CALLAWAY PLANT UNIT 1
LICENSE RENEWAL APPLICATION

REQUEST FOR ADDITIONAL INFORMATION (RAI) SET #23 RESPONSES

RAI B2.1.3-1b

Background:

By letter dated November 20, 2012, the applicant responded to RAI B2.1.3-1a, and stated that the threads for stud No. 18 and its stud hole were inspected immediately prior to installation of the stud. The applicant also stated that when the stud became stuck, excessive force was not used in an attempt to free the stud, and therefore no threads were damaged by installation of the stud. The applicant further stated that although the threads of stud No. 18 have not been inspected for damage due to wear or corrosion, the other 53 reactor vessel studs and stud holes have been inspected. The applicant also stated that since 1992, no damage to the threads of the other studs and stud holes has been observed. The applicant further stated that since stud No. 18 is exposed to the same environment as the other studs, except during refueling, it is reasonable to conclude that damage to the threads due to corrosion or wear has not occurred. The applicant stated that the ultrasonic test (UT) examination is capable of identifying cracking and severe corrosion of the threads.

In addition, the applicant provided a sketch of the stuck stud and the stud hole to demonstrate its basis that with the stud 2 5/8 inches from the bottom of the stud hole, the stuck stud still has 6.505 inches of thread engagement. The applicant also provided the basis for stating that only 6.31 inches of thread engagement is required to meet the ASME code limits.

Issue:

The staff finds that the applicant's response still did not address the possibility of thread damage to the vessel flange or stud threads as a result of the stud getting stuck. In addition, in its response to RAI B2.1.3-1, the applicant had stated that stud No. 18 had two locations on threads 10 and 11 which were reworked just prior to the stud getting stuck (burrs which were removed).

The staff noted that the applicant is assuming that conditions for the stuck stud are the same as the others without providing any technical basis. The staff noted that at the location of the stuck stud, the stresses would be higher than at the other locations due to less thread engagement. Furthermore, the staff noted that the applicant is assuming that future tensioning and detensioning operations will not cause any wear, and that there will be no loss of material due to corrosion. The staff finds that this reasoning is nonconservative and contrary to the engineering evaluations performed in 1987 and 1989, which the applicant has relied on to justify the continued the use of stud No. 18 in its current stuck position. Specifically, the 1989 evaluation recommended that if damage approaches the limiting value (6.3 inches of engagement or 19.5 threads missing), or if the vessel is operated with a missing stud, vessel hydrotest should be avoided, and the plant heat up rate should be limited to half the design value in order to minimize the risk of localized plastic deformation.

The staff also noted that, as stated by the applicant in its response, the current UT examinations performed on the stuck stud and its flange hole would only be able to detect cracking or severe thread corrosion. Since the number of fully engaged threads for this location is near the acceptance level, a marginal reduction in the number of properly engaged threads may bring the effective number of engaged threads below the acceptance criteria. Furthermore, the staff does not agree with the applicant's assertion that the conditions at this location are typical of the remaining 53 locations. Specifically, since the stud at No. 18 is stuck 2 5/8 inches from the bottom of the flange hole and has fewer threads engaged, it has higher stresses than those that have no thread damage or more threads engaged. As stated earlier, this location would be more susceptible to localized plastic deformation.

Since the applicant's stated acceptance criteria for the minimum allowable thread engagement (6.31 inches) is very close to the acceptable calculated thread engagement for stud No. 18 (6.505 inches). The staff does not have reasonable assurance that the applicant's current UT examinations will detect thread degradation prior to exceeding the acceptance criteria.

Request:

Clarify how the applicant's aging management program will detect thread damage on the stud and vessel flange hole threads at locations with stuck studs, as the future condition of these threads cannot be deterministically verified given the applicant's current assumption and inspection methodology if a stud remains in place.

Callaway Response

Based upon staff concerns associated with minimum allowable thread engagement required to meet ASME Code limits and the thread engagement of Reactor Pressure Vessel (RPV) head stud #18 being close to the minimum allowable thread engagement, the following Callaway practices are used to manage RPV head stud thread damage and to detect thread damage through validation of intended functions at locations with stuck RPV head studs:

- Confirming intended function each refueling outage
- Validating that no unacceptable thread damage or loss of intended function due to aging is occurring
- Following the Reactor Closure Stud Bolting program and existing RPV head stud handling procedures

Confirmation of intended function each refueling outage:

Currently, only RPV head stud #18 is stuck, a condition that was identified during Refueling Outage 8 in the Fall of 1996. Detensioning RPV head stud #18 during each refueling outage confirms its intended function will be maintained. Normal RPV head stud tensioning and detensioning operations performed during each refueling outage are a form of “proof test” of the adequacy of the threaded connection to support in-service RPV head stud loads. The minimum tensioner load applied to RPV head stud #18 during detensioning operations is 1825 kips. The largest in-service load that is experienced by the RPV head studs during normal, upset, or emergency conditions occurs during the heatup transient. The minimum RPV head stud load experienced by RPV head stud #18 during detensioning is a 113% proof test of the maximum in-service primary plus secondary RPV head stud load during heatup. Therefore, if RPV head stud #18 withstands detensioning pressure without failure, then it is expected to withstand all in-service loads in the subsequent operating cycle.

The 1987 evaluation calculated that RPV head stud #18 has a 6.31 inch minimum required thread engagement length. This calculation was based on a conservative methodology; specifically, the minimum required thread engagement length was calculated by taking all primary and secondary loads associated with the heat-up transient and comparing the resulting vessel thread engagement thread shear stress to a 0.6 S_m value intended only for primary shear. However, a 2013 evaluation demonstrates that the minimum RPV head stud engagement required to resist all primary loads is 4.77 inches. The 2013 evaluation also develops appropriate acceptance criteria for primary plus secondary thread shear and shows that the required thread engagement to meet these acceptance criteria is bounded by the 4.77 inch value. Therefore, the minimum length of engagement which still meets ASME Code requirements is 4.77 inches.

As noted by the staff in the Issue statement, the 1989 evaluation provided recommendations to minimize risk of localized plastic deformation if Callaway was to operate with a missing RPV head stud or a damaged RPV head stud where the damage approached the limiting value (6.31 inches of engagement or 19.5 threads missing, per the 1989 evaluation). These recommendations were provided as mitigating actions for Callaway's consideration, and did not form the basis of any of the calculations in the 1987 or 1989 evaluations. Nonetheless, as supported by the 2013 evaluation, the stuck RPV head stud #18 nominally has in excess of 35% more thread engagement than is required to meet ASME code limits. This is a sufficiently large margin that the comments in the 1989 evaluation regarding localized plastic deformation do not apply to RPV head stud #18.

