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Influence of Statistical Compilation of Meteorological Data on Long Term Atmospheric Dispersion Factor in Routine Operation of a Nuclear Power Plant

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1. Introduction

Relative atmospheric dispersion factor and deposition factor, given by X/Q and D/Q values, respectively, are computed from different sites for each directional sector in order to ensure regulatory compliance for an independent meteorological evaluation of routine or intermittent release of radionuclides in a nuclear power plant. Several physical parameters, along with meteorological data such as release height, aerodynamic downwash, plume rise and terrain features must be taken into account in the straight-line based trajectory of the Gaussian-plume model. Several scenarios can therefore be analyzed, given a continuous or intermittent release point [1].

Several recent studies have evaluated the dispersion of radioactive materials following a postulated accident in a nuclear reactor, using specific atmospheric modelling [2, 3]. Although the Gaussian plume model is simple, it offers a valuable tool and good approximation to assess different atmospheric parameters in a short-range distance from a nuclear power plant. The following study focuses on the analysis of the atmospheric dispersion factor factor during a normal or routine operation of a nuclear power plant.

2. Methods

Meteorological data, that is, Joint Frequency Data (JDF)—specifically, wind speed, wind direction and, along with stability classes for 4 years, were obtained from the Shingori meteorological station located in the Shingori Nuclear Power Plant in Busan, South Korea, during the period 2008 to 2011.

The computer code XOQDOQ version 2 [4], which implements Regulatory Guide 1.111 [5] from the USNRC, was used to model the transport of the source term for the considered years and to calculate the relative concentration and deposition factors of routine radioactive effluent dispersed in the atmosphere within the vicinity of the operational nuclear plant.

The XOQDOQ computer code is based on a straight-line trajectory Gaussian dispersion plume model, which is given by the following equation for the ground level concentration χ (in Bq per cubic meter) at the point (x,y) [4]:

$$\chi(x,y,z) = \frac{Q}{2\pi\sigma_y\sigma_z U} exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] * exp\left[-\frac{1}{2}\left(\frac{z}{\sigma_z}\right)^2\right] \quad (1)$$

Where:

- Q is the source emission rate, in Bq per second
- U is the average wind speed, in meters per second
- σ_y, σ_z are the standard deviations of the concentration distributions in the crosswind and vertical directions, respectively, in meters
- H is the effective stack height
- x is the distance downwind from the stack, in meters
- y is the crosswind distance from the center line, in meters
- z is the vertical distance from the ground, in meters.

The analysis was based on 4-years data, assuming a continuous and single release point at the ground level. The atmospheric dispersion factor was calculated at 560 meters of the release point wiyh 11 wind speed classes. The height used was 58 meter.

3. Results and Discussion

The long-term atmospheric dispersion factor X/Q, for a non-decay and undepleted atmospheric release was calculated within the 16 directions using the meteorological Joint Frequency data. The annual occurrence probabilities for different Pasquill atmospheric stabilities are given in figure 1 and show the prevalence stability classe D (that is neutral) during the every year of selected meteorological data. Furthermore, Figure 2 shows that the maximum value of the dispersion factor was found in SSE direction during the analyzed period.

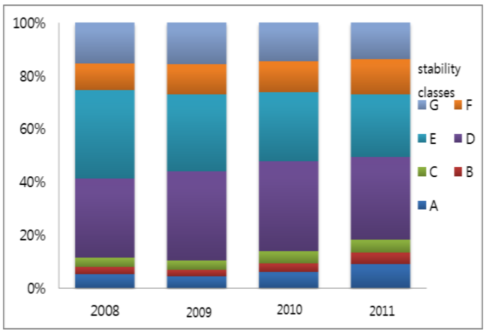

Fig.1. Annual occurrence probabilities of atmospheric stability in Shingori Nuclear Power Plant site (A: Very unstable, B: Unstable, C: Slightly unstable, D: Neutral, E: Slightly stable, F: Stable, G: Very stable).

