CALLAWAY PLANT UNIT 1
LICENSE RENEWAL APPLICATION

REQUEST FOR ADDITIONAL INFORMATION (RAI) Set #9 RESPONSES

RAI 4.3.1

Background:

License renewal application (LRA) Table 4.3-2 describes Transient 1b as "Plant Cooldown at 100 °F/hr, Pressurizer Cooldown at 200 °F/hr" and indicates that there are 29 occurrences of Transient 1b between 1983 and 2011.

Final Safety Analysis Report (FSAR) Table 3.9(N)-1A SP indicates that the "plant cooldown cycle at less than 100 °F/hr" is defined as "cooldown cycle T_{ave} from ≥ 550 °F to ≤ 200 °F." FSAR Table 3.9(N)-1A SP also indicates that the "pressurizer cooldown cycle at less than 200 °F/hr" is defined as "pressurizer cooldown cycle temperature 'from ≥ 650 °F to ≤ 200 °F."

Issue:

It is not clear to the staff why the plant cool down and pressurizer cooldown cycles are grouped together as a single transient (Transient 1b) in LRA Table 4.3-2 and whether Transient 1b should be considered separately based on the definition in the FSAR SP. In addition, it is not clear whether Transient 1b is considered to have occurred when either a (1) plant cooldown ***or*** pressurizer cooldown occurs or (2) when both plant cooldown ***and*** pressurizer cooldown occur.

Request:

a) Provide the basis for combining these two transients when they are being monitored by the Fatigue Monitoring Program.

b) Explain whether Transient 1b is considered to have occurred when either a (1) plant cool down ***or*** pressurizer cool down occurs or (2) when both plant cooldown ***and*** pressurizer cooldown occur.

c) With respect to the baseline value of 29 occurrences in LRA Table 4.3-2, clarify whether the two transients have been monitored separately or together since the beginning of power operations (considering that manual records and fatigue monitoring software have been used).

Callaway Response

a) The plant cooldown and pressurizer cooldown transients were combined to be consistent with FSAR Table 3.9(N)-1 SP.

b) The plant cooldown transients are counted separately from the pressurizer cooldown transients. When the plant is shutdown the plant and pressurizer cooldown transients are each incremented by 1 and Transient 1b is also incremented by 1.

c) The plant and pressurizer cooldown transients each were baselined separately. The baseline work encompasses monitoring of each transient since the beginning of power operations.

Corresponding Amendment Changes

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

RAI 4.3-2

Background:

LRA Section 4.3.1.2 states the baseline cycle counting results were projected to a 60-year operating life based on the actual accumulation history since the start of plant life. A rate of future cycle accumulation is computed for each transient and the cycle projections are based on a long term rate and a short term rate of cycle accumulation. In addition, these accumulation rates are then combined based on a weighting factor of one for the long term and three for the short term.

Issue:

Since the applicant used the 60-year transient projections to support the disposition of the time-limited aging analyses (TLAAs) evaluated in LRA Sections 4.7.2 and 4.7.7, the staff requires additional information to determine whether the long-term and short-term weighting factors and the associated transient occurrences for these weighting factors used in the projection methodology is appropriate and conservative.

Request:

a) Identify the transients in LRA Table 4.3-2 in which the long-term and short-term weighting factors, described in LRA Section 4.3.1.2, are applicable and provide the short-term and long-term occurrence for each transient.

b) If any design transient in LRA Table 4.3-2 used a different 60-year projection methodology, other than the one discussed in LRA Section 4.3.1.2, describe and justify that this "alternative" 60-year projection methodology is conservative.

Callaway Response

a) All transients in LRA Table 4.3-2, except those described below in part b of this RAI response, use a weighting factor of 1 for the long term and 3 for the short term. The short-term period is the preceding 9 years (2002 through 2011) for all transients.

b) The below transients used a different 60 year projection methodology than that discussed in LRA Section 4.3.1.2. The transients are grouped according to the method used.

   The following transients have a 60 year projection that is set equal to the baseline because the tests were performed during initial startup and no more tests are expected.

   - Normal Transient #13, Turbine roll test
   - Test Transient #1, Primary side hydrostatic test
   - Test Transient #2, Secondary side hydrostatic test

   The following transients have a 60 year projection that is set equal to the baseline because this is the value analyzed in the EAF calculations. The justification for the use of the baseline value is provided in LRA Section 4.3.4.

   - Upset Transient #2, Loss of Power (with natural circulation in the RCS)
   - Upset Transient #8, Inadvertent safety injection actuation

   For the following transients there have been no historical events recorded on which to base an accumulation rate. Therefore, the projected number of events was conservatively set equal to 1 event.

- Upset Transient #1, Loss of load (without immediate reactor trip)
- Upset Transient #3, Partial loss of flow (loss of one pump)
- Upset Transient #4b, Reactor trip from full power, with cooldown, without safety injection
- Upset Transient #4c, Reactor trip from full power, with cooldown, with safety injection
- Upset Transient #5a, Inadvertent RCS depressurization due to inadvertent auxiliary spray
- Upset Transient #6, Inadvertent startup of an inactive RCS loop
- Upset Transient #7, Control rod drop
- Upset Transient #9, Operating Basis Earthquake
- Upset Transient #10, Excessive Feedwater Flow
- Upset Transient #11, RCS Cold Overpressurization
- Test Transient #3. Tube leakage test
- Auxiliary Transient #1, Normal charging and letdown shutoff and return to service (Alt)
- Auxiliary Transient #4, Charging flow shutoff with prompt return to service (Alt)
- Auxiliary Transient #11, Accumulator actuation, accident operation
- Auxiliary Transient #12, Inadvertent accumulator blowdown
- Auxiliary Transient #14, High head safety injection (Loop B / C / D)
- Auxiliary Transient #23, Low Pressure Safety Injection

The following transients use a unique method to develop the 60 year projection.

- Normal Transient #7a/b, Loop out of service, Normal loop shutdown/startup: The 60 year projection is 0 because Callaway is not licensed for N-1 loop operation.
- Normal Transient #11, Reduced temperature return to power: Maneuver is not utilized because Callaway does not load follow.
- Auxiliary Transient #28, Excess letdown heat exchanger operation: Based on a linear projection of the available data. The projection is explained in LRA Section 4.3.8.

Corresponding Amendment Changes

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

RAI 4.3-3

Background:

LRA Table 4.3-2 describes that for normal condition Transients Nos. 16a and b, the baseline results were judged to be conservative based on a review of instrumentation data available from 2000 to 2011.

Issue:

It is not clear to the staff whether the baseline numbers of 56 and 12, for normal condition Transient Nos. 16a and 16b, respectively, are the results of a review of instrumentation data available from 2000 to 2011 or whether they incorporate a backward-projection to include the years from 1983 to 2011.

The applicant also did not provide the technical basis why using the data from 2000 to 2011 was conservative and whether the 1:3 ratio for long term to short term weighting factor was used to calculate the 60-year projection for this transient.

Request:

a) Provide the number of occurrences for Transient Nos. 16a and 16b from 2000-2011 and the calculation performed to obtain the baseline values for 56 and 12 in LRA Table 4.3-2. Provide the technical justification that the data from 2000-2011 is conservative to represent the occurrences of these transients between 1983 and 2011.

b) Provide the short-term and long-term weighting factors used to calculate the 60-year projection and the associated transient occurrences for these weighting factors. In addition, provide the basis that the 60-year projection is conservative.

Callaway Response

a) Callaway experienced 56 events of Normal Transient #16a, “Feedwater heaters out of service: One heater out of service,” between 1983 and 2011; 22 of the events occurred between 2000 and 2011.

   Callaway experienced 12 events of Normal Transient #16b, “Feedwater heaters out of service: One bank out of service,” between 1983 and 2011; 1 of the events occurred between 2000 and 2011.

   The input to baseline from 1983 to 1999 is based on a review of manual records. There was a concern that the manual records available would not identify all events. In order to ensure the accumulation rates from manual records conservatively cover back to the initial plant startup the manual records accumulation rates were compared to the accumulation rates from the available plant computer data that covers between 2000 and 2011. There have been no changes to the operating strategy of the feedwater system that would indicate either a reduction or increase in the event accumulation rate should have occurred. The computer data from 2000 to 2011 was not used to create events prior to 2000. The computer data was used to verify the information available is sufficient for developing a baseline since the beginning of power operations.

b) These transients use the same methodology to perform the 60 year projection as the other transients. A weighting factor of 1 for the long term and 3 is used for the short term. The short-term period consists of the preceding 9 years.

In the past 9 years there have been:

- 12 events of Normal Transient #16a, “Feedwater heaters out of service: One heater out of service.”
- 0 events of Normal Transient #16b, “Feedwater heaters out of service: One bank out of service.”

Corresponding Amendment Changes

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

RAI 4.3-4

Background:

LRA Table 4.3-2 indicates that for Normal Transient 5b “Steady State Fluctuations, Random Fluctuations,” the number of cycles is beyond the endurance limit of the fatigue curve and therefore this transient does not need to be counted.

Issue:

The staff noted that the endurance limit of the fatigue curve is typically referred to as the stress level below which it results in an infinite number of allowable cycles. Based on the information in the LRA, it may be interpreted that the endurance limit is based upon a certain number of cycles, thus, the applicant has not explained why the transient does not need to be counted when the number of cycles is greater than 10^6.

Request:

a) Clarify and explain the statement that “the number of cycles is beyond endurance limit of the fatigue curve.”

b) Provide the basis for not counting this transient when the number of cycles is greater than 10^6.

Callaway Response

a) The statement was meant to note that if this transient ever resulted in a fatigue significant stress, then the allowable number of cycles will be less than 10^6 cycles; thus resulting in a CUF greater than 1.0.

b) Temperature and pressure variations due to this event are very small. The resulting stress intensity ranges do not result in any contribution to the fatigue usage; therefore, it is not necessary to explicitly count this transient. LRA Table 4.3-2 normal condition transient 5b has been revised as shown in LRA Amendment 11 in Enclosure 2 to state that the transient does not result in the accumulation of fatigue usage.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 11, LRA Changes from RAI Responses”, for a description of LRA changes with this response.

RAI 4.3-5

Background:

LRA Table 4.3-2 indicates that there are 29 occurrences of the plant heat-up transient, 29 occurrences of the plant cool-down transient, 66 occurrences of the reactor trip transient, 2 occurrences of the inadvertent reactor coolant system (RCS) depressurization transient and one occurrence of the loss of power transient.

Issue:

Based on the baseline cycle occurrence data in LRA Table 4.3-2 it is not clear to the staff how there are an equal number of plant heat-up and cool-down transients when considering there have been occurrences of reactor trip, inadvertent RCS depressurization and loss of power transients. Thus, it is not clear to the staff whether there is a plant heat up recorded after each occurrence of the reactor trip, RCS depressurization, or loss of power.

Request:

a) Provide the basis that there are an equal number of plant heat-up and cool-down transients when considering there have been occurrences of reactor trip, inadvertent RCS depressurization and loss of power transient.

b) Clarify whether there is a recorded plant heat-up after each occurrence of an inadvertent RCS depressurization, loss of power, and reactor trip transient.

c) Identify the transient occurrences that would subsequently result in a recorded plant heat-up transient.

Callaway Response

a) A plant cooldown is counted independently from the reactor trip, inadvertent RCS depressurization and loss of power transients. Therefore, if one of these upset events occurs, it will not eliminate a plant cooldown event from being counted, if the plant does cooldown. It is anticipated that a subsequent heatup event will occur in order to return the unit to power following a cooldown, regardless of what caused the cooldown.

b) The occurrence of an inadvertent reactor coolant system (RCS) depressurization, loss of power, and reactor trip transient would also require a plant heatup transient to be recorded if the transient resulted in a plant cooldown. The Fatigue Monitoring program records inadvertent RCS depressurization and loss of power independent of changes in RCS temperature. The Fatigue Monitoring program recording of an inadvertent RCS depressurization is dependent on the occurrence of a rapid RCS pressure drop, which could be caused by either the actuation of a pressurizer safety valve, inadvertent opening of a pressurizer power operated relief valve or by sudden inadvertent or malfunctioning pressurizer spray actuation. The Fatigue Monitoring program recording of the loss of power transient is manually counted. The various reactor trip transients counted by the Fatigue Monitoring program require either a rapid pressure drop or a safety injection system actuation and are counted independently of whether a subsequent plant cooldown actually occurred. All plant cooldowns and plant heatups are counted separately, regardless of whether or not they follow a reactor trip or any other event.

c) The transient that would subsequently result in a recorded plant heat up transient is plant cooldown.

