March 14, 2013

Mr. Frederick Schiffley
BWROG Chairman
Exelon Generation Co., LLC
Cornerstone II at Cantera
4300 Winfield Road
Warrenville, IL 60555

SUBJECT: FINAL SAFETY EVALUATION FOR BOILING WATER REACTORS OWNERS' GROUP TOPICAL REPORT BWROG-TP-11-023, REVISION 0, NOVEMBER 2011, "LINEAR ELASTIC FRACTURE MECHANICS EVALUATION OF GENERAL ELECTRIC BOILING WATER REACTOR WATER LEVEL INSTRUMENT NOZZLES FOR PRESSURE-TEMPERATURE CURVE EVALUATIONS' (TAC NO. ME7650)

Dear Mr. Schiffley:

By letter dated November 17, 2011 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML113250288), the Boiling Water Reactor Owners' Group (BWROG) submitted Topical Report (TR) BWROG-TP-11-023, Revision 0, November 2011, "Linear Elastic Fracture Mechanics Evaluation of General Electric Boiling Water Reactor Water Level Instrument Nozzles for Pressure-Temperature Curve Evaluations," to the U.S. Nuclear Regulatory Commission (NRC) staff. By letter dated November 2, 2012, an NRC draft safety evaluation (SE) regarding our approval of TR BWROG-TP-11-023, Revision 0, was provided for your review and comment. By e-mail dated December 4, 2012 (ADAMS Accession No. ML13063A526), the BWROG stated it had no comments on the draft SE.

The NRC staff has found that TR BWROG-TP-11-023, Revision 0, is acceptable for referencing in licensing applications for boiling water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed final SE. The final SE defines the basis for our acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that the BWROG publish an accepted version of this TR within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed final SE after the title page. Also, the approved version must contain historical review information, including NRC requests for additional information (RAI) and your response after the title page. The accepted version shall include an "-A" (designating accepted) following the TR identification symbol.

As an alternative to including the RAIs and RAI responses behind the title page, if changes to the TR were provided to the NRC staff to support the resolution of RAI responses, and the NRC staff reviewed and approved those changes as described in the RAI responses, there are two ways that the accepted version can capture the RAIs:

1. The RAIs and RAI responses can be included as an Appendix to the accepted version.
2. The RAIs and RAI responses can be captured in the form of a table (inserted after the final SE) which summarizes the changes as shown in the approved version of the TR. The table should reference the specific RAIs and RAI responses which resulted in any changes, as shown in the accepted version of the TR.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, the BWROG and/or licensees referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

Sincerely,

/RA/

Sher Bahadur, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 691

Enclosure:
Final SE

cc w/ encl: See next page

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1. The RAIs and RAI responses can be included as an Appendix to the accepted version.
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/RA/

Sher Bahadur, Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

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Enclosure:
Final SE

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FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

LICENSING TOPICAL REPORT (LTR) BWROG-TP-11-023, REVISION 0

"LINEAR ELASTIC FRACTURE MECHANICS EVALUATION OF GENERAL ELECTRIC

BOILING WATER REACTOR WATER LEVEL INSTRUMENT NOZZLES FOR

PRESSURE-TEMPERATURE CURVE EVALUATIONS"

BOILING WATER REACTORS OWNERS' GROUP

PROJECT NO. 691

1.0 INTRODUCTION AND BACKGROUND

In a letter dated November 17, 2011, the Boiling Water Reactor (BWR) Owners' Group (BWROG) submitted Licensing Topical Report (LTR) BWROG-TP-11-023, Revision 0, dated November 2011, "Linear Elastic Fracture Mechanics [(LEFM)] Evaluation of General Electric Boiling Water Reactor Water Level Instrument [(WLI)] Nozzles for Pressure-Temperature [(P-T)] Curve Evaluations" (Agencywide Documents Access and Management System (ADAMS) Accession No. ML113250288), to the U.S. Nuclear Regulatory Commission (NRC) for review and acceptance for referencing in subsequent licensing actions. LTR BWROG-TP-11-023, Revision 0 (hereafter referred to as the LTR), provides a fracture mechanics solution for a partial penetration WLI nozzle for an internal pressure load case and a 100 Degree-Fahrenheit-per-hour (°F/hr) thermal load case. The solution will then be used in developing plant-specific P-T curves.