Validation that no unacceptable thread damage or loss of intended function due to aging is occurring

Unacceptable thread damage or loss of intended function due to aging is not expected. However, this is validated through visual and nondestructive evaluation techniques.

Estimated thread damage from attempts to remove RPV head stud #18:

Prior to installation in 1996, the threads on RPV head stud #18 and RPV stud hole #18 were visually examined. No damage was observed on RPV stud hole #18. A burr was observed on threads #10 and #11 and was removed prior to installation. Although the condition of the threads on the inside of RPV stud hole #18 cannot be observed through direct visual examination, a 2013 evaluation performed a bounding estimate and concluded that the effective damage could be no more than 20% of a single thread, resulting in less than 0.025 inches of lost effective thread engagement. This estimate was based on the maximum torque developed by the turnout tool at an air pressure of 100 psi applied over a 120 degree angle, consistent with the documented efforts to remove RPV head stud #18 at the time it became stuck.

Aging due to boric acid corrosion or wear:

RPV head stud #18 is protected from boric acid corrosion by encapsulation during refueling to prevent exposure to the boric acid in the refueling pool. Exposure to boric acid is the primary corrosion threat for aging of RPV head studs. Because it is not removed or installed, RPV head stud #18 experiences essentially no wear (loss of material). Most wear occurs when a RPV head stud is threaded in or out of the RPV head stud hole.

Reactor Closure Stud Bolting program and existing stud handling procedures

RPV head studs and RPV stud hole threads will be managed by the Reactor Closure Stud Bolting program and existing RPV head stud handling procedures.

Existing RPV head stud handling procedures:

Callaway's existing RPV head stud handling procedures and practices do not (and did not in 1996) damage threads. With the exception of minor maintenance on RPV head stud #18 (burr removal) and RPV head stud #20 (chasing lead threads), no threads have been damaged in over twenty years. The integrity of the other 53 RPV head studs confirms the integrity of the RPV head stud #18 which experiences the same service and maintenance practices as the other RPV head studs.

Consistent with the 1987 or 1989 evaluations, burr removal or chasing of lead threads are not considered thread damage. The 1987 and 1989 evaluations focused on thread damage as a gross geometric change to the cross-sectional area of the threads. The evaluation method included a factor for circumferential extent. In this context, removal of a small burr with an extremely limited circumferential extent would not compromise the bearing or shear area of the RPV head stud threads that engage the RPV threads.

Reactor Closure Stud Bolting program:

The Reactor Closure Stud Bolting program manages cracking and loss of material by conducting ASME Section XI inspections of the RPV flange stud hole threads, RPV head studs, and RPV stud nuts. Volumetric examinations are performed as required by the ASME Code, Section XI, Examination Category B-G-1. Volumetric exams for cracking are performed every ten years on RPV flange stud hole threads and RPV head studs (either in place or when removed). RPV head stud #18 was volumetrically examined in place during the April 2013 refueling and met Examination Category B-G-1 acceptance standards.

Callaway has not destructively removed a RPV head stud since Refueling Outage 3 (1989), when five stuck studs were removed due to their interference with the fuel transfer path and to restore functionality of RPV head stud #2. At that time, the risks associated with destructive removal were acceptable in order to repair the RPV. These risks include possible introduction of foreign material, worker safety, dose exposure, possibility of additional damage during the repair process, technical challenges associated with the RPV head stud removal tooling, and failure to restore the normal fuel transfer path. RPV head stud #18 has continually met ASME Section XI Examination Category B-G-1 acceptance standards, can be successfully tensioned and detensioned to confirm intended function, and its location does not interfere with the fuel transfer path. Given these considerations and that the risks noted previously still apply, Callaway staff considers it appropriate to monitor and manage the continued use of RPV head stud #18 rather than pursue its removal.

<u>Corresponding Amendment Changes</u>

No changes to the License Renewal Application (LRA) are needed as a result of this response.

RAI B2.1.3-2b

Background:

By letter dated November 20, 2012, the applicant responded to RAI B2.1.3-2a, stated that review of plant records confirmed that reactor vessel stud No. 15 was replaced in June of 1984, and stud No. 35 was replaced in the spring of 1989. The applicant also stated that these studs were replaced due to thread damage. The applicant further stated that no other repair or replacement activities were discovered in the review of plant records.

In addition, the applicant provided a brief summary of two engineering evaluations which were performed on its RV closure head studs in 1987 and 1989. The applicant stated that the two evaluations were related to the problems the applicant has experienced with the reactor vessel studs and flange threads. The applicant stated that both of the evaluations addressed minimum thread engagement, and based on those evaluations the value of 6.31 inches has been used by the applicant to determine acceptability of the reactor vessel stud thread engagement. The applicant further stated that the 1989 evaluation provided criteria for taking partial credit for damaged threads, however all damaged threads were removed from the stud holes in 1989 and 1992, and all studs with damaged threads were replaced.

The applicant stated that the first evaluation was performed in 1987, when in refueling outage (RFO) 2, five reactor vessel studs became stuck. The applicant also stated that the evaluation provided justification for operation in the subsequent cycle with one stud untensioned and the other four studs with partial engagement. The applicant further stated that the evaluation provided three recommendations in addition to the conclusion that the plant could operate with stud No.2 untensioned. The applicant stated that all three recommendations were satisfied.

In addition, the applicant stated that the purpose of the 1989 report was to develop criteria to accept or reject reactor vessel thread degradation on a generic basis. The applicant also stated that the report provided five recommendations. The applicant further stated that it has met all five recommendations.

Issue:

During its review, the staff noted that both evaluations (1987 and 1989) assumed that, with the exception of the five studs hole locations (Nos. 2, 4, 5, 7, and 9) all the other remaining studs and stud hole threads had no degradation. Furthermore, the 1989 report also anticipated that a laser inspection technique would be used to accurately evaluate thread damage at the facility, noting that the laser inspection technique would yield high quality profile of damaged threads; the report further stated that care should be exercised in the evaluation of areas with uniform wear, because they may appear intact but may in fact be out of tolerance. It is not clear to the staff whether the applicant has employed this specific technique in evaluating thread damage.

In contrast to the conditions assumed in the 1987 and 1989 evaluations, additional stud hole locations have known thread damage (i.e., 13, 25, 39, 53, and 54). Furthermore, stud No. 18 has been stuck since 1996, with partial thread engagement. The staff also noted that the affected locations are mostly on one side of the RPV flange periphery.

