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Effects of Different Calm Conditions on the Radiation Exposure Due to the Operation of a Nuclear Facility at KAERI Site

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Abstract

Wind-speed has much effect on the dispersion of the radioactive effluents released into the atmosphere. Accurate measurement of low wind-speeds is very important for the realistic assessment of radiation exposure. The objective of this study is to analyze the effects of different calm conditions on the radiation exposure due to the normal operation of a nuclear facility at KAERI (Korea Atomic Energy Research Institute) site. When calm condition is changed from 0.5 m/sec to 0.21 m/sec, the effects on radiation exposure show a distinct difference.

1. Introduction

Radiation exposure due to the radioactive effluents released from a nuclear facility is given through several exposure pathways; (1) External exposure from radioactive plume or from radionuclides deposited on the ground, (2) Internal exposure due to inhalation and ingestion of radioactive materials, *etc.*

For the estimation of the radiation exposure due to the normal operation of a nuclear facility, annual meteorological data (wind-speed, wind-direction, atmospheric stability) are needed for analyzing the atmospheric dispersion and the deposition of radioactive materials. Accurate measurement of low wind-speeds is very important for the realistic assessment of radiation exposure.

Calm is defined as the absence of air motion or wind with a speed of less than 1 knot ($\approx$ 0.45 m/sec) in the WMO (World Meteorological Organization) [1]. The U. S. NRC (Nuclear Regulatory Commission) and the JAESC (Japan Atomic Energy Safety Commission) recommend that the anemometer is required to have a starting threshold of less than 0.45 m/sec and 0.5 m/sec, respectively [2,3]. As the development of anemometer, the starting threshold of wind-speed is becoming low gradually. Therefore it is necessary to analyze the site-specific effects of different calm conditions on radiation exposure.

In this study, the effects of different calm conditions on the radiation exposure due to the normal operation of a nuclear facility in KAERI site have been analyzed.

2. Analysis of Meteorogical Data

The meteorological data measured at KAERI in 1995 were used for this analysis. A meterological tower of 75 m height was built for the measurement of meteorological data. The several meteorological data (wind-speed, wind-direction, temperature, humidity, solar radiation, visibility, *etc.*) have been measured at the height of 3 points (10m, 27m, 67m), and the 15-minute averaged values have been stored in a personal computer. A starting threshold of anemometer which was installed on the meterorological tower of KAERI is 0.22 m/sec. The Fig. 1 shows the wind roses which give the distribution of velocities over a year with the starting threshold of 0.22 m/sec [4].

The joint frequency distribution f_{ijk} represents the probability that wind blows from the direction of k with wind-speed class i, and the atmospheric stability class is j.

$$\sum_i \sum_j \sum_k f_{ijk} = 1. \tag{1}$$

The occurrence probability of calm for each stability class is assigned proportionally to the directional frequency distribution of the first non-calm wind-speed class [5].

3. Atmospheric Dispersion of Radioactive Effluents

For the calculation of annual average dispersion factor $\overline{\chi}/Q$, it is assumed that the effluent is released continuously and dispersed evenly over 22.5° directional sector. For the ground-level release, dispersion factor is calculated using the following equation [5].

$$\frac{\overline{\chi}}{Q}(x,k) = \frac{2.032}{x} \frac{RF(x,k)\sum_{ij}^{N7} DP_{ij}(x,k)\ DC_i(x)\ f_{ij}(k)}{\overline{U_i}\ \sigma_{zj}(x)} \tag{2}$$

where,

$\overline{\chi}/Q$ = average atmospheric dispersion factor [sec/m^3]

x = downwind distance [m]

k = wind-direction

i = wind-speed class

j = atmospheric stability class

$\overline{U}$ = mid-point value of wind-speed class [m/sec]

σ_z = vertical plume spread [m]

DP = reduction factor due to plume depletion

DC = reduction factor due to radioactive decay

RF = correction factor for the recirculation and the stagnation of air

The effect of building wake is not considered in Equation (2). As shown in Equation (2), the influence of calm on $\overline{\chi}/Q$ is dependent on the parameters f_{ij} and U_i.

$$\frac{\overline{\chi}}{Q}(x,k) \propto \frac{f_{ij}(k)}{\overline{U_i}} \quad (3)$$

There is a linear relationship between $\overline{\chi}/Q$ and radiation exposure dose.