This review also includes an evaluation of the BWROG's responses to the NRC staff's requests for additional information (RAIs), which were provided to the NRC in a letter from the BWROG dated June 13, 2012 (ADAMS Accession No. ML12167A239). Please note the NRC staff asks that you revise the final "-A" version of the LTR to reflect the clarification made in your response to RAI-2.

During the review of the BWROG's LTR BWROG-TP-11-023, Rev. 0, the NRC staff found that, in general, the LTR meets the objectives of an LTR and reinforces previously established NRC regulations and guidelines as noted within this SE. The NRC has evaluated this LTR against the criteria of 10 CFR Part 50, and has determined that it does not represent a backfit. Specifically, NRC Staff technical positions outlined in this SE are consistent with the aforementioned regulations and established staff positions, while providing more detailed discussion concerning the methodology and data required to support linear elastic fracture mechanics evaluations of General Electric BWR WLI Nozzles for P-T Curve Evaluations. This SE endorses staff positions previously established through licensing actions and interactions with industry.

2.0 REGULATORY EVALUATION

The NRC has established requirements in Appendix G, "Fracture Toughness Requirements," of Part 50 to Title 10 of the *Code of Federal Regulations* (10 CFR Part 50), in order to protect the integrity of the reactor coolant pressure boundary in nuclear power plants. The regulation at 10 CFR Part 50, Appendix G, requires that the P-T limits for an operating light-water nuclear reactor be at least as conservative as those that would be generated if the methods of Appendix G, "Fracture Toughness Criteria for Protection Against Failure," to Section XI of the American Society of Mechanical Engineers *Boiler and Pressure Vessel Code* (ASME Code) were used to generate the P-T limits.

The regulation at 10 CFR Part 50, Appendix G, also requires that applicable surveillance data from reactor pressure vessel (RPV) material surveillance programs of 10 CFR Part 50, Appendix H, "Reactor Vessel Material Surveillance Program Requirements," be incorporated into the calculations of plant-specific P-T limits, and that the P-T limits for operating reactors be generated using a method that accounts for the effects of neutron irradiation on the material properties of the RPV beltline materials.

Table 1 to 10 CFR Part 50, Appendix G, provides the NRC staff's criteria for meeting the P-T limit requirements of ASME Code, Section XI, Appendix G, as well as the minimum temperature requirements of the rule for bolting up the vessel during normal and pressure testing operations. In addition, the NRC staff regulatory guidance related to P-T limit curves is found in Regulatory Guide (RG) 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," and Standard Review Plan Chapter 5.3.2, "Pressure-Temperature Limits Upper-Shelf Energy and Pressurized Thermal Shock."

The regulation at 10 CFR Part 50, Appendix H, provides the NRC staff's criteria for the design and implementation of RPV material surveillance programs for operating light-water reactors.

In March 2001, the NRC staff issued RG 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence." Fluence calculations are acceptable if they are performed with approved methodologies or with methods which are shown to conform to the guidance in RG 1.190.

For RPV instrument nozzles located in the beltline region, such as the WLI nozzles, the increased neutron fluence may cause an embrittlement concern during the period of extended operation of plants that have received a license extension. Subparagraph G-2223(c) of the ASME Code, Section XI, Appendix G states that, "fracture toughness analysis to demonstrate protection against nonductile failure is not required for portions of nozzles and appurtenances having a thickness of 2.5 in. (63 mm) or less, provided the lowest service temperature is not lower than RT_{NDT} plus 60 °F (33 °C)." Therefore, when Subparagraph G-2223(c) is referenced, the ART value (i.e., RT_{NDT} adjusted to account for the effects of radiation) must be determined for the instrument nozzles and the associated nozzle-to-RPV welds to determine if the lowest service temperature criterion will be met through the end of the evaluation period. If not, the instrument nozzles and the associated nozzle-to-RPV welds must be considered in the P-T limits in accordance with 10 CFR Part 50, Appendix G, and the ASME Code, Section XI, Appendix G.

On January 31, 1996, the NRC staff issued Generic Letter 96-03 to inform licensees that they may request a license amendment to relocate the P-T limit curves from the Technical Specifications (TS) into a pressure temperature limits report (PTLR) or other licensee-controlled document that would be controlled through the TS.

