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Applications of Innovative Safety Analysis Methodology (ISAM) to Reload Safety Evaluation

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1. Introduction

KNF has developed the **I**nnovative **S**afety **A**nalysis **M**ethodology (ISAM) using RETRAN[2] code for Non-LOCA transient analysis during three years from 2006. The first objective of this project is to secure safety analysis methodology required to the export of X-GEN Fuel which KNF is developing. The second is to set up the improved methodology to be applied to the licensing safety analyses for all the OPR1000 and APR1400 plants. The ISAM possesses the characteristics of a designer-friendly methodology. To verify its applicability to the reload safety evaluation, most transients for safety analysis report and for COLSS/CPC setpoint have been analyzed and compared with current safety analysis results. Comparison results show good agreement between them, and it is concluded that the ISAM can be used in the licensing calculations for all the OPR1000 and APR1400 plants.

In this paper, presented are the application results of the transients for COLSS/CPC setpoint such as the single CEA withdrawal (SCEAW) event and the asymmetric steam generator transients (ASGT).

2. Methodology and Applications

2.1 Overview of ISAM

In the existing methodology, CESEC-III [1] computer code is used to simulate the nuclear power plant system behavior during the Non-LOCA transients. CESEC-III code is consisted of the very simple calculation and various constitutive models to compensate its simple logics.

However, for the ISAM, the RETRAN computer code is selected to utilize its merit of best-estimate thermal-hydraulic analysis model. The standard nodal scheme for the ISAM is constructed as equivalent to that of CESEC-III code that is familiar with most designers. But, there are some minor differences in the nodal scheme because of the discrepancy in two codes.

RETRAN basedeck for the ISAM is automatically generated based on the standard nodal scheme by using program GRIG (GUI-based RETRAN Input Generator). GRIG is the tool which can generate the RETRAN input deck via the graphic user interface from plant data base. RETRAN input can be generated easily by drawing the nodes, junctions, and control blocks.

In the ISAM, all the Non-LOCA transients analyses are performed by running the ASSIST [3] (**A**utomatic **S**teady-**S**tate **I**nitialization and **S**afety analysis **T**ool) based on the GRIG generated RETRAN basedeck together with transient specific input. The ASSIST has been developed to assist the unhandy designers to analyze various Non-LOCA transients by using RETRAN code. Thus, designers can generate the ready-to-go RETRAN input, set up the designer specified initial transient conditions automatically and get designer-friendly formatted output by ASSIST run only.

2.2 Application to single CEA withdrawal accident

The purpose of this analysis is to calculate the ROPM (Required Overpower Margin) lest SAFDL (Specified Acceptable Fuel Design Limit) are violated from single CEA withdrawal. The SCEAW accident, which is the reactivity inserted transient, is analyzed at 95%, 65%, 50%, 20% and 0% of the design power. So, the capability of ISAM and reactivity effects can be checked at each power level.

Table I show the comparison results of ROPM to be maintained by the LCO (limiting conditions for operation) at 95% and 65% power level. Figure 1 and 2 show the comparisons of the normalized power and reactivity behaviors at 0% power case, respectively. Per the results, there are a little difference between ISAM and current methodology.

Table I. Comparison of the ROPM

Power Level (%)	CESEC-III	RETRAN
95	1.148	1.141
65	1.348	1.350

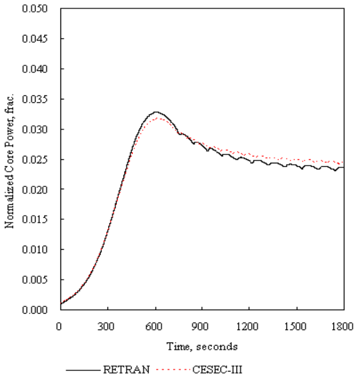

Fig. 1. Normalized core power vs. time

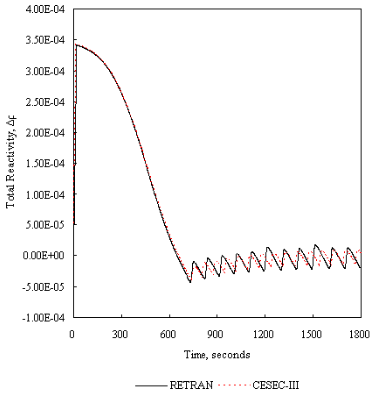

Fig. 2. Total reactivity vs. time

2.3 Application to asymmetric SG transients

The objective of ASGT analysis is also to determine the ROPM that must be maintained. There are four scenarios causing asymmetric SG transient as below:

