SUPPLEMENTAL RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**394-8460**
SRP Section:	**06.02.01.03 – Mass and Energy Release Analysis for Postulated Loss-of-Coolant Accidents (LOCAs)**
Application Section:	**6.2.1.3**
Date of RAI Issue:	**02/03/2016**

Question No. 06.02.01.03-10

SRP Section 6.2.1.3 Acceptance Criterion No. 1C(iv) asks for a description of the long-term cooling (or post-reflood) model. However, the DCD or TeR do not provide any discussion or justification of the methods used to calculate the core inlet and exit flow rates and removal of the sensible heat from primary system metal surfaces and the steam generators (SGs). Liquid entrainment correlations for fluid leaving the core and entering the SGs are neither described nor justified by comparison with experimental data. No statements are made about steam quenching by ECCS water or the applicable experimental data, or whether and how all the remaining stored energy in the primary and secondary systems would be removed during the post-reflood phase. No references are made to compare the results of post-reflood analytical models with the applicable experimental data. The applicant is requested to add these descriptions in the DCD, or appropriately reference them.

Response

The post-reflood model is identical to the reflood model except that the CRF is changed from 0.8 to 1.0. The post-reflood transient is a continuation of the reflood model. Therefore, any assumption and method of the reflood phase is applicable to the post-reflood phase as well.

The liquid entrainment (CRF) is assumed to be 1.0 during the post-reflood period, while the applicable value in the NRC SRP Section 6.2.1.3 Acceptance Criterion No. 1C(iii) is 0.05. This assumed CRF of 1.0 is a conservative value which increases the system flow rate and eventually maximizes the break flow during the post-reflood period.

The assumption of steam quenching is also identical to that of the reflood period which is expressed as “the steam condensation”. As mentioned in the item i of Section 3.6 of the TeR (APR1400-Z-A-NR-14007, Rev.0), credit is not taken when the SI flow is too low to thermodynamically condense all of the steam in the annulus. Thus, credit is not taken for the condensation after the turndown to low SIT flow by the fluidic device during post-reflood period.

For the removal of all the remaining stored energy in the primary and secondary systems, the detailed descriptions are provided in the section of the reflood model description, Section 3.6 of the TeR.

During the decay heat phase after the EOPR, which is relatively stable period characterized by decay heat release, the M/E release through the break is calculated using the RCS model based on the GOTHIC lumped-parameter volume approach.

The RCS model has three lumped-parameter volumes that represent a RCS core, a downcomer and a piping (hotleg or coldleg). The RCS core volume contains a thermal conductor that models the RCS metal sensible energy release and three GOTHIC heater components that model heat releases from the core decay heat, metal and coolant energies stored in SGs secondary side. All energies stored in metal and coolant in SGs secondary side are modeled to be directly released to the core coolant and exhausted within 24 hours after accident initiation.

This modeling approach is to demonstrate that the containment pressure at 24 hours of the accident is compliant with the requirement (SRP 6.2.1.1.A) describing that the containment pressure should be reduced to less than 50 % of the calculated peak pressure within 24 hours after the accident initiation.

The RCS model and the analysis method for the decay heat phase are described in detail in the Appendix A, Section A.2.3 and Section A.2.4 of the Technical report APR1400-Z-A-NR-14007-P, Rev. 0 “LOCA Mass and Energy Release Methodology”.

Supplemental Questions

Public Teleconference (August 9, 2016)

No references are given that would compare the results of post-reflood analytical models to applicable experimental data.

Public Teleconference (September 22, 2016)

The staff issued RAI 8460, Question 28927 (06.02.01.03-10) to request the applicant to add description of the long-term cooling (or post-reflood) model and its comparison with the applicable experimental data, in the DCD, or appropriately reference them. The applicant’s response dated, June 8, 2016, stated that the post-reflood transient is a continuation of the reflood transient, all modeling assumptions and method are identical, except that the liquid entrainment (CRF) is changed from 0.8 for reflood to 1.0 for post-reflood. The response also provided details of the lumped-parameter GOTHIC model for the RCS used to calculate the M&E release through the break during the decay heat phase. The RCS model has three lumped-parameter volumes that represent a RCS core, a downcomer and a hot/cold leg piping segment. However, in the July 7, 2016 public teleconference, the staff inquired whether the use of the GOTHIC code for the decay heat phase M&E release analysis can be considered appropriate for this application. In the August 9, 2016 public teleconference, the applicant provided justification regarding the use of the GOTHIC model for the decay heat phase M&E release that the staff would consider acceptable when the applicant submits the revised RAI response with the supplemental information. Therefore, RAI 8460, Question 28927 (06.02.01.03-10) and the associated DCD and TeR revisions are tracked under an open item**.**

Supplemental Response

Public Teleconference (August 9, 2016)

The post-reflood transient is a continuation of the reflood phase transient. The post-reflood model is identical to the reflood model. Therefore, any assumption and method for the reflood phase is applicable to the post-reflood phase, except for the CRF assumption.

As mentioned in the response to the RAI 8460 Question 06.02.01.03-5, during reflood/post-reflood periods, no critical break flow is predicted and the mass release calculation in the FLOOD3 code is performed using the flow resistances in the hydraulic network presented in Figure 1 of Reference 10 [“Computer Code Description and Verification Report for FLOOD 3,” Nuclear Power Systems, Combustion Engineering, Inc., February 4, 1988.] in DCD Section 6.2.9. Since the flow resistances in the hydraulic network were conservatively considered in the calculation of the break flow (i.e. minimized), and although the experimental data of reflood break flow is not available, the mass release calculation in the FLOOD3 code is still conservative.

The decay heat phase is a relatively stable period characterized by the release of core decay heat and RCS/SGs metal sensible energy to containment, thus it doesn’t require specific conservative models to calculate the break flow. The RCS with both SGs is modeled as a single volume containing a thermal conductor and several heaters that model the heat release from the decay energy plus the stored energy in the RCS and the SG secondary side. This modeling approach is based on the definition of the decay heat phase describing; “The RCS and SGs are in thermal equilibrium during the decay heat phase.” [ANS/ANSI 56.4]

As an example that uses the GOTHIC for the decay heat phase M&E release, it is known the Dominion’s power plant. The GOTHIC is used for the M&E calculation during the post-reflood by Dominion in their containment analysis methodology, which was previously approved by the NRC for Surry. [DOM-NAF-3 NP-A, “GOTHIC Methodology for Analyzing the Response to Postulated Pipe Ruptures inside Containment.” ML063190467]

Public Teleconference (September 22, 2016)

This supplemental response to RAI 8460, Question 06.02.01.03-10, provides answers to NRC staff questions based on the August 9, 2016 and September 22, 2016 public teleconferences.

Impact on DCD

There is no impact on the DCD.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.