In addition, during review of the applicant's reply, the staff noted that recommendation 2 (from the 1989 report), stated in part that studs used in vessel flange holes with degraded threads should be free from damage. Since the applicant stated that two threads on the No. 18 stud were re-worked, it is not clear to the staff that recommendation 2 from the 1989 report will be met for this location. Furthermore, recommendation 4 (also from the 1989 report) states in part that if damage approaches the limiting values, or if the vessel is operated with a missing stud, vessel hyrdotests should be avoided, and the plant heat-up rate limited to 50 °F/hr in order to minimize the risk of localized plastic deformation. It is not clear to the staff that this aspect of recommendation 4 is met.

Request:

a) Clarify if the thread inspections for the vessel flange hole and stud threads include a laser inspection method referenced in the 1989 report, which can accurately gauge thread degradation so that there is assurance that any damage which is present does not exceed the acceptance criteria prior to the next inspection.

b) The evaluations performed in 1987 and 1989 assumed that with the exception of location Nos. 2, 4, 5, 7, and 9, there were no other damaged locations. Since additional damage has occurred, provide justification that the evaluations and the acceptance criteria provided by these reports will be valid during the period of extended operation and that the overall adequacy of the entire RPV flange assembly will be adequately managed during the period of extended operation.

Callaway Response

a) The 1989 evaluation referenced an inspection method of the RPV stud holes as follows:

> It is our understanding that the Babcock & Wilcox laser inspection method is to be used to inspect those holes which show significant damage. This method should yield high quality video tapes of the thread profiles in damaged areas. Care should be taken when evaluating these tapes to watch for areas where the threads are uniformly worn such that they appear to be intact but are actually out-of-tolerance. A template of the video image from areas of known intact threads should be used to check for this condition.

Babcock and Wilcox was contracted to remove damaged threads from the RPV stud holes in 1989 and 1992, which included performing an inspection of the RPV stud holes prior to thread removal to assess the condition of the threads and an inspection after the repair was complete to assess the results of the repair. For the inspection, Babcock and Wilcox used a tool designed especially for inspection of RPV stud holes called the Stud Hole Video Inspection Device, which produced high quality video of the threads in the RPV head stud holes by using a laser to illuminate and map the profile of the threads. This method was described in an approved Callaway procedure and is consistent with the description contained in the 1989 evaluation. Evaluation of the threads was performed as recommended in the 1989 report. Since 1992, due to improved RPV head stud handling procedures, only one minor indication has been found on the RPV stud hole #20 threads, which was repaired by chasing the thread with a RPV head stud hole tap. Thus, it has not been necessary to use the Babcock and Wilcox inspection device since 1992. The guiding Callaway procedure is now historical as it was specific to a vendor no longer in business, but it serves as a record for past thread removal and as guidance for future thread removal activities, should they ever be needed.

b) The staff has noted that the 1987 and 1989 evaluations assumed that only RPV head stud holes #2, #4, #5, #7, and #9 have damaged threads. Since several additional RPV stud holes have had threads removed, the staff has requested justification that the 1987 and 1989 evaluations remain valid and that the RPV flange assembly will be adequately managed during the period of extended operation.

The 1989 evaluation was intended to apply to the remainder of the RPV design life and does include discussion of the pattern of degraded RPV head studs in the vessel at that time. However, the thread damage existing at that time was used only to support the discussions estimating the effective thread engagement in hole locations 2, 4, 5, 7, and 9. Any other damaged locations that would arise subsequent to the 1989 report do not invalidate the evaluations included in the 1989 report, provided that minimum thread engagement criteria are met. Subsequent RPV stud hole thread damage that has occurred to RPV stud holes #53, #13, #25, #39, and #54 has been addressed consistent with the 1989 evaluation methodology by the Callaway corrective action process.

The thread degradation evaluation criteria developed in the 1989 report were analyzed such that each RPV/stud engagement region fully meets applicable ASME code rules, provided that the thread degradation evaluation criteria are met for each vessel hole. Using this evaluation method, the RPV flange as a whole would fully meet ASME code rules even if the effective thread engagement of all 54 RPV head stud locations were at the minimum. Therefore, there is no interaction mechanism between adjacent RPV stud hole locations, provided that each one meets the acceptance criteria given in the 1989 evaluation. All of Callaway's RPV head studs meet the criteria established in the 1989 evaluation.

Recommendation 2 from the 1989 evaluation states the following:

> Studs with more than a few degraded threads should be replaced. Studs used in vessel flange holes with degraded threads should be free of damage.

The context of the recommendation can be inferred from the basis of the 1989 evaluation. This evaluation analyzed seven different types of vessel thread damage, with a focus on gross geometric changes to the cross-sectional area of the vessel threads. It was assumed in these analyses that the vessel threads would engage with RPV head stud threads that were each locally fully intact. Furthermore, the evaluation method included a factor for circumferential extent. In this context, removal of a small burr with an extremely limited circumferential extent clearly does not compromise the bearing or shear area of the RPV head stud threads that engage the RPV head stud hole threads. The use of RPV head stud #18 after removing a small burr was not in conflict with the recommendation that "studs used in vessel flange holes with degraded threads should be free of damage."

As noted in the Issue section of the RAI, the 1989 evaluation also recommends that if damage to the RPV stud hole threads approaches the limiting values, then RPV hydrotests should be avoided and the plant heat-up rate should be limited to 50°F/hr in order to minimize the risk of plastic deformation to the threads. The staff has noted that the RPV head stud #18 stuck position of 6.505 inches approaches the limiting value of 6.31 inches used to determine the acceptability of RPV head stud #18.

None of the recommendations regarding hydrotesting or plant heat-up rate formed the basis of any of the calculations in the 1987 or 1989 evaluations. The ASME code evaluations performed in these reports assumed the full design 100 °F/hr heat-up rate, and the estimates of inner o-ring springback were similarly based on the full design 100 °F/hr heat-up rate. The 1987 and 1989 reports did not include any evaluation of closure-region stresses under hydrostatic test conditions. The recommendations were provided as additional mitigating factors that could be used to gain additional margin against o-ring leakage when operating with an inactive RPV head stud, and as a secondary effect, to minimize stresses on any RPV head stud with reduced thread engagement. It is noted that the 1989 evaluation considered all of these recommendations to be optional, using language such as “should” rather than “must” or “shall.”

