RESPONSE TO AUDIT ISSUES

APR1400 Topical Reports

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

Docket No. PROJ0782

Review Section	**TR Realistic Evaluation Methodology for LBLOCA of the APR1400**
Application Section	**Topical Report: APR1400-F-A-TR-12004 Realistic Evaluation Methodology for Large-Break LOCA of the APR1400**
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Audit Issues No. 5

The guidance in RG 1.157, Section 4.3.1 establishes acceptable controls for the utilization of conservative parameters in best estimate analysis. The topical report states that the methodology is best-estimate. However, the actual implementation of the methodology incorporates a mixture of best-estimate and conservative assumptions. The reason for the conservative treatment is provided for only certain parameters. The Applicant will need to provide the basis and justifications for the selecting the parameters to be treated conservatively instead of a best-estimate manner, involving the quantification and propagation of uncertainties.

Response

The phenomena treated conservatively are shown in the Table 1. The PIRT table in the topical report contains some errors and will be revised in association with audit issue no. 15. The part of the revised PIRT table is shown in Table 1 for conservatively treated phenomena. The basis and justification of the conservatism for each phenomenon are organized by components and are given below. According to regulatory guide 1.157, conservatism may be introduced by the following reasons.

1. The model simplification or conservatism has little effect on the result, and therefore the development of a better model is not justified.

2. The uncertainty of a particular model is difficult to determine, and only an upper bound can be determined.

3. The particular application does not require a totally best-estimate calculation, so a bias in the calculation is acceptable.

The category of conservatism of each phenomenon described below is also provided.

1) Containment

- Pressure and temperature history

The calculated peak cladding temperature must be very sensitive to the containment pressure and temperature during reflood period. In other words, if the containment pressure and temperature were considered as the uncertainty parameters, the calculated results (SRS) would vary widely. In practical application, the severe variation of the calculation result is not desirable. Therefore, the most conservative condition is imposed for the containment condition. In LBLOCA view point, the lower containment pressure and temperature, the more unfavorable for PCT calculation. The containment pressure and temperature condition is determined to have minimum pressure and temperature that can be obtained by CONTEMPT/MOD4, which is the conservative code with conservative user input. The category of conservatism of this belongs to Category 2.

2) SIT

- Gas discharge to piping

The nitrogen gas is injected just after the SIT injection ends. The SIT injection ends at the end of early reflood period. Thus the influence of the nitrogen gas is possible for period 3 and 4. The importance rank 5 is imposed for period 4, differently from the PIRT in the topical report. From the assessment against VAPER test, which is the full scale SIT-FD test, the gas discharge to piping phenomena is modeled to give the most conservative results. The details are well described in Appendix H of the topical report. The category of conservatism of this belongs to Category 3.

- SIT/Fluidic device high-flow delivery, low-flow delivery

The high- and low-flow deliveries of SIT-FD are treated conservatively by applying the most conservative combination of K-factors as discussed in Appendix H of the topical report. The other parameters related with SIT-FD such as inventory, pressure and temperature are treated as uncertainty parameters.

As the results of the various assessments in Appendix H of the topical report, it is concluded that the modeling difference does not produce significant changes in the injection flow rates on the plant calculation results. The conservative treatment of high-flow and low-flow deliveries in SIT/FD component belongs to Category 1.

3) Break

- Delta P (1-phase, 2-phase)

Delta P consideration at the break plane is given in Section 4.2.2.7 and 5.2.1.1 of the topical report. The break mass flow rate is influenced by Delta P at the break plane and discharge coefficients. From the Marviken test assessment, discharge coefficients are determined to be the best-estimate approach. Delta P is determined according to the flow condition of single-phase or two-phase flow. It is also influenced by the configuration of the break plane. By performing the break location sensitivity study, the most conservative break location is determined. The sensitivity calculation with varying break locations gives the cladding temperature variations and those results of cladding temperatures are always lower than the selected break location. The most conservative break location is cold leg (pump discharge line) break. The limiting break configuration and size is determined through the break spectrum and configuration sensitivity studies. As a result, the limiting break location, size and configuration is determined. Therefore, the uncertainty of Delta P is conservatively treated through the limiting break location, size and configuration considerations. Also, the uncertainty of loop Delta P is covered by RCP K-factor uncertainty. The conservative treatment of Delta P belongs to Category 3.

