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Towards Optimization of Emergency Management for Radiological Accidents

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1. Introduction

Safety management in nuclear power plants or other relevant organizations such as nuclear utility or regulatory body, in general, may be regarded as consisting of three elements: risk management (RM), accident management (AM), and emergency management (EM). From a chronological perspective: 1) RM identifies and manages potential risk associated with the nuclear power plant operation; 2) AM develops prevention measures to stop accident progression at the earliest possible time and implements mitigation measures to reduce potential consequences; and 3) EM makes emergency plans at the levels of the central government, local governments, nuclear regulatory body as well as the nuclear utility, and then implements them as a last barrier for the defense in depth against radiological accidents.

The purpose of this paper is to provide our viewpoints on how the emergency management can be optimized in order to minimize the consequences of a radiological accident should it ever occur. Our viewpoints are presented in consideration of the domestic and international status of emergency or disaster management in the nuclear community and beyond.

2. Goal Tree for Optimal Emergency Management

In order to identify the essential aspects of optimal emergency management for radiation leakage accidents, a logic tree was developed using a goal-tree success-tree approach [1], although only a simple goal tree was found to be necessary for this study. The goal tree shown in Fig.1 has been developed with a top goal of "Optimize Emergency Management for Radiological Accidents," which is then decomposed into the following subgoals by asking how the top goal can be achieved: 1) Optimize Emergency Management Organization; 2) Optimize Emergency Classification System; and 3) Optimize Response Actions against Radiological Accidents. Although the top goal might be decomposed in many different ways depending on a specific focus or the analyst's perspective, the goal tree was developed as depicted in the figure in consideration of the domestic and international status of emergency/disaster management in the nuclear community and beyond.

2.1 Optimal Emergency Management Organization

It is well known in the area of accident causal analysis that organization factor plays a very important role in major accidents [2]. For instance, Space Shuttle Challenger and Columbia disasters are regarded as organizational accidents. The recent accident at the Fukushima Daiichi nuclear power plants also involved several organizational issues, e.g., a distortion of the decision making framework due to the sudden visit of the Japanese Prime Minister to the site in the top-down disaster management hierarchy of the society.

In case of a nuclear plant accident, the operators at the Main Control Room (MCR) first respond to the initiating event. The Technical Support Center (TSC) and Emergency Operations Facility (EOF) will then be activated if deemed necessary as per the pre-established plant guideline. The TSC and EOF staff make important decisions to deal with the severe accident. Various emergency response centers are also activated, including central and local governments, nuclear regulatory body (e.g., central and site radiation-emergency response command centers of Nuclear Safety and Security Commission [NSSC], radiation-emergency response technical support center of Korea Institute of Nuclear Safety [KINS]), and radiation-emergency response headquarter of Korean Hydro and Nuclear Power Company [KHNP]). In addition to these emergency response organizations, a number of private organizations will also come into play (e.g., not only voluntary organizations, but also business corporations according to their own business continuity plans [BCP] to minimize adverse impact on their business from the accident). As a result, it is extremely important that any potential intra- or inter-organizational issues be properly resolved in advance to avoid aggravation of the accident progression due to organizational issues. IAEA also puts the greatest emphasis on the establishment and maintenance of an integrated and coordinated emergency management system for preparedness and response for a nuclear or radiological emergency [3].

2.2 Optimal Emergency Classification System

Establishment of an adequate Emergency Classification System (ECS) is also essential for optimization of emergency management, because it facilitates timely activation of the various emergency response organizations and determination of how best to balance the benefits of an action against the associated radiation risks (e.g., evacuation, sheltering) and any other detrimental impacts to which it gives rise.

Korean ECS for nuclear accidents is composed of three categories, namely, white, blue, and red depending on the severity of the event. Even more delicate ECS is employed in the U.S. nuclear industry, in terms of so-called Emergency Action Levels (EALs). Four classes of EALs are established which replace the classes in Regulatory Guide 1.101, each with associated examples of initiating conditions: 1) Notification of Unusual Event (NOUE); 2) Alert; 3) Site Area Emergency (SAE); 4) General Emergency (GE). NEI 99-01 is being used as the EAL development guide, since it has been endorsed by the NRC. It incorporates the development frameworks for various EALs, including recognition categories such as: 1) radiological effluent; 2) cold shutdown / refueling system malfunction; 3) fission product barrier degradation; 4) hazards and other conditions affecting plant safety; and 5) system malfunction. Recently, the NRC is endeavoring to further improve the ECS by risk-informing the emergency action levels based on the accident scenarios from Probabilistic Safety Assessment (PSA) [NUREG/CR].

2.3 Optimal Emergency Response Actions

As emergency management and the associated emergency response actions involve a large number of different organizations as indicated above, effective coordination and adequate joint command control are needed for the successful response to the emergency condition. In addition, adequate public communication with respect to the accident situation and prospective evolution of the accident will greatly help the public take appropriate actions to minimize the consequences on their health or properties. In Korea with high-population-density nuclear plant sites, optimizing evacuation routes depending on the evolving accident situation, environmental condition or other decision factors is utmost important. An advanced simulation technique, such as Agent Based Modeling (ABM) [4], might be utilized in order to simulate evacuation of the residents around the site (e.g., 10 km or 20 km from the site boundary), and thereby, identify the issues that need to be addressed to optimize the emergency response actions (e.g., traffic control, construction of additional roads).

3. Conclusions

Various ways to optimize emergency management for radiological accidents have been discussed. In view of the critical importance of emergency management as a part of safety management, it is recommended that more attention and research efforts be directed toward this technical discipline.

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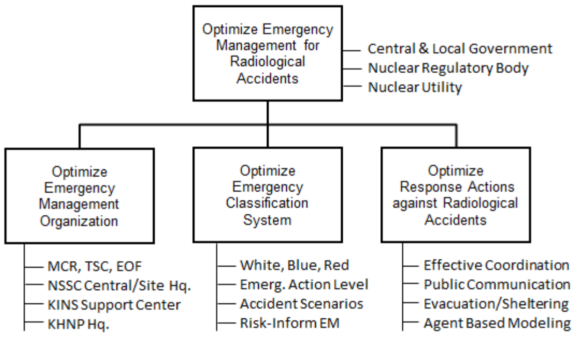

Fig. 1 Optimization of Emergency Management