Corresponding Amendment Changes

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

RAI 4.3-6

Background:

In the response to Question 11 in "Callaway Plant Application of Proprietary Leak-Before-Break Methodology Reports and Draft Regulatory Guide DG-1108," (non-Proprietary letter) dated December 9, 2003 (ADAMS Accession Number ML033530468), the applicant stated that the value of the maximum American Society of Mechanical Engineers (ASME) Code, Section III, Class 1, cumulative usage factor (CUF) of the pressurizer surge line previously calculated under the effects of thermal stratification is 0.4.

LRA Section 4.3.2.4 indicates that the fatigue results, including the effects of thermal stratification, for the 14-in. pressurizer surge nozzle on hot leg loop 4 and the 14-in. pressurizer surge line is 0.3 and 0.099, respectively. LRA Table 4.3-7, as amended by letter dated May 3, 2012, also indicates a CUF value of 0.3 for the surge line (hot leg surge nozzle).

Issue:

Based on the reported CUF values in the LRA, including LRA amendment 2 by letter dated May 3, 2012, and the applicant's response letter dated December 9, 2003, it is not clear to the staff if the CUF values are referring to the same or different locations of the pressurizer.

Request:

a) Clarify the specific locations that are represented by the CUF values of 0.099, 0.3, and 0.4.

b) If the CUF value of 0.4 refers to the same location as the 14-in pressurizer surge nozzle on hot leg loop 4, provide the basis for recording a lower CUF value in LRA Section 4.3.2.4 and LRA Table 4.3-7, as amended by letter dated May 3, 2012.

Callaway Response

a) The CUFs are explained below:

- The CUF of 0.099 represents the maximum CUF in the surge piping at points intermediate to the two terminal ends. The two terminal ends include the hot leg surge nozzle and the pressurizer surge nozzle
- The value of 0.3 represents the CUF at the hot leg surge nozzle.
- The value of 0.4 represents the CUF at the surge line piping to pressurizer surge nozzle weld.

b) The CUF of 0.4 was the result of the 1995 supplement to Callaway's initial NRC Bulletin 88-11 analysis. The design reports for the pressurizer surge line piping and pressurizer surge nozzle have since been revised. The CUF of 0.4 no longer represents the licensing/design basis for the surge line weld to the pressurizer surge nozzle. A structural weld overlay (SWOL) was applied to the pressure surge nozzle weld in 2007. A fatigue crack growth analysis was performed using the ASME Code Section XI methodology to address the fatigue qualification at the weld overlay region.

Corresponding Amendment Changes

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

RAI 4.3-7

Background:

LRA Table 4.3-3 indicates that the CUF value for "RHR Nozzles, Hot Leg Loop 1 & 4" is 0.81, the CUF value for "Loop 1 Hot Leg Safety Injection Line" is 0.661 and the CUF value for "Loop 4 Hot Leg Safety Injection Line" is 0.110. In the response to residual heat removal (RHR) Line Question 1 in "Callaway Plant Application of Proprietary Leak-Before-Break Methodology Reports and Draft Regulatory Guide DG-1108," (non-Proprietary letter) dated December 9, 2003 (ADAMS Accession Number ML033530468), the applicant stated that the value of the ASME Code, Section III, Class 1, CUF of the RHR Line Loop 1 is not 0.81.

LRA Table 4.3-7, as amended by letter dated May 3, 2012, identifies the final locations, including the NUREG/CR-6260 locations that will be used as sentinel locations during the period of extended operation to manage environmentally-assisted fatigue (EAF).

Issue:

The staff noted that in some instances multiple loops on a particular line may have the same CUF value and in other instances they have different CUF values; thus, the basis for multiple loops having the same CUF value is not clear.

The LRA did not annotate or explain whether the CUF values, for entries of multi-loop systems in LRA Tables 4.3-3 to LRA Table 4.3-7, are intended to demonstrate that the CUF value of one loop bounds the "calculated" CUF value of another; or to demonstrate that the CUF value of one loop represents all other identical or less limiting loops.

Without a clear indication of the CUF values of multi-loop systems, the staff cannot verify the applicant's conclusion that LRA Table 4.3-7 identifies the final locations, including the NUREG/CR-6260 locations that will be used as sentinel locations during the period of extended operation to manage EAF.

Request:

a) Identify any components or locations in LRA Tables 4.3-3 to 4.3-7 for which the CUF value in the design-basis calculation is the same for each loop in a multi-loop system.

b) Identify any components or locations in LRA Tables 4.3-3 to 4.3-7 for which a CUF value of one loop was used to bound any "calculated" CUF values of another loop in a multi-loop system. Provide the basis for each circumstance discussed and provide the associated CUF values.

c) Identify any components or locations in LRA Tables 4.3-3 to 4.3-7 for which the CUF value of one loop represented all other identical or less limiting loops. Provide the basis for each circumstance discussed and provide the associated CUF values.

Callaway Response

a) The following are locations in LRA Table 4.3-3, "ASME Class 1 Fatigue Analyses Under the Fatigue Management Program," for which the maximum CUF value from the design basis calculation is the same for each loop in a multi loop system. Each loop has been independently analyzed for fatigue.

- Normal/Alternate Charging - Loops 1 & 4
- RHR Loops 1 & 4 Suction Line
- Accumulator Lines - Loops 1, 2, 3, & 4
- Boron Injection Header Lines – Loops 1, 2, 3, & 4
- Pressurizer Spray Nozzle-Cold Leg Loop 1 & 2
- Drain Nozzle-Crossover Leg Loop 1 & 2
- SIS Nozzle-Hot Leg Loops 2 & 3
- Boron Injection Header Nozzles-Cold Leg Loops 1, 2, 3, & 4
- Accumulator Nozzle-Cold Leg Loops 1, 2, 3, & 4
- RHR Nozzle-Hot Leg Loops 1 & 4

The following are locations in LRA Table 4.3-7, "Sentinel Locations for EAF Monitoring," for which the maximum CUF value from the design basis calculation is the same for each loop in a multi loop system. Each loop has been independently analyzed for fatigue.

- RHR Nozzles, Hot Leg Loops 1 & 4
- BIT Nozzles (All Loops)
- Accumulator Nozzles (All Loops)
- Hot Leg SIS Nozzles, Loops 2 & 3

b) The following are locations in LRA Table 4.3-3 for which the maximum CUF was used to bound all CUF in multi-branch system.
   - Spray/Aux. Spray Loop 1 & 2: This is justified because the location of the maximum CUF of 0.84 is in the common section of piping leading to the pressurizer spray nozzle.
   - Pressurizer Safety and Relief Valve Piping: The maximum CUF of 0.975 is in the safety valve piping. The maximum CUF in the relief valve piping is 0.970. This is justified because the piping lines perform a similar function and experience similar thermal events.

   The following are those components and/or locations in LRA Table 4.3-7, "Sentinel Locations for EAF Monitoring," for which the maximum CUF was used to bound all CUF in multi-branch system.
   - Pressurizer Safety and Relief Valve Piping, CUF = 0.975. See above for justification.

c) The following are those components and/or locations in LRA Table 4.3-3 for which one model represents multiple plant locations. This is justified because the geometry, material, and the thermal transients for the locations that share the analyses are identical.
   - RPV Inlet Nozzles, CUF = 0.0795; and Supports, CUF = 0.0306
   - RPV Outlet Nozzles, CUF = 0.1078; and Supports, CUF = 0.0205
   - RCP Weir Plate, CUF = 0.440
   - RCP Casing at Discharge Nozzle Junction, CUF = 0.915
   - RCP Bolting Ring, CUF = 0.086
   - RCP Main Closure Bolting, CUF = 0.45
   - RCP Casing at Large Support Feet Juncture, CUF = 0.083
   - RCP Thermal Barrier Flange at CCW connection, CUF = 0.9334
   - Safety and Relief Nozzles, CUF = 0.169
   - Pressurizer Safety Valves, CUF = 0.018
   - Power Operated Relief Valves (PORVs), CUF = 0.139
   - PORV Solenoid, CUF = 0.68
   - Loop SI / RHR Check valves, CUF = 0.17

- RHR and SI System Loop 2 & 3 Recirculation Supply Header Check Valves, CUF = 0.17
- RHR Pumps to RCS Cold Leg Check Valves, CUF = 0.1647
- RCS Cold Leg SI Accumulator Check Valves, CUF = 0.26
- SI Accumulator Outlet Upstream Check Valves, CUF = = 0.26
- RHR Pump Suction Isolation Valves, CUF = 0.64
- RCS Hot Leg to RHR Pump Isolation Valves, CUF = 0.64
- RCS Hot Legs, CUF = 0.95
- RCS Crossover Legs, CUF = 0.50
- RSC Cold Legs, CUF = 0.37
- SI Hot Leg Loop 2, 3, CUF = 0.090
- Cold Leg Thermowells, CUF = 0.025
- Hot Leg Thermowells, CUF = 0.017
- Mid-Loop Level Tap from Hot Leg 1 and 4, CUF = 0.327
- Hot Leg RTD Scoop Nozzles, CUF = 0.65*
- Cold Leg RTD Scoop Nozzles, CUF = 0.15*
- Normal & Alternate Charging Nozzles, CUF = 0.90

* The RTD bypass piping has been removed at Callaway. A portion of the RTD bypass nozzles remains in place. The loads after removal of the RTD bypass piping are much lower than their original values due to the elimination of the piping loads. The CUF for these nozzles prior to the elimination are provided to conservatively represent the design basis usage factors since these nozzles will not accumulate any additional fatigue usage.

All components in LRA Table 4.3-4, “Callaway Replacement Steam Generator Cumulative Fatigue Usage,” use a single model to represent all four steam generators. All four steam generators have identical geometry, materials, and design conditions.

The following are those components and/or locations in LRA Table 4.3-6, “Summary of Fatigue Usage Factors at NUREG/CR-6260 Sample Locations,” for which one model represents multiple plant locations. This is justified because the geometry, material, and the thermal transients for the locations that share the analyses are identical.

- RPV Inlet Nozzles, CUF = 0.0795
- RPV Outlet Nozzles, CUF = 0.1078
- Safety Injection Nozzles, CUF = 0.1135
- Residual Heat Removal Inlet Nozzles, CUF = 0.0234

The following are those components and/or locations in LRA Table 4.3-7, “Sentinel Locations for EAF Monitoring,” for which one model represents multiple plant locations. This is justified because the geometry, material, and the thermal transients for the locations that share the analyses are identical.

- RPV Inlet Nozzles, CUF = 0.0795
- RPV Outlet Nozzles, CUF = 0.1078
- PORV Solenoid, CUF = 0.68
- Normal & Alternate Charging Nozzles, CUF = 0.90
- RSG Tubesheet (Continuous Region), CUF = 0.428

Corresponding Amendment Changes

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

<u>RAI 4.3-8</u>

<u>Background:</u>

LRA Section 4.3.1.1 states that a benchmark was performed to demonstrate that the charging nozzle stress-based fatigue (SBF) algorithm produces a conservative CUF when compared to an independent ASME Section III, Division 1, Subsection NB, Subarticle NB-3200 fatigue calculation of the same component. The benchmarking consisted of inputting the temperature, pressure and flow rate time histories for the most severe transient pairs into the SBF algorithms. These time histories are the same as those assumed in the NB-3200 fatigue calculation and constitute about 88 percent of the NB-3200 CUF.

The LRA states that a comparison demonstrated that the CUF for those transient pairs as computed by the SBF algorithms is more conservative than the CUF calculated with all transient pairs as computed using the detailed NB-3200 methodology. Furthermore, the LRA states that for two of the transients, the SBF algorithms calculated stress ranges approximately one to two percent less than the NB-3200 analysis. The LRA also states that the small difference in results is within the accuracy of the analysis.

<u>Issue:</u>

The LRA did not provide an explanation of how the CUF calculated by single-stress component SBF would be more conservative than that of the NB-3200 calculation. In addition, the LRA did not provide sufficient detail to support its statement that single-stress component SBF is more conservative than the NB-3200 calculation.

For the two transients that the SBF algorithms calculated stress ranges approximately one to two percent less than the NB-3200 analysis, the applicant did not explain or quantitatively define "the small difference in results" and "the accuracy of the analysis." The LRA also has not identified or compared the results between the single-stress component SBF and NB-3200 calculations; thus, without the information, the staff cannot verify the adequacy of the applicant's calculation to support the use of single-stress component SBF for the charging nozzle.

