Comparison of Atmospheric Dispersion Factors Using Different Approaches in Decommission of a Nuclear Power Plant

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1. Introduction

Decommissioning is a critical issue in Korean nuclear power plant industry. During decommissioning, radioactive materials will be released to the environment, and will affect radiological dose to nearby residents via various pathways. To evaluate off-site radiological dose, the prediction of atmospheric dispersion is required as the first step.

Generally, atmospheric dispersion is predicted under the recommendation of the NRC's Regulatory Guide 1.111 [1] in routine releases of gaseous radioactive materials. This approach would be produced conservative results. It can be applied to protect health detriment during decommissioning process. However, the realistic estimation may be necessary to avoid overestimating results for the optimal decommissioning strategy. In this study, comparison of atmospheric dispersion factors using different approaches in decommission of a nuclear power plant was performed.

2. Comparison of Atmospheric Dispersion

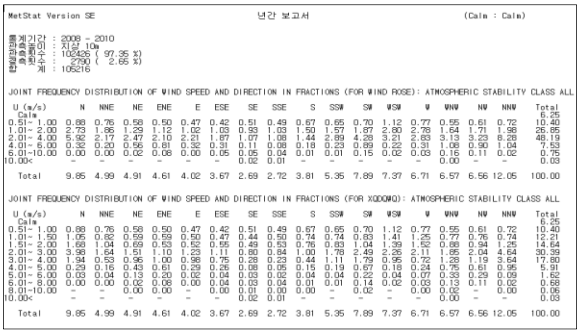
2.1 Calculation of Atmospheric Dispersion Factor

A computer code XOQDOQ [2] has been developed to evaluate atmospheric dispersion in a routine release of radioactive effluents according to methodology recommended in the U.S. NRC's Regulatory Guide 1.111

A straight-line Gaussian plume model has been adopted to calculate annual averaged atmospheric dispersion factor (χ/Q, sec/m^3), which represents a dispersion capability of radioactive effluents released into the environment.

2.2 Meteorological Data Analysis

Joint Frequency Distribution (JFD) is a statistical data representing occurrence probability as function of wind speed and wind direction according to atmospheric stability. It was obtained using measured data at 10m height of a meteorological tower of Kori nuclear power plant site for 3years from 2008 to 2010, as shown in Fig. 1.



MetStat Version SE　　　년간 보고서　　　(Calm : Calm)

통계기간 : 2008 - 2010
관측높이 : 지상 10m
관측횟수 : 102426 (97.35 %)
결측횟수 : 2790 (2.65 %)
합　계 : 105216

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION IN FRACTIONS (FOR WIND ROSE): ATMOSPHERIC STABILITY CLASS ALL

U (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
Calm																	6.25
0.51~ 1.00	0.88	0.76	0.58	0.50	0.47	0.42	0.51	0.49	0.67	0.65	0.70	1.12	0.77	0.55	0.61	0.72	10.40
1.01~ 2.00	2.73	1.86	1.29	1.12	1.02	1.03	0.93	1.03	1.50	1.57	1.87	2.80	2.78	1.64	1.71	1.98	26.85
2.01~ 4.00	5.92	2.17	2.47	2.10	2.21	1.87	1.07	1.08	1.44	2.89	4.28	3.21	2.83	3.13	3.23	8.28	48.19
4.01~ 6.00	0.32	0.20	0.56	0.81	0.32	0.31	0.11	0.08	0.18	0.23	0.89	0.22	0.31	1.08	0.90	1.04	7.53
6.01~10.00	0.00	0.00	0.02	0.08	0.00	0.05	0.05	0.04	0.01	0.01	0.15	0.02	0.03	0.16	0.11	0.02	0.75
10.00<	-	-	-	-	-	-	0.02	0.01	-	-	-	-	-	0.00	-	-	0.03
Total	9.85	4.99	4.91	4.61	4.02	3.67	2.69	2.72	3.81	5.35	7.89	7.37	6.71	6.57	6.56	12.05	100.00

