

Staff Responses to Public Comments on Proposed NRC Regulatory Issue Summary 2008-XX
 “Fatigue Analysis of Nuclear Power Plant Components”
 May 1, 2008 (73 FR 24094)

Source of Comments

- I. Comments from Gary L. Stevens, Structural Integrity Associates, Inc.
- II. Comments from John C. Butler, Nuclear Energy Institute
- III. Comments from David Steininger, EPRI
- IV. Comments from T. Moser, STARS
- V. Comments from J. A. Gresham, Westinghouse

#	Source	Comment	Response
1	I-1	<p>The Intent section of the RIS indicates that nonconservative results could be obtained if the methodology is not correctly applied. However, the final results of the example boiling-water reactor feedwater nozzle confirmatory analysis cited in the RIS do not support this statement. For the sample boiling-water reactor plant cited in the RIS, the cumulative usage factor (CUF), including environmental effects, at the feedwater nozzle corner was calculated to be 0.63 in the original (refined) analysis. This value is conservative compared to the CUF value (including environmental effects) of 0.35 calculated at the feedwater nozzle corner in the follow-on confirmatory analysis. Whereas the CUF value, prior to adjustment for environmental effects, was higher for the confirmatory analysis than for the refined analysis, the higher value of CUF in the confirmatory analysis was the result of the different implicit conservatisms present in each analysis. When these conservatisms are all collectively considered, the refined analysis methodology is observed to be conservative, as</p>	<p>As stated by the commenter, the CUF value, prior to adjustment for environmental effects, was higher for the confirmatory analysis. The final environmental CUF was lower in the confirmatory analysis of the BWR feedwater nozzle due to refinement of the calculation to remove additional conservatism that existed in the environmental adjustment factor (Fen) value. The staff could not conclude that the Fen values used for the CUF calculation at other locations that may have used the simplified methodology contained the same level of conservatism. As a consequence, the staff concluded that the methodology could be nonconservative if not correctly applied. The intent of the RIS is to inform licensees that the simplified methodology could produce a nonconservative result.</p>

		<p>demonstrated by the final CUF results. Similar reductions in CUF (including environmental effects) were also reported for a second boiling-water reactor confirmatory analysis reported since the publication of the draft RIS.</p> <p>Please clarify the intent of the RIS.</p>	
2	I-2	<p>To our knowledge, the ASME Code fatigue analysis methodology never has been explicitly required for environmental fatigue calculations. The NRC has not defined the specifics of the underlying fatigue analysis requirements to address environmental fatigue effects for license renewal. As a result, there are no clear rules for performing such fatigue evaluation, beyond the environmental fatigue (F_{en}) methodology referenced in the GALL Report (NUREG-1801, Revision 1) and specified in associated documents NUREG/CR-6583 and NUREG/CR-5704. Since the evaluation of environmental effects is not associated with the current licensing basis (CLB), but rather for license renewal purposes, it seems that any approach that can be defended technically as conservative with respect to fatigue can be used to establish a fatigue usage factor upon which to apply environmental factors. For example, the use of strain rates for CLB transients may not be bounding for use in an environmental fatigue assessment, since F_{en} values are increased for lower strain rates that are typical of actual plant operation. An additional example is those plants that have a piping design basis of ANSI B31.1 where no explicit fatigue evaluation exists. In these cases, most plants choose to perform fatigue calculations using ASME Code Section III methodology to provide a fatigue basis to evaluate the effects of environmental fatigue, but there does not seem to be any requirement that the ASME Code methodology be used in these circumstances.</p> <p>Is it the intent of the RIS to establish the ASME Code fatigue analysis methodology as the only NRC-approved method for environmental fatigue evaluations?</p>	<p>The RIS is intended to remind licensees of that the ASME fatigue analysis methodology is the NRC-approved method for performing environmental fatigue evaluations. The environmental fatigue evaluation applies the F_{en} factor to the usage factor computed using ASME fatigue curves. The use of the ASME analysis methodology is implicit in the use of the ASME fatigue curves and the ASME acceptance criteria. The ASME Code methodology was used for the evaluations performed in NUREG/CR-6260, "Application of NUREG/CR-5999 Interim Fatigue Curves to Selected Nuclear Power Plant Components." NUREG/CR-6260 is referenced in the GALL Report. The staff allows use of the methodology from later ASME Code Editions.</p>

