Off-site Dose Assessment from Routine Effluents of Shin-Kori Unit 3

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1. Introduction

In general, nuclear facilities release radioactive nuclides into environment and human, it contributes to radiation exposure through 2 main pathways: External exposures by direct radiation from radioactive plumes or from radioactive nuclides deposited on the ground, and internal exposure due to inhalation and ingestion of radioactive substances [1]. Nuclear power plants release liquid and gaseous radioactive effluents to the environment during normal operation [2]. The numbers of radioactive nuclides released to the environment and the in resulting certain amount of radiation doses to members of the public living around NPPs [3]. In South Korea, 24 NPPs are operating safely and generating one third electricity demand. The aim of this study was to assess radiation dose of radioactive effluents released from the nuclear power plant.

2. Materials and Methods

2.1 Study area

The study area is Shin Kori unit 3 (APR 1400) at Saeul nuclear power site that is latest technology of pressurized water reactor developed by Korean nuclear industry.

2.2 Computer code description

NRCDose72 is a good candidate for the calculation of offsite radiation doses to the public, and its advanced capability enhance confidence in the accuracy of off-site public radiation doses assessment. This computer code consists of three computation program which are GASPAR, XOQDOQ and LADTAP. GASPAR is a used in radiation dose assessment for individuals and groups of people contaminated by the release of radioactive nuclides into the air environment of nuclear power plants in normal operation conditions [4]. XOQDOQ is used in the independent meteorological evaluation of routine or anticipated, intermittent releases of radioactive nuclides [5]. LADTAP is used in calculating radiation exposure to public from routine release of liquid effluent.

2.3 Input parameters

- Data on population distribution for three distinct groups of age: child, teenager and adult in each sub-region.
- Data on production of meat, milk, vegetable
- Source term Table I and Table II [6]
- Receptor locations
- Meteorological data: stability class, wind direction and wind speed class [7]. The wind direction is classified into 16 cardinal directions. Atmospheric stability is grouped according to seven categories from extremely unstable to extremely stable.

Table I: Radionuclides for source term of GASPAR.

Nuclide	Ci/y	Nuclide	Ci/y	Nuclide	Ci/y
H-3	1.60E+02	Nb-95	4.19E-05	Xe-133	7.00E+01
Ar-41	3.41E+01	Zr-95	1.00E-05	Xe-135m	8.00E+00
C-14	7.30E+00	Ru-103	1.70E-05	Xe-135	5.11E+01
Cr-51	9.70E-05	Ru-106	7.81E-07	Xe-137	3.00E+00
Mn-54	5.70E-05	Sb-125	6.11E-07	Xe-138	3.00E+00
Fe-59	2.81E-05	I-131	1.80E-03	Cs-134	4.81E-05
Co-57	8.19E-06	I-132	4.81E-02	Cs-136	3.30E-05
Co-58	4.81E-04	I-133	2.30E-02	Cs-137	9.00E-05
Co-60	1.10E-04	I-134	7.89E-02	Ba-140	4.19E-06
Kr-85	4.89E+03	I-135	4.59E-02	Ce-141	1.30E-05
Kr-85m	7.00E+00	Xe-131m	2.20E+03		
Sr-90	6.30E-05	Xe-133m	1.30E+02		

Table II: Radionuclides for source term of LADTAP.

Nuclide	Ci/y	Nuclide	Ci/y	Nuclide	Ci/y
Na-24	1.90E-03	Sr-91	1.87E-05	I-132	7.19E-04
P-32	1.80E-04	Y-91m	1.70E-05	I-133	3.41E-03
Cr-51	6.00E-03	Y-91	9.00E-05	I-134	2.50E-05
Mn-54	4.89E-03	Y-93	2.89E-05	Cs-134	1.10E-02
Fe-55	8.11E-03	Zr-95	1.30E-03	I-135	2.30E-03
Fe-59	2.40E-03	Nb-95	2.10E-03	Cs-136	3.89E-03
Co-58	1.10E-02	Mo-99	7.59E-04	Cs-137	1.60E-02
Co-60	1.40E-02	Tc-99m	5.59E-04	Ba-137m	4.19E-04
Ni-63	1.70E-10	Ru-103	3.89E-03	Ba-140	4.51E-03
Zn-65	3.51E-04	Rh-103m	3.70E-03	La-140	4.89E-03
W-187	1.40E-04	Ru-106	7.11E-02	Ce-141	3.00E-04
Np-239	2.20E-04	Rh-106m	6.19E-02	Ce-143	1.90E-04