3.0 TECHNICAL EVALUATION

3.1 The BWROG's Evaluation

The LTR provides an LEFM evaluation of the WLI nozzles to be used in P-T limit applications. Section 1, "Introduction," provides the relationship among P-T limits, PTLR, and the proposed LEFM evaluation for WLI nozzles. Section 2, "Methodology," provides the proposed LEFM methodology, starting from the stress analysis based on the finite element method (FEM) to the LEFM analysis based on the boundary integral/influence function (BIE/IF) method. Section 3, "Assumptions," provides assumptions adopted in each step of the proposed methodology, such as the heat transfer coefficients for the WLI nozzle and RPV external and internal surfaces, material properties for various components, and the stress free temperature for evaluating cladding stresses. Section 4, "Finite Element Model," provides information on development of the 38 FEM models first introduced in Section 2, considering various types of nozzle and FEM models with and without a crack. This section also addressed FEM model validation through mesh density check for models with and without a crack. Section 5, "Instrument Nozzle Load Cases," addresses the loads on the nozzle: internal pressure, thermal transient, and pipe reaction load. Section 6, "Pressure, Thermal, and Piping Load Results," presents FEM results (i.e., stresses and applied stress intensity factors (K_Is)) under these three types of load. Section 7, "Observations and Discussions," offers the BWROG's observation of the behavior of the applied K_Is and a discussion of the modeling choices that could affect the results. Section 8, "Generic Methodology for K_I Estimation," provides generic K_I Formulas derived from the FEM results for a variety of nozzles for licensees to use for WLI nozzles in their plant-specific P-T limit applications. Section 9, "Summary," provides summary findings and conclusions.

3.2 The NRC Staff's Evaluation

Since Section 1 of the LTR provides only an introduction on P-T limits, PTLR, and the proposed LEFM evaluation for WLI nozzles, the staff's evaluation starts from Section 2, which discusses the stress analyses due to pressure, thermal transient, and pipe reaction loads using quarter and full FEM models. Section 2.2 of the LTR states, "Since there is no specific material specification identified for the CS [(i.e., carbon steel)] nozzle inserts from Table 2-1 of Reference [13], SA-541 Class 1 is assumed." Depending on the material properties used, this assumption could change the calculated stresses significantly. Hence, the NRC staff issued RAI-1. RAI-1 also includes questions regarding the assumption of Alloy 600 material for the weld metal for all nozzles and the assumption of certain heat transfer coefficients for the inside and outside surface of the vessel and nozzle.

The BWROG's June 13, 2012, response to RAI-1 indicated that; in addition to Alloy 600, stainless steel, and CS as the WLI nozzle insert material as reported in the LTR; low alloy steel (LAS) is also found to be the material for the WLI nozzle insert. Therefore, a revision was made to the LTR to reflect this new finding. The BWROG performed a LEFM analysis based on FEM on a representative nozzle using CS and LAS material properties and found that their K_I values under the thermal transient are within 3.7 percent. Since this magnitude of difference is within the accuracy of the inputs and overall methodology, the staff accepts the difference in K_I due to material difference. Therefore, the first part of RAI-1 is resolved. For the second part of RAI-1 regarding the assumption of using Alloy 600 material for the weld metal for all nozzles, the BWROG revised the LTR to limit the application of this LTR to only WLI nozzle configuration/design using Alloy 600 material for the weld metal. Hence, the second part of RAI-1 is resolved. For the last part of RAI-1 regarding the use of certain heat transfer coefficients for the inside and outside surface of the vessel and nozzle, the BWROG revealed that the convection coefficient for the outside surface is from NEDO-21821-A, "Boiling Water Reactor Feedwater Nozzle/Sparger Final Report," and the convection coefficient for the inside surface is consistent with the range of values considered in the same report. In addition, an evaluation was provided in the BWROG's response to demonstrate that further increase in the assumed convection coefficient has an insignificant effect on the maximum thermal stresses. Based on these, the staff considers the last part of RAI-1 resolved.

For the load cases discussed in Section 2.3 of the LTR, it is not clear whether "piping loads" are loads from only the piping attached to the safe-end of the instrument nozzle, or also from the various large piping (not shown in Figure 4-1) attached to the RPV. This is the basis for RAI-2. The BWROG's June 13, 2012, response to RAI-2 confirmed that piping loads are loads from only the piping attached to the safe-end of the instrument nozzle. RAI-2 is therefore resolved but the BWROG is asked to revise the LTR to reflect this clarification.

The 45° line (Figure 2-1) is chosen for extracting hoop stresses from the FEM analysis. Although the orientation of this path is consistent with the necessary inputs for the BIE/IF solution for the nozzle corner crack, it has not been established in the LTR that this approach will produce conservative, or the most accurate results. This is the basis for RAI-3.