4) Reactor vessel upper head

- Upper head to upper plenum via upper guide structure support plate flow

The upper head water can flow down to the upper plenum and may affect the core cooling behavior during blowdown. This phenomenon is considered by the noding scheme. By performing several sensitivity studies on the nodalization of upper guide structure (UGS, the volume between upper guide structure support plate and inner vessel assembly), the noding that gives the most conservative result is determined. The limiting UGS noding is used for the plant calculation of the topical report. Figure 1 and Figure 2 show the conventional noding scheme and the most conservative noding scheme, respectively. Figure 3 shows the effect of the noding scheme on the cladding temperature. Although reflood PCT is changed more, the phenomenon is important for blowdown because the phenomenon is related with blowdown quenching. The category of conservatism of this phenomenon belongs to Category 2.

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Figure 1. The conventional noding diagram of UGS [ ]TS

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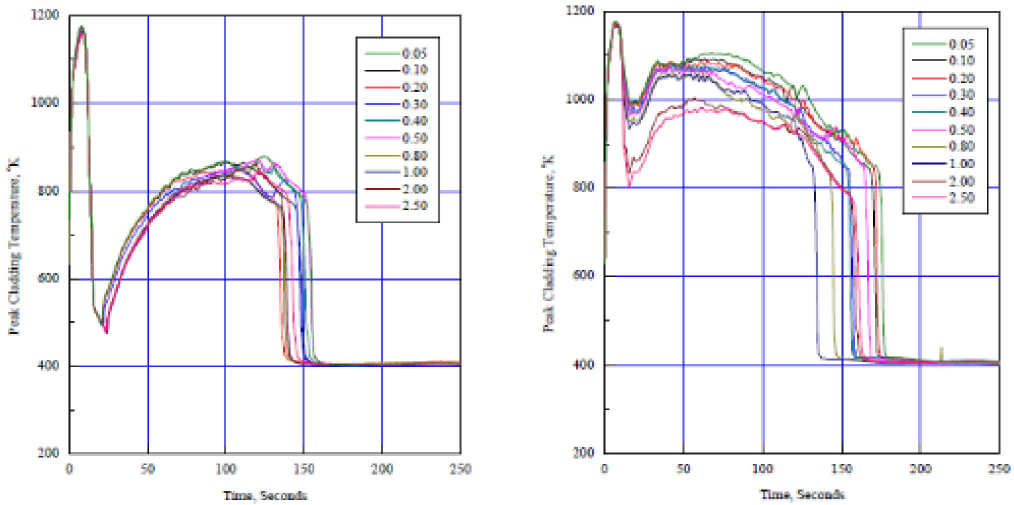
Figure 2. The most conservative noding diagram of UGS [ ]TS



a) [ ]TS b) [ ]TS

Figure 3. The effect of the noding sensitivity

5) Reactor vessel core region

- Radiation heat transfer to surfaces, vapor & liquid

The radiation heat transfer to surfaces will always reduce the peak cladding temperature since the radiation heat transfer from fuel rod to other structures (e.g., the nearby fuels) will contribute to the cooling of the hot fuel at certain amount. The radiation heat transfer to surface to surface is neglected for conservatism. However, as described in the response to audit issue 37 (a) and (b), the radiation heat transfer to vapor and liquid is not neglected. The effect of radiation heat transfer to surfaces is shown in Figure 4 and shows the conservatism of the neglected radiation heat transfer assumption. Also refer to the response of the audit issue 37. The effect of the radiation heat transfer on PCT is about -22 K. The conservative treatment of this phenomenon belongs to Category 3.