Sr-89	1.60E-04	Sb-124	4.30E-04	Pr-143	1.90E-04
Sr-90	2.20E-05	Te-129m	8.81E-05	Ce-144	6.59E-03
Te-131	1.80E-05	Te-129	6.19E-05	Pr-144	2.70E-03
Te-132	2.00E-04	Te-131m	9.89E-05	H-3	1.46E+03
I-131	2.70E-03	Ag-110m	2.10E-03		

3. Results and Discussion

The results of this study are shown in table III and table IV. According to result of NRCDose72, radiation dose to public caused by radioactive gaseous and liquid effluent released from Nuclear power plant under scenario of normal working conditions was below compared to National safety and security commission limits. The radioactive isotope 3H induce the greatest contributions to the annual total population dose. This can be naturally understandable because that isotope with the very long half-life is produced by the typical nuclear reactions in moderator and reactor core materials.

Table III: Annual doses to organs.

Annual dose (mSv)			
	Adult	Teenager	Child
Skin	3.31E-06	1.85E-05	3.86E-06
Bone	2.19E-05	3.56E-05	3.59E-05
Liver	3.17E-05	4.57E-05	4.46E-05
Thyroid	2.76E-05	4.05E-05	6.77E-05
Kydney	1.78E-05	2.48E-05	2.40E-05
Lung	1.54E-05	2.22E-05	2.11E-05

Table IV: Annual effective doses to individuals for three age groups (child, teenager and adult) at the locations of interest.

Location	Direction	Annual effective dose to individual for age groups (mSv)		
		Adult	Teenager	Child
Wollae	SSW	3.96E-06	4.35E-06	7.15E-06
Ilgwang	SSW	2.31E-07	3.16E-07	5.18E-07
Gijang	SSW	3.01E-07	3.75E-07	4.45E-07
Seosaeng-myeon	NNE	3.56E-06	3.92E-06	6.23E-06

4. Conclusion

In this study, data inputs built for two computer codes GASPAR, LADTAP and XOQDOQ based on collecting and processing a huge database including the data on population and population distribution for distinct age groups, the data on agricultural production activities. The obtained calculation results for the annual integrated population dose and the annual individual dose at the specific locations within the 80 km radius from the site of NPP at Saeul site showed that under a normal operation scenario with the routine release of radioactive nuclides from the NPP to the atmosphere all the dose values are much less than the limit value for publics.

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REFERENCES

[1] International Atomic Energy Agency, Radiation protection aspects of design for nuclear power plants. Vienna, Safety guide No.NS-G-01-13, 2005.

[2] USNRC, 1977. Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Discharges from Light-Water-Cooled Reactors. NRC, Regulatory Guide, 1.111, Washington D.C.

[3] Qiong Zhang, Rui Ping Guo, Chun Ming Zhang, Xiao Qiu Chen, Bo Wang, “Radioactive airborne effluents and the environmental impact assessment of CAP1400 nuclear power plant under normal operation”, Nuclear engineering design, volume 280, pages 579-585, December 2014.

[4] Strenge, D.L., Bander, T.J. and Soldat, J.K. GASPAR II—Technical Reference and User Guide. NUREG/CR4653, US Nuclear Regulatory Commission, Washington DC, March 1987.

[5] Sagendorf, J.F., Goll, J.T. and Sandusky, W.F. XOQDOQ: Computer Program for the Meteorological Evaluation of Routine Releases at Nuclear Power Stations. NUREG/CR-2919, US Nuclear Regulatory Commission, Washington DC, September 1982.

[6] Korea Electric Power Corporation and Korea Hydro & Nuclear Power Co., Ltd, “APR 1400 Design Control Document” Tier 2, Revision 3, August 2018

[7] Nguyen Tuan Khai, Nguyen Hao Quang, “Assessment of Radiation Dose Caused by Radioactive Gaseous Effluent Released from Nuclear Power Plant Ninh Thuan 1 under Scenario of Normal Working Conditions”. World Journal of Nuclear Science and Technology, pages 183-191, August 2015.