LTR-NRC-15-18 NP-Attachment

WCAP-17721-P NRC Set 2, Safety and Code Review Branch - Response to Selected RAIs (Non-Proprietary)

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The table below summarizes the Set 2 RAIs from the Safety and Code Review Branch[1] which have responses included in this attachment.

RAI #	Title
2.7	RAI-3 – Upper plenum entrainment
2.10	RAI-3 – Equipment Qualification (EQ) and Net Positive Suction Head analysis (NPSHa)
2.11	RAI-3 – Long term boil-off
2.12	RAI-3 – Event definitions
2.13	RAI-3 – Main feedwater
2.14	RAI-2 – Auxiliary feedwater
2.16	RAI-3 – Safety Injection (SI) water volume and temperature
2.17	RAI-3 – Nodalization
2.23	RAI-3 – Hot leg condensation in NPSHa and EQ
2.28	RAI-3 – Heat transfer directly to containment
2.29	RAI-3 – Inactive metal
2.33	RAI-3 – Secondary side heat transfer
2.34	RAI-6 – Definitions for acronyms

Note: RAI 2.7 was previously addressed via LTR-NRC-15-5[2] by reference to the Westinghouse response to SCVB-RAI-11 which was included in that transmittal. Subsequent clarification calls with the NRC reviewer responsible for set 2 have led to a request for Westinghouse to supplement the previously supplied response with additional information relative to upper plenum entrainment and de-entrainment. This supplemental information is provided in the attachment to this letter.

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology," - Set 2 (Safety and Code Review Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A251)

[2] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," January 2015.

2.7 RAI-3 – Upper plenum entrainment

RAI: Demonstrate that method for modeling the upper plenum entrainment/de-entrainment and condensation in WC/T is appropriate for the M&E evaluation model such that the mass and energy release is adequately predicted.

Comment: In section 2.5 of their initial submittal [1], Westinghouse stated that the same upper plenum entrainment/de-entrainment and condensation model was used for the ECCS evaluation model as were used in the M&E evaluation model. However, the ECCS evaluation model is focused on obtaining an adequate prediction of PCT. On the other hand, the M&E evaluation model is focused on obtaining an adequate prediction of the mass and energy release rates to obtain an adequate prediction of containment pressures and temperatures. Because the figure of merit between the two evaluation models is substantial different, what may be conservative or adequate in one evaluation model may be non-conservative or inadequate in the other. For example, the M&E release is generally decreased to generate a conservative PCT calculation. On the other hand, the M&E release rate is generally increased to generate a conservative containment pressure calculation.

Westinghouse Response

Upper Plenum Entrainment/De-Entrainment and Condensation are discussed in the Westinghouse response to SCVB-RAI-11[1] which was transmitted to the NRC via LTR-NRC-15-5[2]. Subsequent clarification calls between Westinghouse and the NRC have led to a request for Westinghouse to supplement the previously supplied response with additional information regarding upper plenum entrainment and de-entrainment. This supplemental information is provided below.

Supplemental Information Re: RAI 2.7 – Upper Plenum Entrainment / De-entrainment

SCVB-RAI-11 questioned the applicability of WCAP-12945-P-A (WCOBRA/TRAC loss of coolant accident (LOCA) peak clad temperature (PCT) code qualification document) to the LOCA mass and energy (M&E) methodology, considering the figures of merit for LOCA PCT and LOCA M&E are different. The Westinghouse response to SCVB-RAI-11 contained a summary of key LOCA M&E phenomena and related them back to WCAP-12945-P-A from a LOCA M&E perspective.

[1] Request for Additional Information Re: Westinghouse Electric Company Topical Report WCAP-17721-P, Revision 0, and WCAP-17721-NP, Revision 0, "Westinghouse Containment Analysis Methodology - PWR [Pressurized Water Reactor] LOCA [Loss-Of-Coolant Accident] Mass and Energy Release Calculation Methodology" - Set 3 (Containment and Ventilation Branch) (TAC No. MF1797), October 20, 2014 (ADAMS Accession No. ML14254A260).

[2] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," January 2015.