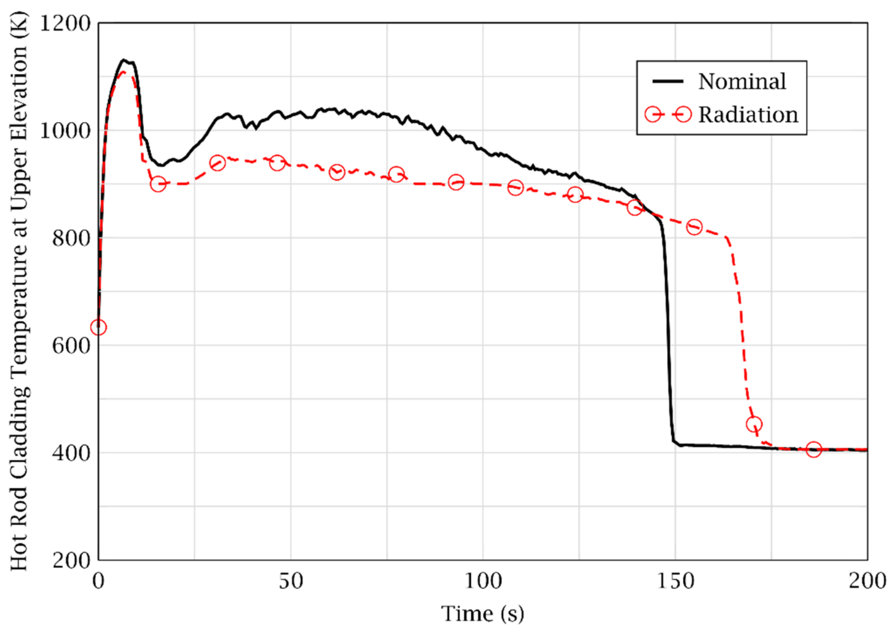


Figure 4. The effect of radiation heat transfer to surfaces on PCT

- Reactivity

As described Section 5.1.2 of the topical report, the most conservative moderator density vs. reactivity curve provided by the core design group is used to bound the uncertainty of the moderator density reactivity. This curve is made assuming non-uniform voiding and hot zero power. However, this curve causes unphysical power increase at the early stage of the transients, as pointed out by the staffs during the audit. Therefore the conservative curve at the hot full power condition will be used for the plant calculations. The topical report will be revised later. The category of conservatism of this phenomenon belongs to Category 2.

- Boron reactivity effect

The boron reactivity which gives negative reactivity is not considered for conservatism. The conservative treatment of this phenomenon belongs to Category 2.

- Fuel relocation into clad-ballooned region

As stated in section 4.2.2.1.1 of the topical report, clad ballooning has favorable effect on PCT because of the increased distance between cladding and fuel pellet. Fuel relocation into the clad ballooning region can increase PCT but this phenomenon is not considered as uncertainty parameters due to the limited occurrences of the fuel relocation. It seems that the use of higher Fq in CAREM can encompass the uncertainty of this phenomenon. [

]TS The category of this conservatism treatment belongs to Category 3.

- Spacer grid heat transfer effects

As described in Sec 4.2.2.1.2 of the topical report, spacer grids of the fuel assembly usually have three effects on core cooling; (1) heat transfer enhancement by the agitation of the flow, (2) rewetting of spacer grids, and (3) breakup of entrained water drops into fine droplets. All three have favorable effects on core cooling. By neglecting the spacer grid heat transfer effects, the conservative cladding temperature is obtained. The phenomenon is treated conservatively because this belongs to Category 3.

6) Reactor vessel downcomer region

- Non-condensable gas effect

As described in Appendix H of the topical report, non-condensable gas behavior on Apr1400 is modeled using the model C. Non-condensable gas injection before end of SIT-FD was considered to be non-conservative due to the reduced amount of remaining non-condensable gas in the SIT dome during SIT-FD injection period. This issue is assessed in Appendix H and it is concluded that the non-condensable injection before end of SIT-FD should be neglected to be conservative. Moreover, non-condensable gas effect varies with the non-condensable injection rate from the SITs. The injection rate of non-condensable gas depends on the initial SIT pressure, water volume, and temperature. These are selected as uncertainty parameters to treat their uncertainties. This conservative treatment belongs to Category 3.

Table 1. Phenomena treated conservatively in CAREM

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Impact on DCD

There is no impact to 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 Report

Topical report will be revised according to the PIRT revision as described in the attachment for the response of Audit Issue No. 14.

There is no impact on any Technical or Environmental Report.