The 1987 evaluation calculated a 6.31 inch minimum vessel/stud engagement length based on a conservative calculation methodology. Specifically, the minimum required thread engagement length was calculated by taking all primary and secondary loads associated with the heat-up transient and comparing the resulting vessel thread engagement thread shear stress to a 0.6 S_m value intended only for primary shear. However, a 2013 evaluation demonstrates that the minimum RPV head stud engagement required to resist all primary loads is 4.77 inches. The 2013 evaluation also develops appropriate acceptance criteria for primary plus secondary thread shear and shows that the required thread engagement to meet these acceptance criteria is bounded by the 4.77 inch value. The stuck RPV head stud #18 nominally has in excess of 35% more thread engagement than is required to meet ASME code limits. This is a sufficiently large margin that the comments in the 1989 evaluation regarding localized plastic deformation do not apply to stuck RPV head stud #18, and it is not necessary to avoid vessel hydrotests or limit the heat-up rate to 50 °F/hr. The 2013 evaluation also evaluated the impact of reducing the heat-up rate on the RPV head stud stress, and found that the reduced heat-up rate would reduce the service load on the RPV head stud by only 5%.

Corresponding Amendment Changes

No changes to the License Renewal Application (LRA) are needed as a result of this response.

Follow-up RAI 4.3-22

Background:

In its response dated October 11, 2012, to Part (c) of RAI 4.3-20, the applicant made the following assumptions:

- The applicant stated that "it is assumed that the same fatigue curves for each material were used for the analyses relied upon for the screening." It is not clear to the staff how the applicant justified or verified that the assumption is valid for its components.

- The applicant also stated that "the level of analytical rigor has not been specially reviewed." It is not clear how the applicant can draw conclusions from a comparison of its fatigue analyses for the Environmentally Assisted Fatigue (EAF) screening. The applicant has not substantiated its conclusion that the cumulative usage factor (CUF) values are expected to have been performed using the same level of rigor.

- The applicant also claimed that "[b]ased on analytical experience and engineering judgment, the relative design report CUF values of the components indicate that any transient lumping used in the various analyses have not skewed the screening and ranking results." However, the applicant did not further elaborate or discuss the specific "engineering judgment" it used and any associated actions to come to the conclusion that transient lumping did not skew the EAF screening and ranking results.

In its response dated October 11, 2012, to Part (a) of RAI 4.3-21, as revised by letter dated December 13, 2012, the applicant made the following assumption:

- The applicant assumed that the comparison of CUF including the effects of the environment (U_{en}) calculations across multiple thermal zones is valid. The applicant provided an example supporting one of its principles for removing "sentinel locations" that one thermal zone can bound another thermal zone is conservative. The staff noted that the original design reports may have been performed by different vendors, which may result in different fatigue analyses performed at different times. The applicant has not demonstrated that the level of rigor is comparable across these different design reports. Three examples of this are whether the transients are consistently bundled or not bundled in the calculation of different CUF values, whether consistent material properties are used, and whether the American Society of Mechanical Engineers (ASME) Code editions are consistent.

Issue:

In essence, the staff noted that the applicant has not demonstrated that the U_{en} values of the applicant's systems were calculated with the same level of rigor or conservatism. Without demonstrating that the U_{en} values share a common calculational basis, the resulting ranking and comparisons may not appropriately determine the "sentinel" locations to be monitored by the Fatigue Monitoring Program.

Request:

For each of the four assumptions identified above and any other assumptions made, provide plant-specific situations that are based on the applicant's data and analyses to further justify that these assumptions would allow meaningful and valid comparisons among calculated U_{en} values at the applicant's facility.

Callaway Response

The use of assumptions #1 through #3 is limited to the same generation of analyses. For example, the assumptions only apply to a replacement steam generator (RSG) component CUF when comparing it with another RSG component CUF. Another example is that these assumptions would apply when comparing the Pressurizer CUFs unless a component CUF was later revised, e.g. insurge/outsurge. Since the use of these assumptions is limited to the same generation of analysis, the U_{en} share a common calculational basis, and the resulting ranking and comparisons are appropriate to determine the "sentinel" locations. The justification for each of these assumptions is provided below.

1. Same fatigue curve for each material was used for the analyses: All fatigue calculations are performed to the ASME Code, although different editions were used. The response to RAI 4.3-25 addresses how the ASME fatigue curve edition affects the fatigue results. The use of a different fatigue curve, e.g. the EAF fatigue curves from NUREG/CR-6909 for Ni-Cr-Fe steels, would be a deviation from ASME Code which would be recorded in the design reports. A comparison of CUFs generated from non-ASME and ASME fatigue curves would not be a straight comparison and would require additional consideration/evaluation in order to place them on an equivalent basis. No non-ASME fatigue curves were used in the design of Callaway. In the absence of the identification of another fatigue curve, the same ASME fatigue curve was used for all components with the same generation of analyses.
2. The analyses have been performed using the same level of rigor: The most important aspect of the “level of rigor” is whether an elastic or elastic-plastic fatigue analysis was performed. Any deviation from the typical elastic analysis is identified in the design report. When more rigorous elastic-plastic fatigue analyses are performed, this is considered in the review. For example, the pressurizer heater well was qualified using an elastic-plastic fatigue analysis. This was considered in the review; however, the screening is performed using the results of the elastic fatigue analysis in order to keep the same “level of rigor” in the comparison. Other aspects, as identified in the EPRI screening report, that factor into the “level of rigor” are the transients used in the analysis and whether they are design, actual, and/or lumped transients. The screening is based on the design basis analyses which only use the design transients. The lumping of transients is addressed below in response to assumption #3 of this RAI.
3. Any transient lumping used in the various analyses have not skewed the screening and ranking results: Transient lumping might promote some fatigue usage values to higher rankings than they might otherwise possess and result in these components being skewed upward. However, this skewing will not affect the identification of the leading component, either because (1) all of the components used the same lumping set (particularly when comparing components from the same design report) or (2) the leading component does not use lumping, thus any lumping in the bounded location will

not affect the top of the ranking. Additionally, if the determination of the sentinel location was based on a "common basis stress evaluation," discussed in RAI 4.3-23, then the conclusion is not affected by any lumping. To verify that the lumping will not affect the top of the rankings in each thermal zone, all bounded locations (locations with a U_{en} > 0.8 and within 50% of the top U_{en}) are reviewed below.