JOINT FREQUENCY DISTRIBUTION OF WIND SPEED AND DIRECTION IN FRACTIONS (FOR XQDQMQ): ATMOSPHERIC STABILITY CLASS ALL

U (m/s)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	Total
Calm																	6.25
0.51~ 1.00	0.88	0.76	0.58	0.50	0.47	0.42	0.51	0.49	0.67	0.65	0.70	1.12	0.77	0.55	0.61	0.72	10.40
1.01~ 1.50	1.05	0.82	0.59	0.59	0.50	0.47	0.44	0.50	0.74	0.74	0.83	1.41	1.25	0.77	0.76	0.74	12.21
1.51~ 2.00	1.68	1.04	0.69	0.53	0.52	0.55	0.49	0.53	0.76	0.83	1.04	1.39	1.52	0.88	0.94	1.25	14.64
2.01~ 3.00	3.98	1.64	1.51	1.10	1.23	1.11	0.80	0.84	1.00	1.78	2.49	2.26	2.11	1.85	2.04	4.64	30.39
3.01~ 4.00	1.94	0.53	0.96	1.00	0.98	0.75	0.28	0.23	0.44	1.11	1.79	0.95	0.72	1.28	1.19	3.64	17.80
4.01~ 5.00	0.29	0.16	0.43	0.61	0.29	0.26	0.08	0.05	0.15	0.19	0.67	0.18	0.24	0.75	0.61	0.95	5.91
5.01~ 6.00	0.03	0.04	0.13	0.20	0.02	0.04	0.03	0.02	0.04	0.04	0.22	0.04	0.07	0.33	0.29	0.09	1.62
6.01~ 8.00	0.00	0.00	0.02	0.08	0.00	0.04	0.03	0.04	0.01	0.01	0.14	0.02	0.03	0.13	0.11	0.02	0.68
8.01~10.00	-	-	0.00	0.00	-	0.00	0.01	0.00	0.00	-	0.02	-	0.00	0.02	-	0.00	0.06
10.00<	-	-	-	-	-	-	0.02	0.01	-	-	-	-	-	0.00	-	-	0.03
Total	9.85	4.99	4.91	4.61	4.02	3.67	2.69	2.72	3.81	5.35	7.89	7.37	6.71	6.57	6.56	12.05	100.00

Fig. 1. Joint Frequency Distribution Data at Kori Site.

2.3 Comparison Between Different Approaches

The evaluation locations are 16 overall directions of Exclusion Area Boundary (EAB). In the conservative approach, the atmospheric stability classes are 7 (A-G), and effect of recirculation and stagnation is considered, while in the realistic approach, the atmospheric stability classes are 6 (A-F), and effect of recirculation and stagnation is not considered.

Table 1. Major items between conservative and realistic approaches

Items	Conservative approach	Realistic approach
Atmospheric stability class	7 classes (A-G)	6 classes(A-F)
Recirculation and Stagnation	Considered	Not considered

Table 2. Results between the conservative and realistic approaches

	Conservative(C) (χ/Q, sec/m^3)	Realistic(R) (χ/Q, sec/m^3)	Ratio (C / R)
S	4.499×10^{-5}	1.099×10^{-5}	4.09
SSW	2.789×10^{-5}	6.877×10^{-6}	4.06
SW	2.190×10^{-5}	5.370×10^{-6}	4.08
WSW	1.722×10^{-5}	4.168×10^{-6}	4.13
W	1.941×10^{-5}	4.534×10^{-6}	4.28
WNW	1.903×10^{-5}	4.534×10^{-6}	4.19
NW	1.959×10^{-5}	4.724×10^{-6}	4.15
NNW	1.841×10^{-5}	4.424×10^{-6}	4.16
N	2.393×10^{-5}	5.589×10^{-6}	4.28
NNE	3.289×10^{-5}	7.450×10^{-6}	4.41
NE	3.793×10^{-5}	9.066×10^{-6}	4.18
ENE	4.563×10^{-5}	1.110×10^{-5}	4.11
E	3.325×10^{-5}	8.215×10^{-6}	4.04
ESE	2.641×10^{-5}	6.541×10^{-6}	4.04
SE	3.226×10^{-5}	7.908×10^{-6}	4.08
SSE	4.333×10^{-5}	1.065×10^{-5}	4.07

The results of the atmospheric dispersion factor using conservative approach were predicted about 4 times higher than those using realistic approach for every 16 overall directions.

Additionally, we evaluated the atmospheric dispersion factor for the distance of 3 inland directions (N, NNE, NE) at the site boundary using conservative approach.

Table 3. The distance of 3 directions at the site boundary

Direction	N	NNE	NE
Distance(m)	1200	2550	3350
Atmospheric Dispersion Factor (χ/Q, sec/m^3)	9.137×10^{-6}	1.991×10^{-6}	1.257×10^{-6}

Table 4. Comparison of maximum Atmospheric Dispersion Factor at EAB and Site boundary

	EAB (E)	Site Boundary (S)	Ratio (E / S)
Max. Atmospheric Dispersion Factor (χ/Q, sec/m^3)	4.499×10^{-5} (Direction: S)	9.137×10^{-6} (Direction: N)	4.92

3. Conclusions

According to the conservative and realistic approaches, we compared the results of the atmospheric dispersion factors using XOQDOQ code. It was shown that there were a great difference between the conservative and realistic approaches. And the results were also depends on the location of the estimation.

It is desirable to evaluate the dose by the radioactive effluents released into the environment separately according to the purpose.

ACKNOWLEDGEMENT

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