Table 1. Atmospheric Dispersion Factors at the Radius of 560 m with Respect to the Analyzed Meteorological Data Period.

Year that meteorological data were to be considered		Maximum atmospheric dispersion factor (s/m^3)
1 year	2008	1.84E-05
	2009	2.15E-05
	2010	1.58E-05
	2011	1.67E-05
2 years	2008-2009	2.00E-05
	2010-2011	1.58E-05
4 years	2008-2011	1.70E-05

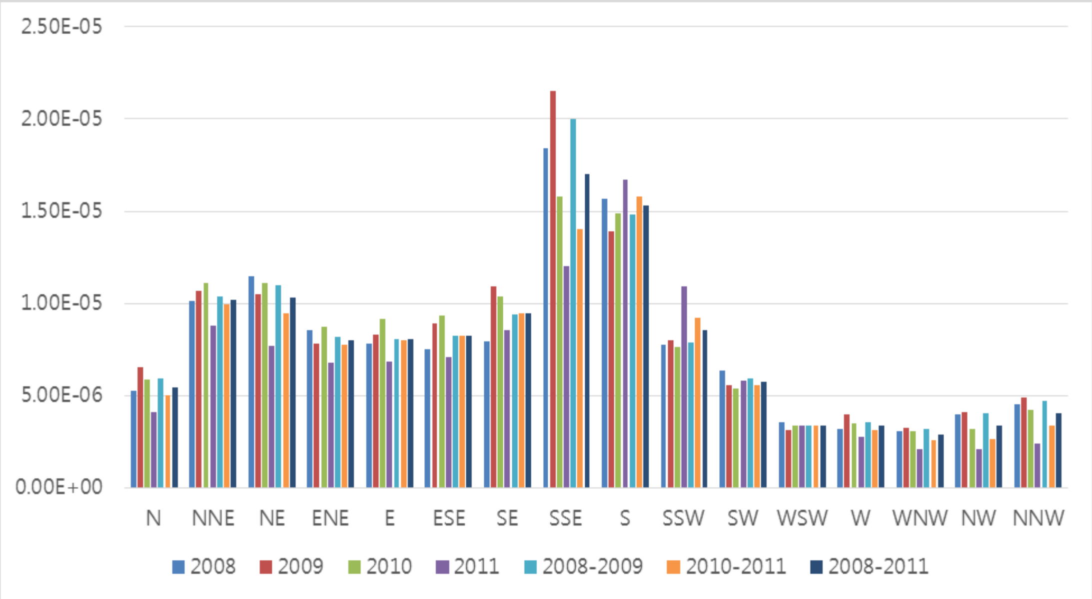

Fig. 2. Atmospheric Dispersion Factors with respect to the 16 directions within specific data period.

On the other hand, the range of the variation of the long-term atmospheric value decreases when long averaged data period is considered, as it can be seen on figure 3.

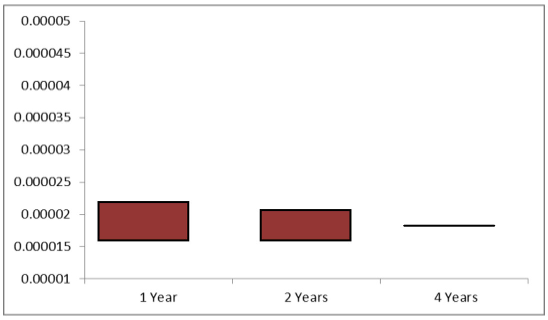

Fig.3. Range of Variation of X/Q (s/m^3) within 560 m with respect to the analyzed meteorological data.

4. Conclusion

The long-term atmospheric dispersion factor for a non-decay and undepleted atmospheric release was calculated and it was shown that the X/Q values depend on the period of measurement and the averaged effect.

For conservative measures, maximum values of X/Q, for different wind directions must be taken into account in order to evaluate the dose in the environment.

Therefore, in assessing the long-term atmospheric dispersion factor, a significant averaged effect on the analysis period of the data to be applied must be considered in the study.

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