One of the phenomena addressed in the Westinghouse response to SCVB-RAI-11 was upper plenum entrainment and de-entrainment, which was specifically mentioned in RAI 2.7. The Westinghouse response, documented in LTR-NRC-15-5, was focused on how test simulations with WCOBRA/TRAC suggested that [ ]a,c during the reflood process, and the two phase core effluent was transported out of the upper plenum. A key figure used in this argument was WCAP-12945-P-A Figure 14-2-24, which showed that WCOBRA/TRAC predicted a [ ]a,c for the Cylindrical Core Test Facility (CCTF) Run 62. In subsequent discussions, it was agreed that the [ ]a,c

It is recognized that the ability of WCOBRA/TRAC to predict upper plenum entrainment and de-entrainment must be determined [ ]a,c. There are other aspects of CCTF Run 62 that aid in determining the level of de-entrainment occurring in the upper plenum. WCAP-12945-P-A Figure 14-2-25 shows general good agreement in the [ ]a,c. The pressure drop from the lower plenum to the upper plenum is influenced mainly by [ ]a,c in the prediction than the test data. Additionally, WCAP-12945-P-A Figures 14-2-29 and 14-2-30 demonstrate that the measured vs. predicted flow rates through the broken and intact loops are well predicted as compared to test data. Taken in conjunction with the [ ]a,c, the good agreement on the [ ]a,c and the good agreement on the broken and intact hot leg fluid flow rates indicate that WCOBRA/TRAC is accurately predicting the net effect of the upper plenum entrainment / de-entrainment phenomena.

Additionally, Section 15-2-3 of WCAP-12945-P-A provides information on the Upper Plenum Test Facility (UPTF) Test 29B. This was a separate effects test where a two phase mixture was injected into an upper plenum simulator, and the predicted upper plenum fluid mass was compared to the value calculated from test data. The conclusion of this comparison is that WCOBRA/TRAC tends to [ ]a,c

2.10 RAI-3 – Equipment Qualification (EQ) and Net Positive Suction Head analysis (NPSHa)

RAI: Provide an explanation of the methodology for EQ and NPSHa analysis. With this methodology, define the acceptance criteria which are used, how those criteria are demonstrated to be met. Provide this explanation for each of the three containment types (large dry, sub-atmospheric, and ice-condenser). Additionally, address the relevant phases of each methodology, including the post-reflood phase and the decay heat phase. Also address the determination of the single active failure for both types of analyses.

Comment: In table 4-1 row 20 their initial submittal [1], Westinghouse stated that they would assume no steam-water mixing during the long-term containment pressure and temperature analysis for EQ and complete steam-water mixing for minimum NPSHa analysis. However, Westinghouse did not provide an explanation of the methodology for EQ or NPSHa analysis, what acceptance criteria were used, and how those criteria were demonstrated to be met.

Westinghouse Response

WCAP-17721-P includes information on how Westinghouse intends to calculate mass and energy releases used for input to the EQ and NPSHa analyses. Because the loss of coolant accident mass and energy (LOCA M&E) release calculation is considered to be input to the EQ and NPSHa calculations, the acceptance criteria relative to EQ and NPSHa do not lie within the methodology described in WCAP-17721-P. Westinghouse may supply mass and energy releases biased to maximize steam release to the containment atmosphere to a third party responsible for containment response. If Westinghouse is cognizant of the containment response, limiting long term transients will be supplied to the party responsible for determining if equipment will remain operational under the calculated conditions (typically utilities are responsible for EQ programs). The NPSHa calculations are analogous, except that the biases applied maximize sump liquid temperature.