3	I-3	<p>ASME Code, Subsection NB, Subarticle NB-3200 methodology is not prescriptive. As a result, all analyses performed using this methodology rely on the judgment of the analyst, including judgment on items such as stress components, transient definitions, heat transfer coefficients, material properties, and other input parameters to ensure that the analysis results are appropriate and bounding for the intended application. In fact, the confirmatory analysis performed for the one boiling-water reactor feedwater nozzle component referenced in the RIS uses many of the same judgments – judgments that have routinely been applied in CLB analyses for Class 1 components throughout the industry.</p> <p>Given the lack of specific requirements related to environmental fatigue assessment, any methodology may be nonconservative if not correctly applied. Why is the single-stress analysis method singled out in the RIS? Has the NRC reviewed all approaches used to assess environmental effects and determined that all other methods are always conservative?</p>	<p>The staff agrees with the general comment that the ASME Code, Subsection NB, Subarticle NB-3200 methodology is not prescriptive. However, the single stress component analysis was cited because the staff had evidence that it could produce nonconservative results and that the single stress component analysis approach had been used at a number of other facilities. The staff did not identify other widely used analysis methodologies that produced nonconservative results in the environmental fatigue analysis. The staff has issued other generic communications regarding potentially nonconservative analysis methodologies that are not related to the environmental fatigue analysis. One example is IEB 79-07, “Seismic Stress Analysis of Safety-Related Piping.” IEB 79-07 dealt with a potentially nonconservative methodology in computer code used to perform piping analyses.</p>
4	I-4	<p>Whereas the ASME Code methodology is intended to use six stress components in fatigue evaluation, allowance is made to simplify the analysis when the situation warrants. Specifically, ASME Code, Paragraph NB-3215(d) states:</p> <p>“In many pressure component calculations, the t, l, and r directions may be so chosen that the shear stress components are zero and σ_1, σ_2, and σ_3 are identical to σ_t, σ_l, and σ_r.”</p> <p>The above is true for cylindrical component geometries such as those prevalent throughout the nuclear industry (e.g., reactor vessels and piping). In fact, CLB fatigue analyses have traditionally used only component (σ_x, σ_y, σ_z or σ_t, σ_l, σ_r) stresses. This practice assumes shear stresses are negligibly small such that the component stresses essentially equal the principal stresses, and simplifies the evaluation by negating the need to solve a cubic equation to resolve a six-component stress tensor into three principal stresses. This simplified approach has been</p>	<p>The RIS only provides information and does not impose any new requirements. In addition, the RIS does not imply that all six stress components must be used in the ASME Code analysis. The RIS states that detailed stress analysis requires consideration of all six stress components. The RIS further states that simplification of the analysis to consider only one value of the stress may provide acceptable results for some applications. The logic described by the commenter can be used to simplify the ASME Code calculation. As stated in the response to the previous comment, the staff had evidence that an analysis that used a single stress component produced a nonconservative value for the fatigue usage.</p>

		<p>widely adopted over many years of industry use for a variety of component analyses, including nozzle corner locations. In fact, responses to additional information (RAIs) associated with the one boiling-water reactor feedwater nozzle confirmatory analysis cited in the RIS demonstrated that shear stresses were negligible, and Advisory Committee on Reactor Safeguards (ACRS) testimony earlier this year indicated that the nonconservatism in those results was the result of “twenty differences... of conservatisms” and approximations between the refined and confirmatory analyses.</p> <p>In view of all of the foregoing discussion, it is unclear why the RIS requires the use of all six stress components, why it is acceptable for CLB analyses to not do so and why the RIS is limited to those select few environmental fatigue evaluations that have used a simplified Green’s Function methodology associated with license renewal. Please clarify.</p>	
5	I-5	<p>The RIS is misleading in that the Green’s Function methodology does not have anything to do with the potential non-conservatism. Rather, it is the single stress calculation methodology used after the Green’s Function analysis that is the area of concern. Therefore, all references to Green’s Function methodology should be removed from the RIS to avoid misinterpretation.</p>	<p>The staff agrees with the comment that Green’s function methodology does not have anything to do with the potential nonconserveatism. However, the simplified analysis assumption of concern was coupled with the use of the Green’s function. Therefore, the summary of the issue should reference Green’s function. The RIS clearly states, “The Green’s function methodology is not in question.” The staff revised the RIS to eliminate redundant references to the Green’s function.</p>
6	I-6	<p>It is not clear based on the reference to fatigue monitoring programs whether those applications are also being questioned. If not, reference to “fatigue monitoring systems” should be removed from the RIS to avoid misinterpretation. If so, please clarify what aspects of those applications are in question, what actions are necessary, and identify whether the NRC is familiar with the fatigue monitoring literature that has been published over the past 20 years that documents the technology used by these applications and its acceptability for ASME Code evaluation.</p>	<p>The concern does involve “on-line” monitoring systems where the input used for the monitoring was derived using the same simplifying assumption.</p>

