An Observation on Radiological Safety Analysis for Multi-Unit Site or Multi-Site of Nuclear Power Plants

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1. Introduction

In these days, the number of units or nuclear facilities in the same site is increasing and additional sites tend to be formed adjacent to an existing site. As a result, there is an increasing interest about how radiological safety analysis should be carried out for such multiple radiological facilities. For sites containing multiple radiological facilities, safety analysis must be performed in an integrated manner accounting for extreme events potentially affecting multiple facilities (e.g., strong earthquake or high wind) and inter-facility dependencies in terms of human/technological/ organizational factors [1].

In this paper, we first review radiological safety assessment for single unit, and for multi-unit site and multi-site of nuclear power plants(NPPs). Then, we propose an approach to how the radiological safety of multi-unit site or multi-site of NPPs must be evaluated.

2. Review of Radiological Safety Analysis

2.1 Radiological Safety Analysis for Single Unit

Safety of NPPs must be ensured by a thorough evaluation of various accident conditions envisioned over the plant lifetime and incorporating reliable countermeasures against natural or artificial disasters. Continual safety evaluation of the NPP sites also must be carried out (e.g., via periodic safety reviews) to guarantee that plant safety is not compromised due to unforeseen circumstances. The NPP safety analysis is mainly composed of core performance evaluation and system safety analysis. System safety analysis mainly covers analysis of design basis accidents (DBAs) including loss of coolant accidents (LOCAs) and transients, and also analysis of severe accidents such as station blackout (SBO) or natural disasters. In case of single-unit sites, safety analysis is performed in consideration of multiple equipment failures and human errors.

In the aftermath of the Fukushima accident in March 2011, the following countermeasures have been implemented at each unit of Korean NPPs:

- Against earthquake and tsunami : enhanced safety of structures systems and components (SSCs) to prevent loss of function by tsunami, extension of seawalls, recovery measures in case of a prolonged SBO
- Against external flooding : emergency power and power connection junk boxes, measures against loss of ultimate heat sink and loss of cooling to spent fuel pool
- Against severe accidents : enhanced mitigation strategy, measures against loss of power and depletion of cooling water, prevention of severe accident phenomena
- Emergency response : emergency plan, environmental radiation monitoring
- Miscellaneous : hydrogen control system, severe accident management guideline, aging management, design changes

The exposure dose of person off the site under the above considered accidents should take into account all the effects from each site or each unit. Therefore, the dose constraint for each site should be assigned based on the relevant dose limits [2-4]; in normal operation, the legal limit of effective dose for any person off the site is 1mSv/yr [4].

2.2 Radiological Safety Analysis for Multi-Unit Site and Multi-Site of NPPs

In a multi-unit site, the progression and resulting consequence of an accident affecting multiple units (e.g., due to extreme natural hazards) could be affected by the nature and degree of SSC sharing among units. In a supplementary report on the regulation of site selection and preparation of the OECD Nuclear Energy Agency (NEA)), it is indicated that impacts from other units and facilities in a multi-unit site need to be considered, and interactions should be evaluated and prevented. And there are no limits on source term and number of units for contribution of all facilities to the source term including spent fuel storages, waste

management facilities and nuclear reactors[5]. And the Office for Nuclear Regulation (ONR) of the UK recommended that, when assessing the radiological risks, all the facilities, services and activities on it need to be considered [6].

The ONR also recommended that, where multiple sites are adjacent, a dose constraint should be applied to each site to ensure that the overall dose to a person off the site is below the dose limit [3].

3. Proposed Approach

Figure 1 shows a simplified diagram of the overall dose analysis to a person off the KORI site and assignment of site dose constraint. There are 10 units including the planned units in the KORI site. The regulatory agency of Korea recommended that the safety analysis should be carried out assuming that KORI and SHINKORI are separate sites. However, SHINKORI 1&2 units are adjacent to the KORI site rather than the SHINKORI site and the Hyoam-cheon (stream) is located between the SHINKORI 1~2 units and the SHINKORI 3~6 units. Therefore, it does not seem to be appropriate to decide that they are in the SHINKORI site and the terrain and geological surveys should be conducted for site separation.

The above example would be applied equally to an accident condition at a multi-unit site or multi-site. Therefore, in consideration of multi-unit accidents or multi-site accidents, the dose constraint for each site or each unit at the time of accident should be evaluated and assigned.

4. Conclusions and Discussions

We reviewed the open literature on comprehensive radiological safety analysis for multi-unit site and multi-site of NPPs. The Fukushima accident is an actual illustration of a multi-unit accident. As happened in the Fukushima accident in reality, extreme natural disasters in a multi-unit site might cause loss of electric power and loss of cooling functions throughout the entire site, resulting in serious radioactive accidents.

Therefore, even if the multi-unit site and multi-site are affected by extreme natural disasters, safety functions should be implemented independently in each unit and in each site. And the comprehensive measures should be provided for the multi-unit site and multi-site. In particular, the dose constraint for each site or each unit should be assigned and managed through the comprehensive evaluation for multi-unit site and multi-site of NPPs.

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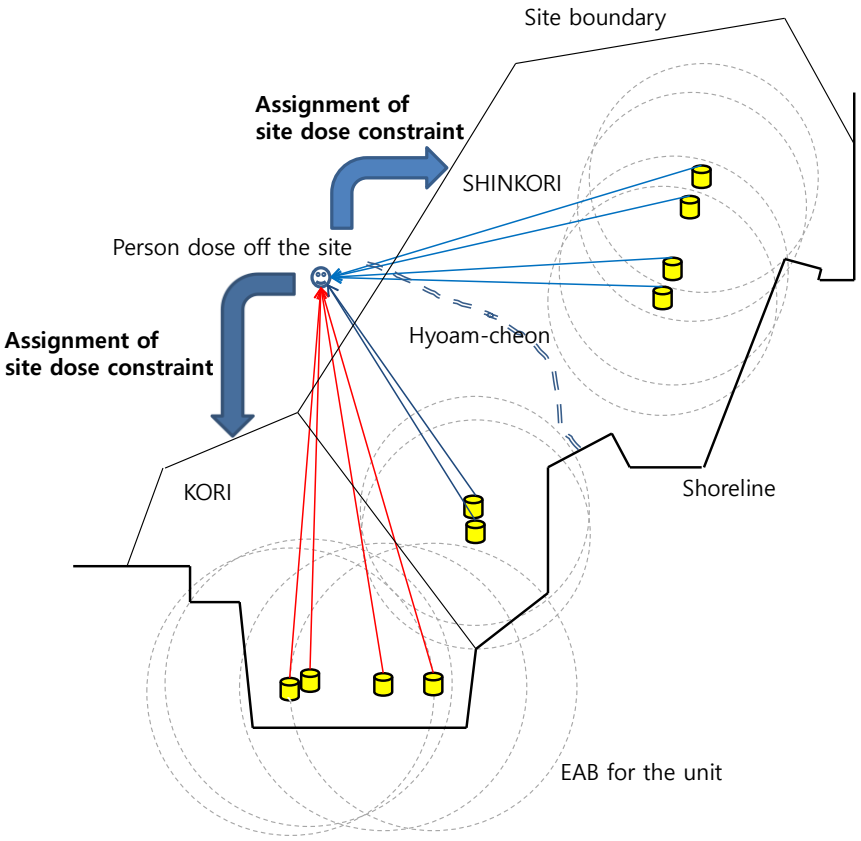

Fig. 1 Example of the overall dose analysis to a person off the KORI site and assignment of site dose constraint