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Proposed Improvement of Existing SBLOCA M/E Analysis Methodology

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1. Introduction

Environmental Qualification(EQ) is conducted to demonstrate that safety-related equipment of nuclear power plants can perform safety functions even in harsh environments caused by design basis accidents. For EQ, mass and energy(M/E) analysis is performed using the system thermal hydraulic computer code, and pressure and temperature(P/T) analysis is performed using the containment analysis code based on the M/E. However, when the existing M/E methodology was used, it was confirmed that there was a scenario in which the pressure of containment did not reach containment spray set point and the temperature of the containment excessively increased among some cases of SBLOCA. Therefore, in this paper, we proposed a new M/E methodology to solve these problems.

2. Methods and Results

For the code used in this analysis, the system analysis code RELAP5/MOD3 was used for M/E analysis, and the containment analysis code CONTEMPT-LT was used for P/T calculation. Single volume containment node was used for P/T calculation.

2.1 Reviewed Scenario

In this study, the pump discharge 3 inch break case from full power was selected as a representative scenario and the analysis was performed.

This scenario is a scenario in which all three fan coolers operate without considering a single failure of one emergency diesel generator system. As a result of the analysis, the atmospheric temperature of the containment continued to rise as the pressure of the containment did not reach the operating set point of the containment spray system during the long-term cooling period. Accordingly, in order to propose a solution, the existing methodology is reviewed and a solution is proposed.

2.2 Existing Methodology Assumptions

The main assumption of the mass and energy release model of the long-term cooling phase are as follows.

-Assume that all heat is removed through evaporation as it is released into the containment in the form of steam during the long-term cooling phase.

-Assume that the coolant discharged in liquid form is discharged to the safety injection inlet temperature without changing the temperature.

-Developed a boil-off model that assumes that all possible heat, such as decay heat, superheated steam release rate of primary system, metal energy release rate of primary system, heat transfer from secondary system, etc., is used to generate steam from saturated cooling water in the core.

2.3 Containment analysis code input

The input of the CONTEMPT-LT code, which is a containment analysis code, was assumed as follows.

-Assume that there is no heat/material transfer between the containment gas and the sump liquid.

-Assume that all residual energy other than decay heat is released within 24 hours and that steam is generated by all heat sources, including decay heat.(This is a conservative approach that assumes that steam generation is larger than it actually is.) This assumption is thought to increase the temperature of the containment in the form of adiabatic compression.

2.4 Steam/Liquid Heat Removal Ratio Sensitivity

In order to solve the conservative assumption presented above, the following sensitivity calculation was performed. The assumption of our proposed methodology is that the energy removal of steam and liquid is released at a 1:1 ratio(50%) for the previous conservative assumption that steam generation is assumed by all heat sources, including decay heat. This is because SBLOCA has a smaller break area than LBLOCA, so that the amount of coolant discharged is smaller, and when safety injection water is supplied, liquid and vapor coexist in the core and RCS pipe, and heat may be removed by water. In the long-term cooling, the active core is likely to be completely covered in water and most of heat will be removed by liquid. As a result of the calculation, it can be seen that the temperature and pressure of the containment building decrease in the long-term cooling phase as shown in Figures 1 and 2.

As a result of the calculation, the atmospheric temperature of the containment continues to increase as the pressure of the containment does not reach the operating value of the containment spray system during the long-term cooling period. When the atmospheric temperature of the containment continues to increase, above saturation temperature, which seems none physical considering break flow contains a lot of liquid. To solve this problem, it is assumed that about 50% of energy is released in liquid form, and as a result, it can be seen that the temperature does not increase.

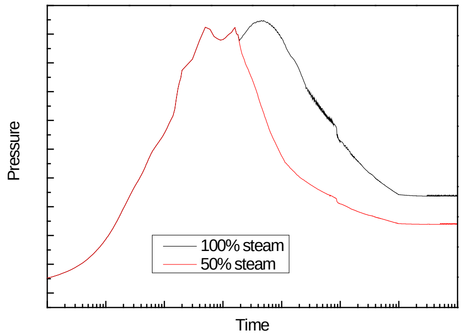

Fig. 1. Comparison of pressure changes over time.

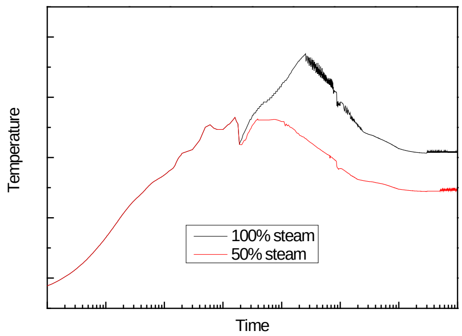

Fig. 2. Comparison of temperature changes over time.

2.5 Future Study

Our proposed methodology is a partial modification of existing conservative assumption for a particular scenario. To develop this into a new methodology, it will be necessary to validate the entire scenario and obtain enough data before in can be licensed and used for actual analysis.

3. Conclusions

SBLOCA mass and energy release may have a relatively small impact on environmental devices in the long-term cooling phase. Furthermore, since the thermal energy of the core and system is low enough, verification of environmental devices in the long-term cooling stage has not been evaluated as important, and the analysis method is not described separately. When the existing SBLOCA M/E analysis method is applied, abnormal temperature increase results are derived. For some cases, containment temperature increased significantly above saturation temperature, which seems abnormal considering break flow contains a lot of liquid. The abnormal temperature increase is caused by assuming steam generation by all heat sources, including decay heat. In fact, it is judged that most of the energy will be removed by the increase in the temperature of the liquid. To solve this problem, we propose to re-calculate the thermal energy fraction of the steam phase and liquid phase by modifying the assumptions conservatively applied to the existing SBLOCA M/E calculation.

REFERENCES

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