<u>Request:</u>

a) Identify those most severe transient pairs that "constitute about 88% of the NB-3200 CUF" and provide the associated CUF contribution for these "most severe transient pairs."

b) For the two transients that the SBF algorithms calculated stress ranges approximately one to two percent less than the NB-3200 analysis, clarify whether the term "results" is related to a stress value, CUF value, or some other parameter.

c) Explain what was meant by "the accuracy of the fatigue analysis" and explain how it was quantitatively determined.

d) Identify the CUF contributions (both in SBF and NB-3200 calculations) for these two transients. Demonstrate and justify that the defined "small difference in results" is within the "accuracy of the fatigue analysis."

e) Justify that the results calculated from the single-stress component SBF is conservative compared to the NB-3200 for the charging nozzle.

Callaway Response

a) Table 1 (refer to table following this response) identifies the transient pairs which "constitute about 88% of the NB-3200 CUF" of 0.164 for the charging nozzles. This CUF is the result of an elastic-plastic fatigue analysis performed to support license renewal, specifically Environmentally Assisted Fatigue.

b) The term "results" refers to the alternating stress ranges.

c) This refers to the SBF ability to predict the differences in alternating stress ranges. These differences and their effects on fatigue usage are shown in response to Request d) of this RAI.

d) Table 2 (refer to table following this response) identifies the CUF contributions (both in SBF and NB-3200 calculations) for the two transients.

   Most of the contribution to the CUF comes from the "Loss of Letdown" transient. The Fatigue Monitoring Program is conservative by over 11% when calculating the alternating stress range. This results in the Fatigue Monitoring Program being over 40% conservative when calculating the fatigue usage. Given the degree of conservatism associated with the "Loss of Letdown" transient, the 2% difference in alternating stress range for the non-conservative transient pairs identified in Table 2 are within the accuracy of the analysis.

e) SBF algorithm for CUF (CUF = 0.172) is more conservative by approximately 5% than the NB-3200 analysis for CUF (CUF = 0.164).

Corresponding Amendment Changes

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

Table 1: Transient Pairs for Charging Nozzle Benchmark

Transient Pairs		Usage	Individual Contribution	Total Contribution
Loss of letdown with prompt return	Zero load	0.054	33.1%	33.1%
Charging decrease	Letdown increase	0.036	22.2%	55.3%
Zero load	Loss of letdown with prompt return + OBE	0.017	10.5%	65.8%
Charging and letdown shutoff	Zero load	0.012	7.2%	73.0%
Charging and letdown shutoff	Plant Heatup	0.011	6.8%	79.8%
Charging increase	Letdown increase	0.008	4.8%	84.6%
Loss of letdown with delayed return	Zero load	0.006	3.7%	88.3%

Table 2: Comparison for SBF and NB-3200 Results

Transient Pairs		NB-3200		SBF		% Difference	
		S_{Alt} (ksi)	Usage / event	S_{Alt} (ksi)	Usage / event	S_{Alt}	Usage / event
Loss of letdown with prompt return	Zero load	84.81	3.02E-4	94.19	4.48E-4	11.1	48.3%
Charging decrease	Letdown increase	30.33	1.7E-6	29.75	1.5E-6	-1.9%	-13.1%
Charging increase	Letdown increase	21.30	0.4E-6	21.06	0.4E-6	-1.1%	-4.8%

RAI 4.3-9

Background:

LRA Table 4.3-3 states that the CUF value for the Class 1 piping of “Normal/Alternate Charging-Loops 1 & 4” is 0.93. LRA Table 4.3-7, as amended by letter dated May 3, 2012, states the “Normal Charging Nozzles, Loop 1” and “Alternate Charging Nozzles, Loop 4” have CUF values of 0.90, which are the sentinel locations for EAF monitoring for the “Charging” thermal zone within the chemical and volume control system (CVCS).

Issue:

The applicant did not explain why the Normal and Alternate Charging nozzles would bound Class 1 piping of “Normal/Alternate Charging-Loops 1 & 4” given that the CUF values of the Class 1 piping of “Normal/Alternate Charging-Loops 1 & 4” is higher.

Request:

Justify that the Normal and Alternate Charging nozzles are sentinel locations for the “Charging” thermal zone within the CVCS. As part of justification, specifically include the materials, transient experienced, system configuration, water chemistry and other factors when comparing the Class 1 piping of “Normal/Alternate Charging-Loops 1 & 4” and the Normal and Alternate Charging nozzles.

Callaway Response

The charging nozzle CUF of 0.9 was computed more recently in response to high letdown flow (120 gpm vs 75 gpm), which is discussed in the operating experience of LRA Section B3.1. The evaluation of fatigue in the CVCS piping system focused exclusively on the charging nozzle because it was determined to be the controlling location. Therefore the straight comparison of the CUFs is not on a common basis. The charging nozzle CUF taken from the same design report revision as the charging piping with a CUF of 0.93 is equal to 0.95. The determination of the sentinel locations applies to limiting EAF CUFs. The components are both constructed of stainless steel. The CUFs are based on the same design basis transients shown in LRA Table 4.3-2 and the same system configuration which rotates between normal and auxiliary charging paths. The F_{en} estimation assumes the same low oxygen water chemistry. The components are assigned a similar estimated strain rate, but the piping will experience a higher strain rate for the important transients that contribute to F_{en}; thus, the F_{en} values will be similar but the nozzle will experience a higher F_{en}. Therefore the EAF CUF of the charging nozzle will be greater than the piping and is the sentinel location.

Corresponding Amendment Changes

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

RAI 4.3-10

Background:

LRA Section 4.3.5 states that piping in the scope of license renewal that is designed to American National Standards Institute (ANSI) B31.1 or ASME Section III Class 2 and 3 required the application of a stress range reduction factor to the allowable stress range (expansion and displacement) to account for thermal cyclic conditions.

In addition, the LRA provides a list of several systems and states that these systems are subject to thermal fatigue effects and were therefore included in the aging management review (AMR) results presented in LRA Section 3. Specifically, the main feedwater system and boron recycle system were included as part of this list of systems subject to thermal fatigue effects.

Issue:

Title 10 Section 54.21(a)(1) of the *Code of Federal Regulations* (10 CFR 54.21(a)(1)) requires, in part, that for those systems, structures, and components (SSCs) within the scope of license renewal as delineated in 10 CFR 54.4, the applicant identify and list those structures and components subject to an AMR. However, the staff noted that LRA Table 3.4.2-3, "Steam and Power Conversion System - Summary of Aging Management Evaluation - Main Feedwater System" and LRA Table 3.3.2-28, "Auxiliary Systems - Summary of Aging Management Evaluation - Miscellaneous Systems in scope ONLY for Criterion 10 CFR 54.4(a)(2)" does not provide AMR results for components subject to "cumulative fatigue damage."

Request:

a) Provide the basis for the discrepancy between the LRA Section 4.3.5 and LRA Tables 3.3.2-28 and 3.4.2-3 or provide the appropriate AMR results for components subject to thermal fatigue effects for the main feedwater system and boron recycle system.

b) Confirm that there are no other components designed to ANSI B31.1 or ASME Section III Class 2 and 3, including reactor coolant sample lines, subject to thermal fatigue effects and subject to AMR for "cumulative fatigue damage" in accordance with 10 CFR 54.21(a)(1) or make appropriate revisions to the LRA to identify these additional components subject to AMR.

c) If components within the scope of license renewal designed to ANSI B31.1 or ASME Section III Class 2 and 3, including reactor sample lines that required the application of a stress range reduction factor, were excluded from the AMR results by the temperature screening criteria; provide the basis for excluding these components as AMR results that identify "cumulative fatigue damage" as an aging effect in accordance with 10 CFR 54.21(a)(1).

Callaway Response

a) Table 3.3.2-28 has been revised as shown on LRA Amendment 11 in Enclosure 2 to add an AMR line for the thermal effects of fatigue in the boron recycle system and condensate system.

   Table 3.4.2-3 has been revised as shown on LRA Amendment 11 in Enclosure 2 to add an AMR line for the thermal effects of fatigue in the main feedwater system.

b) It is confirmed that no other additions to AMR lines for thermal effects of fatigue are needed other than those noted above.

c) If the design temperature of a line is greater than 220°F for carbon steel components or 270°F for stainless steel, then an AMR line was generated. This threshold temperature is based on EPRI Report 1010639, “Non-Class 1 Mechanical Implementation Guideline and Mechanical Tools.” These values indicate that systems or portions of systems with operating temperatures below these thresholds may generally be excluded from fatigue concerns since the fluid temperature would not be expected to vary more than 150°F for carbon steel or 200°F for stainless steel, and thereby will not be subject to significant thermal fatigue effects.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 11, LRA Changes from RAI Responses”, for a description of LRA changes with this response.

RAI 4.3-11

Background:

LRA Section 4.3.5 states that a review of FSAR Table 9.3-3 SP and Callaway Chemistry Schedule identified that the only sample piping in the scope of license renewal that meets the temperature screening criteria, and could possibly exceed 7,000 cycles, is the RCS hot leg sample piping. In addition, it states that a review of operating practice at Callaway indicates that RCS samples are taken weekly from the hot leg during operation. Therefore none of the lines associated with this sample location will exceed 7,000 cycles during the period of extended operation. FSAR Table 9.3-3 SP provides the "typical sampling frequency" for the primary sampling systems; specifically, it lists a frequency of 3 per week and/or 1 per week for the RCS hot legs sample (loop 1 or 3).

Issue:

Based on information presented in the LRA for the Callaway Chemistry Schedule and the operating practice at Callaway and FSAR Table 9.3-3 SP, the sampling frequency of the RCS hot legs sample (loop 1 or 3) is not clear to the staff. The FSAR indicates that the sampling frequency can be up to 3 per week and it appears that the Callaway Chemistry Schedule indicates a sampling frequency of once per week.

Request:

a) Provide the reason that the FSAR indicates the sampling frequency for the RCS hot legs sample (loop 1 or 3) may be 3 per week, while the LRA indicates that the sampling frequency is weekly. Describe any actions that are required to clarify this discrepancy between the LRA, site procedures, and FSAR.

b) If it is determined that the sampling frequency is or should be 3 per week, provide the reason that the disposition for the TLAA of reactor coolant sample lines in accordance with 10 CFR 54.21 (c)(1)(i) is still appropriate.

c) Provide the reason that the RCS hot leg sample piping is only affected by the RCS samples taken weekly from the hot leg during operation and is not affected by the thermal cycles that are likely to produce full-range thermal cycles or other events that may contribute part-range cycles in ASME Class 2, 3, and B31.1 piping.

Callaway Response

a) FSAR Table 9.3-3 identifies 3 times per week as a "typical sampling frequency." This is reflected in the design calculations for the hot leg sample lines which reduced the allowable secondary stress range from 1.0 S(A) to 0.9 S(A). This accounts for up to 14,000 thermal cycles or over 4 samples per week for 60 years.

   However, the current practice is to only draw one of these samples from the hot leg sampling lines per week. The remainder of the samples are drawn downstream of the letdown heat exchanger which drops the temperature to below 115°F, which is below the screening criterion for stainless steel.

b) The disposition for the TLAA for the reactor coolant sample lines is in accordance with 10 CFR 54.21 (c)(1)(i) and is still appropriate. LRA Amendment 11 in Enclosure 2 has revised the reactor coolant sample lines portion of LRA Section 4.3.5 to note that the design calculations have reduced the allowable secondary stress range from 1.0 SA to 0.9 SA. This accounts for up to 14,000 thermal cycles or over 4 samples per week for 60 years.

c) The sole function of the RCS hot leg sample piping is to obtain RCS hot leg samples. There are no other functions or events of the nuclear sampling system that are likely to produce full range thermal cycles or part range cycles. As noted previously, design calculations have reduced the allowable secondary stress range and account for up to 14,000 thermal cycles or over 4 samples per week for 60 years.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 11, LRA Changes from RAI Responses", for a description of LRA changes with this response.

RAI 4.3-12

Background:

LRA Sections 4.3.2.2 and A3.2.1.2 state that for license renewal, Callaway has committed to monitor the CUF of the limiting location out of the pressurizer lower head, pressurizer surge line nozzle, and heater well nozzles using fatigue monitoring software consistent with RIS 2008-30. In addition, LRA Section 4.3.2.2 states that to mitigate pressurizer insurge-outsurge transients, Callaway has used modified operating procedures (MOPs) since 1996.