7	I-7	<p><i>Licensees may have also used the simplified Green's function methodology in operating plant fatigue evaluations for the current license term. For plants with renewed licenses, the staff is considering additional regulatory actions if the simplified Green's function methodology was used.</i></p> <p>If this RIS is intended for license renewal only, the first sentence of this paragraph should be stricken, as any statements concerning the current license term are extraneous.</p>	<p>The RIS is not intended only for license renewal applications. It is intended for any application where the simplified methodology was used.</p>
8	I-8	<p>The text of the RIS seems to suggest that the following four conditions are relevant:</p> <ol style="list-style-type: none"> 1. Fatigue analyses are being performed to support operation during the period of extended operation. 2. These fatigue analyses are being performed in accordance with ASME Code, Subarticle NB-3200 methodology. 3. Green's Functions are being used. 4. An abbreviated stress tensor that ignores some of the non-zero terms is used. <p>Is it intended that confirmatory analyses are required only for situations where all four of the above conditions are satisfied? If the answer to this question is "yes", why is this issue limited to license renewal evaluations and not the other legacy work where the four conditions above are satisfied? If the answer to this question is "no", please clarify under which conditions that confirmatory analyses are required.</p>	<p>As stated in the backfit discussion, the RIS does not impose any requirements. The RIS only provides information. It is up to licensees to take appropriate actions. Thus far, the staff has pursued this issue directly with license renewal applicants on a case-by-case basis as part of the review process. Any generic recommendation will be considered through an additional generic communication.</p>
9	I-9	<p>It is not clear from the language in the RIS whether utilities must perform confirmatory analyses and submit notice of such work to the NRC, or whether utilities are being informed of the issue and that no actions are necessary unless specifically requested by the NRC. Please clarify.</p>	<p>As stated in the response to Comment 8, the RIS does not impose any requirements. It provides information.</p> <p>The staff agrees with the comment that the confirmatory analyses that have been performed to date have demonstrated acceptable fatigue usage. However, all of</p>

		<p>Also, there have been several other confirmatory analyses performed to-date, in addition to the one boiling-water reactor feedwater nozzle analysis identified in the RIS, all of which demonstrate acceptable fatigue usage factors with environmental fatigue effects incorporated. Don't these results collectively suggest that the RIS is unnecessary?</p>	<p>the confirmatory analyses have taken advantage of additional conservatisms that existed in the original analyses. The staff has not been able to draw a generic conclusion based on the current confirmatory analyses. Therefore, the staff still concludes that the RIS is necessary.</p>
10	II	<p>The proposed RIS addresses an NRC concern that involves a simplified input for applying the Green's function methodology to demonstrate the ability of nuclear power plant components to withstand cyclic loads. The stated intent of the proposed RIS is to "inform licensees of an analysis methodology [simplified Green's function] ... that could be nonconservative if not correctly applied."</p> <p>The proposed RIS cites a single case where results using the simplified Green's function were less conservative than results obtained using more detailed analyses. However, both analyses demonstrated acceptable results for the component being analyzed. The proposed RIS fails to identify any instances in which the simplified Green's function methodology has been incorrectly applied or instances in which a nonconservative result was obtained.</p> <p>While it is important, as noted in the proposed RIS, that proper judgment be used in performing Time Limited Ageing Analyses (TLAA), the proposed RIS provides no information to assist license renewal applicants to this end. Therefore, we recommend that the proposed RIS be withdrawn.</p> <p>Instead, we support actions on the part of industry and NRC staff to develop more specific guidance on the conduct of TLAA. The NEI License Renewal Task Force (LRTF) will discuss this topic, and the means by which this can be accomplished, at an upcoming public meeting with NRC staff.</p>	<p>The RIS only provides information and does not contain any requirements. The purpose of the RIS is to alert licensees of the potential for nonconservative results if certain simplifying assumptions are used to perform ASME Code fatigue analyses. The staff is willing to work with the industry on the development of additional guidance to address this issue.</p>

