Assessment of Radiation Dose Resulting from Gaseous Effluent Based on Representative Person Concept

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1. Introduction

Nuclear Safety and Security Commission (NSSC) set a notice to manage radiation dose to the public resulting from the radioactive effluent from nuclear power plants[1]. The licensee of the nuclear power plants assesses the radiation doses and provides the results in the Radiological Environmental Report (RER).

The International Commission on Radiological Protection (ICRP) published the ICRP 101 report and recommended applying the concept of representative person to reasonably assess radiation doses to the public[2]. However, such concept was not fully accepted in the current regulation system. The maximum exposure individual concept instead of representative person has been used for radiation protection. The new concept is expected to be reflected in regulation system in the future.

The objective of the present study was to assess radiation dose resulting from gaseous effluent using the representative person concept. Therefore, this study conducted dose assessments for critical groups residing around actual nuclear power plants. In the case of ingestion, a 95 percentile value was applied for the two food groups that were dominant in dose contribution. In addition, atmospheric dispersion factor and soil deposition factor for dose assessment were applied taking into account the direction in which the actual critical group is located.

2. Material and Methods

2.1 Representative Person

ICRP defined a representative person as the concept of a person representing more people exposed in a group in the assessment of public exposure dose. This corresponds to the average member of the critical group previously recommended by the ICRP. The critical group should be where the actual person can exist. ICRP recommended that 95 percentile values should be used for the dominant exposure pathways and lower values should be applied for other pathways to perform dose assessment for the representative person. It is also recommended that radiation doses should be assessed by applying three age groups when applying the representative person concept.

2.2 Source Term

The emission of gaseous effluent was assumed for this study (Table 1). The emission rate was assessed by PWR-GALE code with value recommended by American National Standards Institute (ANSI). Assumed gaseous effluent can be classified into noble gases, particle-based sources, H-3, and C-14.

Table 1: Source term of gaseous effluent (TBq/y)

Nuclide	Emission Activity	Nuclide	Emission Activity
I-131	2.6×10^{-3}	Cr-51	6.7×10^{-6}
I-132	1.3×10^{-2}	Mn-54	3.7×10^{-6}
I-133	8.5×10^{-3}	Co-57	5.6×10^{-7}
I-134	2.2×10^{-2}	Co-58	2.6×10^{-5}
I-135	1.6×10^{-2}	Co-60	5.2×10^{-6}
H-3	3.4×10^{1}	Fe-59	1.9×10^{-6}
C-14	2.7×10^{-1}	Sr-89	1.0×10^{-5}
Ar-41	1.3×10^{0}	Sr-90	4.1×10^{-6}
Kr-85m	2.1×10^{0}	Zr-95	3.7×10^{-7}
Kr-85	1.3×10^{2}	Nb-95	2.1×10^{-6}
Kr-87	7.4×10^{-1}	Ru-103	1.2×10^{-6}
Kr-88	2.6×10^{0}	Ru-106	2.9×10^{-8}
Xe-131m	5.6×10^{1}	Sb-125	2.3×10^{-8}
Xe-133m	3.6×10^{0}	Cs-134	2.6×10^{-6}
Xe-133	1.7×10^{2}	Cs-136	2.2×10^{-6}
Xe-135m	2.6×10^{-1}	Cs-137	4.8×10^{-6}
Xe-135	1.9×10^{1}	Ba-140	1.6×10^{-7}
Xe-138	1.9×10^{-1}	Ce-141	8.9×10^{-7}

2.3 Exposure Scenarios and Exposure Pathways

In order to establish a representative person concept for assessing public dose around the nuclear power plant, critical group should be defined. In order to define a critical group, an exposure scenario must be established and a critical group suitable exposure scenario must be selected. In this study, five exposure scenarios were set up: (1) agricultural residents, (2) fishery residents, (3) industrial workers, (4) 10-year residents, and (5) 1-year residents, considering the characteristics of residents living around nuclear power plant. The scenarios for residents were segmented by occupation and age group. Additionally, industry workers represented the exposure scenario of residents living in external area but commuting to area around nuclear power plant.

The exposure pathways of the gaseous effluent considered in this study was referred to the exposure pathways given in the Regulatory Guide 2.2 of the Korea Institute of Nuclear Safety (KINS)[3]. Four pathways of exposures were considered: (1) external exposure due to air submersion of radioactive materials, (2) external exposure due to contaminated soil, (3) internal exposure due to breathing, (4) internal exposure due to ingestion of crops and livestock products.

2.4 Radiation Dose Assessment

Critical group was selected that were most likely to be exposed for each exposure scenario. Radiation dose conversion factors for internal exposure were referred to ICRP 72. Radiation dose conversion factors for external exposure were referred to FGR-15, which is the latest dose conversion factors presented in EPA for external exposure[4, 5].

The ingestion rate given in the KINS report was used for the radiation dose assessment[6]. The 99 percentile value should be used for all food groups if the maximum exposure individual concept is applied to perform dose assessments. However, in this study, 95 percentile values were used for the dominant exposure pathway. Also average values were used for other exposure pathways in accordance with the definition of representative person presented by the ICRP. The dominant exposure pathways were selected as grain group and leafy vegetable group pathways.

In the case of atmospheric dispersion factor and soil deposition factor were used Exclusion Area Boundary (EAB) values to assess the maximum exposure individual dose. However, in this study, actual critical group values to assess the dose of the representative person.

3. Result and Discussion

Table 2, 3 show the results of dose assessments by exposure scenarios and exposure pathways considered in this study. The radiation dose of the representative person was 70.3 μSv/y for the 1-year residents. The results are approximately 10% lower than 76.7 μSv/y which is assessed as maximum exposure individual concept.

Table 2: Representative person dose assessment results (μSv/y) (1/2)

Exposure Pathway	Agricultural Residents	Fishery Residents
Air submersion	5.25×10^{0}	5.25×10^{0}
Contaminated soil	3.24×10^{0}	1.93×10^{0}
Breathing	1.51×10^{0}	1.51×10^{0}
Ingest crops and livestock	2.29×10^{1}	2.29×10^{1}
Total	3.29×10^{1}	3.16×10^{1}

Table 3: Representative person dose assessment results (μSv/y) (2/2)

Exposure Pathway	Industrial Workers	10-year Residents	1-year Residents
Air submersion	5.25×10^{0}	6.08×10^{0}	6.89×10^{0}
Contaminated Soil	1.93×10^{0}	3.55×10^{0}	3.85×10^{0}
Breathing	1.51×10^{0}	2.13×10^{0}	1.68×10^{0}
Ingest crops and livestock	1.61×10^{1}	3.22×10^{1}	5.79×10^{1}
Total	2.48×10^{1}	4.39×10^{1}	7.03×10^{1}

4. Conclusion

In this study, the concept of representative person was applied to assess the public dose assessment of gaseous effluent. The result indicated that the dose for the 1-year residents was derived the highest at 70.3 μSv/y. The result of this study will be used as a prior study for the introduction of representative person concept recommended by ICRP 103 in Korea in the future.

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