LRA Table A4-1 contains Commitment No. 36, which states the following, “[i]mplement SBF or CBF consistent with RIS 2008-30 to monitor the CUF of the limiting location out of the pressurizer lower head, surge nozzle and heater penetrations to accommodate the insurge-outsurge transient."

LRA Table A4-1 contains Commitment No. 37, which states in part that "[i]n order to determine if the pressurizer contains a limiting EAF location, the fatigue analyses will be revised to incorporate the affect effect of insurge-outsurge transients on the pressurizer lower head, surge nozzle, and heater well nozzles at plant specific conditions." LRA Amendment 2 dated May 3, 2012, revised Commitment No. 37 in LRA Table A4-1 to state that this portion of the commitment was completed. In addition, Commitment No. 37 was revised to state in part that [t]he pressurizer contains a limiting EAF location. The fatigue analyses will be revised to incorporate the effect of insurge-outsurge transients in the pressurizer lower head."

Issue:

Based on this part of Commitment No. 37 that was completed and the addition to Commitment No. 37, both of which are described above, it is not clear to the staff whether the effects of insurge-outsurge transients has been incorporated into the fatigue analyses of the pressurizer. Furthermore, based on LRA Table 4.3-7, as amended by letter dated May 3, 2012, there are a total of seven sentinel locations for three different regions (pressurizer lower head, pressurizer spray, and pressurizer SRV/PORV) of the pressurizer. The staff noted that this is different from the revised Commitment No. 37 that the pressurizer contains a single limiting EAF location.

Considering the completion of this part of Commitment No. 37 described above, LRA Sections 4.3.2.2 and A3.2.1.2 were not revised to capture the incorporation of insurge-outsurge transients on the pressurizer lower head, surge nozzle, and heater well nozzles at plant-specific conditions. In addition, the staff noted that locations to be monitored are different between LRA Section A3.2.1.2 and Commitment No. 36; thus, it is not clear to the staff what the basis is for the discrepancy.

In addition, it is not clear how the effects of insurge-outsurge transients were incorporated into the fatigue analyses of the pressurizer prior to the implementation of MOPs in 1996.

Request:

a) Provide the basis for the discrepancy in Commitment No. 37, as revised by letter dated May 3, 2012, and explain whether the effects of insurge-outsurge transients has been incorporated into the fatigue analyses of the pressurizer.

b) Given that there are seven sentinel locations identified for the pressurizer, provide the basis for the discrepancy in Commitment No. 37, as revised by letter dated May 3, 2012, that the pressurizer contains a single limiting EAF location.

c) Provide the basis that LRA Sections 4.3.2.2 and A3.2.1.2 were not revised to capture the incorporation of insurge-outsurge transients on the pressurizer lower head, surge nozzle, and heater well nozzles at plant specific conditions, considering the part of Commitment No. 37 that was identified as completed by letter dated May 3, 2012.

d) Clarify the locations to be monitored for CUF using fatigue monitoring software. Revise LRA Section A3.2.1.2 and Commitment No. 36 to address discrepancy in monitored locations. Or provide the reason that the locations discussed in Commitment No. 36 are different from those in LRA Section A3.2.1.2.

e) Describe how the effects of insurge-outsurge transients were incorporated into the fatigue analyses of the pressurizer prior to the implementation of MOPs in 1996. If actual plant data at Callaway was not used to incorporate the effects of insurge-outsurge transients, provide the reason that the methods used are bounding to capture the plant-specific condition prior to implementing MOPs to ensure an accurate baseline to manage fatigue through the period of extended operation.

Callaway Response

a) Callaway completed the incorporation of the insurge-outsurge transient into the design analysis for the pressurizer lower head, surge nozzle, and heater well nozzles after submittal of the May 3, 2012 LRA Amendment. LRA Section 4.3.2.2, Appendix A3.2.1.2, and LRA Table A4-1 Commitment #37 have been revised as shown on Amendment 11 in Enclosure 2.

b) The only thermal zone affected by the insurge-outsurge transient is the Pressurizer Lower Head. All Pressurizer Lower Head components LRA Table 4.3-7 were revised by LRA Amendment 2 to account for the insurge-outsurge transient. LRA Table A4-1 Commitment #37 has been revised as shown on Amendment 11 in Enclosure 2.

   The immersion heater CUF was deleted from the LRA Table 4.3-3 as shown on Amendment 11 in Enclosure 2, because the insurge-outsurge analysis did not include this component. The CUF is for the immersion heater sheath. This is a non-structural item and is not an ASME Class 1 pressure boundary component. The critical location is the heater to weld junction. These attachment welds between the heaters and the heater wells are significantly removed from the pressurizer environment and are not impacted by the pressurizer thermal transients including the insurge/outsurge. The fatigue analysis of these welds from the original design report results indicates that there will be no accumulation of fatigue.

c) The insurge-outsurge analysis was not complete when the LRA Amendment was submitted on May 3, 2012.

d) Based on the completed insurge-outsurge analysis and the EAF screening, the aging of the pressurizer lower head, surge nozzle, and heater well nozzles can be disposition without SBF monitoring. Instead, managing fatigue for the pressurizer lower head, surge nozzle, and heater well nozzles will be accomplished with cycle counting. LRA Table 4.3-1 and LRA Appendix A3.2.1.2 have been revised as shown in Amendment 11 in Enclosure 2 to delete CUF monitoring of the pressurizer lower head, pressurizer surge nozzle, and pressurizer heater well nozzles. LRA Table A4-1 Commitment 36 has been revised as shown in

Amendment 11 in Enclosure 2 to indicate the commitment to implement SBF or CBF monitoring consistent with RIS 2008-30 pressurizer limiting locations is not required.

These locations can be monitored by counting the plant transients which comprise the design transient for the following two reasons.

1) All EAF CUF values are less than 1.0:
   - Surge Nozzle U_{en} = 0.032 x 15.35 = 0.4912 < 1.0
   - Heater Penetration U_{en} = 0.0103 x 15.35 = 0.158 < 1.0 (The Heater Penetration would be considered the limiting location since it resulted in highest CUF based on the elastic analysis.)
   - Pressurizer Lower Head U_{en} = 0.019 x 15.35 = 0.29165 < 1.0

2) A conservative spectrum of insurge-outsurge transients was developed to represent the current MOP mode of operation. The spectrum is indexed to the number of pressurizer heatups and cooldowns, thus counting the heatups and cooldowns is sufficient to demonstrate that the insurge-outsurge transients are in design compliance.

e) The insurge-outsurge transients before implementation of MOPs are derived from WCAP-12893, *Structural Evaluation of the Wolf Creek and Callaway Pressurizer Surge Lines, Considering the Effects of Thermal Stratification*, March 1991. WCAP-12839 was the basis for Callaway's initial response to NRC Bulletin 88-11. Its insurge-outsurge transients were developed following the generic approach originally established by the Westinghouse Owners Group on thermal stratification. The plant-specific applicability of these transients was addressed in WCAP-12893 through the use of surge line monitoring results, plant operating procedure and operator interviews, and plant historical records.

   The number of Pre-MOPs transients was determined using the number of heatup/cooldown events experienced through 1996 as determined through the baseline work discussed in LRA Section 4.3.1. The remaining number of insurge-outsurge transients was classified as Post-MOPs events.

   The insurge-outsurge transients after implementation of MOPs are based on modified steam bubble method from WCAP-14950, *Mitigation and Evaluation of Pressurizer Insurge-Outsurge Transients,* February 1998. Callaway has used both the modified steam bubble and the water solid methods for heatup and for cooldown, but the modified steam bubble method is used in the analysis for conservatism due to the higher values for ΔTs. The generic transients from WCAP-14950 were compared to the recorded data from October 1995 (date when automated cycle counting was initiated) to June 2010, which included a total of 16 heatups and 16 cooldowns. From these comparisons, insurge-outsurge transients were constructed to be representative of Callaway.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 11, LRA Changes from RAI Responses", for a description of LRA changes with this response.

RAI 4.3-13

Background:

LRA Section 4.3.2.1 describes that the fatigue analysis for the thermal barrier flange at the component cooling water (CCW) connection has a CUF of 0.9334. Furthermore, the transients used in the design of the CCW connection are 200 cycles of elevated CCW injection temperature; 40 cycles of seasonal temperature change; and 200 cycles of loss of CCW flow.

The LRA states that the seasonal temperature change is the only transient not counted; thus, its usage contribution during the period of extended operation can be estimated by multiplying its 40-year usage contribution by 1.5, which results in the CUF exceeding the Code allowable of 1.0. It also states that the transient that contributes most significantly to fatigue is the 200 cycles of elevated CCW injection temperature. In order to account for the increase in usage described above caused by the 20 additional years of operation and to keep the usage below the Code allowable of 1.0, the LRA describes that the number of the most severe transient will be limited to 75 percent of its design value (i.e., limited to 150 elevated CCW injection temperature) and this will keep the CUF less than 0.9. Therefore, the LRA states that the fatigue analysis will be managed for the period of extended operation, and the TLAAs are dispositioned in accordance with 10 CFR 54.21 (c)(1)(iii).

Issue:

Additional information regarding the CUF contribution for each of the transients in the original fatigue analysis for this component is required for the staff to verify the adequacy of the TLAA disposition. Furthermore, ASME Code Section III Paragraph NB-3224(e)(5) Step 1 indicates that transients shall be paired in order to produce a total stress difference range greater than the stress difference range of the individual cycles.

It is not clear to the staff whether the applicant has performed a CUF “re-calculation" consistent with ASME Code NB-3224(e)(5) Step 1, to arrive at the conclusion that restricting elevated CCW injection temperature transients to 75 percent of its design occurrences will keep the CUF less than 0.9. Furthermore, the technical basis that supports the statement that the CUF value can be kept less than 0.9 is not clear, considering that the number of past and future occurrences of the seasonal temperature change transient was not accounted for and shown to be bounding through the period of extended operation.

Request:

a) Provide the CUF contribution, as documented in the original fatigue evaluation, for each of the transient pairing (including number of cycles used in each pairing) consistent with Code NB-3224(e)(5).

b) Clarify whether the CUF value has been recalculated consistent with ASME Code Section III NB-3224(e)(5) to reach the conclusion that restricting the occurrence of the elevated CCW injection temperature to 75 percent of the design limit will result in a CUF of less than 0.9.

    I. If yes, provide the CUF contribution for each transient pair (including number of cycles used in each pairing) and demonstrate that this restriction results in a CUF of less than 0.9.

    II. If not, justify that the determination in using this 75 percent restriction on the elevated CCW injection temperature transient is based on an evaluation consistent with requirements in ASME Code Section III NB-3200.

c) Justify that the accumulated fatigue usage will remain less than 0.9 without monitoring and/or confirmation that the number of occurrences of the seasonal temperature change transient will not exceed the design limit.

Callaway Response

a) Table 3 (refer to table following this response) was extracted from the thermal barrier stress report and provides the CUF contribution, as documented in the original fatigue evaluation, for each of the transient pairing (including number of cycles used in each pairing) consistent with Code NB-3224(e)(5).

b) Yes, the conclusion that restricting the occurrence of the elevated CCW injection temperature to 75 percent of the design limit will result in a CUF of less than 0.9 was determined with an evaluation that is consistent with ASME Code Section III NB-3224(e)(5). The conclusion is not based on an entire reanalysis, but a manipulation of the current ASME Section III design report results. The design report meets the ASME Section III NB-3200 requirements.

   i. The CUF contribution for each transient pair is included in the table provided in Part A of this RAI response. The seasonal temperature change is the only transient that is not counted. Its usage contribution during the period of extended operation can be conservatively estimated by multiplying its 40 year usage contribution by 1.5. If this is done the CUF will exceed the Code allowable of 1.0 [0.4878 + 0.1818 + (1.5 x 0.16) + 0.1 + 0.0038 = 1.0134]. If the number of elevated CCW injection temperature transients is limited to 75% of its design value, i.e. limited to 150 elevated CCW injection temperature transients, the CUF will be less than 0.9 [(150/200) x 0.4878 + 0.1818 + (1.5 x 0.16) + 0.1 + 0.0038 = 0.8915].

   ii. N/A

c) For design purposes, a seasonal temperature changed is represented by the component cooling water temperature dropping instantaneously from an initial temperature of 130°F to a minimum of 47°F and then returned instantaneously to 130°F. Since the seasonal temperature change will occur once per year, 40 events are assumed for 40 year life and 60 events are assumed for 60 year life. A single event per season is conservative because the actual transient will be very slow and the actual change in CCW temperature will have less magnitude.

