Preliminary Study to Identify the Initiating Events for Multi-Unit PSA

Ar Ryum Kim [a], Seung Woo Lee [a*], Joong Taek Lim[a], Ki Han Jeon [a], Namchul Cho [a], Dohyoung Kim [a],
[a] *Korea Institute of Nuclear Safety, 62 Gwahak-ro, Yuseong-gu, Daejeon, Korea, 34142*
[*] *Corresponding author: k727lsw@kins.re.kr*

1. Introduction

Recently, necessity for developing multi-unit probabilistic safety assessment (MUPSA) has been raised since the Fukushima nuclear power plant (NPP) accident occurred in March, 2011. The earthquake and tsunami affected all six units at Fukushima Daiichi and four units at Fukushima Daiini [1]. This accident has highlighted that the multi-unit events can occur in reality [2], and the public concern about the occurrence of the multi-unit events has been significantly increased.

In worldwide, most sites contains two or more NPPs [3], and especially in Korea, there are four NPP sites and more than six units are operating in each NPP site. Also, the number of individuals in the vicinity of NPP is higher compared to other countries. Regarding these situations in Korea, evaluating risks from multi-unit NPPs has become an important issue. However, there has been no comprehensive MUPSA method because traditional approach to conduct PSA is based on single unit basis.

Currently, a few research is conducted and various suggestions were made for MUPSA. To briefly explain the current status of the MUPSA research, the international atomic energy agency (IAEA) published a draft safety report on a technical approach to MUPSA in 2015. This report includes the outline of an approach to integrated probabilistic safety evaluation of multi-unit site [4]. In Canada, multi-unit interactions are already included in existing reactor-unit PSAs because of extensive sharing systems and use of common containment. Also, regulatory body in Canada recently modified the regulatory requirements to include multi-unit impacts following Fukushima accidents [4]. In Korea, KAERI (Korea Atomic Energy Research Institute) has conducted a research to develop site risk assessment methodology and model, including extremely complicated multi-units accidents [5]. Also, KINS (Korea Institute of Nuclear Safety) is conducting research to develop regulatory framework for MUPSA.

Although, a few research is conducted, there are still huge technical issues and challenges such as safety goal, risk aggregation, and etc. [4].

The purpose of this paper is to identify the potential multi-unit initiating events. To do that, potential multi-unit events are identified by analyzing operational experience of NPPs in Korea, and dependencies between SSCs (Systems, Structures, and Components) between units. This paper shows how the potential multi-unit initiating events are derived only by using operational experience of NPPs. This paper is a part of research conducted by KINS and it should be noted that this result does not show regulatory positions from KINS.

2. Identification of the Multi-unit Initiating Events using Operational Experience

2.1 Data-source

In this section, data-source which was used for the identification of multi-unit initiating events is briefly described. OPIS (Operational Performance Information System for Nuclear Power Plant) which is a comprehensive database system providing data on design, operation and event in Korea is used. This system includes NEED (Nuclear Event Evaluation Database) which manages and uses the valuable information extracted from the existing events [7]. In NEED, there are total 725 events occurred from 1978 to 2017, and all events provide information regarding name of unit which event occurred, date of event, causes and consequence of event, event sequence, and so on. Based on these information, multi-unit initiating events are analyzed.

However, there are some cases that only single unit event happened even though it has potential to become multi-unit events. In this paper, these events are also considered as the potential multi-unit initiating events. The typical example mentioned above is the multi-unit events caused by loss of off-site power due to some problems in switchyard (SWYD). Even only single unit event occurs, there is possibility to become multi-unit event since SWYD is a shared system between units.

2.2 The Event Classification Schema to Analyze Multi-unit Events

In order to systematically analyze the potential multi-unit initiating events, the event classification schema suggested by Scheroer was applied [6]. Scheroer proposed six main commonality classification and verified the classification schema by analyzing LERs (Licensee Event Reports). The event classification schema is comprised of ‘initiating event’, ‘shared connections’, ‘identical components’, ‘proximity dependencies’, ‘human dependencies’, and ‘organizational dependencies’. In this study, ‘proximity dependencies’ is excluded since this one does not exactly meet the situation of Korea. The brief description of each class is shown in the followings [6].

