

Analysis on the Establishment of Domestic and Foreign Emergency Planning Zones

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1. Introduction

Since the Fukushima nuclear accident in 2011, each nuclear power plant operating country has been making efforts to improve its effectiveness in the scope of Emergency Planning Zones (EPZs) and the scope and implementation of resident protection measures, such as evacuation and indoor evacuation of emergency areas.

In Korea, EPZ have been set up and operated in a single area ranging from 8 km to 10 km radius. However, considering extreme disasters (complex accidents and contingencies), it has been suggested that protection measures are unrealistic and ineffective in terms of implementation. For this reason, the NSSC amended the Act on Measures for Protection of Nuclear Facilities and Radiation Prevention in 2014. Under the Act, the scope of EPZ was expanded to a maximum of 30 km. In addition, the existing single zone concept has been subdivided into preventive Protection Action Zones (PAZ: 3~5 km) and Urgent Protective Planning Zones (UPZ: 20~30 km).

Some local governments are calling for expanding the scope of EPZ that have been reset by parliament or civic groups. Reflecting this demand, however, will dramatically increase the population of emergency planning zones, resulting in many difficulties in effectively establishing and implementing emergency response plans (such as evacuation of residents, drug distribution, etc.). On the other hand, if the scope of the radiation emergency planning zone is set to be narrow, the effects of radiation from nuclear accident may exceed the pre-planned range and threaten the safety of residents. Therefore, when radioactive materials are leaked, the extent of their impact, local characteristics, population, road networks, etc. should be considered and an appropriate range of radiation emergency planning zones should be established to establish an effective emergency response plan.

In this paper, the background of setting up domestic and international EPZ was analyzed and compared.

2. IAEA Requirements and Guidelines for EPZ

The IAEA has the authority to establish or adopt safety standards and may prescribe the application of relevant standards. Standards established by the IAEA are published in a series of IAEA safety standards. These series cover nuclear safety, radiation safety,

transportation safety and waste safety, and the publications in these series are divided into "Safety Fundamentals", "Safety Requirements" and "Safety Guides."

2.1 IAEA General Safety Requirements GSR Part 7

IAEA General Safety Requirements GSR Part 7[1] establishes requirements related to the preparation and response of nuclear or radiation emergency situations for nuclear safety. This safety requirement is intended for use by relevant international organizations at the international level, as well as government, emergency response agencies, regional and national levels, other authorities, operating bodies and regulators. This document contains requirements relating to radiation EPZ. Requirement 4 of GSR part7 specifies the following for hazard assessments in relation to EMZ.

"Requirement 4: Hazard assessment

The government shall ensure that a hazard assessment is performed to provide a basis for a graded approach in preparedness and response for a nuclear or radiological emergency.

...

"4.19 ... assessed hazards are grouped in accordance with the emergency preparedness categories..."

"4.20 The government shall ensure that for facilities and activities, a hazard assessment on the basis of a graded approach is performed..."[1]

Table 1 : EMERGENCY PREPAREDNESS CATEGORIES[1]

Category	Description
I	Facilities such as nuclear power plants that can have serious deterministic effects on off site in the event of an incident.
II	Facilities requiring off-site emergency protection measures in case of an accident, such as a research reactor
III	Facilities requiring protective measures for the site in the event of an incident, such as industrial radiation facilities
IV	Activities that can cause nuclear or radiation emergencies, such as the transport of radioactive materials
V	Areas within EPZ and emergency planning distances in a State for a facility in category I or II located in another State

Emergency protection measures and other response measures are specified in 5.38 of requirements 9. This specifies that EPZ and Extended Planning Distance(EPD) should be set for off-site. In this requirement, EPZs and EPDs are divided into preventive action zones, emergency protective action

planning zones, extended planning distances, and consumption and commodity distances.

2.2 IAEA General Safety Guide GS-G-2.1

IAEA General Safety Guide GS-G-2.1[2] provides guidance on preparedness for possible emergencies at nuclear facilities and other radiation-use facilities as detailed guidance for implementing the requirements of IAEA GSR part7. This guidance includes detailed guidance on EPZs mentioned in IAEA general safety requirements GSR part7[1].

The following two EPZs are recommended in this guidance. **PAZ** : This area is a preventive emergency protection area before or immediately after the release of radioactive materials in order to reduce serious deterministic health effects. This zone should be designated around power generation nuclear facilities, such as hazardous category I facilities.

UPZ : This area is designated around a dangerous category I or II facility. This zone should be prepared for immediate implementation of emergency protective measures to reduce exposure dose.

Table II : Size of EPZ[2]

Facility	PAZ radius	UPZ radius
Reactors over 1000 MWth	3 ~ 5 km	5 ~ 30 km
100MWth to 1000MWth reactors	0.5 ~ 3 km	5 ~ 30 km

GS-G-2.1 presents the recommended size of EPZ for risk category I facilities, depending on the reactor facility capacity, which is shown in Table II[2]. The PAZ radius of up to 5 km presented in Table II is the approximate distance from which a life-threatening dose can be exposed to acute (2 days). This was selected based on the calculation results of RASCAL 3.0. The dose assessment assumed average weather conditions, clear weather, surface emissions and 48 hours of exposure. In addition, the size of the UPZ is an approximate distance from which the effective dose from 48 hours of breathing, radioactive cloud and surface exposure does not exceed 1 to 10 times the GIL for the evacuation.

