A Test of a System Modeling Method for a Trip Model Development

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1. Introduction

In this paper, we present a method for a system modeling for the development of a trip model. We developed a trip model for a main feedwater (MFW) system and reviewed the appropriateness of the modeling method through its quantification.

The primary use of trip models has been for trip monitors that are used by operators during a decision-making when prioritizing and selecting components for a online maintenance.

Trip monitors are valuable tools for keeping track of:

- Current expected failure rates for SSCs
- Ability of a plant to respond to SSC failures
- Online trip risk as a function of which components are in and out of service during operation

2. Modeling Method and Assumptions

For the trip model structuring, we modeled a demand event and initiating event when a component failure is regarded as an initiator or an enabler.

The following assumptions are used to develop the MFW trip fault tree (FT).

- The mission for the initiator and the enabler are 1 year and 24 hours, respectively
- Consideration of the only TDP line
- No consideration of the failure mode due to a test and maintenance for a component on the operating train, the failure due to a false signal, the supporting system failure, the failure due to human error, and the CCF for a normally open valve during the normal operation
- If a supporting system failure is necessary, it is modeled as an undeveloped event

3. Development of an FT Model of MFWS

3.1 System Operation and Boundary

MFWS supplies feedwater to the two steam generators at the required pressure, temperature and fluid rate. During a normal power operation, two-motor driven booster pumps and two turbine-driven feedwaetr pumps provide the required feedwater flow.

When the plant is operated at over a 75% reactor power, if one or more main feedwater pump is stopped, the reactor power cutback system (RPCS) is started to prevent a reactor trip.

The system boundary of the MFW considered in this FT modeling is shown in Figure 1. The components in the box are the modeled objects. In this study, the condensate storage tank (CST) and the deaerator storage tank (DST) are dealt with as undeveloped events.

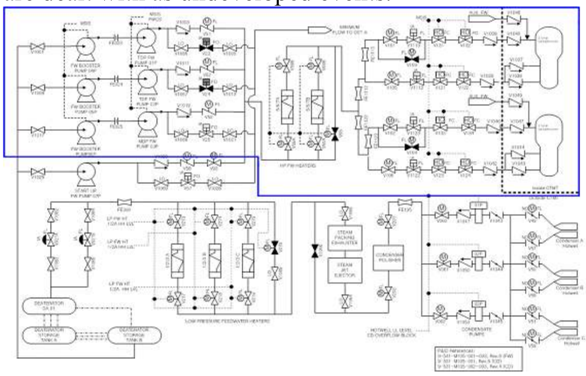

Figure 1 P&ID of Main Feedwater System

3.2 Trip Condition

Plant trip conditions caused by the MFW system are as follows:

- Failure of 2 turbine-driven pumps (TDP) or
- Failure of 1 TDP and the RPCS

The MDP is used as a supportive service when the TDP output is not normal, and the MDP can not be started immediately when the operating TDP is stopped. Therefore, the MDP is excluded from trip conditions. MFW line through the economizer is not satisfied by the load during the normal operation. Thus, we did not include those lines in the FT model. The high level logic of the MFW trip model is developed as shown in Figure 2. When a component is used as an initiator, the cutsets including the enabler are removed during the quantification.

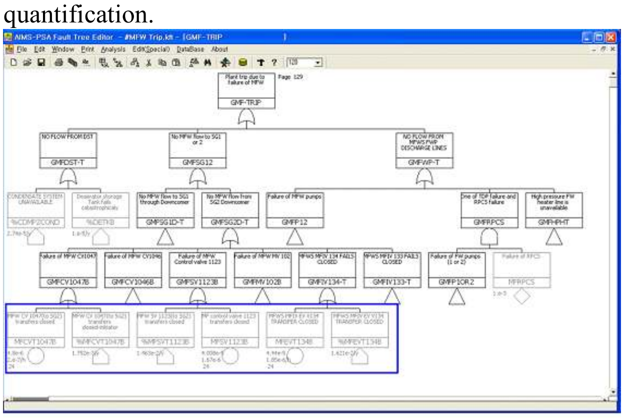

Figure 2 High Level Logic of MFW System Trip Model

4. The Quantification and the Results

The Quantification results showed that the frequency of the MFWS failure is 1.3e-1/yr, and total the CDF is 5.81e-6/yr when the cutoff value is 1.0E-11.

We reviewed a change of the CDF and the number of minimal cut sets (MCS) according to the cutoff value through a quantification for the loss of a feedwater event tree (LOFW ET). In the case of using the trip model, truncated MCS is increased compared to the case of using the initiating event value. Therefore, a lower cutoff value is recommended. Test result in Figure 3 shows that the recommended cutoff value is 1e-13. Also, we found that the number of MCSs is increased by about 4~5 times as shown in Figure 4.

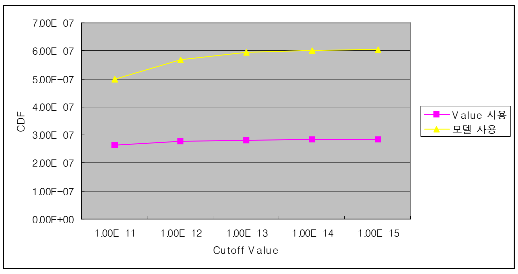

Figure 3 Comparison of the CDF Change

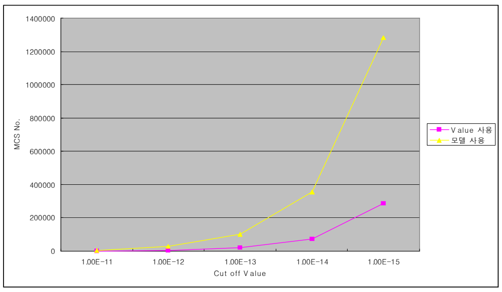

Figure 4 Comparison of the number of MCSs

The results of the importance of the components are presented in Tables 1 and 2. When we use the trip model, we can obtain the importance of components causing a trip as shown in Table 2. This is the result we need to obtain through the trip model development.

Table 1 Importance of the Components in the case of the IE value

Comp	FV	RRW	RAW	Balancing RAW
3541FW-V0058	0.000117	1.000117	1.52	1.52
3541FW-V0093	0.001717	1.00172	2.23	2.23
3541FW-V1026	0.000117	1.000117	1.52	1.52
3541M-PP07	0.062403	1.066556	6.73	2.66

Table 2 Importance of the Component in the case of using the MFW Trip Model

Comp	FV	RRW	RAW	CCF Factor RAW
3541M-MP05	0.006403	1.006444	1.87	1.72
3541M-PP07	0.059505	1.06327	6.46	2.59
3541FW-V1039	0.001147	1.001148	1.65	1.65
3541M-TP01	0.007106	1.007156	2.86	1.03
3541FW-V0131	0.013179	1.013355	2.4	1.8
3541M-TP02	0.010334	1.010442	1.87	1
3541FW-V1025	0.000179	1.000179	1.72	1.72
3541FW-V1046	0.001147	1.001148	1.65	1.65

5. Conclusions

We identified that we can obtain the importance of components and CDF normally in the condition of combining a trip model and a risk model. Therefore, the developed modeling method can be used for a trip model development. However, the number of cutsets produced during the quantification is increased because a demand event (enabler) and an initiating event (initiator) are modeled for a component simultaneously. Therefore, the quantification time is longer.

Acknowledgments

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