- The Pressurizer Heater Well (SS) (CUF = 0.562, F_{en} = 13.117, U_{en} = 7.372) bounds the Lower Pressurizer Instrument Nozzle (SS) (CUF = 0.439, F_{en} = 13.117, U_{en} = 5.758). While the U_{en} are within 50% of each other, the locations are exposed to the same transients in terms of number and severity over the life of the plant, so the relative ranking of U_{en} values will not change as fatigue accumulates in each component. This ranking is not affected by lumping because all of the components used the same lumping set.
- The Pressurizer Safety Valve Piping (SS) (CUF = 0.975, F_{en} = 11.486, U_{en} = 11.199) bounds the Pressurizer Relief Valve Piping (SS) (CUF = 0.970, F_{en}= 11.486, U_{en} = 11.142). While the U_{en} are within 50% of each other, the locations are exposed to the same transients in terms of number and severity over the life of the plant, so the relative ranking of U_{en} values will not change as fatigue accumulates in each component. This ranking is not affected by lumping because all of the components used the same lumping set.
- The Pressurizer Shell at Support Lug (LAS) (CUF= 0.992, F_{en} = 2.455, U_{en}= 2.435) bounds the Pressurizer Upper Head/Upper Shell (LAS) (CUF= 0.928, F_{en} = 2.455, U_{en} = 2.278). While the U_{en} are within 50% of each other, the locations are exposed to the same transients in terms of number and severity over the life of the plant, so the relative ranking of U_{en} values will not change as fatigue accumulates in each component. The fatigue analyses do not use lumping.
- The Pressurizer Spray Nozzle (SS) (CUF = 0.411, F_{en} = 9.013, U_{en} = 3.704) bounds the Spray Piping at Pressurizer Spray Nozzle (SS) (CUF = 0.84, F_{en} = 9.568, U_{en} = 8.037) and the Spray Line Nozzle at the Cold Leg (SS) (CUF = 0.84, F_{en} = 9.568, U_{en} = 8.037). The sentinel location was determined with a common basis stress evaluation which is not affected by lumping. The common basis stress evaluation is justified in the response to RAI 4.3-23 request (e).
- The Charging Nozzle (SS) (CUF = 0.95, F_{en} = 10.350, U_{en} = 9.833) bounds the Charging Piping (SS) (CUF = 0.93, F_{en} = 9.568, U_{en} = 8.898), Letdown and Drain Line Piping (SS) (CUF = 0.95, F_{en} = 10.350, U_{en} = 9.833); Excess Letdown Nozzle (SS) (CUF = 0.804, F_{en} = 10.350, U_{en} = 8.322); and Seal Water Piping (SS) (CUF = 0.114, F_{en} = 13.117, U_{en} = 1.495). The sentinel location was determined with a common basis stress evaluation which is not affected by lumping.
- The RCS Hot Legs (SS) (CUF = 0.95, F_{en} = 13.117, U_{en} = 12.461) are bounded by attached nozzles. The sentinel location was determined with a common basis stress evaluation which is not affected by lumping. The common basis stress evaluation is justified in the response to RAI 4.3-23 request (e).
- RSG Tubesheet Continuous Region (LAS) (CUF = 0.428, F_{en} = 2.455, U_{en} = 1.051) bounds the RSG Primary Manway Drain Tube (LAS) (CUF = 0.391, F_{en} = 2.455, U_{en} = 0.960). While the U_{en} are within 50% of each other, the locations are exposed to the same transients in terms of number and severity over the life of the plant, so the

relative ranking of U_{en} values will not change as fatigue accumulates in each component. The fatigue analyses do not use lumping.

4. The comparison of CUFs across multiple thermal zones is valid: The examples provided in the RAI 4.3-21(a) response are the only instances where one thermal zone bounds another. They are justified below with respect to the level of rigor in the analyses.

   Example #1, The "Pressurizer Safety and Relief Valve piping" thermal zone bounds the "Pressurizer Upper Head" thermal zone:

   This results in the Pressurizer Safety Valve piping (SS) (CUF = 0.975, F_{en} = 11.486, U_{en} = 11.199) being used as the sentinel location to manage the Pressurizer Shell at Support Lug (LAS) (CUF = 0.992, F_{en} = 2.455, U_{en} = 2.435) and the Pressurizer Upper Instrument Nozzle (SS) (CUF = 0.236, F_{en} = 13.117, U_{en} = 3.096). The results are all from the same generation of analysis, the RSG design project. However the Pressurizer Safety Valve piping was calculated using NB-3600 methods while the pressurizer upper head components were calculated using NB-3200 methods. The NB-3600 method is more conservative than the NB-3200 method, but the level of conservatism cannot be quantified without additional analysis. So the NB-3600 results cannot be said to bound the NB-3200 results simply because the CUF is higher. Therefore locations for the "Pressurizer Upper Head" thermal zone have been added to the list of sentinel locations in LRA Tables 4.3-6 and 4.3-7. Further refinement of these locations may provide clear indication of a leading location. This further refinement will be accomplished consistent with the commitment in LRA Table A4-1 item #31.

   Example #2, The "Tubesheet" thermal zone bounds the "RSG Primary Head" thermal zone:

   The Replacement Steam Generator (RSG) Primary Manway Drain Tube (LAS) (CUF=0.391, F_{en}=2.455, U_{en}=0.960) in the RSG Primary Head thermal zone is bounded by the RSG Tubesheet (Continuous region) (LAS) (CUF=0.428, F_{en}=2.455, U_{en}=1.051) in the Tubesheet thermal zone. The Tubesheet and RSG primary head thermal zones were analyzed within the same generation of analysis, the RSG design project. The analyses were performed by the same vendor; the transients were not lumped; consistent material properties were used; and the same Code edition was used.

The above 4 assumptions represent all assumptions made when performing the CUF and U_{en} comparison to determine the sentinel locations.

LRA Section 4.3.4, Table 4.3-6, and Table 4.3-7 have been revised as shown in Amendment 23 in Enclosure 2, to add two additional sentinel locations for the Pressurizer Upper Head and delete examples associated with one material in a thermal zone bounding other materials in the same thermal zones or another thermal zone.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 23, LRA Changes from RAI Responses and Commitment Updates," for a description of LRA changes with this response.

Follow-up RAI 4.3-23

Background:

In its letter dated December 13, 2012, the applicant revised LRA Section 4.3.4 stating that a location that can be shown to be bounded by another location on a "common basis stress evaluation" may be removed from the "sentinel location" list. The applicant provided a qualitative explanation that this judgment relies upon the comparison of transients in terms of severity and/or number of occurrences.

Issue:

In order for the staff to determine whether the "common basis stress evaluation" is appropriate or valid for the applicant's facility, additional information is needed related to the scope, parameters considered, and assumptions involved.

Request:

(a) Clarify whether the "common basis stress evaluation" performed the comparison of only the transient severity and the number of transient occurrences.

1. If yes, justify why comparing only severity and the number of occurrences would result in a valid evaluation to eliminate a sentinel location.

2. If not, identify all other parameters that were used in the comparison and justify that those parameters are sufficient to evaluate the elimination of a sentinel location.

