Feasibility of Operator Manual Actions for Vital Area Identification in PHWR Plants

Ji-Hwan Cha*
Physical Protection Division, Korea Institute of Nuclear Nonproliferation and Control,
1418, Yuseong-daero, Yuseong-Gu, Daejeon, 34101, Republic of Korea
** jh_cha@kinac.re.kr*

1. Introduction

Identification of vital areas is an important step in the process of protecting against sabotage. Vital area identification (VAI) is the process of identifying the area in a nuclear facility around which protection will be provided in order to prevent or reduce the likelihood of sabotage. INFCIRC/225/Rev. 5 (IAEA Nuclear Security Series No. 13) indicates that nuclear material in an amount which if dispersed could lead to high radiological consequences (HRCs) and a minimum set of equipment, systems, or devices needed to prevent HRCs, should be located within one or more vital areas, and be located inside a protected area. All measures that have been designed into the facility for safety purposes should be taken into account when identifying vital areas. It was briefly described in Fig. 1 [1]. 10 CFR 73.55 specifies requirements for protection of nuclear power plants against radiological sabotage, including the location of vital equipment in vital areas and protection measures to be applied to vital areas [2]. However, in building logic models for the VAI analysis, it is not necessary to consider that the operator manual actions occur concurrently with the sabotage attack. In this paper, in particular, the feasibility of the operator manual actions in the process of the vital area identification of the PHWR plants operated differently from the PWR plants are analyzed.

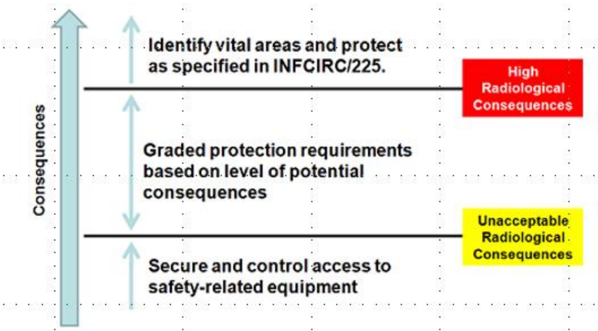

Fig. 1. Sabotage regulation standard of IAEA NSS No.13

2. Operator Manual Actions for Vital Area Identification in PHWR Plants

The PHWR plant is designed to supply cooling water to the steam generator by gravity from a dousing tank located at the top of a reactor building in addition to a motor-driven auxiliary water pump so that the core could be cooled using a steam generator in an accident. Such facilities are useful facilities for core cooling in the event of a power plant power outage in which AC power is lost due to the same function as the turbine-driven auxiliary water supply pump of a PWR plant.

In the event of a station black out (SBO), the PWR plant use a turbine drive auxiliary water pump to cool the core through the steam generator, and on the other hand, the PHWR plant is designed to use a gravity filling flow path in a dousing tank instead of the turbine drive auxiliary water pump. The advantages and disadvantages of the turbine-driven auxiliary water supply pump of the PWR plant and the gravity filling flow path of the PHWR plant are as follows.

- Turbine driving auxiliary water pump: The available time is limited depending on the battery depletion time, and the steam in the steam generator is used to drive the turbine to boost the cooling water supply pressure, so no steam generator decompression is required.

- Gravity filling flow path: Regardless of the battery depletion time, steam generator gravity needs to be depressurized.

The compassion of sabotage strategies in PHWR and PWR are shown in Table I. Both PWR and PHWR plants used secondary heat removal for prevent core damage. The main difference between PWR and PHWR in sabotage counteract is whether or not to consider operator manual actions. In PWR plants, a manual decompression measure is not required because the PWR utilizes an automatically operated auxiliary water pump, but in the case of PHWR plants, manual decompression measure is required because a dousing tank is used. Therefore, manual operator action must be included in the procedure.