The acceptance criteria for EQ are described in NUREG-0588 Revision 1. Item (1) under Section 1.1 indicates that the time dependent temperature and pressure transients established for the containment design may be used for EQ purposes (i.e. peak containment pressure transient). For large dry and sub-atmospheric containments, WCAP-17721-P Section 4.2 states that mass and energy releases with WCOBRA/TRAC (WC/T) will be calculated for at least one hour in order to capture the transfer to sump recirculation. During this one hour period, the blowdown, reflood, and post reflood (long term) phases are covered. After the WC/T mass and energy release calculation is terminated, the long term boil off (decay heat phase) calculation is initiated (see Westinghouse response to RAI 2.11). The long term boil off calculation, or steaming calculation as it may be called, conservatively maximizes steam release to the containment atmosphere. The WC/T M&E release calculations for ice condenser plants are run through the time of peak containment pressure. A transient time of 20,000 seconds is typically long enough to capture ice bed meltout, reach the resulting peak containment pressure, and demonstrate a downturn in containment pressure subsequent to the peak. After the WC/T release calculation is terminated, an enhanced version of the typical steaming calculation is used to calculate M&E releases (see Westinghouse response to RAI 2.11). The ice condenser steaming calculation conservatively maximizes steam release to the containment atmosphere. Note that long term EQ containment calculations are normally 30 day containment integrity runs; therefore the WC/T mass and energy releases are used only in a short portion of the overall transient. Whether the subject plant is a large dry, sub-atmospheric, or ice condenser design, the mass and energy releases used for EQ purposes will be a composite of WC/T calculated results (3,600-20,000 seconds) and steaming calculation results (up to 30 days).

Sump conditions become limiting when various pumps providing either core cooling or containment spray flow switch from refueling water storage tank (RWST) injection mode to sump recirculation mode, challenging NPSHa. These changeovers occur prior to 1 hour after the double ended reactor coolant system (RCS) pipe rupture. At this time, the sump is at an elevated temperature and the concern is that cavitation may occur due to the warm sump fluid and pressure drop associated with the pumps and piping, and reduce the emergency core cooling system (ECCS) or containment spray effectiveness. This is true for large dry, sub-atmospheric, and ice condenser designs. The WC/T LOCA M&E release calculation is biased to maximize energy in the liquid phase of the break releases. This is completed by calculating the [

]^{a,c} Specific calculations for a plant application would determine the limiting single failure, which could either be the loss of an emergency diesel generator, the loss of a containment spray pump, or loss of a train of containment fan coolers (if the plant analysis models safety grade fan coolers).

2.11 RAI-3 – Long term boil-off

RAI: Describe how the steam-water mixing is calculated in this long-term boil off calculation.

Comment: In table 4-1 row 22 of their initial submittal [1], Westinghouse discussed the long-term phases of the event, but the definitions of each phase were not entirely clear. Additionally, some additional phases were discussed, but not defined. Also, further documentation was needed to clarify the differences between the event itself and how that event was simulated. During an audit at Westinghouse, the information requested above was discussed and the NRC staff believed the information helped to provide a clearer understanding of the event and how the event was simulated.

Westinghouse Response

The LOCA M&E transient can be broken down into four phases; blowdown, reflood, post-reflood, and long term decay heat removal. The blowdown through post-reflood phases are calculated using the WC/T code, and are characterized by the blowdown peak calculated pressure followed by an established trend of decreasing containment pressure after reflood for a large dry containment, or after ice bed meltout for an ice condenser containment. The long term decay heat removal phase is not calculated by WC/T. The long term decay heat removal phase, also known as the boil-off calculation or steaming calculation, is calculated either in the containment code (for example, using control variable logic in GOTHIC), or through hand calculations (typically with a spreadsheet type application). The information provided below details how the long term decay heat removal phase is modelled for the large dry, sub-atmospheric, and ice condenser plant designs.

Large Dry and Sub-atmospheric Containments

The WC/T calculation is terminated at approximately 1-1.5 hours after break initiation. At this time, there is energy stored in the RCS metal, steam generator metal, and steam generator fluid. The quantity of stored energy for each of these terms is reported in WC/T output. Using the code output, [

]a,c

This calculation maximizes the steam release to containment, as described in WCAP-17721-P Table 4-1 row 22. Although this calculation is non-mechanistic, the large dry containment heat removal systems are capable of continuous depressurization in the long term transients.

