Accident Sequence Analysis of a Main Feed Line Break for the KSNP

Seok-Jung Han & Joon-Eon Yang
Korea Atomic Energy Research Institute, P.O. Box 105, Yuseong, Daejeon, South Korea, hanseok@kaeri.re.kr

1. Introduction

A main feed line break (MFLB) accident and a main steam line break (MSLB) accident have been summed as a large secondary side break (LSSB) accident sequence in the current PSA model for the Korea Standard Nuclear Power Plant (KSNP) [1]. This was because of the estimation that both accidents showed a similar behavior in the KSNP [1]. Each sequence, however, had been analyzed much differently in the Final Safety Analysis Report (FSAR) of the KSNP [2]. According to the FSAR, the MSLB accident showed a typical reactivity-related transient behavior, i.e., a main concerning point of the MSLB accident was the "return to power" due to reactivity impact by an over cooling effect. While the MFLB accident showed a typical pressure-related transient behavior, i.e., a main concerning point of the MFLB accident was the Reactor Coolant System (RCS) pressure behavior which can threaten the RCS integrity. The MFLB accident was described as a decrease of heat removal by the secondary side event in the FSAR, so the RCS pressure is rapidly arisen to the set point of the Pressurizer Safety Valves (PSVs). Although the MFLB accident sequence in the FSAR was too conservative to describe a realistic behavior of the RCS pressure, a remarkable thing of this fact is the difference between the MSLB accident sequence and the MFLB accident sequence from the viewpoint of a PSA modeling. Now we tried to deal with this fact in order to improve the PSA model.

In the present paper, a LSSB accident sequence in the current PSA separated as a MSLB accident sequence and a MFLB accident sequence. The MFLB accident sequence analysis as a part of the PSA model has been performed for the estimation of its impact on the entire risk profile of the KSNP.

2. Transient Behavior of the MFLB

In the FSAR for the KSNP [2], the MFLB was described in Chapter 15.2.7 & Appendix 15.A "feed water system pipe breaks" as a part of Chapter 15.2 "decrease in heat removal by the secondary side" events. Main characteristics of this group were described as following:

- Decreased heat removal by the secondary side
- Causes either a decrease or termination of stream flow to the turbine
- Increase in RCS pressure and temperature with a reactor trip
- Major concern is with regard to peak RCS pressure

Figure 1 shows a typical RCS pressure behavior in the FSAR Appendix 15.A for the analysis of a worst case of the MFLB accident sequences.

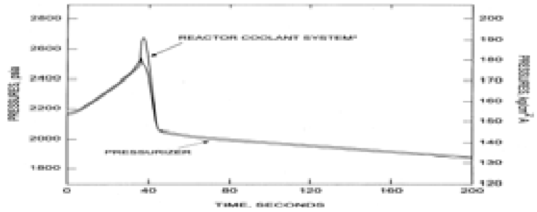

Fig. 1. RCS pressure behavior of the MFLB [3]

As shown in Fig. 1, the MFLB event in the FSAR was analyzed as a RCS heat-up event. When a feed line break occurs close to a Steam Generator (SG), plant transient behavior has a potential for two opposing situations. One is a RCS cooling; the other is an inventory loss of the broken-side SG. The FSAR analyzed the MFLB close to the latter case. This was strictly conservative assumption because of the exclusion of cooling effect and the inclusion of the inventory loss as possible as. According to this influence, the RCS pressure rises up to the PSV actuation condition as shown in Fig. 1. As considering the facts mentioned above, a simplified accident sequence analysis was performed as described in the following section.

3. Accident Sequence Analysis

As performing an accident sequence analysis in PSA by based on the analysis results in the FSAR, there are two critical issues for the MFLB accident. One is related with a PSV actuation; the other is related with an isolation of the broken-side SG.

A PSV actuation can make an induced accident sequence like an induced-medium break size loss of coolant accident (LOCA) by the PSV stuck open failure, so PSV actuation is a critical issue in the MFLB accident sequence analysis. According to the reliability data used in the PSA, PSV stuck open failure has a low reliability. The induced event by a PSV stuck open failure should be carefully estimated.