Table I: Comparison of sabotage strategies in PHWR and PWR

	PHWR	PWR
Heat removal strategy	Secondary heat removal	Secondary heat removal
SG feed water supply	Dousing tank	Turbine driven aux feed water pump
Feed water valve	Fail-open	Fail-open
Steam purge	MSSV set point open-close	MSSV set point open-close
Operator manual action	Depressurize for feed water supply	-

In other words, in the PHWR plants, steam generator decompression through MSSV opening must be performed, and one of the following two procedures must be performed to supply water using a dousing tank.

1) Open MSSV using portable battery set at secondary control area (SCA) → operator manual action required
2) Opening and fixing the valve in the MSSV compartment → operator manual action required to the MSSV compartment outside the reactor control building (RCB).

The event trees of level 1 PSA report in case of total loss of class IV power in PHWR plants are shown in Fig.2.

Through the event trees, it could be confirmed that core damage does not occur if the following three heading events which are steam generator pressure relief and cool-down (SGPRC), no consequential LOCA via D_2O storage tank (CLPRV), steam generator makeup via dousing tank (SGMKUP) succeed after the total loss of class IV power. It means that the decompression of the steam generator is appropriately performed as a measure of the operator manual actions and feed water is supplied through the dousing tank, it could be verified through the event trees that protection could be successfully carried out without damage to the core in the situation of the sabotage.

Through the Sandia National Laboratory (SNL), Vital Area Identification for U.S. Nuclear Regulatory Commission Nuclear Power Reactor Licensees and New Reactor Applicants, credit can be taken for operator actions if all of the following conditions are met [3],

a. There is sufficient time to implement the actions between the sabotage act(s) and the onset of core damage or spent fuel melting.
b. Environmental conditions in the area where the actions must be performed allow access of personnel.
c. Adversary interference with the completion of the actions is precluded.
d. Any equipment needed to complete the actions is available and ready for use.
e. Approved procedures for the actions exist.
f. Training is conducted on the procedures covering the actions under conditions similar to the scenarios for which the actions are credited.

The judgement on the credit is determined by the examiner after inquiring the relevant data on the nuclear power operator and using it for examination which is deal with confidential. Consequently, it could be confirmed that it is reasonable for the operator manual actions to be included in the vital area identification in case of the PHWR plants.

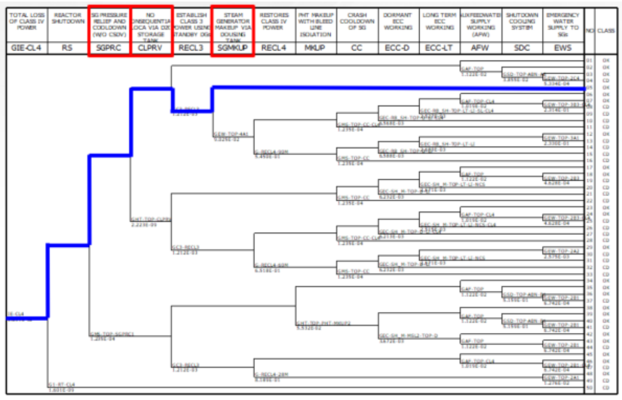

Fig.2. Event trees of level 1 PSA report in case of total loss of class IV power(SBO)

3. Conclusion

In this paper, the feasibility of the operator manual actions in the process of the vital area identification of the PHWR plants operated differently from the PWR plants are analyzed. Comparison of sabotage strategies in PWR and PHWR are conducted. The sabotage strategies, in particular, operator manual actions verified its feasibility using by the event trees and Vital Area Identification for U.S. Nuclear Regulatory Commission Nuclear Power Reactor Licensees and New Reactor Applicants of SNL.

Acknowledgement

This work has been supported by the Nuclear Safety Research Program through the Korea Foundation of Nuclear Safety(KOFONS), using the financial resource granted by the Nuclear Safety and Security Commission (NSSC) of the Republic of Korea. (No. 2106013-0121-SB110)

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