4. Results and Discussion

The individual dose and the population dose were calculated for the different calm conditions. XOQDOQ and GASPAR program were used for estimating the atmospheric dispersion of radioactive effluents and the resulting exposure dose, respectively [5,6]. The ground-level release of radioactive effluents was assumed in this study. The annual meteorological data measured at the height of 10 m in 1995 were used. An important fission product ^{133}Xe was assumed to be released with 1.0 Bq/yr into the atmosphere.

By changing the calm condition from 0.5 m/sec (U_c=0.5 m/sec) to 0.21 m/sec (U_c=0.21 m/sec), the occurrence percentage of calm is decreased from 48.18% to 39.18%. According to the Equation (3), the ratio of the $\overline{\chi}/Q$ calculated with U_c =0.21 m/sec to that with U_c=0.5 m/sec is approximately a factor of 2 without considering other meteorological conditions.

Fig. 2 shows the individual dose for the whole body of an adult for 16 wind-directions at radius 800 m from the center of the site with both calm conditions of U_c=0.21 m/sec and U_c=0.5 m/sec. The individual dose calculated with U_c=0.21 m/sec is higher than that calculated with U_c=0.5 m/sec over the most wind directions. Especially, the ratio of individual dose calculated with U_c=0.21 m/sec to that with U_c=0.5 *m/sec is about a factor of 10 in SW.* The directional difference of the ratios is dependent on the joint frequency distributions in the first non-calm wind-speed class. The wind-direction representing maximum individual dose is ENE and the ratio of individual dose calculated with U_c=0.21 m/sec to that with U_c=0.5 m/sec is about a factor of 1.5. In the worst case, the difference of individual dose for both calm conditions may be showed in ENE such like SW. In this case, the application of U_c=0.5 m/sec may cause a great underestimation in maximum individual dose assessment.

Fig. 3 shows the population dose for the whole body within 80 km from the site for both calm conditions. *The ratio of population dose calculated with* U_c=0.21 m/sec to that with U_c=0.5 m/sec is about a factor of 2.

4. Conclusions

The effects of the different calm conditions on radiation exposure have been analyzed with the annual meteorological data measured at KAERI site. The obtained results show a distinct influence of the change of calm condition. Therefore, it is necessary to reconsider the calm conditions recommended by several regulatory commissions in the site where the occurrence probability of low wind-speeds is high.

References

1. WMO, "International Meteorological Vocabulary", WMO No. 182, World Meteorological Organization

2. USNRC, "Meteological Programs in Support of Nuclear Power Plants", Regulatory Guide 1.23, Nuclear Regulatory Commission, 1980

3. Shze Jer Hu, Hiroshi Katagiri and Hideo Kobayashi, "Effect of Modified Calm Conditions on Nuclear Dispersion Estimates", *Health Physics*, **68(1)**, 67-70, 1995

4. 한문희 외 4인, "대덕 원자력시설주변 기상정보 종합해석", KAERI/RR-270/95, 한국원자력연구소, 1995

5. USNRC, "XOQDOQ : A Computer Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations", NUREG/CR-2919, Nuclear Regulatory Commission, 1982

