Transactions of the Korean Nuclear Society Spring Meeting
KwangJu, Korea, May 29-31, 2013

Qualitative Analysis Results for Applications of a New Fire Probabilistic Safety Assessment Method to Ulchin Unit 3

Dae Il Kang, Kilyoo Kim, Seung-Cheol Jang

KAERI, P.O.Box 105 Yusong, Daejeon, Korea, 305-353, dikang@kaeri.re.kr

1. Introduction

KAERI is performing a fire PSA for a reference plant, Ulchin Unit 3, as part of developing the Korean site risk profile (KSRP). The fire PRA Implementation Guide [1] has been used for performing a fire PSA for NPPs in Korea. Recently, USNRC and EPRI developed a new fire PSA method, NUREG/CR-6850, to provide state-of-the-art methods, tools, and data for the conduct of a fire PSA for a commercial nuclear power plant (NPP) [2]. Due to the limited budget and man powers for the development of KSRP, hybrid PSA approaches, using NUREG/CR-6850 [2] and Fire PRA Implementation Guide, will be employed for conducting a fire PSA of Ulchin Unit 3.

In this paper, the qualitative analysis results for applications of a new fire PSA method to Ulchin Unit 3 are presented.

2. Qualitative Analysis

2.1 New Fire PSA approach

Figure 1 shows the overall approach of a new fire PSA method.

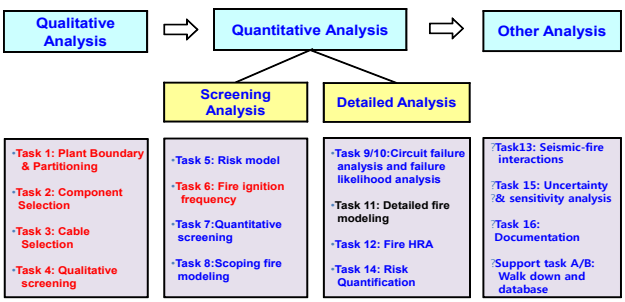

Figure 1. Overall approach of new fire PSA method

The qualitative analysis includes Tasks 1, 2, 3, and 4. The main differences between the Fire PRA Implementation Guide and new fire PSA method in a qualitative analysis are scope and depth for the selection of components and cables for a fire PSA.

2.2 Analysis of fire compartments

The fire compartments form the fundamental basis of the subsequent fire PSA. The analysis of fire compartments includes Tasks 1 and 4 in Figure 1. It identifies the physical characteristics of fire compartments and performs qualitative screening of each compartment, assuming that fires confined to that single compartment will fail all safe shutdown components and cables in the compartment. The screening criteria of a fire compartment are as follows:

- The compartment does not contain any of the equipment and their associated circuits identified in Tasks 2 and 3,
- Fires in the compartment will not lead to an automatic trip or a manual trip. A fire in a compartment that is qualitatively screened does not contribute to fire-induced risk individually or collectively.

Ulchin Unit 3 is partitioned into 150 fire areas and can be further divided into 883 fire rooms. In the process of analysis of fire compartment for fire initiation and fire propagation, it was assumed that a fire can occur at any fire area and there was no possibility of fire suppression by the use of manual and automatic fire suppression facilities. A qualitative screening analysis for fire compartments was performed mainly based on the existence of equipment/cables and fire propagation paths in fire compartments.

2.3 Selection of equipment and cables

Fire-induced function loss or spurious operations of active components in fire compartments can cause initiating events or can be a source of undesirable response adverse to accident mitigations. Also, fire-induced function loss or spurious operations of instrumentation equipment affect the performance of operators. Figure 2 shows the equipment and cables affected by a fire at a nuclear power plant. Equipment and cables to be selected for the fire PSA are components powered by electricity such as valves, fans, pumps, instrumentation and control equipment, etc., and instrumentation, control, and power cables relating to them.

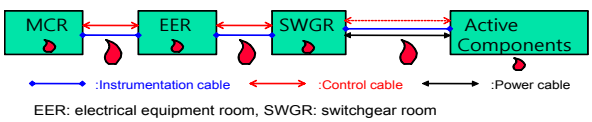

Figure 2. Equipment and cables affected by a fire at a nuclear power plant

Components and cables selected for the fire PSA were those relating to multiple spurious operations as well as an internal event PSA. The selection of cables was carried out by reviewing the cable tray diagrams, cable conduit diagrams, cable block diagrams, etc., and performing a cable routing analysis.

3. Results and discussion

67 fire areas of 150 fire areas were qualitatively screened, and 83 fire areas were found to be quantitatively analyzed. In this study, 32 fire areas were additionally identified to be quantified compared with fire areas for the quantification identified in the previous industry fire PSA [3]. The main reasons that the number of fire areas for quantification has increased are as follows. The previous industry fire PSA excluded fire areas not important contributors to the fire risk, but this study included them. Also, this study additionally considered equipment relating to MSO scenarios and operator behaviors.

The number of equipment selected in this study is more than 770 and the number of cables is greater than 6,000. If the equipment connecting cables is added, the number of equipment is more than 1,200 and the number of cables is more than 20,000. However, the number of equipment considered in the previous industry fire PSA model using the EPRI method was just more than 300. The reason that the number of equipment selected in this study has increased more than that in previous study is that instrumentation equipment, non-safety system equipment, and MSO equipment has been added. In the future, while performing other tasks of the PSA fire, the number of cables and equipment may be changed.

4. Concluding remarks

This paper introduces the qualitative analysis results for applications of a new fire PSA method to Ulchin Unit 3. Compared with the previous industry, the number of fire areas for quantification identified and the number of equipment selected has increased.

Acknowledgements

This work was supported by Nuclear Research & Development Program of the National Research Foundation of Korea (NRF) grant, funded by the Korean government, Ministry of Science and Technology (MEST).

References

[1]. Najafi, B., et al, “Fire PRA Implementation Guide”, EPRI TR-105928, EPRI, 1995

[2] Najafi, B., et al, “ Fire PRA methodology for nuclear power facilities”, NUREG/CR-6850, USNRC, 2005

[3] “ 울진 3/4 호기 확률론적 안전성 평가, Level 1 PSA 외부사건 분석”, ㈜한수원, 2004.

Table 1. Qualitative analysis results of fire areas

Building	Fire area	Fire areas for quantitative analysis	Previous industry analysis results	Additional analysis
CV(Containment Building)	1	1	1	0
PAB(Primary Aux. Building)	78	52	40	12
SAB(Secondary Aux. Building)	15	4	1	3
TGB(Turbine Generator Building)	11	4	1	3
FB(Fuel Building)	8	5	1	4
ACB(Access Control Building)	4	0	0	0
ESW(ESW Intake Structure)	2	2	2	0
CCW Hx(CCW HX Building)	2	2	0	2
AAC DG	8	4	0	4
RWB(Radwaste Building)	1	0	0	0
Yard	20	9	5	4
Sum	150	83	51	32