Development of Safety Requirements for Systems and Components to Prevent Design Basis Accidents in a Decommissioning Research Facility

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1. Introduction

In order to successfully decommission a nuclear power plant, it is necessary to examine each component of the facility such as radioactive reactor pressure vessels and internal structures [1]. The physical and chemical properties of the radioactive samples are investigated inside a hot cell. The hot cell is about one meter thick concrete walls with radiation shielding windows, doors, feed-through and remote handling systems. This hot cell provides a robust structure for radiation safety to facility workers, public and the environment [2]. To fulfill the safety of the hot cell facility for licensing applications, hazard analysis and accident analysis are conducted, respectively [3]. Design basis accidents (DBAs) are selected after conducting the hazard analysis to evaluate safety of the decommissioning research facility. And then, several types of safety structure, systems, and components (SSCs) are selected to prevent and mitigate likelihood or consequence of the accident after the accident analysis procedure. In this study, two of selected DBAs for a decommissioning research facility are introduced and the preventive measures of them are explained with their descriptions and requirements.

2. Methods and Results

2.1 A list of design basis accidents and preventive measures

A list of the selected DBAs for the decommissioning research facility is shown in Table 1. There are several types of DBA cases and two of them are finally chosen in this study as follows. Each preventive measure is explained and its requirement is described.

Table 1 A selected list of design basis accidents in a decommissioning research facility and their preventive measures

	Design basis accident	Preventive measure
1	Direct radiation exposure to workers during facility operation	· Access prevention interlock system
2	Drop of radioactive materials and exposure to workers	· Access prevention interlock system · Crane drop prevention system

2.2 An access prevention interlock system

2.2.1 Description of the access prevention interlock system

The derived DBAs contain assumptions in which workers enter an area, exceeding the allowable radiation limit due to a human error such as violating work procedures or failing to comply with regulations. In this case, it is also assumed that there is an urgent event to enter the hot cell without conducting any protective action and safety check before the entering due to the human error.

If there is no interlock to prohibit the access, there is a risk of an accident to enter the working area of a hot cell where even radioactive materials exist. When entering a process hot cell or process area, it should be approved by a facility or process manager according to the prescribed work procedures and a work schedule. Even in this case with the approval, however, there would be a possibility that an unexpected radioactive material exists in the area.

In the DBA, a rear door or door is used to enter or exit each process cell or area. Thus, it is necessary to have an interlock system. Accordingly, it is possible to prevent unexpected exposure for workers by applying an interlock system to control the access of the unauthorized workers.

2.2.2 Requirements of the access prevention interlock system

· When entering hot cells and process areas where workers are expected to be exposed to an excessive radiation, the access should be controlled through a door equipped with a safety interlock system.

· Set an interlock system so that the door does not open when exceeding a certain radiation level. However, in an emergency situation, an emergency controller to open the door inside the cell should be operated with a higher priority.

· A radiation monitor and alarm system should be installed in the relevant area and configured to transmit signals to the control room.

2.3 A crane drop prevention system

2.3.1 Description of the crane drop prevention system

In the selected DBA, it is assumed that the worker is directly exposed by staying in the process area due to the occurrence of drop accident during handling of radioactive materials. In case of a cask receiving area, even if a drop accident is assumed, there is a barrier with sufficient radiation shielding ability. Thus, exposure outside the receiving area could be excluded from consideration.

In addition, when working inside the receiving area, all the doors to enter the area should be temporarily closed to prevent unwanted entering of outside workers. At the same time, a necessity of residence for workers inside the area could be extremely low. Because the transfer operation of radioactive materials is carried out with remotely operated equipment such as the shielding window, master-slave manipulator (MSM), crane, and transporting cart.

Nevertheless, as assumed in the DBA, possibility for a drop of a heavy object containing radioactive materials during operation cannot be completely excluded. The potential energy of a heavy object increases during crane moving operation. In that case, there would be concerns about the scattering of radioactive materials in the event of the drop. Therefore, it is necessary to equip the crane itself with a drop prevention system so that it does not occur.

2.3.2 Requirements of the crane drop prevention system

· It must have sufficient capability to handle the weight of equipment and samples for the facility.

· An alternative power supply line or an extra pneumatic drive device should be provided so that the crane can be moved even in the event of a power loss such as a power outage or failure of drive device.

· The cell crane must have single failure proof to prevent drop of the lifting object even in the power loss event. In particular, when handling heavy objects of one ton or more, an independent double braking system must be installed to prevent a drop event.

· The bearings and gear boxes of the cell crane must be shielded to prevent damage by radiation. Exposure to the radiation should be also minimized.

· Components such as the hoist trolley of the cell crane must maintain structural integrity even in seismic conditions, and must be equipped with a fixing device for earthquakes.

· Handling equipment must be equipped with compulsory fastening equipment to prevent accidental loosening, and speed limit values must be set for driving equipment.

3. Conclusions

In this study, two types of DBAs are selected based on the preliminary hazard analysis for a decommissioning research facility. Each of the DBAs is explained with probable assumptions. And then, requirements of their preventive measures such as interlock system and drop prevention system are discussed. There can be additional DBAs for the research facility with hot cell. Thus, it will be further studied to derive additional DBAs and to select not only preventive but also mitigative measures, thus developing their requirements for safety of the decommissioning research facility.

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Acknowledgements

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) granted financial resource from the Ministry of Trade, Industry & Energy, Republic of Korea (No. 202015203000090)