2.3 IAEA Emergency Response Standards Document

IAEA Emergency Response Standards document EPR-NPP-PPA[3] sets out the criteria for emergency response in case of an emergency, reflecting lessons from the Fukushima accident. This document provides criteria for meeting the requirements of GSR part7.

Chapter 4 and Appendix I of this document contain information related to EPZ and EPD. This specifically includes the concepts and technical background settings of the EPZ and EPD presented by the IAEA.

In this document, EPZs are described in PAZs, UPZs, EPDs and Ingestion and Commodities Planning Distance(ICPD). As a general concept, EPZs can be described as shown in Figure 1.

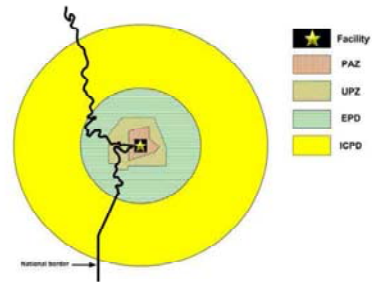


Fig. 1. Emergency zones and distances[3]

However, the actual boundary needs to be defined as river, road, and jurisdiction boundaries to facilitate response to emergency situations, as shown in Figure 2.

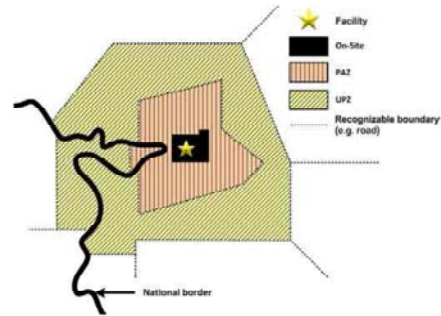


Fig. 2. Example of establishing boundaries for PAZ and UPZ[3]

It also explains that if people in areas within 5 km of nuclear power plants can be introduced more quickly, they can exclude populated villages from the boundaries of PAZ and UPZ as shown in Figure 3.

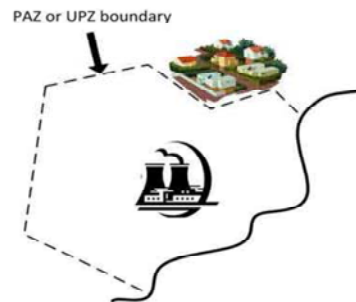


Fig. 3. Example of a PAZ or UPZ with the boundary excluding a town to enable a fast evacuation[3]

Table III is the dose criterion used to determine the size of the emergency zone. This table was calculated

by taking into account the conditions of the plant, the type of dose and the critical exposure pathways[3] It is also a standard for the most sensitive members of the public, and based on it, it says protective measures should be implemented to protect all members of the public.

Table III : Dosimetric criteria used for determining the size of the emergency zones[3]

Zone	Actions taken based on plant conditions to prevent	Dosimetric quantity	Dose criterion	Most important exposure pathway and considered in the calculations ²		
				Inhalation	Cloud shine	Ground shine
PAZ	Severe deterministic effects	$AD_{ind,max}^{a,d}$	1 Gy ^e	X	X	1 day
		$AD_{ind,inh}^b$	1 Gy ^e	X		
UPZ	Stochastic effects	E_{inh}^c	100 mSv ^f	X		
		$H_{ind,inh}^d$	100 mSv ^f	X		

Factors considered in calculating the size of EPZ include emission characteristics, weather conditions, and public behavior in addition to dose assessments.

3. U.S. EPZ Requirements and Status

3.1 Regulatory Requirements and Standards

10CFR

In the United States, nuclear operators are required to include applications such as operational licenses or committed licenses, such as the scope of radiation EPZs and emergency response plans. These requirements are contained in the United States Federal Regulations[6].

According to the above regulations, the U.S. also discloses the general scope of EPZs for power-generating nuclear reactors, similar to those in Korea. In addition, (b) (10) of the 10 CFR 50.47 energy plan specifies that various protective measures for the radiation cloud exposure path EPZ and ingestion exposure path EPZ should be developed in relation to the plant's emergency response plan and that evacuation time assessments should be performed.

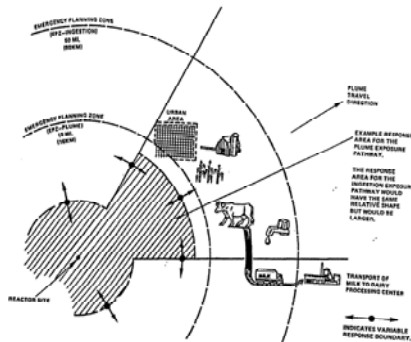


Fig. 4. Concept of EPZ

NUREG-0396[4]

NUREG-0396 was prepared to provide a basis for emergency preparedness organizations of federal, state and local governments to establish appropriate emergency response plans for areas around nuclear power plants. The concept of the early U.S. radiation emergency zone presented in NUREG-0396 is shown in Figure 4.