6. USNRC, "User's Guide to GASPAR Code", NUREG-0597, Nuclear Regulatory Commission, 1980

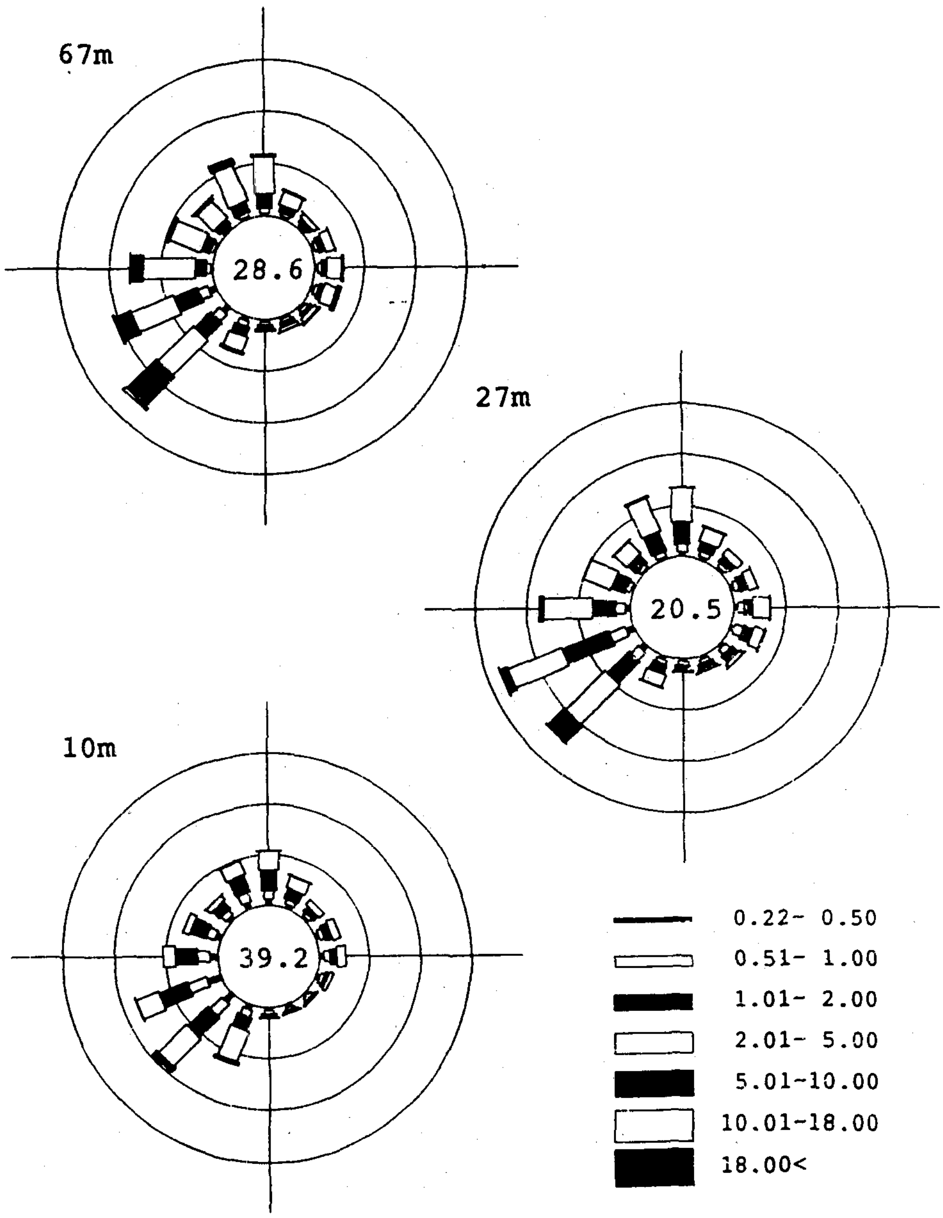

Fig. 1. Wind Roses at KAERI Site in 1995

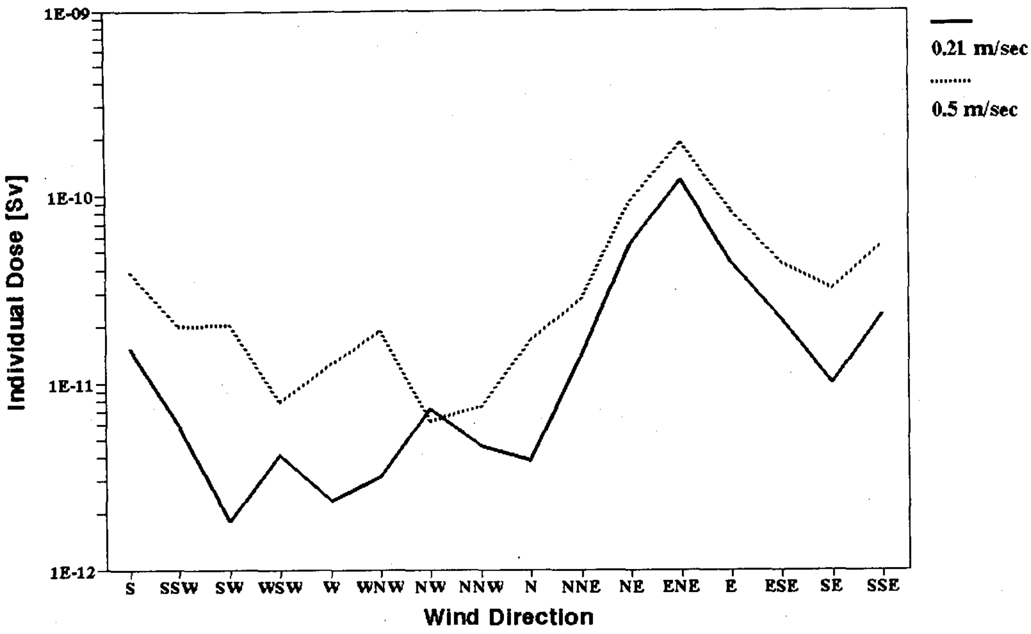

Fig. 2. Individual Dose for the Whole