• Initiating event: It indicates that the single event that have the capacity to affect multi-units of an NPP site. The one example of initiating events is "loss of offsite power" and "loss of ultimate heat sink"
• Shared connections: The multi-unit event occurs due to the links that physically connect of multiple units. The one example of shared connections is "AAC DG (Alternative AC Diesel Generators).
• Identical components: The multi-unit event occurs due to the components that have the same design, operation, and operating environments in multi-units. The one example of identical components is "control card".
• Human dependencies: The multi-unit event can occur when a person's interaction with a machine affects multi-units. This could be an operator, a maintenance team member, a member of an installation crew, or the like.
• Organizational dependencies: The multi-unit events occur when an organization somehow connects multiple units, typically by some sort of logic error that permeates the organization.

2.3 Case study

Two cases were chosen to show how the event classification schema was applied and analyzed. One case is "The multiple reactor trips due to the earthquake near Gyeong-ju on Sep. 12th, 2016" and the other case is "A single reactor trip by abnormal open of PCB (Power Circuit Breaker) on June, 3rd, 2016" [7]. The brief description and results of applying event classification schema for two cases are shown in Table I.

Table I. Results of case study

	Units	Brief description	Event class
Case # 1	Wolsong-1,2,3,4	All four units in Wolsong site were tripped because of the earthquake near Gyeong-ju.	Initiating event
Case # 2	Hanbit-2	At that time, a single unit was tripped because of abnormal open of two PCBs. However, multi-unit event might have occurred because the SWYD is shared between Hanbit-1 and Hanbit-2. Also, this event happened due to incorrect procedures that has been mirrored for multi-units.	Shared connection & Organizational dependency

As shown in Table I, the potential multi-unit initiating events are analyzed using event classification scheme. Currently, total 721 events occurred from 1978 to 2016 in NEED are under analyzing using this approach and these events will be categorized into five event classes.

3. Conclusions

As the necessity to evaluate the risks from multi-unit NPPs has been raised, the preliminary study to identify the initiating events for MUPSA has been performed. In this paper, approach to identify the potential initiating events using operational experience is addressed. To do that, NEED which provides the information for total 725 NPP events occurred from 1978 to 2017 has been used as data-source, and the event classification schema has been applied. As shown from the case study, the potential multi-unit initiating events will be derived. For the future study, the screening analysis would be performed for the potential initiating events and the frequency for the derived multi-unit initiating events would be assessed.

Acknowledgements

This work was supported by the Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety (KOFONS), granted financial resource from the Multi-Unit Risk Research Group (MURRG), Republic of Korea (No. 1705001).

REFERENCES

[1] M. D. Muhlheim, G. F. Flanagan, W. P. Poore, Initiating Events for Multi-Reactor Plant Sites, ORNL/TM-2014/533, Oak Ridge National Laboratory, 2014.
[2] I. S. Kim, M. S. Jang, S. R. Kim, Holistic Approach to Multi-unit Site Risk Assessment: Status and Issues, Nuclear Engineering and Technology, Vol.
[3] The Database on Nuclear Power Reactor, The PRIS, http://www.iaea.org/PRIS
[4] CNSC, Summary Report of the International Workshop on Multi-Unit Probabilistic Safety Assessment, Ottawa, Canada, Nov. 17-20, 2014.
[5] KAERI, Development of Site Risk Assessment & Management Technology including Extreme External Events, KAERI/RR-4225/2016, 2016.
[6] S. Schroer, M. Modarres, An Event Classification Shema for Evaluating Site Risk in a Multi-Unit Nuclear Power Plant Probabilistic Risk Assessment, Reliability Engineering and System Safety, Vol. 117, p. 40-51, 2013.
[7] OPIS, http://opis.kins.re.kr