The BWROG's June 13, 2012, response to RAI-3 cited EPRI NP-339, "Improved Evaluation of Nozzle Corner Cracking," and an Oak Ridge National Laboratory (ORNL) report ORNL/TM-2010/246, "Stress and Fracture Mechanics Analyses of Boiling Water Reactor and Pressurized Water Reactor Pressure Vessel Nozzles," to support the conclusion that good agreement exists between the stress intensity factors calculated from detailed analysis and the simplified one-dimensional stress distribution. The staff confirmed that the ORNL report concluded that the combined K_I due to both pressure and thermal loading is estimated reasonably well in the analyses using uncracked and cracked FEM models for the BWR WLI nozzle where the hoop stress extraction path is the 45° line through the nozzle thickness. Therefore, using the same extraction path in the current application should also produce reasonable and acceptable results. RAI-3 is resolved. After resolution of RAI-1 to RAI-3, the staff has no additional concerns over the proposed methodology, pending evaluation of the remaining sections of this LTR.

Section 3 of the LTR discusses assumptions used in the analysis. The staff had a question on the BWROG's applying the weaker base metal properties instead of weld material properties in the FEM analyses. This is the basis for RAI-4.

The BWROG's June 13, 2012, response to RAI-4 clarified that "base metal" is intended to mean an equivalent ASME Code material for the weld metal, not to mean the use of LAS properties.

The LTR is revised to reflect this clarification. Therefore, RAI-4 is resolved. For other assumptions summarized in Section 3 of the LTR, Assumption 1, Assumption 2, and part of Assumption 4 have already been discussed in Section 2 regarding the proposed methodology. The staff's evaluation and acceptance of these assumptions can be found above in the discussion of the BWROG's response to RAI-1. Assumption 5 regarding constant density and Poisson's ratio is appropriate because it has only secondary effect on the results and is consistent with the common practice, and the remaining part of Assumption 4 regarding vessel pad material and nozzle-to-safe end weld material has negligible effect due to their distance from the location of interest. Assumption 6 regarding a stress free temperature of 550° F is commonly used in stress and fracture mechanics analyses for RPV with cladding, and is acceptable.

Section 4 of the LTR provides information for the 3-dimentional (3-D) FEM un-cracked models for the structural and thermal analyses. Moderate details for 3-D FEM cracked models for the structural and thermal analyses are also provided for validating the BIE/IF K_I results. To demonstrate that a proprietary FEM meshing algorithm used in the analyses can produce accurate results, the BWROG provides a benchmark of its FEM fracture mechanics modeling methodology in Appendix A of this LTR. The staff examined the comparison of results from various approaches and accepted the BWROG's use of this meshing algorithm in the current application because the algorithm is not very sensitive to mesh size and the results are more conservative than those provided by the closed-form solution. However, the staff is not sure that coupling the nodes on the free end of the safe end in the nozzle axial direction best simulates the real situation. This is the basis for RAI-5.

The BWROG's June 13, 2012, response to RAI-5 clarified that coupling the nodes on the free end of the safe end is used in the mesh sensitivity study to demonstrate that the spatial discretization selected for the FEM models was sufficient to resolve the parameters of interest. The BWROG further stated that for the piping load cases analyzed as part of the evaluation in Sections 5.3 and 6.3 of the LTR, the nodes at the end of the safe end are connected to a pilot node on which the appropriate forces and moments are applied. The staff accepts this explanation because coupling the nodes on the free end of the safe end is not used in the nozzle FEM models under piping load cases discussed in Section 6.3 and, instead, a more realistic modeling of the piping end is used. RAI-5 is resolved. In addition, mesh density checks for FEM un-cracked and cracked models were also performed by the BWROG with results shown in Tables 4-1 and 4-2 and Figure 4-8. The staff examined these results based on different mesh densities and determined that reasonable stability of the stresses and K_Is has been achieved by the current FEM models and the results presented later in Section 6 are credible.

Section 5 of the LTR provides information for the three types of loadings considered in the LTR: internal pressure, thermal transient, and pipe reaction loads. Additional FEM modeling details such as specific elements used and boundary conditions are also provided here. Except for the concern raised in RAI-2 regarding the source of piping loads which has been resolved as mentioned before, the staff found that all sources of loading have been considered and the top-level modeling schemes are consistent with industry practice.

