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The Effect on APR1400 SI Optimization according to the Changes of ECCS Acceptance Criteria of USNRC

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1. Introduction

In early 2006, U.S. NRC has finalized the Option 3 approach for Large Break LOCA(LBLOCA) requirement. This is recognize that the initiating frequency of LBLOCA, specially double-ended guillotine(DEG) break, is small and small break and transients are high contributor to the risk. The rule determines the transition break size and for the size above the transition break, it is to be considered as beyond design basis accident. In this case, the best estimate analysis will be performed without single failure constraint.

In this study, we perform sensitivity analyses for transition break size to optimize safety injection system and to evaluate the effect of the new 10CFR50.46(ECCS acceptance criteria) for APR1400 using RELAP5/Mod 3.3 code [1]. To evaluate ECCS performance, LBLOCA has been set up best estimate methods such as CSAU [2], KREM [3] and so on. However, there is no uncertainty quantification method for small break LOCA. Therefore, in this study, we apply Limit Value Approach for the transition break LOCA and best estimate approach for the LBLOCA.

2. Basecase Analysis

For the best estimate analysis about LBLOCA using APR1400 model, major initial / boundary conditions having nominal values are given as Table 1.

Table 1 Initial/Boundary Condition for APR1400 LBLOCA

Conditions	Value
Break size	1.0 cold leg guillotine
Reactor power	100%
Decay heat	1979 ANS
SI flow	Nominal
# of SIPs	4 (no single failure)
SI temperature	302.44K

As shown in Basecase of Fig. 4, the maximum Peak Cladding Temperature (PCT) at reflood phase is 834.5K and it has the margin as much as 642.5K. The PCT margin, 642.5K by best estimate analysis tells us that current ECCS evaluation method has very large conservatism.

For the transition break LOCA analysis, we have to find the limiting break size and location. According to the draft 10CFR50.46, the limiting break size is equivalent to the double ended break of attached line to the RCS, i.e., surge line or SI line. To determine limiting break location, we have performed sensitivity analyses for DVI line break and cold leg break. Fig. 1 shows the comparison of PCTs between cold leg and DVI line break accidents. Best estimate analyses have been performed for both cases. As shown in the graph, DVI line break is more limiting break location than that of cold leg break.

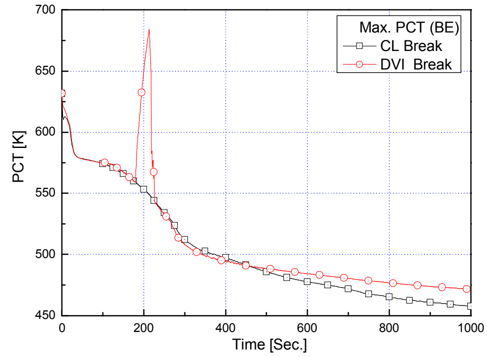

Fig. 1 The comparison between cold leg and DVI line breaks

Table 2 The difference between BE and LV

Parameter	BE	LV
Reactor power	100%	102%
Decay heat	1979 ANS	1973 ANS + 20%
Power shape	Chopped cosine	Top skewed
# of SIP	2	2
SI flow	Nominal	Minimum
SI temperature	302.44K	322.44K

In Table 2, we summarized the differences between best estimate values and limit values. The PCT behavior of 8" DVI line break accident by limiting value approach is shown in Fig. 2. As shown in Fig. 1 and 2, the difference of maximum PCT about two cases are over 300K. It means that limit value approach is enough to preserve conservatism as a preliminary approach.

3. Sensitivity Analysis

To see the effects of the revision of 10CFR50.46, we have performed sensitivity analyses for 8" DVI line break LOCA for the important safety injection system parameters of APR1400.[4] These sensitivity cases are summarized in Table 3. Fig. 3 shows the PCT behaviors for 6 cases including basecase. As shown in the figure, the maximum PCT for the basecase, Case 1, and Case 2 are almost same.

