A Detailed Investigation on Human-Related Unplanned Reactor Trip Events in Korea

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1. Introduction

Human errors have been reported as one of the most significant causes of major events in nuclear power plants (NPPs). For example, Kim and Park[1] found that about 23% of the major events that occurred at NPPs in Republic of Korea from 1986 to 2006 were caused by human errors. For this reason, a detailed analysis on human errors is an important task for increasing the safety of NPPs.

Kim and Choi[2] analyzed 100 human-related unplanned reactor trip events in the Republic of Korea from 1986 to 2006 to consider the type of human errors based on the simple path model for human-induced unplanned reactor trips developed by Kim and Park.

In this paper, we will investigate and perform a detailed analysis of the data to identify human-related unplanned reactor trip trends.

2. Detailed Analysis

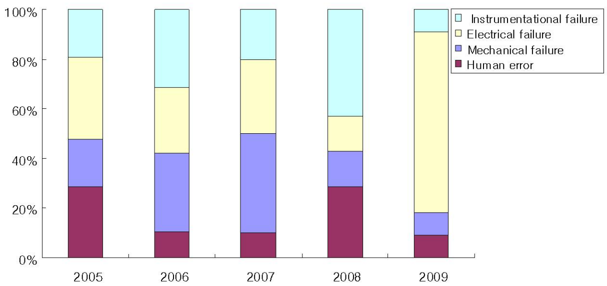

Fig. 1 Unplanned Reactor Trip Causes

Figure 1 shows the percentages of unplanned reactor trip causes with the 100 unplanned reactor trip data from 1986 to 2006. The data source is Operational Performance Information System (OPIS) for NPPs provided by KINS. The first group from the bottom line per each year presents the portions of human errors. They range from more than 10% to around 30%. The average of unplanned trip by human error for five years is 17.6%.

Similarly to the three types of human errors considered in the field of probabilistic safety assessment (PSA), human errors related to unplanned reactor trips are categorized into the following three types:

- Pre-transient or pre-reactor-trip human errors (Type I)
- Transient-inducing or reactor-trip-inducing human errors (Type II)
- Post-transient human errors (Type III)

Based on the classification, Type I human errors are caused by the problems during maintenance, setting, procedure, and design/implementation/manufacturing/ installation. Type II human errors are caused by problems during maintenance, test, and operation. Type III human errors are caused by a failure during a response to a transient.

Figure 2 shows the distribution of tasks related to each human error type grouped by the primary and the secondary system. Due to the difference in task types and working conditions in the primary system and the secondary system, the two systems are considered separately.

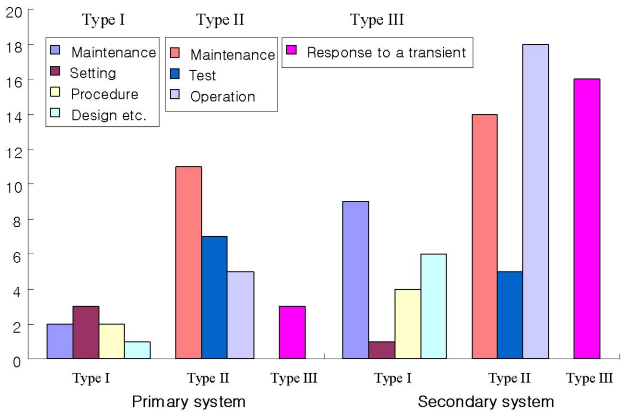

Fig. 2 Number of Events Corresponding to Tasks of Each Type of Human Errors

From Figure 2, the number of human-related unplanned reactor trips in the secondary system is considerably larger than that of human-related unplanned reactor trips in the primary system.

In the primary system, Type II human errors are dominant, followed by Type I human errors. It means that the main human errors occur during maintenance and tests which result in immediate reactor trips. In the secondary system, the portion of Type II human errors in operation and Type III human errors in response to a transient are relatively high. This is highly contributed by the failures in steam generator (SG) level control.

Type II human errors in operation are largely affected by the failure in SG level control during startup. A high portion of Type III human errors in operation is largely affected by the failure in SG level control during transient situations.

There are 30 human-related unplanned reactor trips by SG level control. 17 events are due to SG level "Lo" and the others are due to SG level "High."

Figure 3 shows the number of human-related unplanned trips due to SG level control grouped by each occurrence time. From Figure 3, about 60% of the human-related unplanned trips due to SG level control failure occur during SG level manual control operation period and when changing the operation mode from manual control to automatic control for SG level. It means that SG level manual control and changing from manual control mode to automatic control mode which consider the only parameter, SG level are important operations to prevent human induced unplanned reactor trips.

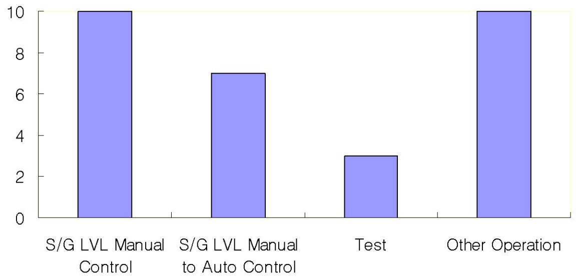

Fig. 3 Human-Related Unplanned Reactor Trips by SG Level Control Corresponding to Occurrence Time

3. Conclusions

The purpose of this paper is to investigate and perform a detailed analysis of 100 human-related unplanned reactor trips from 1986 to 2006 in domestic NPPs to identify human-related unplanned reactor trip trend. The data source is the OPIS by KINS.

The results show the following: (1) In the primary system, Type II human errors are dominant, followed by Type I human errors. It means that main human errors occur during maintenance and testing which result in immediate reactor trips. In the secondary system, the portion of Type II human errors in operation and Type III human errors in response to a transient are relatively high. This is highly contributed by the failures in SG level control. (2) About 60% of the human-related unplanned trips due to SG level control failure occur during the period of SG level manual control and the operation mode changing period from manual to automatic control of SG level.

From the analysis, we found that SG level manual control and changing from manual control mode to automatic control mode which consider a parameter, SG level, only are important operations to prevent human induced unplanned reactor trips. An analysis of risk evaluation due to human-related unplanned trips, including human error during the SG level control, will be completed this year to quantify the amount of risk created by human-related unplanned reactor trip.

ACKNOWLEGEMENT

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