Ice Condenser Containments

Ice condenser containments have a low design pressure and the containment heat removal capabilities are not as robust as a large dry plant once the ice bed is melted out. If after 20,000 seconds the mass and energy releases in an ice condenser containment model were changed from WC/T to the large dry steaming calculation described above, a drastic increase in containment pressure would result from the instantaneous change to the non-mechanistic steaming calculation. In addition, the ice condenser containment volume is approximately 1/3 of a large dry containment. For these reasons, the steaming calculation was enhanced for ice condenser applications [

]a,c

2.12 RAI-3 – Event definitions

RAI: Provide a table which contains the following:

1. The phase of the event (e.g., Blowdown, Refill, Reflood)
2. The conditions which define the beginning of that phase.
3. The conditions which define the end of that phase
4. An approximate duration of that phase (in seconds)
5. An approximate starting time of that phase (in seconds – with 0 being the event initiation)
6. A description of how the phase is simulated (e.g., mechanistically in WC/T, conservatively using certain approximations)

Additionally, provide a second table which contains a description of the energy sources which impact each of the phases listed in the above table:

1. List each major energy source. The sources of energy should include, but not be limited to: Initial stored energy in the fuel, primary water, water in the broken loop SG, water in the intact SGs, primary metal, metal in the broken loop SG, metal in the intact loop SGs, decay heat.
2. The approximate initial energy of that energy source at the beginning of the event (in kW).
3. The approximate amount of energy which is released during phase 1 (include both kW and %)
4. The approximate amount of energy which is released during phase 2 (include both kW and %)
5. The approximate amount of energy which is released during every other phase of the event (include both kW and %)

Comment: In their initial submittal [1], Westinghouse discussed the different phases of the event, but the definitions of each phase were not entirely clear. Additionally, some additional phases were discussed, but not defined. Also, further documentation was needed to clarify the differences between the event itself and how that event was simulated. During an audit at Westinghouse, the information requested above was discussed and the NRC staff believed the information helped to provide a clearer understanding of the event and how the event was simulated.

Westinghouse Response

The requested tables are attached. Table 1 lists the various phases for the double-ended pump suction (DEPS) loss of coolant accident (LOCA) event. It also includes the time frames, the conditions at the beginning and end of each phase, and a brief description of how the transient response for that phase is calculated. Table 2 presents the transient energy inventory and releases for a DEPS LOCA at a typical 4-loop plant with a large dry containment. The units for the energy release are given in MBTU. The percentage values represent the fraction of the total initial energy that is stored in that component or the fraction of the energy released by that component during the period. The fluid energy is referenced to 32°F, and the fuel and metal energy are referenced to 212°F.

Table 1 – Phases of the Large DEPS Break LOCA Event

Phase	Start Time (seconds)	Conditions at Start	Approximate Duration (seconds)	Conditions at End	How Simulated
Blowdown	0	Full power steady state	20-30	The containment pressure has increased substantially due to the rapid mass and energy release. The reactor coolant system (RCS) is mostly voided and the pressure is approximately equal to the containment pressure. The steam generator (SG) pressure is at or near the safety valve setpoint because the turbine is tripped and the main steam isolation valves (MSIVs) are closed.	WCOBRA-TRAC (WC/T)
Refill	20-30	The accumulators are injecting into the cold legs, but the downcomer and lower plenum of the vessel are mostly voided. The lower plenum pressure is starting to increase. The containment pressure is constant or slowly decreasing.	10-20	Accumulator injection has filled the vessel lower plenum to the bottom of the active fuel. The SG pressure remains high. The containment pressure is constant or slowly decreasing.	WC/T
Reflood	30-50	The fuel temperature is slowly increasing. Safety injection has actuated and water is just starting to cover the active fuel.	100-200	Safety injection has quenched the core, the collapsed liquid level in the core is stable and slowly increasing, and the fuel temperatures are dropping. A frothy 2-phase mixture is exiting the vessel. The SG pressure remains high. Containment pressure could be constant or slowly increasing (depending on the design).	WC/T

Table 1 – Phases of the Large DEPS Break LOCA Event (continued)