Corresponding Amendment Changes

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

Table 3: Thermal Barrier Flange Fatigue Table for RCP Seals

Transient Pairs		# of events	# of allowed	Usage
Elevated CCW injection temperature	Cooldown	200	410	0.4878
Seasonal temperature change	Cooldown	40	250	0.16
Elevated seal water injection temperature	Cooldown	200	1,100	0.1818
Elevated seal water injection temperature	Complete loss of CCW flow	200	2,000	0.10
±83°F Step Change Transients(1)		381	100,000	0.0038
			CUF	0.9334

1 The ±83°F Step Change Transient consists of the worst case injection flow temperature change (1) and seal injection flow temperature change (380).

RAI 4.3-14

Background:

LRA Section 4.3.8 states that the fatigue analysis for the letdown heat exchanger indicated a maximum CUF of 1.84 for the flange that accounts for a recent reanalysis to account for operation (1993-2011) with a letdown flow of 140 gpm. The LRA states that the CUF is driven mainly by the "charging flow step decreased and return to normal" transient, which is a load-following transient. Furthermore, the LRA states that Callaway does not practice load-following operation and the number expected to be experienced is a small fraction of the number of assumed transients. The LRA states that the assumed number of this transient was dropped by an order of magnitude, which is about equal to 3 transients a month for 60 years and is more consistent with Callaway's operation, and the CUF dropped to 0.894.

The applicant dispositioned the TLAA for the letdown heat exchanger flange in accordance with 10 CFR 54.21 (c)(1)(ii) to demonstrate that the analysis was projected to be valid through the period of extended operation.

Issue:

The staff noted that the "charging flow step decreased and return to normal" transient with a design limit of 24,000 cycles was based on load-following operation; thus, it may be reasonable to conclude that because the applicant's site does not practice load-following operation there will be margin between the design limit and the expected number of cycles for this transient through the period of extended operation. However, since the applicant reduced the number of cycles for this transient from 24,000 by an order of magnitude (i.e., 2,400), it is not clear to the staff whether there is still margin between the design number and expected number of cycles through the period of extended operation (i.e., approximately [3 cycles per month] x [12 months per year] x [60 years of operation] = 2,160 cycles). Thus, the staff requires additional information to verify the adequacy of the applicant's disposition in accordance with 10 CFR 54.21 (c)(1)(ii), that the CUF of 0.894 for the letdown heat exchanger flange has been projected to be valid through the period of extended operation.

Request:

Given that the CUF value of 0.894 may no longer be valid if the 3-occurrence-per-month assumption through the period of extended operation is exceeded, provide the reason that there is sufficient margin to conclude that the TLAA has been projected to remain valid through the period of extended operation (i.e., 10 CFR 54.21 (c)(1)(i)).

Callaway Response

Following an increase in reactor power, T_{avg} increases and the reactor coolant expands causing pressurizer level to rise. To compensate for this, the charging flow rate decreases while the letdown flow will remain constant. Originally, the plant load was assumed to change twice per day (one increase and one decrease) with an 80% capacity factor. This equates to 24,000 Charging Flow Step Decrease and Return to Normal events.

As a baseload plant, Callaway ideally will experience power changes only at the beginning and at the end of a cycle. This equates to 2 load changes every 18 months or 80 load changes over a 60 year life. This demonstrates that the assumption of 3-occurrence-per-month, or 54 occurrence-per-fuel cycle, is conservative by a factor of 40 and can accommodate any unforeseen operating issues that would necessitate a power reduction and/or increase. Therefore, the 2,400 occurrences used in the analysis will not be exceeded during the 60-year life and is not required to be monitored.

Corresponding Amendment Changes

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

RAI 4.3-15

Background:

LRA Section 4.3.8 states that the fatigue analyses of the letdown heat exchanger also include the tubesheet, tube side nozzles, and the studs, with CUF values of 0.910, 0.843, and 0.635, respectively.

The LRA discusses the transients that were included in the fatigue analyses for these components, the transients that will be monitored by the Fatigue Monitoring Program and the transients that will not be monitored. Specifically, for the "letdown flow step decrease and return to normal" transient with a design limit of 2,000 cycles, the LRA states that it is not a normal operating event with the plant at power but was included in the analysis for conservatism. Furthermore, it states that this transient was assumed to occur approximately once a week for 40 years and if this assumption is extended through the period of extended operation, then 3,000 events will be assumed to occur and the CUF will increase to 0.995, 0.880, and 0.696.

The applicant dispositioned the TLAA for these letdown heat changer components in accordance with 10 CFR 54.21 (c)(1)(ii) to demonstrate that these analyses were projected to be valid through the period of extended operation.

Issue:

Additional information regarding the CUF contribution for each of the transients in the original fatigue analysis for this component is required for the staff to verify the adequacy of the TLAA disposition. ASME Code Section III Paragraph NB-3224(e)(5) Step 1 indicates that transients shall be paired in order to produce a total stress difference range greater than the stress difference range of the individual cycles. It is not clear to the staff whether the applicant has performed a CUF re-calculation, consistent with ASME Code NB-3224(e)(5) Step 1, to arrive at the conclusion that through the period of extended operation with 3,000 cycles of this transient assumed to occur, the CUF values will increase to 0.995, 0.880, and 0.696.

Furthermore, the technical basis to support the assumptions that this transient occurs approximately once a week for 40 years and can be extended to 3,000 cycles for 60 years is not clear to the staff. In addition, it is not clear whether these assumptions are conservative.

Request:

a) Provide the CUF contribution, as documented in the original fatigue evaluation, for each transient pairing (including number of cycles used in each pairing) consistent with Code NB-3224(e)(5).

b) Clarify whether the CUF value has been recalculated consistent with ASME Code Section III NB-3224(e)(5) to reach the conclusion that through the period of extended operation with 3,000 cycles of this transient assumed to occur, the CUF values will increase to 0.995, 0.880, and 0.696 for these components.

   i. If yes, provide the CUF contribution for each transient pair (including number of cycles used in each pairing) and demonstrate that the assumption of 3000 cycles results in CUF values of 0.995, 0.880, and 0.696 for the letdown heat exchanger tubesheet, tube side nozzles, and the studs, respectively.

   ii. If not, justify that the determination in using the assumption of 3000 cycles for the "letdown flow step decrease and return to normal" transient is based on an evaluation consistent with requirements in ASME Code Section III NB-3200.

c) Justify the assumptions that the "letdown flow step decrease and return to normal" transient occurs approximately once a week for 40 years and can be extended to 3,000 cycles for 60 years. In addition, provide the reason that these assumptions are conservative and support the disposition of 10 CFR 54.21 (c)(1)(ii).

Callaway Response

a) Tables 4, 5, and 6 (refer to tables following this response) were extracted from the design report of the letdown heat exchanger.

b) Yes, the conclusion that the letdown heat exchanger CUF will be less than 1.0 if the number of "letdown flow step decrease and return to normal" transient events is increased to 3000 cycles was determined with an evaluation that is consistent with ASME Code Section III NB 3224(e)(5). The conclusion is not based on an entire reanalysis, but a manipulation of the current ASME Section III design report results. The design report meets the ASME Section III NB-3200 requirements.

   i. The CUF contribution for each transient pair is included in the table provided in Part A of this RAI response. The individual contribution of the "Letdown flow decrease and return to normal" transient to the fatigue usage factors will increase as follows:
      - The contribution to the tubesheet CUF will increase from 0.169 [0.144 + 0.018 + 0.007] to 0.2535 [1.5 x 0.169]. This will increase the CUF from 0.910 to 0.995 [0.910 – 0.169 + 0.2535].
      - The contribution to the nozzle CUF will increase from 0.074 [0.067 + 0.007] to 0.111 [1.5 x 0.074]. This will increase the CUF from 0.843 to 0.880 [0.843 – 0.074 + 0.111].
      - The contribution to the stud CUF will increase from 0.121 [0.111 + 0.010] to 0.182 [1.5 x 0.121]. This will increase the CUF from 0.635 to 0.696 [0.635 – 0.121 + 0.182].

   ii. N/A

c) This transient is assumed to occur approximately once a week for 40 years or 2,000 times during the plant design life. If this assumption is extended through the period of extended operation, then 3,000 events will be assumed to occur. The letdown flow rate can be changed manually by switching from one letdown orifice to another or by valving in an additional orifice. Normally, it is changed only to initiate maximum purification or to affect boron concentration changes associated with load follow and plant shutdown. Both of these operations would necessitate an increase in the letdown flow in order to alter the reactor coolant content, e.g. boron concentration. The letdown flow reduction does not support the typical operation of the plant, such as to commence maximum purification or load following operation, and there are currently no plans to implement a letdown flow reduction below nominal (75 gpm). Therefore, the assumption that the transient occurs approximately once a week is conservative and can be extended to 60 years.

Corresponding Amendment Changes

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

Table 4: Tubesheet Fatigue Table for Letdown Heat Exchanger(1)

Transient Pairs(2)				S_{alt} (psi)	Spec. # (n)	Allow. (N)	U
#2	Charging flow shut-off and prompt return	#2	Charging flow shut-off and prompt return	100488	100	1400	0.071
#1	Letdown flow shut-off and prompt return	#5	Letdown flow decrease and return to normal (140°F to 380°F)	62672	200	11000	0.018
#6	Letdown flow decrease and return to normal (490°F to 290°F)	#6	Letdown flow decrease and return to normal (140°F to 380°F)	60170	1800	12500	0.144
#6	Letdown flow decrease and return to normal (490°F to 290°F)	#1	Letdown flow shut-off and prompt return	58734	200	16000	0.013
#4	Charging flow decrease and return to normal	#4	Charging flow decrease and return to normal	45074	24000	47000	0.511
#6	Letdown flow decrease and return to normal (290°F to 140°F)	#7	Letdown flow increase and return to normal (290°F to 405°F)	38514	2000	110000	0.018
#7	Letdown flow increase and return to normal (405°F to 279°F)	#7	Letdown flow increase and return to normal (290°F to 405°F)	33466	24000	300000	0.080
#7	Letdown flow increase and return to normal (405°F to 279°F)	#6	Letdown flow decrease and return to normal (380°F to 490°F)	34529	2000	300000	0.007
#7	Letdown flow increase and return to normal (279°F to 198°F)	#7	Letdown flow increase and return to normal (198°F to 290°F)	22816	24000	1000000	0.024
#5	Charging flow increase and return to normal	#5	Charging flow increase and return to normal	20566	24000	1000000	0.024
						Total U	**0.910**

1 The highlighted transient pairs are those that are altered as a result of an increase in the number of "Letdown flow decrease and return to normal" events to 3,000 as described in response b) of this RAI.

2 Transient numbers correspond to those identified in LRA Section 4.3.8, "Fatigue Analyses of Class 2 Heat Exchangers."

Table 5: Tubeside Nozzle Fatigue Table for Letdown Heat Exchanger[1]

Transient Pairs[2]				S_{alt} (psi)	Spec. # (n)	Allow. (N)	U
#1	Letdown flow shut-off and prompt return	#1	Letdown flow shut-off and prompt return	115552	200	1000	0.200
#2	Charging flow shut-off and prompt return	#2	Charging flow shut-off and prompt return	135462	100	500	0.200
#6	Letdown flow decrease and return to normal (490°F to 290°F)	#6	Letdown flow decrease and return to normal (140°F to 380°F)	46104	2000	30000	0.067
#6	Letdown flow decrease and return to normal (290°F to 140°F)	#6	Letdown flow decrease and return to normal (380°F to 490°F)	32654	2000	300000	0.007
#4	Charging flow decrease and return to normal	#4	Charging flow decrease and return to normal	34560	24000	140000	0.171
#7	Letdown flow increase and return to normal (405°F to 279°F)	#7	Letdown flow increase and return to normal (205°F to 290°F)	33513	24000	160000	0.15
#7	Letdown flow increase and return to normal (279°F to 198°F)	#7	Letdown flow increase and return to normal (290°F to 405°F)	25751	24000	1000000	0.024
#5	Charging flow increase and return to normal	#5	Charging flow increase and return to normal	24826	24000	1000000	0.024
						Total U	**0.843**

1 The highlighted transient pairs are those that are altered as a result of an increase in the number of “Letdown flow decrease and return to normal” events to 3,000 as described in response b) of this RAI.