Body of an Adult for 16 Wind Directions at Radius 800 m from the Center of the Site for Different Calm Conditions

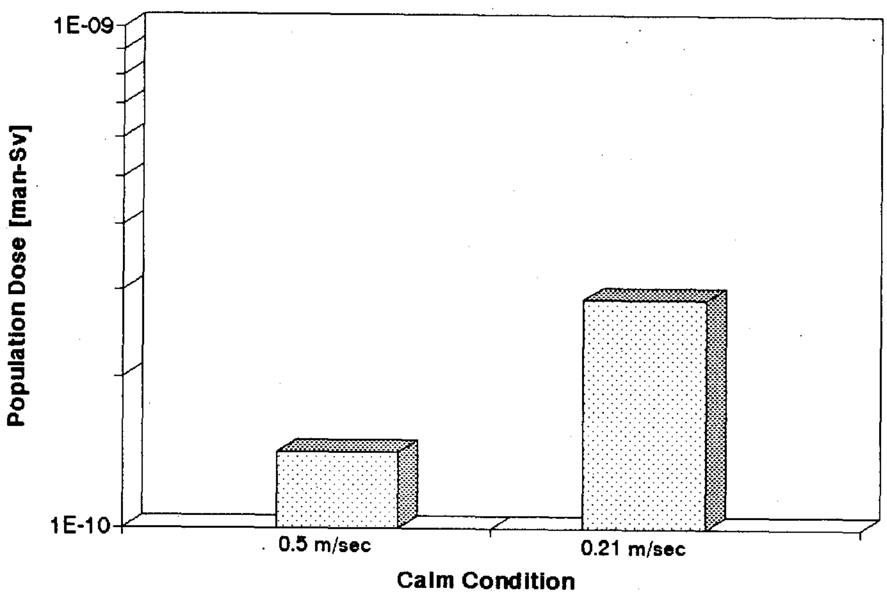

Fig. 3. Population Dose for the Whole Body within 80 km from the Site for Different Calm Conditions