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Development of MAAP 5.03 Model for Evaluation of Capability Coping with Severe Accident for OPR1000

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1. Background

After the Fukushima accident, interest and concern about severe accidents are increasing. Studies on international joint research and computer code bench mark are being conducted related to understanding of accident phenomenon, mitigation of accident, identification and minimization of uncertainty of severe accident phenomenon.

In Korea, It is required to detailed evaluate severe accident phenomena due to Fukushima's follow-up measures and the safety improvement of Wolsong unit 1 stress-test. It is related to steam explosion and spike, molten corium concrete interaction and hydrogen combustion [1, 2].

Modular Accident Analysis Program (MAAP) version 4 has been used to perform accident capability analysis based on Severe Accident policy. However, in order to reduce the uncertainty of severe accidents, it is necessary to use the severe accident analysis code that includes state-of-the-art phenomenological models. As a result, the latest version of MAAP (version. 5.03) has been selected developing the model of OPR1000 nuclear power plant (NPP) for evaluating the capability of coping with severe accidents.

2. Methods and Results

2.1 Description of MAAP 5.03

The Modular Accident Analysis Program (MAAP) is an integral systems analysis code for assessing off-normal transients that can progress to and include severe accidents. The RCS model is structured to evaluate the individual response of each coolant loop and the steam generator in the loop. To address this in a general manner which is consistent with all designs, the models uses a nodalization scheme that is common for all systems. The MAAP containment model is not a fixed compartmentalized structure rather it is an interconnect -tion of compartments and flow paths. The newest “qualified” version of the MAAP is 5.03[3].

2.2 Methodology

The following methodology was applied to develop a model for assessing the capability coping with severe accidents of OPR1000 NPP. First, the MAAP4.04 model-input which was used for the probabilistic safety assessment analysis and had been verified was examined. Then a list of variables need to be modified was derived including the newly defined variables in MAAP 5.03. A new model and its calculations was made based on FSAR, design drawings and analysis reports. For variables that are not inherent design information of the power plant, they are converted by referring to the model distributed with MAAP 5.03 computer code.

2.3 MAAP 5.03 Model for OPR1000

The RCS model was selected as a Combustion Engineering-type (CE) 2-loop model with 35water nodes and 23 flow nodes [4].

The containment model consists of 28 control volumes, 64 flow paths and associated 97 heat-sinks. The nodalization of this model is illustrated in Fig. 1

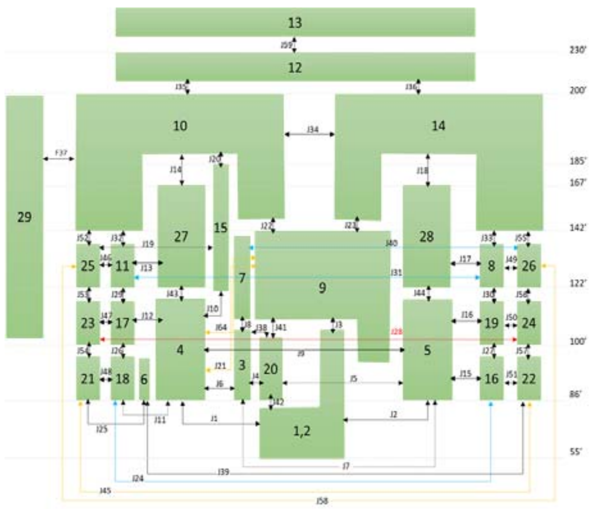

Fig. 1. Containment Nodalization and Flow Path

2.3 Model Validation

MAAP 5.03 model of OPR1000 NPP was assessed during steady-state condition as a part of verification. Steady-state analysis was performed during full power operation using the steady-state analysis input distributed with MAAP 5.03 computer code. The analysis is to confirm whether the variables such as the primary pressure, the secondary pressure, the pressurizer water level, and the steam generator level are stabilized in the steady-state analysis. In order to stabilize these variables, a method was used to adjust the variables suggested by FAI. It is confirmed that the main variables are stabilized by adjusting the FFRICPS and FFRICCL values. The analysis results of the variables related to the primary and secondary pressures are shown in Fig. 2 and the analysis results of the variables related to the water level are shown in Fig. 3.

As a part of verification of developed MAAP 5.03 model, simulation of transient state was also evaluated. To assess the suitability of MAAP 5.03 model, transient-state analysis was performed based on the five representative initial events (LLOCA, MLOCA, SLOCA, SBO and TLOFW). The analysis is to confirm that physically appropriate results are obtained by analyzing the thermal hydraulic phenomena of the reactor coolant system and the containment

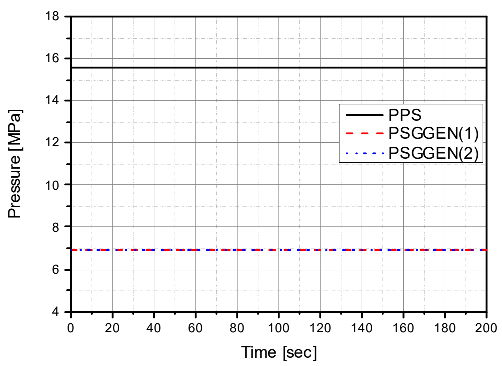

Fig. 2 Pressures of Pressurizer and SGs during Steady-state Analysis

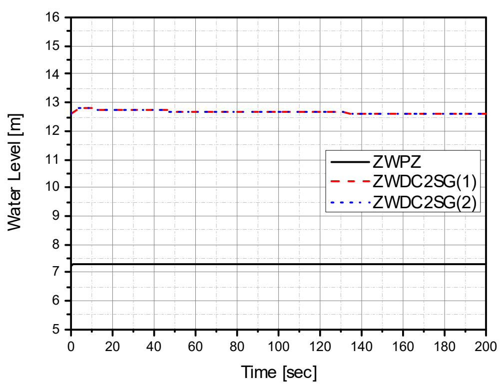

Fig. 3 Levels of Pressurizer and SGs during Steady-state analysis

3. Conclusions

In this paper, the results of the development of MAAP 5.03 model of OPR1000 NPP was described.

The developed earlier version model-input was referred. Some of the variables were modified through a specific design document review.

To verify the model, the steady state simulation capability was evaluated for power operation. In addition, a severe accident analysis was conducted to select transient conditions.

The developed model will be used for the detailed evaluation of severe accident. For the steam explosion evaluation, the MAAP 5.03 analysis result is provided as the input data of the TEXAS-V code, and the output data of the TEXAS-V code is provided as the input data of LS-dyna to evaluate the impact of the containment building on the steam explosion. For analysis of hydrogen behavior and evaluation of combustion, MAAP 5.03 analysis will be used to derive the data necessary for the evaluation of hydrogen combustion load, such as the amount of hydrogen generation in various accident scenarios, and provide them to the detailed analysis code.

REFERENCES

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