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Development of Advanced Non-LOCA Analysis Methodology for Licensing

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1. Introduction

KNF is developing a new design methodology on the Non-LOCA analysis for the licensing purpose. The code chosen is the best-estimate transient analysis code RETRAN [1] and the OPR1000 is aimed as a target plant. For this purpose, KNF prepared a simple nodal scheme appropriate to the licensing analyses and developed the designer-friendly analysis tool ASSIST (Automatic Steady-State Initialization and Safety analysis Tool). To check the validity of the newly developed methodology, the single CEA withdrawal and the locked rotor accidents are analyzed by using a new methodology and are compared with current design results. Comparison results show a good agreement and it is concluded that the new design methodology can be applied to the licensing calculations for OPR1000 Non-LOCA.

2. Methodology and Applications

2.1 Development of the advanced design methodology

Prior to the development of methodology, the KNF standard base model being used in the Non-LOCA analysis for OPR1000 was prepared. This model is for RETRAN code but the equivalent of CESEC-III nodal scheme. Because of the discrepancy between two codes, there are some minor differences. But, the nodal scheme prepared is mostly same as that of CESEC-III code. Using the nodal scheme like CESEC-III can provide some advantages. First, it is possible that the analyses results of two codes can be compared one to one. Second, it is needless for the designers to mind the nodal scheme. Generally, the designers have the inertia to keep the existing way. Therefore, it is important to develop the designer-friendly methodology.

The most significant problem caused in using the best-estimate computer code like RETRAN is that it is very difficult to get the steady-state initialization at the various initial plant conditions. To resolve this, KNF developed the designer-friendly tool ASSIST with the KNF standard model and set up the unique automatic steady-state initialization methodology based on the simple thermal-hydraulic technology. ASSIST has many features as following besides helping the designers to set the steady-state initializations automatically.

(a) Automatic initialization of the form loss coefficients
(b) Automatic initialization of steam generator secondary pressure and feed water flow rate.
(c) Automatic initialization of the control block system
(d) Automatic generations of RETRAN case input deck for design base accident analysis
(e) Automatic conversions of RETRAN output format to the designer-friendly output format
(f) Automatic generations of TAPE76 and TAPE95 for CETOP-D and CPC-FORTRAN codes

The designer will run ASSIST instead of RETRAN code. ASSIST will analyze the accident and generate the designer-friendly output. Using ASSIST, the template of the current methodology can be kept and the safety analysts don't need to worry about the complex steady-state initialization for the various plant initial conditions.

2.2 Application to the single CEA withdrawal event

The developed methodology was applied to the single CEA withdrawal (SCEAW) accident [2]. The SCEAW accident is a no-trip accident and must be analyzed at part power such as 65%, 50%, 20% and 0% of the design power. So, it can be verified the capability of the newly developed methodology for the various power range. Also the reactivity feedback effects in the new methodology can be checked because the SCEAW accident is the reactivity-induced accident

The analysis was performed at 95%, 65%, 50%, 20% and 0% of the design power. In this paper, 0% power case is presented. Figure 1 and 2 show the time-dependent behaviors of normalized power and reactivity compared with those from the current methodology, respectively. Per the results, there are a good agreements between new and current methodologies. But the new methodology shows the slightly conservative results.

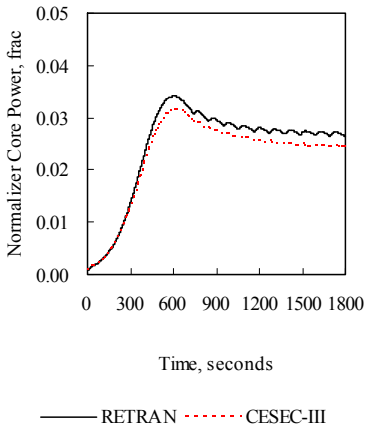

Fig. 1. Normalized Core power vs. Time

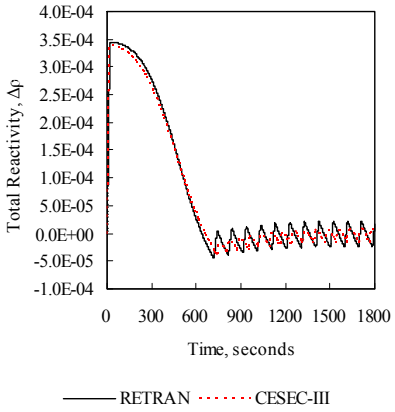

Fig. 2. Total Reactivity vs. Time

2.3 Application to the locked rotor accident

The locked rotor accident [2] is occurred by the instantaneous decrease of the reactor coolant flow in the loop where a reactor coolant pump shaft is locked. The severe flow asymmetry is appeared because the one reactor coolant pump is faulted. In this accident, the conservative manual reactor trip and trip signal delay time are assumed. And the one reactor coolant pump is locked within 0.1 seconds. The loop flow asymmetry and reactor trip sequence through the locked rotor analysis can be investigated.

The analysis was performed at the full power condition with respect to the peak reactor coolant system (RCS) pressure. Figure 3, 4 and 5 show the time-dependent behaviors of the normalized core power, the faulted loop flow rate and the peak RCS pressure, respectively. All the overall trends show good agreement compared with current accident analysis results.

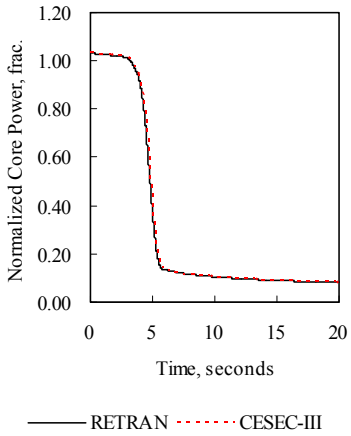

Fig. 3. Normalized Core power vs. Time

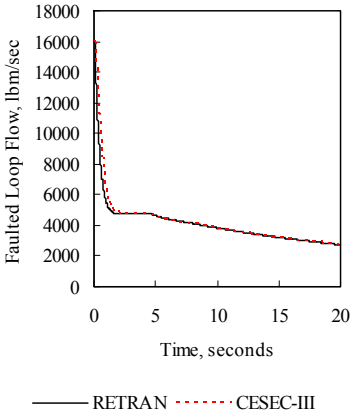

Fig. 4. Faulted Loop Flow vs. Time

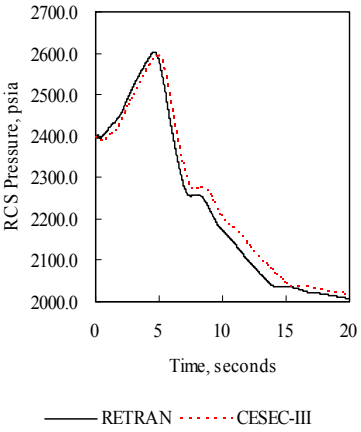

Fig. 5. RCS Pressure vs. Time

3. Conclusions

KNF developed the standard nodal scheme based on CESEC-III code. And the new design tool, ASSIST, was developed to perform the Non-LOCA analysis using the advanced code, RETRAN, for the licensing purpose. Now, even the designer who just knows the current methodology can perform the Non-LOCA analysis using RETRAN code through ASSIST.

As new methodology was checked for two kinds of accidents, its applicability to the licensing analysis was reviewed. In the future, the newly developed safety analysis methodology will be applied to the remaining Non-LOCA analysis like the steam line break, feed line break and steam generator tube rupture, etc.

REFERENCES

[1] RETRAN-3D – A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems, Volume 3: User's Manual, 2004.
[2] YGN Unit 3&4 FSAR Chapter 15