In the FSAR, the isolation of SGs was assumed, but for the sake of the accident sequence analysis the status of the SG availability should be defined. This is because the

SGs isolation status affects on the availability of the secondary system of SGs.
In order to estimate the MFLB accident sequence, a typical approach has two parts described as following:

2.1 An estimation of the initiating frequency

The first is to estimate the initiating event frequency of the MFLB. In the KSNP PSA, the MFLB accident was contained in the LSSB accident category, so the individual frequency estimation didn't performed. In the NUREG/CR-5750 report [4], the MFLB accident was estimated with the leak case. An estimation of initiating frequency by the feed line break was estimated as a mean valve of 3.4E-03/yr as shown in Table 3-1 in Poloski report [4].

Table 1. Initiating event frequency for the MFLB (/yr)

Initiating Frequency	Mean	5%	95%
KSNP's PSA	Non	Non	Non
NUREG/CR-5750	3.40E-03	7.90E-04	7.60E-03

2.2 An estimation of the accident sequence

An accident sequence model for the MFLB according to the FSAR has been prepared. Figure 2 shows an event tree example for the MFLB accident sequence. In order to model the MFLB accident sequence, we should consider two main factors as follows:

1. Stuck open failure of the PSVs
2. Isolation of the broken steam generator.

This is a transferred event. By using the general reliability data for the PSV stuck open and the initiating event frequency of the MFLB reported in NUREG/CR-5750 [4], it estimated about 5.1E-5/yr. This is a comparable amount of the original medium LOCA frequency 4.0E-5/yr by estimated in the KSNP's PSA.

The consideration of the isolation of the broken steam generator is more complicated, so we treat this as a simplified model. Because the isolation problem is closely related with the availability of secondary system, we assumed that one system was available in two systems if the isolation was success.

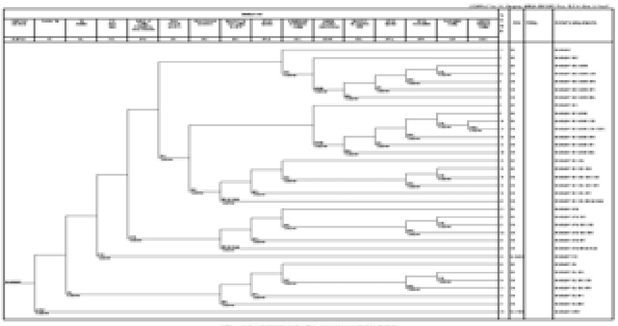

Fig. 2. An event tree example for the MFLB accident sequence

The estimation results of CDF for the MFLB is shown in Table 2. In this study, we used the PRiME model that is the new PSA model for the KSNP by developed in the KAERI [5]. As shown in Table 2, a CDF from the MFLB has a considerable impact on the entire CDF. The CDF from the MFLB itself was small but it cannot be negligible amount. A major impact on the entire CDF was mainly due to the induced event. The CDF from this induced event was larger than that from the medium LOCA itself.

Table 2. A sensitivity results of the CDF for the MFLB

	IE (/yr)	ΔCDF (%)
PRiME-MFLB	3.4E-03	0.646
Induced MLOCA	5.1E-05	2.978
PRiME-MLOCA	4.0E-05	-
Total Impact		3.624

4. Concluding Remark

In this paper, we showed that the MFLB accident sequence should be modeled in the PSA model for the KSNP instead of the LSSB combined with the MSLB and the MFLB. In order to estimate an accident sequence, two factors, i.e., an initiating event frequency and the consequential accident sequences should be estimated. In this paper, initiating frequency was assigned from the NUREG/CR-5750 report and the accident sequence was estimated by using a simplified event tree. As shown in the results, we identified that the MFLB had a larger impact on the entire CDF. This impact was originated from the induced event by the PSV stuck open failure.

In this study, we recommended that the MFLB accident sequence should be considered in the PSA for the KSNP because it could be different to the MSLB accident sequence behavior and this preliminary estimation results had a considerably larger impact on the entire CDF.

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