Phase	Start Time (seconds)	Conditions at Start	Approximate Duration (seconds)	Conditions at End	How Simulated
Post-Reflood	150-250	The core is quenched. A frothy 2-phase mixture is entering the SG tubes and the lower inlet section has started to quench.	5000 (dry) 20000 (ice)	Sump recirculation has started. The SG tubes have quenched and the remaining secondary-side energy is being transferred to containment. The SG fluid and metal is cooling from the tubesheet up. Containment pressure is past peak and decreasing.	WC/T
Long-term Steaming	5400 (dry) 20000 (ice)	Primarily a liquid release from the vessel side and a saturated steam or two-phase release from the SG side of the break.	Until End of Transient		Conservatively calculated, as described in Section 4.2 of WCAP-17721-P and in the response to RAI 2.11.

a,c

2.13 RAI-2 – Main feedwater

RAI: Provide an estimate of the additional energy which the inclusion of main feedwater flow would add to the secondary side of the steam generator and demonstrate that including this additional energy is negligible compared to the total energy already stored in the steam generator.

Comment: In table 4-2 row 9 of their submittal [1], Westinghouse discussed how the main feedwater flow would be ignored in the modeling of the event. Main feedwater flow is relatively hot and will increase the energy stored in the steam generators, which will also increase the mass and energy released to containment and could increase the peak containment pressure and temperature. Therefore, ANS 56.4 suggests that this flow should be considered during analysis. Westinghouse stated that they did not need to consider this flow for their analysis as the additional energy was negligible, but did not any quantitative analysis.

Westinghouse Response

A loss of offsite power is assumed at the start of a LOCA event. The loss of offsite power causes the feedwater pumps to trip and the flow rate to coast down. A safety injection (SI) signal causes the feedwater control valve to start to close. The SI signal is generated fairly quickly in a large LOCA event. Therefore, the main feedwater flow would continue for only a short period of time following the design basis large LOCA event.

During the initial WC/T LOCA mass and energy (M&E) model development program, a sensitivity case was made to examine the containment response to modeling the coast down of feedwater flow. For the sensitivity case, the feedwater flow was ramped down to zero over the first 10 seconds of the transient. This added approximately 5500 lbm of hot water and approximately 2.5 MBTU of energy to each steam generator. This represented about 2% of the total energy in each steam generator. The calculated containment pressure and temperature were not affected by this small increase in the steam generator energy (see response to RAI 10 on page 10-14 of WCAP-17721-P).

From RAI 2.12, the total energy release to containment at the end of the reflood phase is approximately 470 MBTU. Of this amount, about [

]^{a,c} Assuming the additional energy from modeling the coast down of main feedwater would be released at the same rate as the rest of the steam generator energy, the increase in the amount of energy that would be released at the end of reflood phase would be about 0.7 MBTU. This represents 0.15% of the total energy release at the end of the reflood phase and is considered to be negligible.

2.14 RAI-2 – Auxiliary feedwater

RAI: Clarify the modeling of the auxiliary feedwater and extraction steam. If both of these systems are being modeled in the M&E evaluation model, justify the modeling of both of these systems when the modeling of the main feedwater has been deemed negligible.

Comment: In table 4-2 row 10 of their submittal [1], Westinghouse discussed how the auxiliary feedwater flow would be modeled in the event. Auxiliary feedwater flow is relatively cool and will decrease the energy stored in the steam generators, as will extraction steam. In turn, this could decrease the calculated mass and energy released to containment which would decrease the calculated peak containment pressure and temperature. While modeling of these system can be appropriate, the NRC staff questioned the validity of modeling extraction steam and auxiliary feedwater (which would reduce the mass and energy released to containment) but ignoring main feedwater flow (which would increase the mass and energy released to containment).

<u>Westinghouse Response</u>

Row 10 of Table 4-2 in WCAP-17721-P indicates that [

]^{a,c} Revised text will be supplied in a future transmittal collecting changes resulting from responses to all RAIs.

2.16 RAI-3 – Safety Injection (SI) water volume and temperature

RAI: Are measurement uncertainties considered for the values of the initial safety injection tank water volume and water temperature?

Comment: In table 4-2 row 21 of their initial submittal [1], Westinghouse stated that measurement uncertainties were considered in the modeling of the accumulator pressure, but did not state whether measurement uncertainties were considered in the model of the water volume and temperature in the accumulator.

