The Meaning of Nuclear Emergency Preparedness and Changes in Concept

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1. Introduction

Nuclear emergency preparedness internationally have been enhanced after the experiences of nuclear accidents at TMI, Chernobyl and Fukushima. The physical protection and nuclear emergency preparedness act(hereafter, emergency preparedness act) of Korea was enacted in 2003, to enhance physical protection of nuclear facilities and national nuclear emergency preparedness system after JCO criticality accident in Japan in 1999 and 911 terrorist attack in USA in 2011. The emergency preparedness of Korea was also enhanced after Fukushima accident in emergency planning zone and nuclear exercise. But Korean emergency preparedness act and response system have not yet considered seriously of accident progress characteristics and radiation protection objective during emergency exposure situation. In this research, the international concept of emergency preparedness will be introduced. When we understand the basic concept suggested international organization, the harmonized and advanced emergency preparedness system can be established in national base.

2. Emergency Preparedness in Nuclear Safety

In this section, the emergency preparedness (EP) from the viewpoint of nuclear safety was introduced.

2.1 EP in Defense in Depth

Radioactive materials is useful for human societies, but the radiation from this materials can make harmful effects to human health, so the radioactive materials should be properly contained and shielded to prevent unexpected exposure by its radiation. The defense in depth concept is used to protect the public from unexpected exposure, so this concept is used for designing of nuclear facilities. The nuclear power plant has 5 physical barriers for defense in depth, if the all barriers are destroyed by any reason, it can be defined as an accident. In case of an accident, people will get unexpected dose from the radioactive materials released from a nuclear facility, so for this case, additional barrier should be considered for defense in depth to reduce the dose to the public, it is the emergency preparedness. The defense in depth concept including emergency preparedness for nuclear power plant can be described like figure 1.

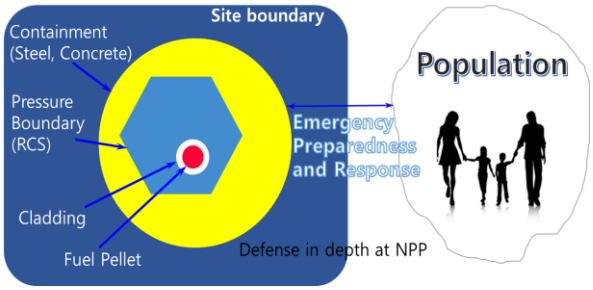

Fig. 1. Defense in Depth including emergency preparedness to protect the public from harmful radiation effect from nuclear power plant.

2.2 EP in Designing Stage of Nuclear Facilities

Applicant of construction and operation of a nuclear facility should summit safety analysis report (SAR) and radiological environmental impact assessment report (ER) to get license. This two documents are important in establishing emergency plan. Through these documents, the emergency planner can understand an accident characteristics and its impact by the facility to the worker involved and the public near the facility. Through this understanding, the emergency planner can establish emergency plan properly to respond the accident considered and to protect the public. During the planning, the organization, facilities, equipment, supplies, cooperation, etc., which are needed to respond the accident situation, are considered for preparation, and the emergency plan should be worked before operation, so the emergency plan should be prepared in advance of the operation of a nuclear facility through understating the accident considered. Similarly, the results of the PSA Level 2 and 3 for nuclear reactor and the hazard assessment for non-reactor nuclear facility can also be used to develop emergency plan.

3. Emergency Preparedness in Radiation Safety

In this section, the emergency preparedness from the viewpoint of radiation safety was introduced. The figure 2 shows the overall relationship between the international recommendations and requirements and the Korean Act of emergency preparedness. So in this section, the basic concept, concept changes of emergency preparedness in time progress are described based on each international document.

