to increase the peaks and valleys and thereby the stress range. The pressure SI value is added to the SI from the combined thermal and external loadings directly as a positive value, since pressure is always positive. As shown in Tables 4 through 6 of calculation VY-16Q-302, for the transient pairs that contribute the most to the CUF at the safe end and blend radius, the stress intensity range is always increased when the mechanical stresses are added to the thermal stress using the same sign convention and that, for VY, they are small in magnitude compared to the other stresses.

Item	Request	Response
388	Provide justification for statement on page 5 of 34 of Calculation No. VY-16Q-302, that "The Greens Function methodology provides identical results compared to running the input transient through the finite element model."	A verification calculation (SIA calculation QA-2000-102) was performed that compared the results of an ANSYS analysis with a Fatigue Pro Green's Function. The calculation was performed on a feedwater nozzle for a turbine roll event. The results showed the stress range difference between the FatiguePro (Green's Function approach) and ANSYS for the safe end location was between -0.06% and 3.43% and for the blend radius location was between -1.73% and 1.56%. Further discussion of Green's Functions and how they are used in a fatigue monitoring system is available in two papers authored by SIA (Kuo, Tang and Riccardella) for the 1986 Pressure Vessel and Piping Conference and Exhibition in Chicago, Illinois. The papers are titled "An On-Line Fatigue Monitoring System for Power Plants: Part I – Direct Calculation of Transient Peak Stress Through Transfer Matrices and Green's Functions" and "An On-Line Fatigue Monitoring System for Power Plants: Part II – Development of a Personal Computer Based System for Fatigue Monitoring". The intent of the statement in this and other calculations was to indicate that equivalent stress history results are obtained from each method (Green's Function vs. FEM) for a given transient.
389	For the blend radius for the feedwater nozzle in Calculation No. VY-16Q-302, Table 4, Page 16: Why are the Total & M+ B stresses for Thermal Transient 3 shown in columns 3 & 4 high at t=0 sec. (zero stress state?) This question also applies to: Transient 4 at t =1801.9 sec. Transient 9 at t = 2524 sec. Transient 21-23 at t= 20144 sec. This question may also apply to transients 11, 12, and, 14.	To maximize stresses in the blend radius, the Green's function was based on a fluid temperature shock of 500°F to 100ºF in the nozzle flow path while the vessel wall portion of the model was exposed to a constant fluid temperature of 500ºF. These temperature conditions are appropriate for Green's Function integration of nearly all feedwater nozzle transients which occur with feedwater flow injecting through the nozzle into a hot vessel. However, these conditions are overly conservative for transients where there is no flow in the nozzle, or for transients where the reactor temperature drops below 500°F, because a large temperature gradient will be induced into the nozzle structure due to the temperature difference between the reactor and nozzle flow path portions of the model. This temperature difference leads to the high stress values observed for Transients 3, 14 and 21-23 at ambient temperatures. All of these transient conditions involve zero feedwater flow. With the above in mind, Table 4 of VY-16Q-302 was set up to yield overall conservative stress pairings by ensuring stress ranges would be maximized. This was accomplished by combining stresses in a conservative fashion, as well as including duplicate occurrences of zero load state conditions. To verify that the above treatment of stress for Transients 3, 14 and 21-23 is conservative, a zero stress was applied to Transients 3, 14, and 21-23 and the non-required zero stress state conditions that were conservatively added to Table 4 were removed to investigate the impact on fatigue usage. The result of this check was that the difference in overall CUF was approximately 5%. Therefore, the method of estimating the stresses for Transients 3, 14 and 21-23 in Table 4 is considered appropriate.