(b) Justify why the geometry of the locations (whether it is a straight pipe, a nozzle, a tee, or a 90-degree bend) being compared does not need to be considered for the charging nozzle/chemical and volume control (CVCS) system.

(c) Clarify whether the locations being compared must be the same type of materials. If not, justify that the "common basis stress evaluation" is valid when comparing different types of materials.

(d) Clarify whether the stress, CUF, or U_{en} values of the locations has been used in the "common basis stress evaluation." Clarify whether the stress, CUF, or U_{en} values have been reviewed to confirm that the results of the common basis stress evaluation are valid for the applicant's site.

(e) Clarify whether the charging nozzle/CVCS system is the only example where a "common basis stress evaluation" was performed. If not, identify all systems in the applicant's site that a "common basis stress evaluation" was performed to remove location(s) from the "sentinel location" list and justify that the common basis stress evaluation is valid.

Callaway Response

(a).1 Yes, the “common basis stress evaluation” is based on transient severity, including analytical features (ASME Section III NB-3600 versus NB-3200), and number of transient occurrences. This is justified because other conditions, such as the dissolved oxygen level and strain-rate, are based on consistent assumptions. These inputs are used to calculate the F_{en} component of U_{en}. The "common basis stress evaluation" is used for common materials and the differences in F_{en} are a much smaller factor in determining the U_{en} ranking.

(a).2 Not applicable.

(b) The geometries of the locations are considered in the fatigue analyses for the charging nozzle/chemical and volume control system (CVCS).

(c) Yes, the locations being compared with a "common basis stress evaluation" must be the same type of materials.

(d) The "common basis stress evaluation" is based on a qualitative assessment of the stresses applied to the components. The CUFs are used to validate the comparison for Callaway based on similar CUF results with other similar vintage Westinghouse plants. The evaluations are appropriate to Callaway because all of the CUF values were taken from the Callaway design reports, which incorporate plant specific geometric characteristics and transients. The U_{en} does not factor into the "common basis stress evaluation."

(e) The "common basis stress evaluation" is used to incorporate individual and industry operating experience into the screening process. The design CUFs were generated with the sole goal of obtaining a CUF < 1.0, not to identify the most fatigue sensitive locations. In order to diligently identify the sentinel locations, areas of high fatigue based on operating experience must be considered. Two additional locations outside the CVCS system used a "common basis stress evaluation" and are validated below.

1. The RCS hot leg piping (SS) (CUF = 0.95, F_{en} = 13.117, U_{en} = 12.461) is bounded by attached nozzles based on a "common basis stress evaluation." The attached nozzles are subjected to transients from two thermal zones (the hot leg thermal zone and one other thermal zone). The surge line thermal zone affects the hot leg surge nozzle (SS) (CUF = 0.3, F_{en} = 11.486, U_{en} = 3.446); the hot leg safety injection thermal zone affects the hot leg safety injection nozzles (SS) (CUF = 0.1, F_{en} = 10.350, U_{en} = 1.035); and the RHR hot leg thermal zone affects the RHR hot leg nozzles (SS) (CUF = 0.81, F_{en} = 10.350, U_{en} = 8.384). Each of these components is included as a sentinel location. All other hot leg locations are subjected only to the hot leg thermal zone transients, which are more benign than the other three thermal zone transients mentioned above.
2. The Pressurizer Spray Nozzle (SS) (CUF = 0.411, F_{en} = 9.013, U_{en} = 3.704) bounds the Pressurizer Spray Piping (SS) (CUF = 0.84, F_{en} = 9.568, U_{en} = 8.037) and Spray Line Nozzle at the Cold Legs (SS) (CUF = 0.84, F_{en} = 9.568, U_{en} = 8.037) based on a "common basis stress evaluation." The validation of each of these instances is provided below:
   - The limiting location in the Pressurizer Spray Line Piping thermal zone is at the Pressurizer Spray Nozzle. This location is now under a structural weld overlay (SWOL). This SWOL covers both the nozzle-to-safe-end dissimilar-metal-butt-weld and the safe-end-to-piping stainless steel butt-weld. The highest fatigue locations are under the SWOL and are qualified for fatigue by a crack growth analysis. The next highest fatigue location is located in the spray piping near the toe of the overlay. The SWOL analysis states that the current fatigue analysis of the spray nozzle without the SWOL is conservative relative to the toe of the SWOL on the piping. Thus, the CUF value of 0.411 reported for the spray nozzle represents a conservative estimate of the refinement of the CUF of 0.84 for the piping attached to the spray nozzle. The Pressurizer Spray Line Piping's next limiting location with

CUF = 0.72, is in the auxiliary spray line and is already identified as a sentinel location.

- The Spray Line Nozzle at the Cold Legs fatigue analysis was performed using NB-3600 methods, which results in a higher CUF value than the value from a NB-3200 analysis. The Pressurizer Spray Nozzle fatigue analysis was performed using NB-3200 methods and thus the CUF is artificially lower than the CUF for the Spray Line Nozzle at the Cold Legs. As with the Charging Nozzle, the Pressurizer Spray Nozzle will experience transients from two thermal zones (Pressurizer Upper Head and Spray Line Piping) and will be subjected to significant thermal transients during pressurizer spray initiation and termination and during auxiliary spray initiation and termination. The spray events are much less severe at the Spray Line Nozzle at the Cold Legs as the temperature at the nozzle remains constant during a spray event. Therefore, the Pressurizer Spray Nozzle will experience many more transients than the Spray Line Nozzle at the Cold Legs, which will primarily experience RCS transients, e.g. heatup and cooldown.

A third location, the RCS 2-inch Crossover Leg Loops 1 & 2 Drain Nozzles, previously was bounded by the Charging Nozzle based on a “common basis stress evaluation.” This disposition was deleted because there is not a sufficient overlap of the transients. The Drain Nozzles are exposed to transients not seen in the Charging Nozzle and vice versa. Therefore the RCS 2-inch Crossover Leg Loops 1 & 2 Drain Nozzles were added as a sentinel location.

LRA Table 4.3-6 and Table 4.3-7 have been revised as shown in Amendment 23 in Enclosure 2, to add the RCS 2-inch Crossover Leg Loops 1 & 2 Drain Nozzles as a sentinel location.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 23, LRA Changes from RAI Responses and Commitment Updates,” for a description of LRA changes with this response.

Follow-up RAI 4.3-24

Background:

In its response dated October 11, 2012 to Part (d) of RAI 4.3-21, as revised by letter dated December 13, 2012, the applicant provided an example supporting one of its principles that one material can bound other materials in the same thermal zone. The applicant also stated in its revised LRA dated December 13, 2012, that a location that can be shown to be bounded by another location on a common basis stress evaluation may be removed from the "sentinel location" list. The applicant indicated that those plant-specific locations, in LRA Table 4.3-6, with U_{en} greater than 1.0 will be evaluated further using the same methods as those to remove conservatisms for NUREG/CR-6260 locations described in LRA Section 4.3.4.

