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Consideration of Yard Facilities for Vital Area Identification at Nuclear Power Plants

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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 [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]. Various safety analysis of nuclear power plants defines and applies the safety state that nuclear power plants must reach after a specific accident to be analyzed. For example, fire safety shutdown analysis evaluates whether a plant can reach a cold-shutdown after a fire event occurs. In other words, in the fire safety shutdown analysis, the cold-shutdown becomes the acceptance criteria of plant safety state. The deterministic seismic margin evaluation evaluates whether there is a successful path through which the plant can reach a cold-shutdown after an earthquake event occurs. In other words, in the deterministic seismic margin evaluation, cold-shutdown becomes the acceptance criteria of plant safety state. In Probabilistic Safety Assessment (PSA), a safe and stable state defined by the analyst is applied as an acceptance criteria of plant safety state. Generally, the safe and stable conditions defined in the PSA allow hot-standby, hot-shutdown, cold-shutdown, and feed and bleed operations accompanying the removal of heat from the reactor building.

Especially, the PSA in building target sets for the VAI analysis, it is necessary to consider that the yard facilities include acceptance criteria of nuclear power plants stable states maintenance period. In this paper, in particular, consideration of yard facilities in the process of the vital area identification of nuclear power plants was analyzed.

2. Consideration of Yard Facilities for Vital Area Identification in Nuclear Power Plants

Since the third generation vital area identification method basically utilizes the PSA analysis results, the acceptance criteria of plant condition and its maintenance period are the same as those applied in PSA event trees. Thus, in the current vital area identification, the acceptance criteria of plant's maintenance period are implicitly 24 hours. However, after the occurrence of sabotage, the requirements for the acceptance criteria of plant's maintenance period may change depending on the plant's available response facilities, procedures. For example, if sufficient facilities and external resources are available to replace or recover damaged plant facilities within 8 hours of sabotage, the acceptance criteria of plant's maintenance period can be performed on a vital area identification.

If the acceptance criteria of plant's maintenance period is applied to 8 hours, the success path of PSA event tree successful accident path 8 is changed as follows.

Thus, it is possible to operate the auxiliary water supply for more than 8 hours as the primary auxiliary water supply source, an additional auxiliary water supply source is not required. In other words, a considerable number of facilities may be excluded from the selection of vital areas. In particular, tanks providing additional auxiliary water supply may be excluded.

Vital area identification is to identify essential facilities that must be protected to avoid causing HRCs in the event of damage to plant facilities by sabotage and to identify structures and rooms that require physical protection to protect these essential facilities. Physical protection system design shall be implemented for structures and rooms selected as vital areas to ensure integrity even in sabotage. However, implementation of physical protection system designs is practically very difficult if the structures and rooms selected as vital areas exist independently of the yards.

The overall plant layout of a OPR-1000 nuclear power plant was shown in Fig. 1. The safety facilities that constitute the main success paths of standard nuclear power plants are summarized in Fig. 2. As shown in Fig. 1., important secondary heat removal systems, such as the Essential Service Water (ESW) system and the Condensate Storage Tank (CST) are installed in a separate structure at the plant site. For this reason, the accident that prevents core damage by performing heat removal on the secondary side among the multiple event tree heading-level prevention sets is selected as the final event tree heading-level prevention set.

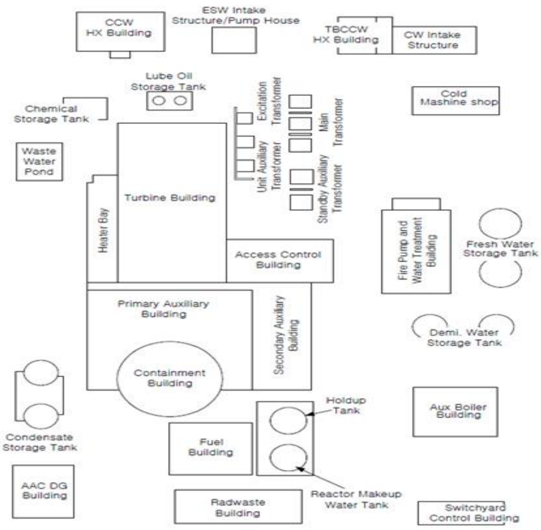

Fig. 1. Overall plant layout of OPR-1000 nuclear power plant

An auxiliary feed-water system and an additional feed-water source are required to maintain heat removal on the secondary side and prevent damage to the core when a sabotage occurs. The main source of the auxiliary feed-water system is the CST, an additional auxiliary source is the Demi-water Storage Tank (DST). As shown in Fig. 2., both CST and DST are installed in yards outside the auxiliary building.

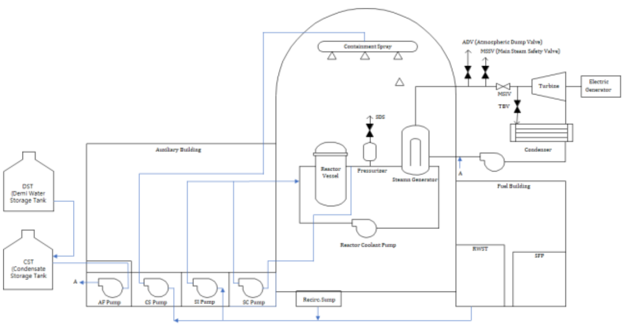

Fig. 2. The safety facilities that constitute the main success paths of OPR-1000 nuclear power plant

The most important yard facility for the safety of nuclear power plants is CST, which provides a source of auxiliary water supply. In particular, in the case of OPR-1000 power plants, auxiliary water supply sources (CST) was installed in yard. In addition, additional means of replenishment for auxiliary feed-water sources are required if the acceptance criteria of plant's maintenance period time is 24 hours. Most of the additional auxiliary feed sources used to fill the auxiliary feed-water are installed in yard. Therefore, it is difficult to protect these facilities from malicious sabotage.

A detailed analysis of the difficulty of implementing physical protection system designs for facilities installed in yard determined as a result of vital area identification analysis will be the basis for determining additional regulatory actions. This analysis should be conducted in conjunction with the acceptance criteria of plant's maintenance period time. Thus, since this consideration analysis is directly related to the burden/cost of the operator in terms of implementing the physical protection system design for the facilities installed in the yard, it is necessary to grasp the wills and strategies of the operator in advance and consider the regulation.

3. Conclusion

The PSA in building target sets for the VAI analysis, it is necessary to consider that the yard facilities include acceptance criteria of nuclear power plants stable states maintenance period. In this paper, in particular, consideration of yard facilities in the process of the vital area identification of nuclear power plants was analyzed.

The vital area identification analysis is performed according to the permissible plant safety status and the duration of the permissible plant safety status, and facilities, connecting pipes, etc. are selected as vital areas, the physical protection system design for these facilities should be implemented. These process could be act as a big burden on nuclear power plant operators.

In domestic light-water reactor's tanks which are additional auxiliary water sources are installed in the yard. Therefore, it is practically very difficult in terms of physical protection system design. Therefore, it is necessary to establish a realistic acceptance criteria of plant's maintenance period time in consideration for the vital area identification.

Acknowledgement

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[1] International Atomic Energy Agency, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities (INFCIRC/225/Revision 5), IAEA Nuclear Security Series No. 13, IAEA, Vienna, 2011.
[2] 10 Code of Federal Regulations, Part 73.55.