A Study on the Function of MCR from the viewpoint of Sabotage

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1. Introduction

Nuclear Safety and Security Commission (NSSC) judged that vital area of nuclear power plants did not meet the latest international standards such as IAEA [1] and NRC [2] suggest [3]. Korea Hydro & Nuclear Power (KHNP) conducted a vital area identification (VAI) based on current design basis threat (DBT) and engineering judgement in accordance with administrative order of NSSC.

To identify a systematic vital area, a sabotage logic model was developed on Probabilistic Safety Assessment (PSA) logic tree and equipment location data. This paper reviews a necessary vital area with the international standards and technical standard of the Korea regulatory body and describe the role of main control room (MCR) as a vital area.

2. Vital area identification

2.1. IAEA Nuclear Security Series

IAEA technical guidance No. 16 refer to the fundamental safety functions to maintain the nuclear power reactor in a safe state under sabotage. These functions are control of reactivity, confinement of radioactive material, and cooling of radioactive material. The cooling functions of radioactive material are reactor coolant pressure control, reactor coolant inventory control, and decay heat removal. Vital area set that should be protected from sabotage will include:

- All areas from which the assumed threat has the capability to cause direct dispersal of radioactive material that exceeds the HRC criteria;
- All areas from which an adversary could cause initiating events (IEs) that exceed the mitigation capability of facility systems; and
- Either all areas in which an adversary could initiate events that safety systems can mitigate or areas in which minimum sets of equipment needed to mitigate the IEs are located [4].

This document does not refer to a specific name of vital area, but describes how certain area should be protected as a vital area.

2.2. U.S. Regulations

According to 10CFR73.55, the following shall be considered vital area at least;

(a) The reactor control room
(b) The spent fuel pool
(c) The central alarm station
(d) The secondary alarm station [2]

This regulation shows that the reactor control room and the spent fuel pool is protected from sabotage. The latter (c) and (d) should be protected from a different angle with the former. Alarm stations are not related with IEs or mitigation system directly.

2.3. Korea Technical Standard

The regulatory body of nuclear nonproliferation and control in Korea established the standard of vital area identification based on DBT in 2015 and revised it in 2016. It requires that the following shall be protected as vital areas [5];

- The main control room
- The spent fuel storage area
- The central alarm system and equipment area of maintaining the function of the central alarm system, including the secondary alarm system
- The uninterrupted power supply system for detection equipment
- The uninterrupted power supply system for communication equipment
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They are based on 10CFR73.55, but are not same to vital areas of 10CFR73.55

Also, it requires that vital area shall be identified and protected, including the success criteria of the critical safety system for each operational state. The critical safety systems are followings.

- Reactivity control system
- Cooling system(reactor coolant pressure control, reactor coolant inventory control, and decay heat removal)
- Radioactive material containment system

The contents are the same as a technical guidance of IAEA.

3. The MCR as vital area

3.1. IEMO prevention

If the adversary occupies the MCR of nuclear power plant, actions like initiation, stop and control of all equipment can be done by the adversary's malicious origin. These actions can affect safe operation of nuclear power plant designed by applying the fail-safe concept, and directly result in core damage and

ultimately unacceptable radiological consequence (URC).

When initiating events of malicious origin (IEMO) is identified in the VAI process, the MCR shall be protected vital area because adversary could cause IEs that exceed mitigation capability of nuclear power plant. This is based on the IAEA document as mentioned above. The safety function of nuclear power plant is performed by fail-safe design without operator's action in the MCR.

3.2. Personal Safety

Several operators always reside in the MCR for operation, control, and monitoring of nuclear power plant. Also, operators should be protected from adversary invasion like sabotage.

3.3. Fault tree analysis result

To identify vital area of nuclear power plant systematically, KHNP developed a sabotage logic tree based on PSA logic tree. The result shows that MCR does not come out except rooms for core damage mitigation strategy. So, essential vital areas including MCR, spent fuel pool (SFP), containment were considered in branch logic tree of main sabotage logic tree.

Therefore, the MCR is very important area in view of IEs by malicious act and operator's safety. The MCR does not play a role as an area for mitigating the core damage.

4. Conclusions

We reviewed why the MCR is considered and protected vital area according to various documentation. The MCR is a very important area under sabotage due to three reasons. First, it should be considered a vital area based on U.S. Regulation and Korea technical standard for VAI. Second, it should be included a vital area as adversary invasion into MCR results in core damage or URC. Third, it should be protected for operator's life safety in the MCR.

However, rooms around the MCR is not included as vital areas necessarily. Because the safety systems of the nuclear power plant are operated automatically by fail-safe design in the emergency state like sabotage.

Also, the result of quantifying a sabotage logic tree shows that MCR does not be identified as a vital area. This indicates that the MCR is not involved with core cooling strategy directly.

Therefore, the only MCR is considered a vital area.

REFERENCES

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