Section 6 of the LTR presents results from applying the three types of loading discussed in Section 5 of the LTR, and thus required close staff examination because of its importance. Four

RAIs were generated for this section: RAI-6 on the determination of the critical crack plane orientation for K_Is, RAI-7 on adjustment of large elastic pseudo-stresses, RAI-8 on definition of a hoop stress extraction path with and without RPV cladding, and RAI-9 on the very different variation of K_I values along the crack front under pressure and thermal loading.

The BWROG's June 13, 2012, response to RAI-6 states that, "The postulated crack is always placed in an orientation such that it is normal to the maximum hoop stress in the RPV from the pressure load case." It further states that, "the thermal stress distribution around the circumference of the nozzle blend radius does not exhibit substantial variation. Consequently, locating the postulated crack, for the thermal load case, in an orientation identical to that selected for the pressure load case results in the bounding combination of the thermal and pressure contributions to K_I, for all nozzles." Since the postulated crack is located in an orientation having the bounding combination of the thermal and pressure contributions to K_I for all nozzles, RAI-6 is resolved. The BWROG's June 13, 2012, response to RAI-7 states that, "No adjustment to stress is made at any time….The comment included in the LTR was intended only to convey that, for the purposes of the figure, the contour scale on the plot was truncated such that the peak stress in the vicinity of the discontinuity was not shown…." This is acceptable because no adjustment is made to the calculated stresses, and the adjustment on stresses is only for better contour plotting.

Regarding the definition of a hoop stress extraction path including or not including RPV cladding, the BWROG's June 13, 2012, response to RAI-8 states that, "It is confirmed that in both cases [i.e., paths including and not including RPV clad] the thermal loading was applied to the cladding and the thermo-elastic stress analysis was performed with cladding in the finite element model. Two different paths were defined to extract path stress distributions: one starting at a radial location corresponding to the ID of the cladding, and one starting at a radial location corresponding to the ID of the LAS shell…Neither path shown in Figure 6-7 passes through the air gap between the nozzle insert and the RPV shell." RAI-8 is resolved because the BWROG confirmed the staff's interpretation of the definition of paths for extracting stresses and confirmed that neither path passes through the air gap between the nozzle and the RPV. Regarding the very different variation of K_I values along the crack front under pressure and thermal loading, the BWROG's June 13, 2012, response to RAI-9 provided physical explanation of the phenomenon based on stresses. The staff considers the explanation reasonable and, therefore, RAI-9 is resolved. In conclusion, RAI-6, RAI-7, RAI-8, and RAI-9 are related to nozzle FEM and BIE/IF modeling, and successful resolution of them has cleared the staff's concerns over the results summarized in Figures 6-3 to 6-5 and Figure 6-9. Consequently, the staff can rely on the analytical results presented in Section 6 to determine acceptability of the LTR.

Section 7 of the LTR states that, "For P-T curve analysis, a conservative ¼ thickness flaw is assumed; a real flaw does not exist. Consequently, the inherent conservatism in assuming a ¼ thickness flaw is considered sufficient such that requiring use of the maximum K_I along the entire crack front is considered to be excessively conservative." The staff had comments on this statement and did seek to gain additional information through RAI-10. RAI-10 also requests the BWROG assess the practicality of applying a factor of 1.1 to the applied pressure K_I values based on the BIE/IF and 1.4 to the applied thermal K_I values based on the BIE/IF to bound the applied K_I values and find out (1) whether these factors will always make the instrument nozzle limiting for the P-T limit curves and (2) whether plant operation will be severely limited if the instrument nozzle becomes limiting.

The BWROG's June 13, 2012, response to RAI-10 provides, among background information and conservatism in the current ASME Code, Section XI, Appendix G approach, convincing arguments regarding the proposed BIE/IF approach:

1. Use of near surface K_I values, rather than the deepest point is not consistent with ASME [Code Appendix] G methods, as well as,

2. The observation that near a free surface the failure is governed more appropriately by a fracture toughness elevated above the plane strain fracture toughness, which implies greater margin to failure at this location, and,

3. The pressure term, which is shown to be 24 % conservative compared to the peak FE LEFM K, is further amplified by the Code required structural factor of 2.0 compared to the Code required structural factor of 1.0 for thermal loads.

4. The observation that a single nodal K_I, near the free surface, from the FE LEFM analysis falls above the conservative BIE/IF solution does not represent a reduction in margin required by the ASME [Code Section] XI, Appendix G methods.