Item	Request	Response
390	Explain why there are differences in the calculated CUF values a between Rev. A and Rev. 0 of the Structural Integrity Calculations. Also, why are the CUFs calculated by Structural Integrity different from the CUFs shown in Tables 4.3.1 & 4.3.3 of the Vermont Yankee License Renewal Application?	Structural Integrity calculations VY-16Q-301 through VY-16Q- 310 issued as Revision A have the Revision Description on each calculation cover sheet labeled as "Initial Draft for Review". These draft calculations were issued for client review and comment. The draft versions of the calculations were never intended to be the issued version until all external and internal reviews and comments were incorporated. The Revision A calculations were provided under Entergy's obligation to provide all documents related to Environmentally Assisted Fatigue for NEC Contention 2. The Revision 0 versions of these calculations were subsequently issued with comments on the draft calculations resolved. Revision 0 (or later) versions of the calculations are the Calculations of Record. The Revision A drafts are no longer applicable. The CUFs shown in Tables 4.3.1 & 4.3.3 of the Vermont Yankee License Renewal Application Tables are based on the design basis fatigue evaluations factored to account for the effects of the 120% Extended Power Uprate, or for locations with no plant specific CUFs, representative values from NUREG/CR-6260. The CUFs calculated by Structural Integrity are different from the CUFs shown in the VY LRA due to a number of factors specific to each location. These include: updated finite element modeling and more modern thermal transient analysis than used in the original design, the use of updated transient definitions for 60 years of operation shown in Design Input Record (DIR) for EC No. 1773, Rev. 0, "Environmental Fatigue Analysis for Vermont Yankee Nuclear Power Station" Revision 1, dated 7/26/07, and for the NUREG/CR-6260 locations, new VY plant specific ASME III fatigue analyses were performed.

Item	Request	Response
391	On page 1-1 of Report VY-16Q-401 it indicates that refined transient definitions 60 years are used in the computation of the CUF including EAF effects. Please explain the refinements in the transient definitions.	The original Design Transients for the Vermont Yankee Reactor Vessel for a 40 Year design life are given in Section 5.1.8 and Attachment D to General Electric Purchase Specification No. 21A1115, "Reactor Pressure Vessel", Revision 4, 10/21/69 and certified on 10/23/69 as contained in the Reactor Pressure Vessel Design Report. Additional clarifications and descriptions for the design transients were provided by General Electric in GE Letter W. J. Zarella to D.W. Edwards - Yankee Atomic, Subject: "V. Y. R.P.V. Temperature Transient / Cycling Events", No. G-HB-5-124, dated November 5, 1975. Earlier versions of the specification made reference to a GE Thermal Cycle Drawing No. 885D941. The final version of the Design Specification relocated this cycle information to Attachment D of the Design Specification and deleted references to GE drawing No. 885D941. Comparisons were made between the VY Design Specification transients and the design transients shown on Thermal Cycle Drawings from other GE BWR 4 plants of the same and a later vintage. The later plants have a more defined thermal cycle history based on the experience from the earlier GE BWRs. In general, VY is designed for a smaller spectrum of more severe transients than the later units. As described in General Electric Letter No. G-HB-5-124, the VY design transients are intended to bound all operating conditions. For example, the single severe design transient for the VY feedwater nozzle of 1500 cycles is intended to envelop all Start-up, Loss of Feedwater Heater, Scram, and Shutdown events. To insure a realistic projection of Design Thermal Transient Cycles and Events for 60 years of operation, the Thermal Cycle Diagrams used at a number of BWR 4 plants were used as a starting point. The VY Design Specification transients were mapped onto the typical BWR 4 Transient Diagrams. Then projections for 60 years were made based on the numbers for 40 years in the VY Design Specification, the numbers actually analyzed in the VY Design Certified Stress Report for Vermont Yankee Reactor Vessel, Chicago Bridge & Iron, Contract 9-6201, and the number of cycles experienced by VY in approximately 35 years of operation. The results of the new transient definitions are documented in Appendix C of calculation VYC-378 Rev.2 and were provided as input to the EAF analysis in EN-DC-141 Design Input Record (DIR) for EC No. 1773, Rev. 0, "Environmental Fatigue Analysis for Vermont Yankee Nuclear Power Station" Revision 1, dated 7/26/07. These new definitions are considered to be more refined than the original single 1500-cycle transient defined for the VY feedwater nozzles.