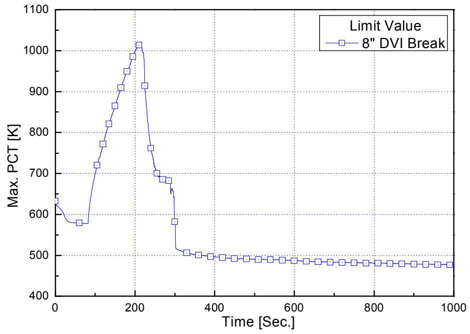

Fig. 2 The PCT behavior for 8" DVI break by limit value approach

Table 3 Sensitivity cases for 8" DVI line break LOCA

Case	Explanation
1	2 SIT - two out of four SITs are eliminated
2	Case 1 + half SIT Pressure - two out of four SITs are eliminated - SIT pressure is reduced by half
3	Case 2 + 8% power increase - two out of four SITs are eliminated - SIT pressure is reduced by half - 108% reactor power
4	Case 2 + 13% power increase - two out of four SITs are eliminated - SIT pressure is reduced by half - 113% reactor power
5	Case 2 + 15% power increase - two out of four SITs are eliminated - SIT pressure is reduced by half - 115% reactor power

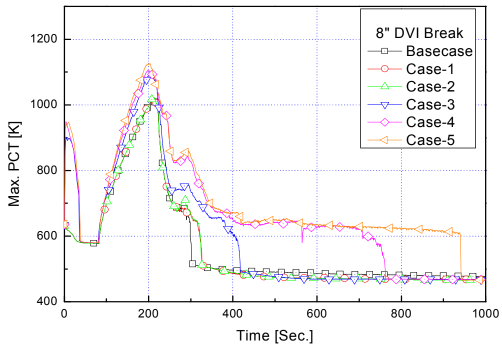

Fig. 3 The PCT behaviors for the sensitivity cases of 8" DVI break for APR1400

It can be explained by collapsed core water and collapsed downcomer water levels for six cases. However, their figures and explanation are omitted on account of space considerations. From these sensitivity analyses, we can conclude that the number of SITs and the injection water flowrate are not major parameters for PCT. For the Cases 3 ~ 5, the maximum PCTs are increased according to the power increase. In case of Case 3, PCT behavior is acceptable and reasonable. In cases of Cases 4 and 5, however, PCT behaviors are still acceptable but long term behavior is not desirable. Therefore, 8% power increase is possible in APR1400 according to these sensitivity analyses.

According to the draft 10CFR50.46, the best estimate LBLOCA analysis is required although LBLOCA is excluded in the design basis accident. So, in this paper, we have performed LBLOCA analyses for the same six cases. 4 SIPs are actuated because single failure criterion is not applied. Double ended pump discharge leg break is assumed. The PCT behaviors for six cases are summarized in Fig. 4. As shown in the figure, the maximum PCT is acceptable for all cases.

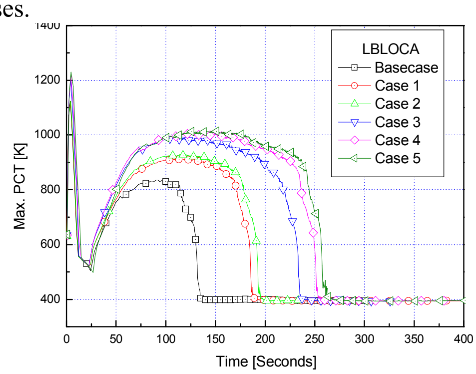

Fig. 4 The PCT behaviors for the sensitivity cases of LBLOCA for APR1400

4. Conclusions

The design basis event to design the safety injection system of APR1400 is LBLOCA although we optimized the design. In this paper, we have performed SBLOCA analyses to evaluate the effects of the rule change on the SIS of APR1400. Based on the preliminary analyses, the following design changes could be possible if the new 10CFR50.46 rule is applied; two out of four SITs can be eliminated, SIT pressure can be reduced by half, and the reactor power can be increased more than 8%. However, uncertainty quantification methodology for SBLOCA should be developed to make final decision and this study will be performed as a further study.

REFERENCES

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