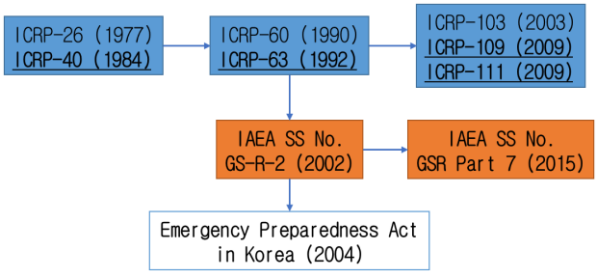

Fig. 2. Relationship of ICRP recommendation, IAEA requirement and Korean Act for nuclear emergency preparedness

3.1 ICRP 40 recommendation

ICRP 40 is the first recommendation for the nuclear emergency preparedness. The ICRP 40 suggests the principles for intervention in the event of an accidents as following [1].

(a) Serious non-stochastic effect should be avoided by the introduction of countermeasures to limit individual dose to levels below the thresholds for these effects.
(b) The risk from stochastic effects should be limited by introducing countermeasures which achieve a positive net benefit to the individuals involved.
(c) The overall incidence of stochastic effects should be limited, as far as reasonably practicable, by reducing the collective dose equivalent.

ICRP 40 suggests lower level of non-stochastic effect of vomiting as 0.5Gy for whole body, this value is used as an important indicator of the dose for the countermeasure to limit stochastic effects, for example, ICRP suggests the dose for evacuation as 500mSv for whole body as upper dose level and 50mSv as lower dose level. The lower dose level is just one tenth of upper dose level.

3.2 ICRP 63 recommendation

The important thing in ICRP 63 is change of the concept of intervention level used during emergency for protective action. ICRP 63 defined the intervention level as averted dose by proactive action as shown in the figure 3 [2].

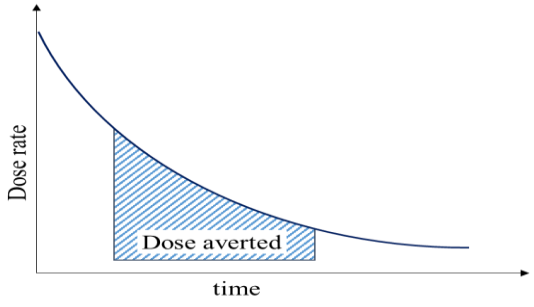

Fig. 3. Averted dose concept in ICRP 63

ICRP 63 used benefit-cost theory to derive the intervention level for some countermeasure that is ICRP 63 considered the advantage of a protective action is the dose averted and the disadvantages of a protective action is the cost needed for the protective action. In the ICRP 63, a protective action is justified whenever there is a positive net benefit from the action and the optimum is when the benefit is maximized.

3.3 ICRP 109, 111 recommendation

ICRP 103 considers three exposure situation, that is planned, emergency and existing exposure situation. ICRP 109 is for the emergency exposure situation and ICRP 111 for the existing exposure situation. The major change in ICRP 109 is the change of the dose concept used during emergency exposure situation. ICRP 109 and 111 suggest reference levels as residual dose for protective action during and after emergency [3,4]. ICRP 63 considers the protective action independently, but ICRP 109 considers the protective action simultaneously when deciding on the optimum course of action. ICRP 109, 111 suggests reference levels as 20-100mSv band for emergency exposure situation and as 1-20mSv band for existing exposure situation [3,4].

3.4 IAEA SS GS-R-2 requirement

IAEA safety standard requirement GS-R-2 follows ICRP 63 recommendation. In GS-R-2, the protection objective for emergency preparedness is to prevent the occurrence of deterministic effects in individuals by keeping doses below the relevant threshold and to ensure that all reasonable steps are taken to reduce the occurrence of stochastic effects in the population at present and in the future [5]. To accomplish the protection objective, IAEA suggest Action Levels(ALs) as the threshold dose to prevent deterministic effects and Generic Intervention Levels(GILs) as averted dose to reduce the stochastic effects by using for the protective action, and IAEA divide nuclear threat based on the health effect at on and off the site like table 1 [5].