NUREG-0654 [5]

NUREG-0654 [15] was issued to provide guidance to state and local governments, nuclear facility operators, FEMA and NRC in relation to the measures and evaluation of the radiation emergency response plan. Of these, the radiation emergency planning zone specifies that the radiation cloud exposure path EPZ with a radius of 10 miles should be large enough to reduce serious health effects even in the event of a worst core melting event.

3.2 Technical Background of EPZ

Appendix I (theoretical basis for planning) of NUREG-0396 [12] provides the rationale that was considered to determine the size of the emergency planning zone. The Task Force Team reviewed all types of accidents considered in the Environmental Impact Assessment Report (Environmental Reports), the plant SAR accident analysis data and past studies (WASH-1400)106), and determined that the scope of the design basis coolant accident (DBA-LC) was appropriate for one of the most severe accidents.

4. Status of Radiation EPZ in Korea

4.1 Regulatory Requirements and Standards

The matters concerning EPZs within the domestic legal system are stipulated in the Protection of Nuclear Facilities, etc. and the Measures for Radioactive Disasters[7]. This was initiated in 2014 to cope with a wide range of nuclear accident following the Fukushima accident. The revised law stipulates that EPZs are managed in accordance with IAEA recommendations by subdividing them into the PAZ(5 km) and UPZ(a radius of 20 to 30 km)

In Korea, an offsite dose assessment was performed assuming a severe accident to produce an appropriate range of EPZ ranges at the time of EPZ reset. These offsite dose assessments were performed using RASCAL 4.2 and were performed assuming the most serious event developments taking into account the failure of various safety facilities and weather characteristics in the area.

Radiation Source Leakage Path

In the above-mentioned studies, an offsite dose assessment was performed assuming the LBLOCA accident and SGTR accident, the most serious accidents that could be assumed in nuclear power plants, to calculate the extent to which the deterministic and probabilistic effects of radioactive materials are likely to occur when released.

Weather Condition

The effects of offsite exposure from the state of release of radioactive materials may vary depending on weather conditions by season and time zone in the area. Therefore, the analysis was carried out by taking into account the maximum annual wind direction, average temperature and wind speed using historical weather data from the areas around each nuclear power plant.

Exposure Path

The study considered the following five paths as exposure pathways by radioactive materials: 1. Direct external exposure from radioactive cloud 2. Inhalation exposure from radioactive cloud 2. Inhalation exposure by inhalation of radioactive materials 3. Exterior exposure by surface erosion 4. Inhalation exposure by resuspended radioactive materials 5. Dermal exposure by deposited substances

Criteria for determination of measures to protect residents

The criteria for determining the protection of residents are pre-determined and notified in order to determine the implementation of protective measures for residents, such as evacuation, restriction on food intake and distribution of thyroid protection medicine, in case of radiation emergency. The study also sets the criteria for probabilistic effects in accordance with relevant statutes, and based on dose values with acute effects for deterministic effects.

Table IV : Criteria for Determination of Measures to Protect Residents

Deterministic Effect	Acute Effect 1.0 Sv ~ 1.4Sv
Probabilistic Effect	Evacuation 50 mSv
	Indoor Evacuation 10 mSv
	Thyroid Protection 100 mSv

4. Results

The radiation EPZ around nuclear power plants in Korea are divided into PAZs (3-5 km) that perform immediate response actions in case of emergency situations by applying IAEA recommendations, and UPZ (20~30 km) that perform partial response actions according to wind direction and environmental monitoring results. In addition, the methodology for

setting up emergency planning zones and the dose criteria for determining measures for protecting residents in case of emergency situations were consistent with those of the IAEA. This section has compared and reviewed the previously described IAEA, domestic and U.S. emergency planning zones, and lists the major differences and features as follows.

① Domestic emergency planning zones have been set up to a range of up to 30 km in accordance with IAEA recommendations and are wide compared to those of overseas nuclear power operating countries. ② The offsite dose assessment for the establishment of emergency planning zones in Korea assumes severe accidents, such as large loss of coolant accident (LOCA) and steam generator tube break (SGTR) accidents, and the probability of such accidents is extremely low compared to those considered for setting up emergency planning zones abroad. ③ In the domestic emergency planning zone, the probability of death or dose by distance has not been assessed according to the implementation of protective measures, such as evacuation, indoor evacuation, and the use of thyroid protection medicine. The range of deterministic probabilistic impact assumed by the implementation of protective measures is expected to be reduced.

REFERENCES

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- [2] IAEA, "Arrangements for Preparedness for a Nuclear or Radiological Emergency", Safety Guide No. GS-G-2.1, 2007
- [3] IAEA, "Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor", EPR-NPP Public Protective Actions, 2013
- [4] NRC, "Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants", NUREG-0396, 1978
- [5]NRC, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants", NUREG-0654, 1980
- [6]NRC, Title 10, Code of Federal Regulations
- [7] Measures for the Protection of Nuclear Facilities, etc. and Prevention of Radiation (Act No. 15280, 2017.12.19. Partially revised, effective (2018.6.20.)