Item	Request	Response
392	For the Feedwater Nozzles there are large differences in the CUFs without the Fen factors shown in shown in Table 4.3.1 of the Vermont Yankee License Renewal Application and those shown in calculation VY-16Q-302. Section 2.0 of the calculation on page 4 of 32 states, " ...several of the conservatisms originally used in the original feedwater evaluation (such as grouping of transients) are removed ...". Please explain what conservatisms were removed.	The original Design Transient for the VY Feedwater Nozzle is given in Attachment D to GE Specification No. 21A1115, "Reactor Pressure Vessel", Revision 4, 10/21/69. It is a single severe design transient intended to envelop all Start-up, Loss of Feedwater Heater, Scram, and Shutdown events. It consists of 1500 cycles of: •□a 546F to 100F step change with 25% feedwater flow, followed by, •□a step change to 260F, followed by, •□a ramp from 260F to 546F at 250F per hour along with increasing feedwater flow 25% to 100% flow. This transient is equivalent to a Startup and Turbine Roll event combination specified on newer BWR plant Thermal Cycle Diagrams. As described in GE Letter No. G-HB-5-124, dated November 5, 1975, the 1500 such events considered in the design fatigue evaluation of the feedwater nozzle exceed the 518 start up, loss of feedwater heater, scram, and shut down events listed in the [original] FSAR. The CUF for the feedwater nozzle shown in Table 4.3.1 of the Vermont Yankee License Renewal Application is based on the design basis fatigue evaluations factored to account for the effects of the 120% Extended Power Uprate (EPU). Changes in temperatures for EPU are from GE Nuclear Energy Certified Design Specification No. 26A6019, "Reactor Vessel - Extended Power Uprate", Rev. 1, 8/29/03. The evaluation of EPU effects on the feedwater nozzle and safe end stress and fatigue analysis is contained in VY Engineering Report, VY-RPT-05-00100, Rev. 0, "Task T0302 Reactor Vessel Integrity-Stress Evaluation EPU Task Report for ER-04-1409". Section 3.3.1.1 of GE Report for Task 302, identified the value for the feedwater nozzle safe end EPU CUF for 40 years = 0.75. This is the value shown in Table 4.3.1. The 0.75 CUF value is based on the original design report. The original design analysis was performed for "loose fit" feedwater spargers where the annular cold gap between the stainless steel thermal sleeve and the nozzle safe end was 0.020 inch. The feedwater spargers and thermal sleeves were replaced in 1978 with new "interference fit" thermal sleeves. The interference fit thermal sleeves significantly reduce leakage flow past the thermal sleeve into the bore region of the nozzles. This reduces the heat transfer from the process fluid to the nozzle base metal, thereby reducing thermal stresses during system thermal transients. Subsequent to the GE report, a re-analysis of the feedwater nozzle was performed. SIA Report No. SIR-04-020 Revision 0, March 2004. "Updated Stress and Fatigue Analysis for the Vermont Yankee Feedwater Nozzles" documents a revised ASME III Stress and Fatigue Analysis for the feedwater nozzle and safe end. This analysis included effects of the interference fit thermal sleeves. The analysis was performed for both the original licensed power and system flow rates using the enveloping design transient, "Startup, Loss of Feedwater Heaters, Scram & Shutdown", from the original Design Specification and for EPU power and flow conditions as modified per the EPU Design Specification. For the safe end , the 40 year CUF using 1500 cycles of the enveloping transient and including EPU effects = 0.4513 (as compared to the 0.75 factored GE values used in the LRA). The primary reason for the

decrease in CUF was a result of the improved heat transfer coefficients.

For the Environmentally Assisted Fatigue (EAF) evaluation, (VY-16Q-302), a realistic projection of Design Thermal Transient Cycles and Events for 60 years of operation based on the Feedwater Nozzle Thermal Cycle Diagram from a typical BWR 4 was used. As described in the response to Question No.391, the enveloping design transient was mapped to the "Turbine Roll & Increase to Rated Power" transient. Other transients including loss of feedwater heaters and scram events were taken directly from the Feedwater Nozzle Thermal Cycles Diagram using VY specific EPU design temperatures. The projections for 60 years were based on the number of events for 40 years in the VY Design Specification, the numbers analyzed in the VY Design Certified Stress Report for VY Reactor Vessel, and the number of cycles experienced by VY in approximately 35 years of operation.

The design transients used in the EAF evaluation for the VY Feedwater Nozzle are shown in Attachment 1 to Design Input Record (DIR) for EC No. 1773, Rev. 0, "Environmental Fatigue Analysis for Vermont Yankee Nuclear Power Station" Revision 1, dated 7/26/07.

393 For stainless steel components listed in table 3-10 in Structural Integrity Report SIR-07-132 (VY-16Q-404), please justify that the calculated CUFen values are conservative.

Conservatisms used in the evaluation of stainless steel components include:

- Use of design transients vs. actual operation transients
- Conservative projections for the numbers of events for 60 years of operation based on 35 years of VY operating history
- Use of bounding Fen values for all transients:

The Fen factors are calculated using NUREG/CR -5704 (ANL-98/31), "Effects of LWR Coolant Environments on Fatigue Design Curves of Austenitic Stainless Steels", April 1999. The Fen values are maximized by using the highest temperatures, minimum strain rates, and conservative dissolved oxygen values at each location.