11	III-1	While the focus of the RIS is fundamentally on License Renewal Applications, the door has been opened to any previous use of the questionable methodology. This is found in the RIS statement; "Licensees may have also used the simplified Green's function methodology in operating plant fatigue evaluations for the current license term."	See response to Comment 7.
12	III-2	The description of the issue is vague and lacks sufficient specificity to understand the problem and develop appropriate plans to addressing it. It states that the Green's function methodology is not in question, but that simplifying assumptions used in its application may cause non-conservative results. It cites one non-conservative case that was found, but does not provide any details about this case that may be used to understand the problem with the simplified approach. This could be a similar issue for many analytical methods used in the design qualification of nuclear power plant components. Additional details on the nonconservative case would be appropriate and needed to find and resolve the issue.	See response to Comment 3.
13	III-3	All engineering analysis is approximate to some degree and uses imperfect data. The focus of the RIS in imposing more exacting levels of legacy methods of analysis, which themselves were based on approximate data and methods is a misdirection of engineering resources when previous work must be revisited and revised. It is sufficient that some analysis using the traditional and approximate methodologies has been performed and that plant evolutions and transients are monitored. Issues identified by the analysis and the adverse trends identified by the monitoring provide the bulk of the benefit of such activities. Further refinement of the effort provides a diminishing increment of safety benefit (if any at all), which must be balanced against the lost opportunity of the misapplied resources.	The staff does not agree with the comment. The RIS does not impose any requirement regarding the analysis rigor. The RIS provided an example where a simplifying assumption used in the analysis led to a nonconservative result. It is the responsibility of the licensee to assure that analysis methodologies have been appropriately verified or benchmarked.

14	IV	<p>STARS endorses the comments submitted by the Nuclear Energy Institute (NEI) suggesting that the proposed RIS be withdrawn. Should the proposed RIS be issued, STARS encourages the Staff to specifically identify the analysis issues leading to the issuance of the RIS and to include specific guidance and recommendations in the issued RIS.</p>	See response to Comment 10.
15	V-1	<p>The issue of concern is not clearly stated, and should not be linked to the Green's function methodology, which is not in question. In the Summary of Issue, the opening discussion emphasizes use of the Green's function approach to calculate stress and fatigue. It is not until about halfway through the summary that the statement is made that the "Green's function methodology is not in question," but in fact a simplification of the stress analysis application that is in question. The issue of concern over using a single stress value to represent the six-component stress tensor is independent of the use of Green's functions. The potential for non-conservatism in the simplified single-value stress application exists for any method used to determine the stresses resulting from thermal and mechanical loads and their combinations in a fatigue analysis. It would be more appropriate to state that the methodology used by some applicants does not adequately follow the ASME Code requirements for fatigue usage calculation.</p> <p>There are multiple vendors that use a Green's function method to calculate stress for ASME Code fatigue evaluations. Not all vendors that use Green's function use the simplified single-stress approach discussed in the proposed RIS. For licensees who have used an approach that applies Green's function methodology in stress analyses using six components of stress, consistent with the detailed treatment of NB-3200, there is no concern, and the emphasis on the Green's function approach can cause unnecessary concern and/or misinterpretation.</p> <p>The RIS should be revised to clarify that Green's function methodology is not the issue of concern. For example, the wording in the second sentence in the Summary</p>	See response to Comment 5.

		<p>of Issue should be revised to reflect the actual concern, such as:</p> <p>from:</p> <p>"This particular analysis methodology involves the use of the Green's function to calculate the fatigue usage during plant transient operations such as startups and shutdowns."</p> <p>to:</p> <p>"This particular analysis methodology involves using a simplified input of only one value of stress, as opposed to six components of stress, to calculate the fatigue usage due to plant transient operations such as startups and shutdowns."</p> <p>The subsequent language describing the Green's function approach, from "The Green's function approach involves ..." to "used to calculate the stresses caused by the actual plant temperature transients," is not necessary to describe the issue in question, and should be removed.</p> <p>The description of the "concern" should be changed, from "The concern involves a simplified input for applying the Green's function in which only one value of stress is used...", to "The concern involves a simplified input for calculating thermal stress in which only one value of stress is used..."</p>	
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16	V-2	<p>It is stated that the "staff has requested that recent license renewal applicants that have used this simplified Green's function methodology perform confirmatory analyses to demonstrate that the simplified Green's function analyses provide acceptable results." The words "simplified Green's function methodology" should be "simplified methodology." As noted, the process for calculation of fatigue usage should be consistent with ASME Code, Section III, Subsection NB, Subarticle NB 3200. As with any analysis, a departure from the required process requires "justification." This justification should be the focus of the RIS. Green's function should not be held "hostage" or inferred as being at fault.</p>	See response to Comment 5.
17	V-3	<p>In cases where the Green's function application was utilized and benchmarked against detailed analyses to demonstrate conservatism of the method, additional confirmatory analyses should not be necessary. In some applications that use Green's function that retain six components of stress, benchmark problems are provided demonstrating the acceptability of the Green's function models compared to other calculation methods, such as detailed finite element analysis. In these cases, the existing documentation should be sufficient to confirm the acceptability of the models.</p>	The staff agrees with the comment. The RIS clearly states, "The concern involves a simplified input in which only one value of stress is used for the evaluation of actual transients."