# Investigation of CET Effect as a SAMG Entry Condition under Severe Accidents of OPR1000

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## 1. Introduction

Core Exit Temperature (CET) is widely used for entry condition to Severe Accident Management Guidance (SAMG). The damage, uncovery level or superheat level of core can be estimated by CET information [1].

The prevention of radioactive materials release from the containment building is the final goal for accident management. Under the hypothesized severe accident situation, SAMG is introduced to minimize the environmental effect to public using all available means. Accordingly, if the reactor vessel failure (RPV) failure time is delayed, the probability of achieving this objective of management becomes higher. Also, that whether the entry to SAMG is too early or too late can be checked in the aspect of how much action time the operator can secure. For these reasons, Park et al. studied the effect of SAMG entry condition on operator action time for prevention of RPV failure in the OPR1000 using SCDAP/RELAP5/MOD3 computer code in detail [2].

In this study, various SAMG entry conditions from the points of view of delaying RPV failure time and available operator's action time were investigated for OPR1000 using level 2 Probabilistic Safety Analysis (PSA) code MELCOR.

## 2., Selecting SAMG Entry Conditions and Scenarios and MELCOR Modeling

### *2.1 Selecting SAMG entry conditions*

Selected entry conditions of SAMG are as follows;

- Combustion Engineering (CE) PWR (Pressurized Water Reactor) , CET = 480°C = 753K,
- OPR (Optimized Power Reactor)1000 in Korea, Westinghouse PWR, CET = 650 °C = 923K,
- Average CET between standards of CE PWR and OPR1000, CET = 565 °C = 838K and
- Uljin 1, 2 of French PWR in Korea, CET = 700 °C = 973K.

### *2.2 Selecting Scenarios and mitigating strategy*

In this study, SBLOCA without SI, SBO and TLOFW are selected since they cover over 50% of severe accident transition probability among initiating events. According to the analysis of level 1 PSA of OPR1000, initiating events which have high probability of transition to severe accidents are summarized in table 1 [4].

Table 1. Probability of transition from initiating events to severe accidents

| Initiating Events | Probability |
|---|---|
| Small Break Loss of Coolant Accident without Safety Injection (SBLOCA without SI) | 22.4% |
| Station Black Out (SBO) | 14.4% |
| Steam Generator Tube Rupture (SGTR) | 13.8% |
| Total Loss of Feed Water (TLOFW) | 13.8% |
| Large Break Loss of Coolant Accident without Safety Injection (LBLOCA without SI) | 12.7% |
| Medium Break Loss of Coolant Accident without Safety Injection (MBLOCA without SI) | 7.7% |

For SBLOCA, 1.35 inches-break is assumed and mitigating strategy is opening one atmospheric dump valve (ADV). For SBO, all power stops at 0 second and mitigating strategy is opening one safety depressurization valve (SDS). Especially in SBO, an assumption is made that emergency battery or diesel generator is available for opening SDS. For TLOFW, main and auxiliary feed water stops at 0 second and mitigating strategy is to open one SDS. In addition, all accident starts at 0 second.

### *2.3 MELCOR Modeling*

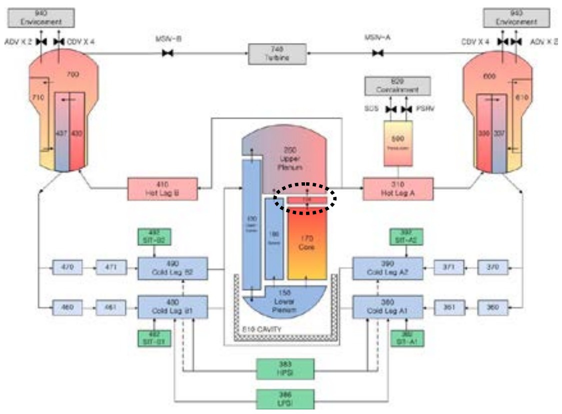


Fig 1. MELCOR nodalization of OPR1000 and CET measurement part (in dotted circle) [3]

MELCOR nodalization of OPR1000 is shown in Figure 1. There are two hot legs, four cold legs, auxiliary feed water, steam generators, various safety injection systems, valves, etc. are modeled. At the top of the core part, the node that can measure CET is allocated [3].