Westinghouse Response

Core cooling fluid is supplied prior to sump recirculation by the accumulators and pumped injection from the refueling water storage tank. The accumulators are located inside containment, [

]a,c The refueling water storage tank (RWST) is located outside containment. The boundary conditions representing pumped safety injection in WC/T [

]a,c

2.17 RAI-3 – Nodalization

RAI: Provide justification which demonstrates that the nodalization used in WC/T results in appropriate predictions of the break flow and flow in the broken and intact loops such that the resulting predictions of mass and energy release will result in appropriate calculations of containment temperature and pressure. Additionally, provide a sensitivity study which demonstrates that the noding sensitivity in the steam generator.

Comment: In table 4-2 row 25 of their initial submittal [1], Westinghouse stated that the same nodalization was used for the ECCS evaluation model as was used in the M&E evaluation model. However, the in section 2.8 of their submittal, Westinghouse stated that the noding was increased to account for physical phenomena. However, there is no data which demonstrates that the solution is not sensitive to the noding chosen and a further increase in noding may be needed.

Westinghouse Response

The break flow modelling and the loop flow split, which are dependent upon the WC/T noding structure, are discussed in the Westinghouse response to SCVB-RAI-11 which was transmitted to the NRC via LTR-NRC-15-5[1].

The statement in Table 4-2 row 25 of WCAP-17721-P was in reference to the general vessel and loop layout, [

]^{a,c} also described in WCAP-17721-P Section 4.1.

The LOCA PCT SG model includes [ ]^{a,c} In order to more accurately model the post-LOCA SG cool down, the LOCA M&E SG model uses [ ]^{a,c} The level of subdivision in the LOCA M&E model has been demonstrated to be sufficient through a FLECHT-SEASET simulation sensitivity study. The number of secondary nodes was [

]^{a,c} The SG outlet vapor temperatures in Figure 2 show that the temperatures of the sensitivity case remain within 2% of the base case results during the first 50 seconds of the transient and within 1% for the rest of the transient. The SG tube wall temperatures were also similar as shown in Figure 3, Figure 4 and Figure 5. This demonstrated

[1] LTR-NRC-15-5, "Submittal of "WCAP-17721-P NRC Set 2, Safety and Code Review Branch, and Set 3, Containment and Ventilation Branch – Response to Selected RAIs" (Proprietary/Non Proprietary)," January 2015.

that the current SG secondary noding structure [ ]a,c was adequate.

a,c

Figure 2: FLECHT Steam Generator Outlet Vapor Temperature Comparison

a,c

Figure 3: FLECHT Steam Generator Wall Temperature Comparison at 1 ft

a,c

Figure 4: FLECHT Steam Generator Wall Temperature Comparison at 4 ft

a,c

Figure 5: FLECHT Steam Generator Wall Temperature Comparison at 10 ft

2.23 RAI-3 – Hot leg condensation in NPSHa and EQ

RAI: Demonstrate that the assumption to ignore any hot leg condensation is also appropriate for NPSHa and EQ analysis.

Comment: In section 2.6 of their initial submittal [1], Westinghouse stated that the hot leg condensation would be ignored as this was conservative for a contaminant pressure as it insured the maximum amount of steam to containment. However, Westinghouse did not address how this assumption would impact the other two purposes of an M&E analysis, NPSHa and EQ analysis.

Westinghouse Response

The NPSHa for the recirculation pumps is only a concern when the operator transfers from the injection mode to the cold leg recirculation mode. This occurs within about an hour after the start of the large break LOCA event. Hot leg condensation is not possible at this time; there is no source of cold water or metal in the hot legs that would condense the steam coming from the core. Therefore, ignoring hot leg condensation has no effect on the NPSHa analysis.

Hot leg condensation does not become important until after the operator transfers from cold leg to hot leg recirculation. This occurs several hours after the start of the large break LOCA event. The relatively cold recirculation water that enters the hot legs condenses steam coming from the core. This reduces the amount of steam released to containment and allows the containment pressure and atmosphere temperature to decrease. This reduction is beneficial when comparing the calculated containment response to the equipment qualification pressure and temperature envelopes. Therefore, ignoring the effect of hot leg condensation is conservative for the EQ analysis.