- Loss of load to one steam generator
- Loss of feed water to one steam generator
- Excess feed water to one steam generator
- Excess load to one steam generator

First, the sensitivity runs to determine the limiting ASGT scenario were performed. To maximize the asymmetry due to the isolation of one steam generator, the no mixing in the core inlet plenum is assumed. Due to the asymmetric temperature profile, the core radial power distribution will be shifted toward the cold side if the moderator temperature coefficient is negative. This shift of core radial power distribution causes the radial peaking factor to increase, which yields a decrease in DNBR. According to the sensitivity results with respect to the core temperature difference between cold and hot side, the loss of load to one SG scenario is the most limiting transient as shown in Table II.

Table II. Results of Temperature Difference

Transients	CESEC-III	RETRAN
Loss of Load	31.44 ˚F	31.15 ˚F
Loss of or Excess FW	1.46 ˚F	1.47 ˚F
Excess Load	0.63 ˚F	0.63 ˚F

For the limiting transient, plant behaviors were simulated at 100%, 70% and 50% power level, respectively. Figure 3 shows the SG pressures vs. time, where the upper lines indicate the pressures of the isolated SG. Due to the isolation of SG, the pressures in the affected SG are increased until the main steam safety valves open. Figure 4 shows the core coolant temperatures vs. time, where the split core coolant temperatures are found due to the asymmetric behaviors of the steam generators. Table III shows the comparison results of the required overpower margin. According to the results, the similarity of the results is found between ISAM and the current methodology.

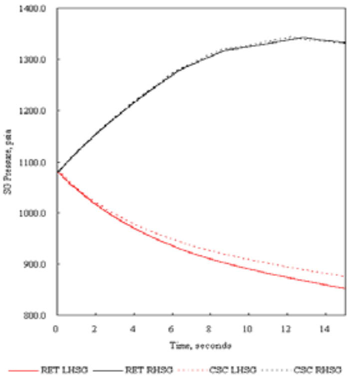

Fig. 3. SG pressures vs. time

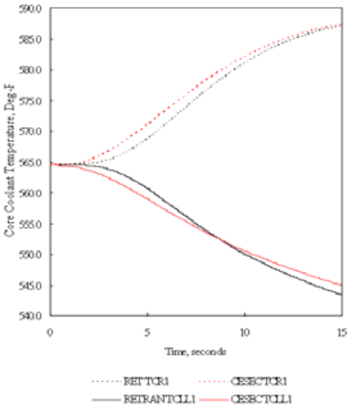

Fig. 4. Core coolant temperatures vs. time

Table III. Comparison of ROPM

Power Level (%)	CESEC-III	RETRAN
100	1.0553	1.0507
70	1.1139	1.1198
50	1.1254	1.1538

3. Conclusions

The designer-friendly innovative safety analysis methodology (ISAM) based on RETRAN computer code is developed for the export of X-GEN fuel. Most Non-LOCA transients are analyzed and compared to the current design results to validate its applicability to the reload safety evaluation. In this paper, only two accidents are presented. The comparison results show that there is close resemblance between the ISAM and current methodology. Thus, it concludes that the ISAM can apply to the reload safety evaluation and licensing calculations for all the OPR1000 and APR1400 plants.

REFERENCES

[1] CESEC – Digital simulation of a combustion engineering nuclear steam supply system, December 1981.

[2] RETRAN-3D – A Program for Transient Thermal-Hydraulic Analysis of Complex Fluid Flow Systems, Volume 3: User's Manual, 2004.

[3] 춘계원자력학회, Development and Application of Advanced Non-LOCA Analysis Methodology for Licensing, 2008.