2 Transient numbers correspond to those identified in LRA Section 4.3.8, “Fatigue Analyses of Class 2 Heat Exchangers.”

Table 6: Stud Fatigue Table for Letdown Heat Exchanger[1]

Transient Pairs[2]				S_{alt} (psi)	Spec. # (n)	Allow. (N)	U
#1	Letdown flow shut-off and prompt return	#1	Letdown flow shut-off and prompt return	30216	200	3600	0.056
#6	Letdown flow decrease and return to normal (140°F to 380°F)	#6	Letdown flow decrease and return to normal (490°F to 290°F)	27698	2000	18000	0.111
#2	Charging flow shut-off and prompt return	#2	Charging flow shut-off and prompt return	36007	100	10000	0.010
#4	Charging flow decrease and return to normal	#4	Charging flow decrease and return to normal	20094	22000[3]	70000	0.314
#6	Letdown flow decrease and return to normal (290°F to 140°F)	#6	Letdown flow decrease and return to normal (380°F to 490°F)	16365	2000	200000	0.010
#7	Letdown flow increase and return to normal (279°F to 198°F)	#7	Letdown flow increase and return to normal (290°F to 405°F)	14196	24000	600000	0.040
#2	Charging flow shut-off and prompt return (Pressure)	#2	Charging flow shut-off and prompt return (Pressure)	15321	100	110000	0.001
#7	Letdown flow increase and return to normal (198°F to 290°F)	#7	Letdown flow increase and return to normal (405°F to 279°F)	15424	24000	350000	0.069
#5	Charging flow increase and return to normal	#5	Charging flow increase and return to normal	9669	24000	1000000	0.024
						Total U	**0.635**

1 The highlighted transient pairs are those that are altered as a result of an increase in the number of "Letdown flow decrease and return to normal" events to 3,000 as described in response b) of this RAI.

2 Transient numbers correspond to those identified in LRA Section 4.3.8, "Fatigue Analyses of Class 2 Heat Exchangers."

3 The original vendor report reduced number of cycles used for this transient to 22000 from the specified value of 24000. This reduction was not explained. This reduction was maintained in order to stay as close to the original analysis as possible.

RAI 4.3-16

Background:

LRA Section 4.3.8 states that the fatigue analysis for the letdown reheat heat exchanger indicated a maximum CUF of 4.431 for the studs that accounts for a recent reanalysis to account for operation (1993-2011) with a letdown flow of 140 gpm. The LRA states that the CUF is driven mainly by the "letdown flow step increase and return to normal" and "load follow boration" transients, which are load-following transients. Furthermore, the LRA states that Callaway does not practice load-following operation and the assumed number of these transients was dropped by an order of magnitude and the CUF dropped to about 0.503.

The applicant dispositioned the TLAA for the letdown reheat exchanger studs in accordance with 10 CFR 54.21 (c)(1)(ii) to demonstrate that the analysis was projected to be valid through the period of extended operation.

Issue:

The staff noted that the "letdown flow step increase and return to normal" and "load follow boration" transients, each with a design limit of 24,000 cycles, were based on load-following operation; thus, it may be reasonable to conclude that because the applicant's site does not practice load-following operation there will be margin between the design limit and the expected number of cycles for these transients. However, since the applicant reduced the number of cycles for these transients from 24,000 by an order of magnitude (i.e., 2,400); it is not clear to the staff whether there is still margin between the design number and expected number of cycles through the period of extended operation. Thus, the staff requires additional information to verify the adequacy of the applicant's disposition in accordance with 10 CFR 54.21 (c)(1)(ii), that the CUF of 0.503 for the letdown heat exchanger studs has been projected to be valid through the period of extended operation.

Request:

Given that the CUF value of 0.503 may no longer be valid if, for each transient ("letdown flow step increase and return to normal" and "load follow boration"), a 3-occurrence-per-month assumption through the period of extended operation is exceeded, provide the basis that there is sufficient margin to conclude that the TLAA has been projected to remain valid through the period of extended operation (i.e., 10 CFR 54.21 (c)(1)(i)).

Callaway Response

The letdown reheat heat exchanger is part of the Boron Thermal Regeneration System (BTRS). The reheat exchanger is used to heat the BTRS process fluid flowing through the shell side. It is arranged so that the letdown flow from the outlet of the regenerative heat exchanger shell side is diverted from the normal letdown path, passes through the tube side of the reheat heat exchanger, and returns to the letdown line upstream of the letdown heat exchanger. Although the reheat heat exchanger is used only intermittently, it is conservatively assumed that the reheat heat exchanger is brought into service for load follow operation.

The numbers of “Letdown Flow Step Increase and Return to Normal” and “load follow boration” transients were reduced in order to get the CUF less than 1.0. These are load following transients and are meant to compensate for changes in the RCS water volume and boron concentration that accompany load changes. As a baseload plant, Callaway ideally will experience power changes only at the beginning and at the end of a cycle. This equates to 2 load changes every 18 months; or 80 load changes over a 60 year life. This demonstrates that the assumption of 3-occurrence-per-month, or 54 occurrence-per-fuel cycle, is conservative by a factor of 40 and can accommodate any unforeseen operating issues that would necessitate a power reduction and/or increase. Therefore, the 2,400 occurrences used in the analysis will not be violated during the 60-year life and is not required to be monitored.

Corresponding Amendment Changes

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

RAI 4.3-17

Background:

LRA Section 4.3.8 states that the fatigue analyses of the letdown reheat heat exchanger also include the shell and tube side nozzles and tubesheet, with CUF values of 0.054 and 0.47, respectively.

The LRA discusses the transients that were included in the fatigue analyses for these components, the transients that will be monitored by the Fatigue Monitoring Program and the transients that will not be monitored. Specifically, for the "letdown flow step decrease and return to normal" transient with a design limit of 2,000 cycles, if the number of events is extended through the period of extended operation, then 3,000 events will be assumed to occur and the CUFs will increase to 0.57 for the tubesheet and 0.0563 for the tube side nozzles. The LRA states that the nozzles CUFs are not affected by this increase.

The applicant dispositioned the TLAA for these letdown reheat heat exchanger components in accordance with 10 CFR 54.21 (c)(1)(ii) to demonstrate that the analysis was projected to be valid through the period of extended operation.

Issue:

Additional information regarding the CUF contribution for each of the transients in the original fatigue analysis for this component is required for the staff to verify the adequacy of the TLAA disposition. ASME Code Section III Paragraph NB-3224(e)(5) Step 1 indicates that transients shall be paired in order to produce a total stress difference range greater than the stress difference range of the individual cycles. It is not clear to the staff whether the applicant has performed a CUF re-calculation, consistent with ASME Code NB-3224(e)(5) Step 1, to arrive at the conclusion that through the period of extended operation with 3,000 cycles of this transient assumed to occur, the CUF values will increase to 0.57 for the tubesheet and 0.0563 for the tube side nozzles.

Furthermore, the technical basis to support the assumption that this transient can be extended to 3,000 cycles for 60 years is not clear to the staff. In addition, it is not clear whether this assumption is conservative.

Request:

a) Provide the CUF contribution, as documented in the original fatigue evaluation, for each transient pairing (including number of cycles used in each pairing) consistent with Code NB-3224(e)(5).

b) Clarify whether the CUF value has been recalculated consistent with ASME Code Section III NB-3224(e)(5) to reach the conclusion that through the period of extended operation with 3,000 cycles of this transient assumed to occur, the CUF values will increase to 0.57 for the tubesheet and 0.0563 for the tube side nozzles.

   i. If yes, provide the CUF contribution for each transient pair (including number of cycles used in each pairing) and demonstrate that the assumption of 3000 cycles results in CUF values of 0.57 for the tubesheet and 0.0563 for the tube side nozzles.

   ii. If not, justify that the determination in using this assumption of 3000 cycles for the "letdown flow step decrease and return to normal" transient is based on an evaluation consistent with requirements in ASME Code Section III NB-3200.

c) Justify the assumption that the "letdown flow step decrease and return to normal" transient can be extended to 3,000 cycles for 60 years. In addition, provide the basis that this assumption is conservative and supports the disposition of 10 CFR 54.2 (c)(1)(ii).

d) Clarify the nozzles CUFs that are not affected by this increase in the "letdown flow step decrease and return to normal" transient described in LRA Section 4.3.8, considering the LRA states that the CUF value increased to 0.0563 for the tube side nozzles.

Callaway Response

a) Tables 7 and 8 (refer to tables following this response) were extracted from the design report of the letdown reheat heat exchanger.

b) Yes, the conclusion that the letdown reheat heat exchanger CUF will be less than 1.0 if the number of "letdown flow step decrease and return to normal" transient events is increased to 3000 cycles was determined with an evaluation that is consistent with ASME Code Section III NB 3224(e)(5). The conclusion is not based on an entire reanalysis, but a manipulation of the current ASME Section III design report results. The design report meets the ASME Section III NB-3200 requirements.

   i. The CUF contribution for each transient pair is included in the table provided in Part a) of this RAI response. The individual contribution of the "Letdown flow decrease and return to normal" transient to the fatigue usage factors will increase as follows:

      - The contribution to the tubesheet CUF will increase from 0.0631 [0.056 + 0.0071] to 0.09465 [1.5 x 0.0631]. This will increase the CUF from 0.46593 to 0.50 [0.46593 – 0.0631 + 0.09465]. The LRA incorrectly states 0.57. LRA Amendment 11 in Enclosure 2 corrects this to 0.50.
      - The contribution to the tube side nozzle CUF will increase from 0.00444 to 0.0067 [1.5 x 0.00444]. This will increase the CUF from 0.05407 to 0.0563 [0.05407 - 0.00444 + 0.0067].

   ii. N/A

c) This transient is assumed to occur approximately once a week for 40 years or 2,000 times during the plant design life. If the number of events is extended through the period of extended operation, then 3,000 events will be assumed to occur. The letdown flow rate can be changed manually by switching from one letdown orifice to another or by valving in an additional orifice. Normally, it is changed only to initiate maximum purification or to affect boron concentration changes associated with load follow and plant shutdown. Both of these operations would necessitate an increase in the letdown flow in order to alter the reactor coolant content, e.g. boron concentration. The letdown flow reduction does not support the typical operation of the plant, such as to commence maximum purification or load following operation, and there are currently no plans to implement a letdown flow reduction below nominal letdown flow (75 gpm). Therefore, the assumption that the transient occurs approximately once a week is conservative and can be extended to 60 years.

d) LRA Amendment 11 in Enclosure 2 revised the letdown reheat heat exchanger portion of LRA Section 4.3.8 to delete the statement that "The nozzles CUFs are not affected by this increase." The deleted sentence reflected the original fatigue analysis which is not the current fatigue analysis which supports the LRA.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 11, LRA Changes from RAI Responses", for a description of LRA changes with this response.

Table 7: Tube Side Nozzle Fatigue Table for Letdown Reheat Heat Exchanger[1]

Transient Pairs[2]				S_{alt} (psi)	Spec. # (n)	Allow. (N)	U
#2	Charging flow shut-off and prompt return	#2	Charging flow shut-off and prompt return	40359	100	70000	0.00143
#6	Letdown flow decrease and return to normal	#6	Letdown flow decrease and return to normal	28800	2000	450000	0.00444
#1	Letdown flow shut-off and prompt return	#4	Charging flow decrease and return to normal	27119	200	500000	0.00040
#11	Load follow boration	#4	Charging flow decrease and return to normal	27069	23800	500000	0.04760
#11	Load follow boration	#7	Letdown flow increase and return to normal	26570	200	1000000	0.00020
#4	Charging flow decrease and return to normal	#7	Letdown flow increase and return to normal	20363	23800	infinity	0
						Total U	**0.05407**

[1] The highlighted transient pairs are those that are altered as a result of an increase in the number of "Letdown flow decrease and return to normal" events to 3,000 as described in response b) of this RAI.

[2] Transient numbers correspond to those identified in LRA Section 4.3.8, "Fatigue Analyses of Class 2 Heat Exchangers."