Issue:

The staff noted that the U_{en} value of different materials may respond differently when the EAF is being refined in the future. Using the information in Part (d) of RAI 4.3-21 as an example, the action to refine the U_{en} of the stainless steel Pressurizer Instrument Nozzle will not always proportionally refine the U_{en} of the low alloy steel for the Pressurizer Upper Head/Upper Shell. The applicant has not justified that the low alloy steel components would remain bounded by the stainless steel components after the EAF has been refined to reduce the U_{en} of the stainless steel components. The applicant has not explained how nor justified that the refinement of a higher U_{en} , in LRA Table 4.3-6, of one material would ensure the reduction of U_{en} for a bounded location of another material.

Request:

(a) Justify that the refinement of a higher U_{en} in LRA Table 4.3-6, of one material would ensure the reduction of the U_{en} for a bounded location of another material, such that the conclusion that one material bounds other materials in the same thermal zone will remain valid.

(b) Justify that the refinement of a higher U_{en} in LRA Table 4.3-6, of one location would ensure the reduction of the U_{en} for a bounded location, such that the conclusion from the common basis stress evaluation will remain valid.

Callaway Response

(a) The example provided in the RAI 4.3-21(d) response, as revised by letter ULNRC-05938 dated December 13, 2012, provides the only example where a location of one material is stated to bound the location of another material. It indicates that the Pressurizer Instrument Nozzle SS material (CUF=0.236, F_{en}=13.117, U_{en}=3.096) bounds the Pressurizer Shell at Support Lug LAS material (CUF=0.992, F_{en}=2.455, U_{en}=2.435) in the Pressurizer Upper Head thermal zone. In order to ensure that the refinement of a higher U_{en} of one material will bound the U_{en} of another material, both the locations have been added to the list of sentinel locations in LRA Tables 4.3-6 and 4.3-7.

(b) The screening process is meant to provide a reliable indication of the environmental fatigue the plant has experienced. It does this by using the concept of a “Peloton” to determine the sentinel locations which currently lead the rest of the locations in environmentally assisted fatigue. The Peloton refers to a densely packed group of bicycle racers. A leader is established, but over time a new leader may emerge as the transient mix accumulates. Monitoring these leaders provides a reliable indication of the environmental fatigue the plant has and will experience. As the plant ages, the Fatigue Monitoring Program, through the monitoring of the plant's conditions and operating experience, will identify instances where another location may take the lead in environmental fatigue.

The qualitative "common basis stress evaluation" can be used to determine relative ranking by considering the following:

- Transient severity
- Transient occurrences
- Analytical features, such as elastic vs. plastic analyses
- Geometric features

Refinement of these sentinel locations will reduce the CUF values, but similar analytical refinement of the bounded locations will produce similar reductions in their CUF values. This conclusion is valid for those locations identified in the response to RAI 4.3-23, request (e) because in the refined analyses, as in the original analyses, the bounding locations will be analyzed with transients from multiple thermal zones. The bounded locations will be analyzed with just a single thermal zone's transients, thus retaining the relative ranking of the bounding and bounded locations. Under the Fatigue Monitoring program, the sentinel locations, when refined, will be revisited to confirm bounding Reactor Coolant Pressure Boundary Environmentally Assisted Fatigue susceptible locations are updated appropriately and remain bounded consistent with the refined analysis, as described in the commitment in LRA Table A4-1 item #31.

LRA Section 4.3.4; Table 4.3-6; and Table 4.3-7 are revised as shown in Amendment 23 in Enclosure 2, to add additional sentinel locations for the Pressurizer Upper Head thermal zone. LRA Section B3.1 and Table A4-1, Item 31 are revised as shown in Amendment 23 in Enclosure 2, to confirm bounding Reactor Coolant Pressure Boundary Environmentally Assisted Fatigue susceptible sentinel locations are updated appropriately and remain bounded consistent with the refined analysis.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 23, LRA Changes from RAI Responses and Commitment Updates," for a description of LRA changes with this response.

Follow-up RAI 4.3-25

Background:

The elastic modulus, E, to be used for the austenitic stainless steel fatigue curve in Figure I-9.2 in the ASME Code Section III Appendix I, has changed from 26 x10^6 psi in the 1980 edition to 28.3x10^6 psi in the 1983 edition.

Issue:

It is not clear to the staff whether the change in the stainless steel material property in the aforementioned ASME Code editions has been considered in the U_{en} comparison.

Request:

Identify all the stainless steel components that were designed to the ASME Code editions that were after the 1980 edition. For each of these components, clarify whether the corresponding thermal zone bounded another stainless steel component that was designed to the 1980 ASME Code edition or earlier. Justify that the comparison of U_{en} values that were calculated with different code editions is appropriate when the values of the elastic modulus are different.

Callaway Response

All ASME Class 1 stainless steel components were analyzed to ASME Code editions which pre-date 1980 except for the pressurizer lower head. The pressurizer lower head was evaluated to the 2004 Edition to incorporate the revised insurge/outsurge transients.

The pressurizer lower head was evaluated as a unique thermal zone with one sentinel location identified. This sentinel location is not used to bound any locations outside the pressurizer lower head thermal zone. Therefore this sentinel location was determined by comparing only CUFs generated with the same ASME Code edition and thus the same elastic modulus.

In addition, the ASME Code requires that the fatigue analysis account for the difference in the elastic modulus between the actual material and that used in the ASME fatigue curve. When the ASME fatigue curves are adjusted to account for the differences in the elastic modulus between the pre-1980 and post-1980 ASME Code editions, the fatigue curves are identical. Therefore the fatigue results (CUF and U_{en}) based on the two Code editions are directly comparable.

For completeness, it is noted that LRA Section 4.3.2 references post-1980 Code editions for the replacement steam generator (RSG) design (LRA Section 4.3.2, 1989 edition) and the NRC Bulletin 88-11 evaluation (LRA Section 4.3.2.4, 1986 edition). The replacement steam generator wetted reactor coolant pressure boundary components contain only low alloy steel clad in stainless steel or low alloy steel manways with stainless steel cover inserts. Therefore, no stainless steel components are included in the sentinel screening for the RSG. The transients developed by the NRC Bulletin 88-11 evaluation were incorporated into the surge line design report which utilizes ASME Section III, 1974 Edition with addenda through Winter 1975. Therefore, these components are not addressed in the RAI response.