2.28 RAI-3 – Heat transfer directly to containment

RAI: Is heat transfer from the primary and secondary metal to containment directly calculated and if not why is this appropriate?

Comment: None.

Westinghouse Response

Direct heat transfer to containment is not modeled from the active RCS and SG metal. Because most of the RCS and SG metal is insulated, the direct heat transfer rate to the containment atmosphere would be fairly low when compared with the heat transfer rate to the corresponding RCS or SG fluid that is in contact with the active metal.

The heat transfer rate from the active RCS and SG metal is modeled in the WC/T LOCA M&E release calculation. The active RCS metal energy that is transferred to the RCS fluid will be released to containment via the break. The active SG metal energy that is transferred to the SG fluid will be transferred through the SG tubes to the RCS fluid, and then released to containment via the break. This approach, to transfer the active metal energy to produce steam from the RCS, is more conservative than direct heat transfer from the metal to containment through the insulation.

2.29 RAI-3 – Inactive metal

RAI: Define inactive metal and discuss how it is treated.

Comment: None.

Westinghouse Response

Inactive metal is defined as metal that is not in direct contact with water at the end of the blowdown phase of the large LOCA event. This includes the RCS upper head and pressurizer metal, along with the metal in the upper regions of the steam generators.

Because the inactive RCS and SG metal is not in direct contact with the RCS fluid, it does not cooldown as quickly as the active metal. If modeled, free convection and radiation from the outside surface, along with conduction to active metal components, would allow the inactive metal energy to be transferred to containment at a much slower rate.

Currently, the inactive metal in the WC/T model is [

]a,c

2.33 RAI-3 – Secondary side heat transfer

RAI: Specify how the heat is treated between the secondary side metal to the secondary side coolant, and from the secondary side coolant to the steam generator tubes.

Comment: In their initial submittal [1], Westinghouse did not specify have this heat transfer was treated.

Westinghouse Response

Heat transfer between the active SG metal and the secondary side coolant, and between the secondary side coolant and the SG tubes, is included in the WC/T LOCA M&E release model. During steady state (prior to the LOCA), nucleate boiling from the tubes to the secondary fluid is the dominant heat transfer mode. After the LOCA starts, the MSIVs close and the feedwater flow stops, causing the steam generators to be isolated. After SG isolation occurs, the heat transfer mode is primarily natural convection from the secondary fluid to the tubes, and either natural convection or nucleate boiling from the secondary shell to the fluid.

The WC/T secondary side heat transfer calculation uses the same correlations that are applied to the TRAC components; the TRAC wall heat transfer model is described in detail in Section 6-3 of WCAP-12945-P-A, Volume 1, Revision 2. The TRAC correlations are: single phase liquid natural convection (the maximum of McAdams – laminar and Holman - turbulent), single phase liquid forced convection (the maximum of Rohsenow/Choi – laminar and Dittus/Boelter – turbulent), nucleate boiling (Chen), critical heat flux (Biasi), transition boiling (Jones/Bankoff), film boiling (Forslund/Rohsenow for wall-to-liquid, when the vapor void fraction is [ ]^{a,c}, and the maximum of Dougall/Rohsenow, Bromley, or McAdams for wall-to-vapor, when the vapor void fraction is [ ]^{a,c}), and single phase vapor (the maximum of McAdams – turbulent natural convection and Dittus/Boelter – turbulent forced convection when the vapor void fraction is [ ]^{a,c}).

2.34 RAI-6 – Definitions for acronyms

RAI: Provide the definition for the following acronyms: PCWG, DEPSG, EQ, NPSHa, DEHLG, GENF

Comment: None

Westinghouse Response

PCWG – Performance Capability Working Group
DEPSG – Double-ended Pump Suction Guillotine
EQ – Equipment Qualification
NPSHa – Net Positive Suction Head – Available
DEHLG – Double-ended Hot Leg Guillotine
GENF – This is not an acronym; it is the name of a computer program that calculates the steady state thermal performance for a steam generator.