Table 8: Tubesheet Fatigue Table for Letdown Reheat Heat Exchanger[1]

Transient Pairs[2]				S_{alt} (psi)	Spec. # (n)	Allow. (N)	U
#11	Load follow boration	#2	Charging flow shut-off and prompt return	63670	100	6500	0.01500
#11	Load follow boration	#1	Letdown flow shut-off and prompt return	44250	200	35000	0.00570
#11	Load follow boration	#6	Letdown flow decrease and return to normal	43400	2000	36000	0.05600
#11	Load follow boration	#4	Charging flow decrease and return to normal	39820	21700	67000	0.32000
#6	Letdown flow decrease and return to normal	#4	Charging flow decrease and return to normal	32970	2000	280000	0.00710
#1	Letdown flow shut-off and prompt return	#4	Charging flow decrease and return to normal	32312	200	290000	0.00069
#5	Charging flow increase and return to normal	#4	Charging flow decrease and return to normal	28070	100	420000	0.00024
#5	Charging flow increase and return to normal	#7	Letdown flow increase and return to normal	27254	23900	650000	0.03700
#4	Charging flow decrease and return to normal	#7	Letdown flow increase and return to normal	23580	100	1000000	0.00010
#4	Charging flow decrease and return to normal	#11	Load follow boration	21276	23900	1000000	0.02400
#2	Charging flow shut-off and prompt return	#11	Load follow boration	16717	100	1000000	0.00010
						Total U	**0.46593**

1 The highlighted transient pairs are those that are altered as a result of an increase in the number of "Letdown flow decrease and return to normal" events to 3,000 as described in response b) of this RAI.

2 Transient numbers correspond to those identified in LRA Section 4.3.8, "Fatigue Analyses of Class 2 Heat Exchangers."

RAI 4.3-18

Background:

LRA Section 4.3.8 provides a list of transients that were in the design specification for RHR heat exchanger and states that all of these transients except "pressurization" are monitored by the Fatigue Monitoring Program. The LRA states that the design specification describes the "pressurization" event as pressurization to the design pressure, at the design temperature and ***can*** occur coincidentally with plant cooldown and plant heatup.

Issue:

It is not clear to the staff whether it is only possible for the "pressurization" transient to occur coincidentally with plant cooldown and plant heatup and will not occur coincident with any other transient.

Request:

a) Confirm that the "pressurization" transient can only occur coincident with plant cooldowns and plant heatups and cannot occur coincident with any other transient. Based on this response, clarify whether the "pressurization" transient ***will*** occur coincident with each and every occurrence of the identified transient(s).

b) If it is possible for the "pressurization" transient to occur coincident with any other transient other than plant cooldowns and plant heatups, provide the reason that the Fatigue Monitoring Program will ensure that this fatigue waiver remains valid during the period of extended operation.

Callaway Response

a) The RHR system can only be placed in service below a RCS temperature of 350°F and a RCS pressure less than 450 psig (RHR pump suction relief pressure). These pressure and temperature conditions require a plant cooldown or plant heatup. Therefore, the plant cooldown and plant heatup transients will conservatively account for the “pressurization.”

b) N/A

Corresponding Amendment Changes

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

RAI 4.3-19

Background:

LRA Table A4-1 contains Commitment No. 38, which states that the number of the most severe reactor coolant pump (RCP) CCW transient, elevated CCW inlet temperature transients, will be limited to 75 percent of its design value (i.e., limited to 150) in order to accommodate the seasonal temperature change transient in the RCP thermal barrier flange fatigue analysis.

LRA Section 4.3.2.1 states that the Seasonal Temperature Change is the only transient not counted.

LRA Section A3.2.1.1 states that the transients used in the fatigue analysis of the thermal barrier flange at the CCW connection will be tracked by the Fatigue Monitoring Program, summarized in Section A2.1.

Issue:

LRA Section A3.2.1.1 does not identify that elevated CCW injection temperature transients will be limited to 75 percent of its design value (i.e., limited to 150). Furthermore, the staff noted that A3.2.1.1 does not clearly indicate that, with the exception of the seasonal temperature change transient, the transients used in the fatigue analysis of the thermal barrier flange at the CCW connection will be tracked by the Fatigue Monitoring Program.

10 CFR 54.21(d) requires that the FSAR supplement contain a summary description of the program and activities for managing the effects of aging. Without an explicit reference to the 75 percent limit of the design value of the elevated CCW inlet temperature transients, the proposed FSAR supplement in LRA Section A3.2.1.1 does not reflect an accurate summary description of the program and activities to manage the effects of aging.

Request:

a) Revise LRA Section A3.2.1.1 to indicate that elevated CCW injection temperature transient will be limited to 75 percent of its design value (i.e., limited to 150) in order to accommodate the seasonal temperature change transient in the RCP thermal barrier flange fatigue analysis. In lieu of this revision, identify the section of the current FSAR that references this limitation for the elevated CCW injection temperature transient.

b) Revise LRA Section A3.2.1.1 to indicate that, with the exception of the seasonal temperature change transient, the transients used in the fatigue analysis of the thermal barrier flange at the component cooling water connection will be tracked by the Fatigue Monitoring Program.

Callaway Response

a) LRA Amendment 11 in Enclosure 2 revises LRA Appendix A3.2.1.1 to state the following:

   To account for the increase in usage caused by 20 additional years of operation associated with the seasonal temperature change transient in the RCP thermal barrier flange fatigue analysis and to maintain the usage below the Code allowable of 1.0, the elevated CCW injection temperature transient will be limited to 75 percent of its design value, i.e. limited to 150 transients.

b) LRA Amendment 11 in Enclosure 2 revises LRA Appendix A3.2.1.1 to state the following:

   With the exception of the seasonal temperature change transient, the transients used in the fatigue analysis of the thermal barrier flange at the component cooling water connection will be tracked by the Fatigue Monitoring program, summarized in Section A2.1.

Corresponding Amendment Changes

Refer to the Enclosure 2 Summary Table "Amendment 11, LRA Changes from RAI Responses", for a description of LRA changes with this response.

RAI 4.3-20

Background:

LRA Section 4.3.4, as amended by letter dated May 3, 2012, states that the CUF for wetted reactor coolant pressure boundary (RCPB) locations were categorized based on the strain rate of the dominant transient, which was determined with a qualitative assessment based on experience and not a quantitative stress analysis. In addition, this estimated strain rate was used to calculate an estimated environmental fatigue effect multiplier (F_{en}.)

It further states that this estimated F_{en} was then averaged with the maximum F_{en} for that material type to calculate the average F_{en}, which was used with the design basis CUFs to calculate the estimated EAF CUF. The estimated F_{en} value was based on NUREG/CR-5704 for austenitic stainless steels, NUREG/CR-6583 for carbon and low alloy steels and NUREG/CR-6909 for Ni-Cr-Fe steels. These estimated EAF CUFs were then organized according to their system, thermal zone and material type.

LRA Section 4.3.4, as amended by letter dated May 3, 2012, defines a thermal zone as a collection of piping and/or vessel components which undergo essentially the same group of thermal and pressure transients during plant operations.

Issue:

Since the estimated strain rate was determined based on a qualitative assessment, judgment of the appropriate strain rate must be made based on knowledge of, at a minimum, the transient, system and/or thermal zone in question. However, the applicant did not provide the details of how this qualitative assessment was performed for its plant nor was it justified that this approach was appropriate or conservative for the Callaway plant.

Since the estimated EAF CUFs were organized according to their system, thermal zone and material type, the staff noted that to have a meaningful comparison of the EAF CUFs, it is important that the CUFs were assessed similarly (e.g., amount of rigor in calculating CUF) and used the same fatigue curves in ASME Code, Section III, Appendix I.

In addition, since the LRA states that NUREG/CR-6909 was used for Ni-Cr-Fe steels, it is not clear whether the fatigue curve in Appendix A, Figure A.3, of NUREG/CR-6909 was used when using the F_{en} expression for Ni-Cr-Fe steels.

Request:

a) Describe the qualitative assessment that was used to categorize the CUF for wetted RCPB locations based on the strain rate of the dominant transient and provide the basis that this assessment is appropriate or conservative for the Callaway plant. As part of this description and justification, specifically include the criteria of the qualitative assessment to determine the appropriate strain rate to use in the categorization of EAF CUF.

b) Provide the reason that the method for calculating the average F_{en} (i.e., average of the estimated F_{en} and the maximum F_{en} for the material type) is appropriate and conservative for the plant-specific conditions.

c) Confirm that the EAF CUFs that were organized according to their system, thermal zone and material type were assessed similarly (e.g., amount of rigor in calculating CUF) and used the same fatigue curves in ASME Code Section III Appendix I to provide a meaningful comparison. If not, provide the basis for ranking or comparing the EAF CUFs to one another to provide an appropriate method for screening and determining a "sentinel" location.

d) Since NUREG/CR-6909 was used for Ni-Cr-Fe steels, confirm that the fatigue curve in Appendix A, Figure A.3, of NUREG/CR-6909 was used for determining the F_{en} of Ni-Cr-Fe steels and EAF CUFs for Ni-Cr-Fe components. If not, provide the basis for not considering Figure A.3 of NUREG/CR-6909 for screening and determining a "sentinel" location.

Callaway Response

a) A qualitative estimate of the strain rate for the controlling fatigue transient(s) was determined, based on experience with the corresponding Callaway plant system. These categorizations of strain rate were guided by transient descriptions described in system design documents. Each component was identified with one of eight possible *f* categories as shown in Table 9 (refer to table following this response).

Based on experience with fatigue analyses of many plant components, a strain-rate category was selected to represent each component. This selection was based on the identified transients that would govern the CUF at the given component, and ranking them with respect to how quickly the maximum and minimum stress states are established. For instance, if the majority of CUF for this component would generally be derived from very large temperature step changes, the "High" strain rate category was used. Conversely, components governed by hours-long ramps of temperature and pressure would be assigned to the "V. Slow" category.

b) The Average F_{en} (average of the estimated F_{en} and maximum F_{en}) is appropriate and conservative on the following basis:

This two-part average F_{en} is based on experience with performing detailed F_{en} analyses; in general, the effective F_{en} from a detailed analysis is similar to the F_{en} value computed for just the controlling transient pairs, but only slightly offset due to contributions from the less-significant fatigue pairs. Choosing an average F_{en} halfway between the estimated F_{en} and the maximum F_{en} provides reasonable assurance that the average F_{en} is higher than the effective F_{en}. This procedure is appropriate for the purpose of screening components for potential further evaluation. In addition, the resulting estimated U_{en} values are compared to a conservative threshold value of 0.8 for inclusion in the ranking of sentinel locations.

c) Based on the ASME Code years of analysis, it is assumed that the same fatigue curves for each material were used for the analyses relied upon for the screening process.

The level of analytical rigor has not been specifically reviewed. However, the CUF values used in the screening were developed from the same generation of analyses and are expected to have been performed using the same level of rigor (i.e. elastically-determined stresses with the same transient list and severity using the same ASME, Section III, Appendix I fatigue curve). No elastic-plastic evaluations, which would skew the ranking results, were found for these components. (An example of the difference between elastic and elastic-plastic analytical techniques is that for the same location in the pressurizer inner heater well, the elastic CUF = 0.562 while the elastic-plastic CUF = 0.0103).

Based 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.

Thus, a consistent technical basis appropriate for providing a meaningful comparison has been used to perform the EAF screening and identify appropriate sentinel locations.

d) The design report CUF values (ASME Section III fatigue curve) and the Ni-Cr-Fe equation from NUREG/CR-6909 for computing F_{en} were used to compute the estimated U_{en} used for comparisons. Thus, the fatigue curve in Appendix A, Figure A.3, of NUREG/CR-6909 was not used for these comparisons and rankings. This is acceptable because the three components identified as Ni-Cr-Fe material that were evaluated had very low CUF values using the ASME Section III Appendix I fatigue curve (maximum CUF = 0.068). If adjusted for the fatigue curve in Appendix A, Figure A.3, of NUREG/CR-6909, they would not have been high enough to change the ranking results.

Corresponding Amendment Changes

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

Table 9: Strain Rate Categories

Strain Rate Category	est. $\dot{\varepsilon}$ [%/sec]
Extreme	≥ 5.0
V. High	~ 1.3
High	~ 0.33
Mid-High	~ 0.087
Medium	~ 0.023
Low-Mid	~ 0.0059
Slow	~ 0.0015
V. Slow	≤ 0.0004

RAI 4.3-21

Background:

LRA Section 4.3.4, as amended by letter dated May 3, 2012, indicates that an initial screening list may have been reduced by using one of the following methods:

- *One Thermal Zone can bound another Thermal Zone in a System*
- *One material in a Thermal Zone can bound other materials in the same Thermal Zone*
- *One material in a Thermal Zone can bound other materials in another Thermal Zone*

LRA Section 4.3.4, as amended by letter dated May 3, 2012, defines a thermal zone as a collection of piping and/or vessel components which undergo essentially the same group of thermal and pressure transients during plant operations.