Table 1: Threat category by radiological hazard

Threat Category	Radiological hazard
I	Severe deterministic health effects off-site
II	Warranting urgent protective actions off-site, deterministic health effects on-site
III	No urgent protective actions off-site are warranted, severe deterministic health effects on-site
IV	Activities with the potential to trigger a radiation emergency that could warrant protective actions in an unforeseen location

V	Nuclear threat from category I or II located in nearby State

GS-R-2 suggests two kinds of emergency planning zone, one is precautionary action zone (PAZ) which is for preventing severe deterministic effects and the other one is urgent protective action planning zone (UPZ) which is for reducing stochastic health effects. The distance of PAZ and UPZ was derived using ALs and GILs in the severe accident and average meteorological condition. Emergency classification is also based on the health effect on or off the site.

3.5 IAEA SS GSR Part 7 requirement

IAEA safety standard requirement GSR Part 7 follows ICRP 109, 111 recommendation. The major change of GSR part 7 is the dose concept used during emergency situation. GSR Part 7 use projected dose or dose received as generic criteria (GC) for protective action. GSR Part 7 chose the upper level suggested by ICRP for the exposure band during emergency, which is 100mSv, but GSR Part 7 approach to use projected dose instead of residual dose [6]. If government take protective action when 100mSv is projected, then the public will avert the dose by the protective action, so as a result, the residual dose of the public will be below of 100mSv, it meets ICRP recommendation. GSR Part 7 and its related IAEA document recommend using operational criteria during emergency like figure 4 [7].

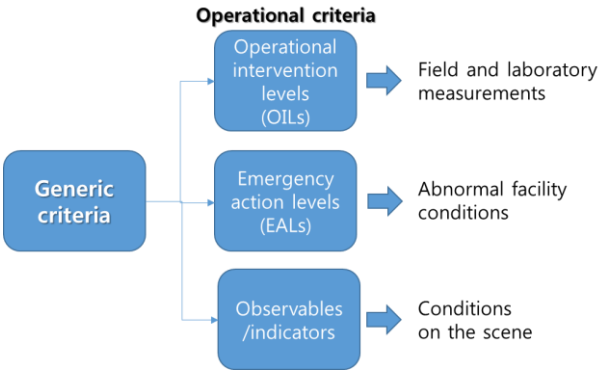

Fig. 4. Generic criteria and operational criteria used during emergency for decision making for protective action

4. Conclusions

The concept of emergency preparedness was originated from ICRP recommendation, and IAEA suggests requirement and guide documents for the emergency preparedness for the States based on the ICRP recommendation. So each State should consider the concept suggested by ICRP for establishing their national nuclear emergency response structures. And also the concept has been changed to reflect the research results and accident experiences, so the following up the recent recommendation quickly is important to increase the effectiveness of the national emergency response structure.

REFERENCES

[1] ICRP (1984). “Protection of the Public in the Event of Major Radiation Accidents: Principles for Planning”, ICRP Publication 40, Annals of the ICRP 14(2)
[2] ICRP (1991). “Principles for the Intervention for Protection of the Public in a Radiological Emergency”, ICRP Publication 63, Annals of the ICRP 22(4)
[3] ICRP (2009). “Application of the Commission’s Recommendations for the Protection of People in Emergency Exposure Situation”, ICRP Publication 109, Annals of the ICRP 23(1)
[4] ICRP (2009). “Application of the Commission’s Recommendations to the Protection of People Living in Long-term Contaminated Areas after a Nuclear Accident of a Radiation Emergency”, ICRP Publication 111, Annals of the ICRP 39(3)
[5] IAEA, “Preparedness and Response for a Nuclear or Radiological Emergency”, IAEA SS GS-R-2, 2002
[6] IAEA, “Preparedness and Response for a Nuclear or Radiological Emergency”, IAEA SS GSR Part 7, 2015
[7] IAEA, “Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency”, IAEA SS No. GSG-2, 2011