## 3. Results

Table 2 shows results of the significant event starting times for selected scenarios without mitigating strategy. Figure 2 represents delayed RPV failure time for each SAMG entry conditions. For SBLOCA without SI and TLOFW, RPV failure time is the longest at CET = 923K, but for SBO, RPV failure time is the longest at CET = 838K

In Table 3, available operator's action times between SAMG entry time and RPV failure time is summarized. The higher the CET chosen, the shorter available operator's action time is. However, there are no significant differences for all three scenarios.

Table 2. Significant event timeline of base case

| Accident / Accident Time (sec) | SBLOCA without SI | SBO | TLOFW |
|---|---|---|---|
| Accident Start | 0 | | |
| Reactor Trip | 150 | 0 | 28 |
| Reactor Coolant Pump Trip | 222 | 0 | 1,517 |
| Oxidation Start | 8,452 | 8,234 | 3,595 |
| Relocation to Lower Plenum | 10,317 | 10,146 | 5,338 |
| RPV failure time | 19,054 | 13,732 | 8,622 |

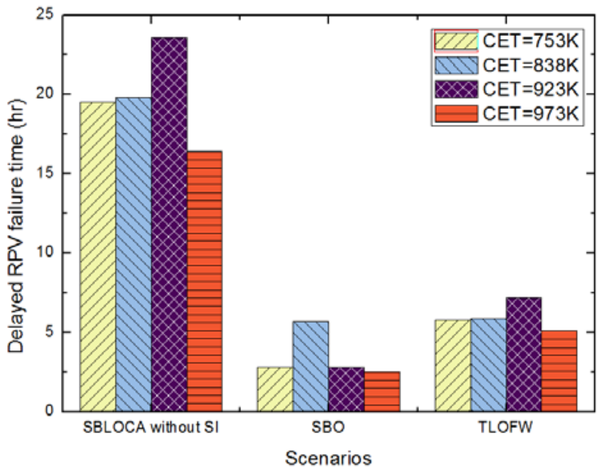


Fig 2. Delayed RPV failure time (hour) as compared with base case

Table 3. Available operator's action time between SAMG entry time and RPV failure time in hours

| CET | SBLOCA without SI | SBO | TLOFW |
|---|---|---|---|
| 753K | 3.07 | 1.69 | 1.51 |
| 838K | 2.98 | 1.63 | 1.45 |
| 923K | 2.93 | 1.54 | 1.39 |
| 973K | 2.91 | 1.51 | 1.38 |

## 4. Conclusions

From the point of view of delaying RPV failure time, SAMG entry condition when CET is 923K is the best for SBLOCA without SI and TLOFW among selected CET conditions. However, for SBO, the best result follows when the SAMG entry condition CET is 838K. For available operator's action time's view, there was no significant difference between selected SAMG entry conditions.

For these reasons, in future study, the standards of CET selection as SAMG entry conditions and the relationship between CET and quantity of oxidation heat should be researched. Also, more SAMG entry conditions should be tested which is far more different from selected conditions, such as EDF PWR standard, CET = 1100 $^{o}$C.

## Acknowledgement

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## REFERENCES

[1] NEA/CSNI, Core Exit Temperature (CET) Effectiveness in Accident Management of Nuclear Power Reactor, NEA/CSNI/R(2010)9

[2] Rae-joon Park and Seong-wan Hong, Effect of SAMG entry condition on operator action time for severe accident mitigation, Nuclear Engineering and Design, Vol. 241, pp. 1807-1812, 2011

[3] Seongnyeon Lee et al., Severe Accident Analysis of OPR1000 Postulating SBO and SBLOCA Using MELCOR, NURETH15-187, Pisa, Italy, May 12-17, 2013

[4] Rae-joon Park et al., Detailed Analysis of a Severe Accident Progression for an Evaluation of In-Vessel Corium Retention in KSNP, KAERI/TR-2959/2005

[5] R. O. Gauntt et al., "MELCOR Computer Code Manuals, Ver. 1.8.6", NUREG/CR-6119, SAND 2005-5713, Sandia National Laboratories