Dose Assessment Resulting from Gaseous Effluent Released from Nuclear Research Facility Based on Representative Person Concept

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1. Introduction

Radioactive effluent is released during operation of a nuclear research facility, and it causes radiation exposure to the public. Therefore, the operator of nuclear research facility should satisfy dose criteria presented in notice for the construction and operation of nuclear research facility [1]. Radiation dose should be assessed to ensure that exposure to the public is not significant.

In Korea, radiation dose assessment of public had been conducted with the maximum exposure individual concept represented by Nuclear Regulatory Commission (NRC) [2]. However, International Commission on Radiological Protection (ICRP) published 103 recommendation and recommended the use of the representative person concept for radiation dose assessment of the public [3]. Representative person concept is expected to be reflected in regulatory system in the future. Therefore, the objective of this study is to apply the representative person concept to assess the radiation dose of the public resulting from gaseous effluent released from the nuclear research facility.

2. Materials and Methods

2.1 Representative Person Concept

Representative person is an individual receiving dose that is representative of the more highly exposed individual in the population. Representative person is equivalent to the average member of the critical group. To reflect the average member of critical group, the population distribution of exposure scenarios should be considered [3, 4].

ICRP recommended representative person should be defined by three age categories. Therefore, 1-year-old infant, (2) 10-year-old child, and (3) adult was used in this study.

2.2 Source Term

The operation of nuclear research facility generates gaseous and liquid radioactive waste. It is assumed that liquid radioactive waste is treated in radioactive waste disposal facility rather than released. Therefore, in this study, liquid effluent was not considered, and only gaseous effluent was considered. Table 1 shows the source term of gaseous effluent assumed in this study.

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

Nuclide	Emission Activity	Nuclide	Emission Activity
H-3	1.07×10^{1}	Sr-89	2.31×10^{-6}
C-14	3.33×10^{-9}	Sr-90	2.77×10^{-6}
Na-24	6.66×10^{-8}	Y-91	3.39×10^{-6}
P-32	1.67×10^{-8}	Zr-95	5.51×10^{-6}
Ar-41	3.58×10^{-2}	Nb-95	2.41×10^{-6}
Cr-51	3.33×10^{-9}	Mo-99	4.00×10^{-7}
Fe-59	3.33×10^{-1}	Ru-103	2.59×10^{-6}
Co-60	3.33×10^{-7}	Ru-106	4.77×10^{-6}
Br-83	8.47×10^{-5}	Sb-125	7.22×10^{-8}
Br-84	3.89×10^{-5}	Cs-134	2.56×10^{-6}
Br-85	4.51×10^{-5}	Cs-137	1.15×10^{-6}
I-129	3.70×10^{-9}	Ce-144	9.21×10^{-6}
I-131	3.47×10^{-3}	Pm-147	1.08×10^{-6}
I-132	6.85×10^{-4}	Eu-154	7.22×10^{-8}
I-133	4.81×10^{-3}	Eu-155	7.22×10^{-8}
I-134	4.88×10^{-4}	Xe-131m	3.65×10^{-5}
I-135	5.70×10^{-3}	Xe-133	7.36×10^{-3}
Kr-83m	6.70×10^{-5}	Xe-133m	1.93×10^{-4}
Kr-85	1.75×10^{1}	Xe-135	2.97×10^{-5}
Kr-85m	3.35×10^{-4}	Xe-135m	2.28×10^{-5}
Kr-87	2.25×10^{-4}	Xe-137	2.92×10^{-5}
Kr-88	6.55×10^{-4}	Xe-138	1.10×10^{-4}
Kr-89	1.81×10^{-5}	-	-

2.3 Exposure Pathway

Exposure pathways of the gaseous effluent for radiation dose assessment were considered which was suggested in the Regulatory Guide 2.2 [5]. In the Regulatory Guide, two pathways to external exposures were considered: (1) Air submersion of radioactive materials, (2) Groundshine of contaminated soil. Also, two pathways to internal exposures were considered: (3) Ingestion of agricultural and livestock products, (4) Inhalation of radioactive materials.

2.4 Exposure Scenario

In the case of exposure scenario, four exposure scenarios were considered: (1) 1-year residents, (2) 10-year residents, (3) Adult residents, (4) Industrial workers. In each exposure scenario, only three age groups were applied: 1-year old, 10-year old, and adults, as recommended by ICRP 103 [3]. Residents are people who live near the nuclear research facility. Industrial workers are people who work 2000 hours a year away from a nuclear research facility.

2.5 Selection of Critical Group Candidates

ICRP recommended that representative person should be assumed to occupy a location where the estimated concentrations lead to the higher doses. That is, location where the actual person lives should be considered [4]. Therefore, the directions and distances of critical group resident were considered. In this study, 10 critical group candidates were assumed. Table 2 shows directions and distances of critical group candidates considered in this study.

Table 2. Direction and distance of critical group candidates

Critical Group Candidate	Direction	Distance (km)
Candidate 1	NNE	2.0
Candidate 2	ENE	1.0
Candidate 3	SE	1.0
Candidate 4	SSE	3.5
Candidate 5	S	4.0
Candidate 6	SSW	4.5
Candidate 7	SW	5.5
Candidate 8	WSW	6.0
Candidate 9	WNW	5.0
Candidate 10	NNW	4.5

2.6 Radiation Dose Assessment

ICRP recommended that it is reasonable to apply 95 percentile intake for major exposure pathways. Also, lower percentile intake for other exposure pathways should be applied [4]. Therefore, in this study, 95 percentile was applied to two food intakes that accounted for the majority of the radiation dose. In this study, the dominant exposure pathways were selected as (1) grains group, (2) leafy vegetable intake pathways.

ICRP also recommended dose coefficients have to be applied according to specific age categories. Therefore, in this study, dose conversion factor separated by age group was used. Dose conversion factor for internal exposure was given in ICRP 72. And dose conversion factor for external exposure was given in FGR-15, which is presented in EPA.

3. Result and Discussion

Table 3 shows the results of the radiation dose assessment. To reflect average member of critical group, population distribution of exposure scenarios was considered. The results of the radiation dose assessment for the ten critical group candidates showed 5.31×10^{-3} – 5.59×10^{-3} mSv/yr. Among the ten critical group candidates, candidate 3 received the highest radiation dose. As a result, candidate 3 was selected as a critical group.

Representative person is equivalent to the average member of the critical group. Therefore, the result of radiation dose of Representative person was 5.59×10^{-3} mSv/yr.

Table 3. Result of radiation dose assessment from gaseous effluent released from nuclear research facility

Critical Group Candidate	Radiation Dose (mSv/yr)
Candidate 1	5.34×10^{-3}
Candidate 2	5.55×10^{-3}
Candidate 3	**5.59×10^{-3}**
Candidate 4	5.35×10^{-3}
Candidate 5	5.34×10^{-3}
Candidate 6	5.33×10^{-3}
Candidate 7	5.32×10^{-3}
Candidate 8	5.31×10^{-3}
Candidate 9	5.31×10^{-3}
Candidate 10	5.31×10^{-3}

4. Conclusion

In this study, the representative person concept was applied to assess public dose resulting from gaseous effluent at nuclear research facility. The result of radiation dose assessment for the representative person dose showed 5.59×10^{-3} mSv/yr. The result of this study can be used as preliminary study for the introduction of representative person concept recommended by ICRP 103 in Korea in the future.

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