Based on the information provided by the BWROG and 10 CFR Part 50, Appendix G, ASME Code, Section XI, Appendix A and Appendix G, the staff believes that, unlike the ASME Code, Section XI, Appendix A method for flaw evaluation of a detected flaw where the nearly peak K_I along the crack front and all load contributions to K_I such as the differential thermal expansion of the clad and welding residual stresses have to be considered, the ASME Code, Section XI, Appendix G method is meant to establish fracture toughness requirements for all RPVs under the normal operation condition based on a postulated flaw, considering specific load contributions to K_I. As long as the proposed LEFM evaluation for WLI nozzles follows the same assumptions made in the ASME Code Section XI, Appendix G method, the WLI nozzles will have the similar margin against brittle fracture as all RPVs when they are operated within the P-T limits based on the ASME Code, Section XI, Appendix G. Therefore, for interpretation of the BIE/IF results, the staff determined that, consistent with the ASME Code, Section XI, Appendix G method, the K_I of the deepest point of the crack front, not the one close to the surface point, should be used when compared to the FEM results. As shown by Figure 6-5 for the pressure load case and Figure 6-9 for the thermal load case, the K_I values based on BIE/IF at points closer to the deepest point of the crack front always bound the K_I values based on FEM at these points, establishing the acceptability of the proposed K_I methodology based on BIE/IF. Therefore, RAI-10 is resolved.

The BWROG summarized the BIE/IF and the FEM root-mean-square (RMS) K_I results in Table 7-1 of the LTR. The table showes that the BIE/IF K_I results using the proposed method are conservative by 39 percent for the pressure case and 46 percent for the thermal load case when compared with those from the FEM method. Consistent with the ASME Code, Section XI, Appendix G methodology, the staff used the FEM K_I results close to the deepest point of the flaw (instead of the RMS K_I results used by the LTR) and revised the conservatism estimate to 26 percent for the pressure case (see Figure 6-5 of the LTR for the FEM K_I value close to the deepest point of the flaw) and 100 percent for the thermal load case (see Figure 6-9 of the LTR for the FEM K_I value close to the deepest point of the flaw). These conservative estimates will be used to resolve RAI-11.

Section 8 of the LTR presents generic, empirical applied K_I equations under pressure and the thermal ramp load based on curve-fitting of applied K_I results for a variety of nozzles. Since the proposed equations are best estimate, instead of bounding, linear equations, the staff issued RAI-11 for additional information.

The BWROG's June 13, 2012, response to RAI-11 states that, "Considering that the BIE/IF solution was shown to be conservative with respect to a plant specific FEA, by 46 percent for the thermal ramp load case and 39 percent for the internal pressure load case, in this same LTR, it is not considered necessary to add further conservatism to this methodology. Consequently, we believe that keeping the curve fit equations as best-estimate curve fits rather than upper bound curve fit equations is justified." The staff determined that using quantified conservatism in one area to offset quantified none-conservatism in another is acceptable as long as the former is greater than the latter. In this case, the staff's revised conservatism estimates of 26 percent for the pressure case and 100 percent for the thermal load case far exceed the non-conservatism of 5 percent for the pressure and 15 percent for the thermal load case for using the best estimate equation instead of the bounding equation. Therefore, RAI-11 is resolved. The staff agrees with the BWROG that using the BIE/IF solution in the P-T limit curve analysis is appropriate.

4.0 CONDITIONS AND LIMITATIONS

Based on the evaluation in Section 3.2, the staff determined that no conditions or limitations are necessary for future potential applicants to address in their application of this LTR to their plant-specific P-T limit submittals.

5.0 CONCLUSION

Based on the evaluation, the NRC staff concludes that LTR BWROG-TP-11-023, Revision 0 provides acceptable methodology for BWR licensees to obtain plant-specific stress intensity factors for an internal pressure load case and a 100 °F/hr thermal ramp load case for use in developing plant-specific P-T limit curves for RPV WLI nozzles. Since the analyses assumed that Alloy 600 material was used for the weld metal for all nozzles, the BWROG revised the LTR to limit the application of this LTR to only WLI nozzle configuration/design using Alloy 600 material for the weld metal. This proposed methodology is consistent with 10 CFR Part 50, Appendix G and the ASME Code, Section XI, Appendix G.

Principal Contributor: S. Sheng

Date: March 14, 2013