Corresponding Amendment Changes

No changes to the License Renewal Application (LRA) are needed as a result of this response.

Follow-up RAI 4.3-26

Background:

In its response dated October 11, 2012, to Parts (d) of RAI 4.3-21, as revised by letter dated December 13, 2012, the applicant stated that the EAF screening was revised to not use the equation in NUREG/CR-6909 for the F_{en} of Ni-Cr-Fe; instead, the revised calculation used NUREG/CR-5704 to compute F_{en} values for Ni-Cr-Fe material. The applicant also revised LRA Table 4.3-7 indicating two Ni-Cr-Fe components (RPV Bottom Head Instrument tubes and RSG Tube-to-tubesheet connection) as the "sentinel locations."

Issue:

The staff noted that in LRA Table 3.1.2.3, there are nickel alloy pressurizer safe ends that are exposed to the reactor coolant environment with the aging effects of cumulative fatigue damage. The staff noted that given the F_{en} value calculated using NUREG/CR-5704 is typically greater than 10, there is a high probability that nickel alloy components would be identified as "sentinel locations." The staff did not find any reference related to these nickel alloy components as "sentinel locations" from the list in LRA Table 4.3-7. It is not clear to the staff how this component has been bounded by the three stainless steel pressurizer locations identified in LRA Table 4.3-7.

Request:

Identify the nickel alloy component(s) in the pressurizer safe ends and the associated CUF and F_{en} values. Demonstrate how the nickel alloy locations have been bounded by the three stainless steel pressurizer locations identified in LRA Table 4.3-7.

Callaway Response

The nickel alloy locations in the pressurizer are in the weld materials associated with the pressurizer safety and relief nozzles, the pressurizer spray nozzle, and the pressurizer surge nozzle. The CUF values for these components in LRA Table 4.3-3 are the highest CUFs in the nozzles including the nickel alloy nozzle-to-safe-end dissimilar-metal-butt-weld. All of these locations in the nozzles have had a preemptive structural weld overlay (SWOL) applied over the nickel alloy material. The weld overlays are supported by fracture mechanics analyses and periodic inspections consistent with ASME Section XI as the means to address aging in the overlaid welds (See LRA Section 4.7.2). ASME Section XI requires a fatigue crack growth analysis and a linear elastic fracture mechanics (LEFM) analysis to calculate the propagation rate of a flaw in order to determine the inspection interval. Since the SWOL region is not governed by an ASME Section III fatigue analysis, it does not need to consider EAF.

Corresponding Amendment Changes

No changes to the License Renewal Application (LRA) are needed as a result of this response.

Follow-up RAI 4.3-27

Background:

The applicant stated in its Fatigue Monitoring Program that, for the Cycle-Based Fatigue (CBF) monitoring method, the fatigue accumulation is tracked to determine the approach to the ASME Code allowable fatigue limit of 1.0. Enhancement 6 of the program stated that procedures will be enhanced to include additional "cycle-count action limits" and "fatigue usage action limits," which will allow adequate time for completion of corrective actions if the "design limits" are projected to be exceeded within the next three fuel cycles.

Issue:

In its letter dated December 13, 2012, the applicant revised LRA Section 4.3.4, indicating that the 60-year projected U_{en} is 0.74 for the safety injection nozzle. The staff noted that the 60-year projected cycle counts are the same as the numbers of cycles to-date for three transients assumed in the safety injection nozzle EAF analysis.

The staff noted that the premise of CBF is that the incremental fatigue usage of each transient can be accumulated to provide a fatigue usage as the components are being monitored during the period of extended operation. Furthermore, the fatigue accumulation is calculated in accordance with the ASME Code because the incremental fatigue usage for each transient was supported by a fatigue analysis with an assumed number of occurrences for each transient.

However, the staff noted the incremental fatigue usage may change after the number of occurrences of a transient had exceeded that assumed in the fatigue analysis. This happens because of the transient-pairing provision delineated in ASME Code Section III Paragraph NB-3222.4(e)(5).

Request:

(a) Clarify how the incremental fatigue usage and fatigue accumulation will be tracked when the cycle count is beyond those assumed in the fatigue analysis. Justify that, prior to reaching the "fatigue-usage action limit," incremental fatigue usage for additional occurrences beyond those assumed in the fatigue analysis will be calculated in accordance with the ASME Code.

(b) Justify that, for the safety injection nozzle, the implementation of a "fatigue-usage action limit" would ensure that corrective action will be initiated before exceeding the design limit.

(c) For all the locations monitored by CBF, clarify whether the safety injection nozzle is the only location that was analyzed for the number of transient cycles to-date. If not, identify all the locations that were analyzed for their respective number of cycles to-date and justify that the implementation of "fatigue-usage action limits" would ensure that corrective action will be initiated before a location exceeds its design limit.

Callaway Response

(a) The cycle count will only be allowed to increase beyond the number assumed in the fatigue analysis if the CUF and/or the U_{en} for the applicable location can be assured to be less than the "fatigue-usage action limit" using detailed monitoring, i.e. cycle-based fatigue (CBF) or stress-based fatigue (SBF). The CBF and SBF methods calculate CUF values which are conservative with respect to the ASME Code. These incremental fatigue usage values are tracked against the "fatigue-usage action limit" to ensure corrective action is taken prior to fatigue accumulation exceeding the ASME Code allowable fatigue limit of 1.0. CBF and SBF methods are not dependent on the numbers of transients assumed in the fatigue analysis. The response to Request b of this RAI describes why CBF is not affected by the numbers of transients analyzed. CBF and SBF methods will be implemented through the fatigue monitoring program, described in LRA Appendix B3.1.

(b) CBF monitoring is being credited for monitoring the safety injection nozzle. CBF is not limited by the number of cycles assumed in the ASME Code fatigue analysis. This monitoring method utilizes the stress intensity for each transient, which are generated with the ASME Section III methods. These stress intensities are paired in accordance with ASME Code Section III Paragraph NB-3222.4(e)(5), but the pairing is performed according to the actual numbers of transients that have occurred and/or projected to occur instead of assuming the design numbers of transients. This remains true when the actual number of transients exceeds the number assumed in the fatigue analysis. The incremental fatigue usage is tracked against the "fatigue-usage action limit" to ensure corrective action is taken prior to fatigue accumulation exceeding the ASME Code allowable fatigue limit of 1.0.

(c) The safety injection nozzle is the only CBF monitored location which used the numbers of transient cycles to-date.

Corresponding Amendment Changes

No changes to the License Renewal Application (LRA) are needed as a result of this response.