Issue:

Since the initial screening list may have been reduced by using one of the methods described above, which is based on the CUF, F_{en}, thermal zone and material type, the staff noted that in order to have a meaningful comparison to screen EAF CUFs it is important that the CUFs were assessed similarly (i.e., amount of rigor in calculating CUF) and used the same fatigue curves in ASME Code, Section III, Appendix I. In addition, the applicant did not provide specific examples of how/when these methods were used to reduce the initial screening list; therefore, it is not clear how each method was applied and a basis was not provided to support that these methods are appropriate and conservative.

In addition, since the LRA states that NUREG/CR-6909 was used for Ni-Cr-Fe steels, it is not clear whether the fatigue curve in Appendix A, Figure A.3, of NUREG/CR-6909 was used when using the F_{en} expression for Ni-Cr-Fe steels.

Specifically for the "One Thermal Zone can bound another Thermal Zone in a System" method, it is not clear that a higher CUF and F_{en} in one thermal zone bounds a lower CUF and F_{en} from a different thermal zone. Factors such as the following should be considered, at a minimum: (1) the CUF values having been assessed similarly in both thermal zones (i.e., amount of rigor in calculating CUF), (2) use of the same fatigue curves in ASME Code, Section III, Appendix I when comparing CUF, and (3) the thermal zone being considered "bounding" should experience thermal and pressure transients that are more severe compared to the other thermal zone.

Specifically for the "One material in a Thermal Zone can bound other materials in the same Thermal Zone" method, it is not clear that a higher CUF and F_{en} for one material in one thermal zone will always bound a lower CUF and F_{en} of all other materials in the same thermal zone. Factors such as the following should be considered, at a minimum: (1) the CUF values having been assessed similarly for all materials (i.e., amount of rigor in calculating CUF) and (2) the material properties of the components in question, which can affect CUF and F_{en}.

Finally, the "One material in a Thermal Zone can bound other materials in another Thermal Zone" method is a combination of the two methods described above. Thus, the staff's concern about those methods is also applicable.

Request:

For the "One Thermal Zone can bound another Thermal Zone in a System" method:

a) Provide two examples of when this method was used to reduce the initial screening list, including a reason that this method was appropriate and conservative for each situation.

b) Provide the reason that a higher CUF and F_{en} in one thermal zone will bound a lower CUF and F_{en} from a different thermal zone. As part of the justification, specifically address any factors or criteria that are applicable when implementing this method.

c) If the following factors and criteria were not included, as part of the response above, provide the reason that they are not appropriate and do not need to be considered: (1) CUF values being assessed similarly in both thermal zones (i.e., amount of rigor in calculating CUF), (2) use of the same fatigue curves in ASME Code, Section III, Appendix I when comparing CUF, and (3) the thermal zone being considered "bounding" should experience thermal and pressure transients that are more severe compared to the other thermal zone.

For the "One material in a Thermal Zone can bound other materials in the same Thermal Zone" method:

d) Provide two examples of when this method was used to reduce the initial screening list, including a reason that this method was appropriate and conservative for each situation.

e) Provide the reason that a higher CUF and F_{en} for one material in one thermal zone will bound a lower CUF and F_{en} of all other materials in the same thermal zone. As part of the justification, specifically address any factors or criteria that are applicable when implementing this method.

f) If the following factors and criteria were not included, as part of the response above, provide the reason that they are not appropriate and do not need to be considered: (1) CUF values being assessed similarly for all materials (i.e., amount of rigor in calculating CUF) and (2) the material properties of the components in question, which can affect CUF and F_{en}.

For the "One material in a Thermal Zone can bound other materials in another Thermal Zone" method:

g) Provide two examples of when this method was used to reduce the initial screening list, including a reason that this method was appropriate and conservative for each situation.

h) Provide the reason that one material in a thermal zone can bound other materials in another thermal zone. As part of the justification, specifically address any factors or criteria that are applicable when implementing this method.

i) If the following factors and criteria were not included, as part of the response above, provide the reason that they are not appropriate and do not need to be considered: (1) CUF values being assessed similarly in both thermal zones for the different materials (i.e., amount of rigor in calculating CUF), (2) the material properties of the components in question, which can affect CUF and F_{en}, and (3) the thermal zone being considering "bounding" should experience thermal and pressure transients that are more severe compared to the other thermal zone.

Callaway Response

In all of the responses that follow, the term U_{en} is used to report computed values of Environmentally-Assisted Fatigue (EAF). These U_{en} computations were performed as the product of a design CUF and the average F_{en} computed as the average of the estimated F_{en} and the maximum F_{en} for the material type.

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

Pressurizer Instrument Nozzle (SS) (CUF=0.236, F_{en}=11.486, U_{en}=2.711) in the Pressurizer Upper Head thermal zone in the Pressurizer component is bounded by the 3" and 6" Pressurizer Safety and Relief Valve piping (SS) (CUF=0.975, F_{en}= 11.486, U_{en}=11.199) in the Pressurizer SRV/PORV thermal zone in the same component (Pressurizer). In this example, both components are made of the same material.

This example is appropriate because the two components are welded to the same pressurizer vessel and are part of the same pressure boundary experiencing most of the same transients in terms of thermal and pressure severity and number of occurrences.

The example is conservative because the computed CUF of the SRV piping is over 4 times greater than the pressurizer instrument nozzles and the average F_{en} values are equivalent based on the similarities in the loading rates of the controlling transients. The SRV piping will experience higher U_{en} throughout component life based on the similar transient sets.

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

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 in the RSG component 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 in the same component (RSG). In this example, both components are made of the same material.

This example is appropriate because the two components are part of the same RSG primary pressure boundary experiencing most of the same transients in terms of thermal and pressure severity and number of occurrences.

The example is conservative because the computed CUF of the RSG Tubesheet (Continuous region) is greater than the RSG Primary Manway Drain Tube and the average F_{en} values are equivalent based on the similarity of the loading rates of the controlling transients. The RSG Tubesheet (Continuous region) will experience higher U_{en} throughout component life based on the similar transient sets.

b) A similar level of analytical rigor and basis (e.g., elastically-determined stresses with the same transient list, number of occurrences and severity using the same ASME, Section III, Appendix I fatigue curve) is assumed. The computed CUFs will represent an appropriate basis for relative CUF ranking.

c) Items (1) and (2) of c) were included in the response to item b). Item (3): this concept was not a part of the example. However, determination of boundedness using this concept requires consideration both that using a more severe set of transients (i.e., larger ΔT's with shorter duration) than those used in the bounded thermal zone will likely cause larger CUF values, but that the possibly countervailing factor that a shorter duration strain rate may produce smaller F_{en} values. The product of these factors is the key attribute to be used for the boundedness determination.

d) Example #1, The SS material bounds the LAS material in the Pressurizer Upper Head thermal zone:

Pressurizer Upper Head/Upper Shell (LAS) (CUF=0.928, F_{en}=2.455, U_{en}=2.278) in the Pressurizer Upper Head thermal zone in the Pressurizer component is bounded by the Pressurizer Instrument Nozzle (SS) (CUF=0.236, F_{en}= 11.486, U_{en}=2.711) in the same Pressurizer Upper Head thermal zone in the same component (Pressurizer). In this example, the two components are made of different materials. The instrument nozzle is in turn bounded by the PSV and PORV. See response (g).

This example is appropriate because the two components are welded to the same pressurizer vessel and are part of the same pressure boundary experiencing most of the same transients in terms of thermal and pressure severity and number of occurrences. The example is conservative for the following reasons:

- The average F_{en} for the stainless steel material (Pressurizer Instrument Nozzle) is over 4.6 times greater than that for Low Alloy Steel (Pressurizer Upper Head/Upper Shell).
- The CUF of the stainless steel component is a factor of 0.25 of the low alloy steel component (this factor is not sufficiently low to overwhelm the 4.6 times higher F_{en} factor).
- Although the U_{en} values are approximately equivalent on a design transient basis, the Pressurizer Upper Head/Upper Shell is dominated by an unlikely event (inadvertent auxiliary spray event), which, if eliminated from the computation, reduces the design CUF significantly (order of magnitude), while the Pressurizer Instrument Nozzle is affected by transients that occur regularly (pressurizer heatup/cooldown and insurge-outsurge). The basis for minimizing the effect of the inadvertent auxiliary spray event is that the event has a design value of 10 occurrences, but has not actually occurred in the life of the plant and only 1 occurrence is conservatively forecast to occur in the period of time to 60 years.

Example #2, The LAS material bounds the Ni-Cr-Fe material in the RSG Tubesheet thermal zone:

Replacement Steam Generator (RSG) Tube-to-Tubesheet Connection (Ni-Cr-Fe) (CUF=0.068, F_{en}=4.093, U_{en}=0.278) in the Tubesheet thermal zone in the RSG component is bounded by the RSG Tubesheet (Continuous region) (LAS) (CUF=0.428, F_{en}=2.455, U_{en}=1.051) in the same Tubesheet thermal zone in the same component (RSG). In this example, the two components are made of different materials.

This example is appropriate because the two components are part of the same RSG primary pressure boundary experiencing most of the same transients in terms of thermal and pressure severity and number of occurrences.

The example is conservative because the computed CUF of the bounding RSG Tubesheet (Continuous region) is over 6 times greater than the RSG Tube-to-Tubesheet Connection while its average F_{en} value is only 1.67 times that of the bounded Ni-Cr-Fe component, resulting in a 3.78 times larger U_{en} value.

e) A higher CUF and F_{en} for one material in a thermal zone is used to bound a lower CUF and F_{en} of all other materials in the same thermal zone is if the U_{en} for the former sentinel location would be more than double the U_{en} values of the other sentinel locations. This degree of margin always is expected to accommodate any differences in transients or environment experienced.

A similar level of analytical rigor and basis (e.g., elastically-determined stresses with the same transient list, number of occurrences and severity using the same set of ASME, Section III, Appendix I fatigue curves) is assumed. The computed CUFs will represent an appropriate basis for relative CUF ranking. The F_{en} values for each material are computed using the similar loading rates, temperatures and DO and are appropriate for comparison purposes.

f) These two factors (1) and (2) are addressed in e).

g) <u>Example #1, The LAS material in the Pressurizer Upper Head thermal zone is bounded by the SS material in the Pressurizer Safety and Relief Valve piping thermal zone</u>:

The Pressurizer Upper Head/Upper Shell (LAS) (CUF=0.928, F_{en}=2.455, U_{en}=2.278) in the Pressurizer Upper Head thermal zone in the Pressurizer component is bounded by the 3" and 6" Pressurizer Safety and Relief Valve piping (SS) (CUF=0.975, F_{en}= 11.486, U_{en}=11.199) in the Pressurizer SRV/PORV thermal zone in the same component (Pressurizer).

This example is appropriate because the two components are either welded to or are an integral part of the same pressurizer vessel, thus being part of the same pressure boundary and experiencing most of the same transients in terms of thermal and pressure severity and number of occurrences.

The example is conservative because the CUF and F_{en} of the bounding component are both greater than those of the bounded component. This is the only example where one material in a Thermal Zone bounds another material in another Thermal Zone.

h) For different thermal zones in the same component or system, a similar level of analytical rigor and basis (e.g., elastically-determined stresses with the same transient list, number of occurrences and severity using the same set of ASME, Section III, Appendix I fatigue curves) was assumed. Since this level of analytical rigor and basis was comparable, the computed CUFs will represent an appropriate basis for relative CUF ranking. The F_{en} values for each material are computed using the appropriate loading rates, temperatures and DO and are appropriate for comparison purposes. Although not a part of the Example #1, for thermal zones in different components in different systems, unless the thermal and pressure transients of the bounding component are demonstrably more severe than those of the bounded component, the comparisons of CUF and F_{en} may not prove to be appropriate.

i) Items (1) and (2) of i) were included in the response to item h). Item (3): this concept was not a part of the example. However, determination of boundedness using this concept requires consideration both that using a more severe set of transients (i.e., larger ΔT's with shorter duration) than those used in the bounded thermal zone will likely cause larger CUF values, but that the possibly countervailing factor that a shorter duration strain rate may produce smaller F_{en} values. The product of these factors is the key attribute to be used for the boundedness determination.

Corresponding Amendment Changes

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