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Onsite Atmospheric Dispersion Factor in OPR 1000 NPP in KOREA

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1. INTRODUCTION

Onsite air dispersion factor is generally used for evaluating the MCR(Main Control Room) dose. Onsite air dispersion factor is related to the MCR habitability issue and to the MCR dose assessment. This issue is generated since NUREG 0737 published. For this issue, ARCON 96 code is used. The code is optimized for a NRC licensed air dispersion model and also to evaluate onsite atmospheric relative concentration. This study provides some results for ARCON96 methodology and some case sensitivity analysis.

In 2016, some studies have been carried out to estimate ARCON 96 specification by KHNP. And also, some methodology of ARCON 96 will be introduced in this paper. A few years ago, ARCON 96 study for Westinghouse NPPs has carried out[1-6].

In this work, ARCON 96 study for OPR 1000 NPP will be introduced. This study includes onsite dispersion factor sensitivity analysis, dispersion model specific characteristics, and impact parameters in case of OPR 1000 NPP.

2. METHODOLOGY

2.1. Release simulation of ARCON 96

ARCON96 code has three possible release models which are ground diffusion, vent release and stack dispersion. If a release height point is lower than 2.5times of the near structures height, it is assumed by 10m height release (ground release). According to NRC's review, this modeling is rather conservative comparing with the case of the vent height being lower than 2.5times of any adjacent structure height.

ARCON96 does not use the plum rise, so a ground level release is the significant dispersion model. This approach is more conservative than any other similar to plum rise model [4-6].

2.2. Essential Parameters of onsite dispersion factor.

In onsite dispersion factor, some parameters are used as below:

a. Release height: Onsite dispersion factor includes a middle point between the minimum point and the maximum point of the wind instrumentation heights. If the release height point is lower than this midpoint, X/Q is calculated using the lower wind data. If not, the higher wind data is used.
b. Wind direction: North is the reference direction used as either 0 or 360 degrees.
c. Calm condition: calm can be defined as hours with no wind or as very small wind speed.
d. Building area: Building wake factor's key point of X/Q near the building structure. This is strongly dependent on the direction and building cross-sectional area [4,5].
e. Wind speed: A wind speed group which is distributed by 13 regions and each maximum value of each wind speed group as like 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0. [4,5].

2.3. Basic Parameters

To calculate onsite dispersion factors, some parameters are needed as below:

a. A surface roughness length : 0.1m ~0.2m
b. An angular width : 90 degree(+/- 45)
c. Minimum wind speed: 0.3m/sec, this wind is calm condition and the input hourly meteorological preparing process is checked by a calm-processing subroutine of ARCON96.
d. A sector-averaged width is used for more than 8 hours.
e. 4 standard deviations of a Gaussian plume are used as sector-average default.
f. Horizontal dispersion coefficient and vertical dispersion coefficient are calculated by using standard deviation of a Gaussian plume.
g. The time averaged scale is ranged from 1 hour to 720hours, in which X/Q are averaged and calculated.

2.4. Meteorological Data Preparation

A meteorological data per year is consists of 50,000 data files roughly. From this data set, onsite dispersion factors must be prepared. ARCON 96 input as matrix input file should be made from the meteorological data prepare-processing.

The data durations are generally set from two years to five years. In this study, the recently four years data set of 2013 ~ 2017 are used to apply the new meteorological data conditions.

The meteorological data set are recorded and saved on the location of the tower at 10 m and 58m, respectively.

ARCON96 analyze the meteorological data file and can calculate the total hours and the hours of missed data over all data.

2.5. Source Dispersion Simulation

For the default condition and the basic analysis, only ground-level release is assumed. Some parameters are considered as the height of stack source, the building area (building wake effect), the radius of stack, the velocity and flow rate of plume.

2.6. Onsite Receptors Condition

Receptors condition and parameters are considered as below:

a. The intake height: The height difference between the source stack and the MCR receptor (assumed ground level in the conservative condition).
b. The directional α: the centerline of angular width.
c. The default parameter β : an angular width (90 degree).

From these values, onsite X/Q can be calculated for each 16 angle sector and their centerline of 22.5 degree intervals.

3. APPLICATION

3.1. Basic Application

In this study, we select the OPR 1000 type NPP in the similar to the conditions of the study of the Westinghouse NPP a few years ago[6].
A ground-level release near building or power plant structure is modeled to determine normalized concentrations at various distances from the building. In this case, it is consider the blocking effect and the vortex effect of building structure.
ARCON96 can generate direction-independent 95 percentile values of X/Q for durations of 2-hours, 8-hours, 24-hours, 96-hours, 192-hours and 720-hours.
The value is averaged at 16 directional downwind distances during time period.

3.2. Basic Input

The basic input value is similar to the study of KHNP in 2016. In order to reflect RG 1.145, the angular width, β is set to 360 degree in the condition of the directional-independent X/Q. Table 1 shows a summary of the input data used for each portion.
In basic parameters, horizontal dispersion coefficient (σ-x) is zero and vertical dispersion coefficient (σ-z) is some changed. This option can reflect the atmospheric stability class methodology of "delta T / delta Z".
And this option is more conservative than the other classification methods. Meteorological data and condition are collected from 10m detector tower and 58m detector tower. This methodology is similar to the data collection method for offsite atmospheric dispersion factor.

In source parameters, the building area is changed with the range from 30m^2 to 1000m^2.
This is for the sensitivity analysis of building wake effect.

Table1. Summary of input parameter

Input	Values
Basic parameters	Surface roughness length : 0.15m Angular width : 360 degree Threshold wind speed : 0.3m/sec Sector-average width : 4 or 90 degree σ-x, σ-z : 0, 0~1. 5 Averaged durations : 1 hour~ 720hours
Meteorological Conditions	Wind Speed : 14 categories Stability class : 7 categories (delta T/deltaZ) Detector tower : 10m and 58m
Source parameters	Release type, Release height : Ground, 0~10 m Building area : 30 m^2 ~ 1000 m^2 Velocity, Stack radius : default
Receptor parameters	Distance to receptor : 10m ~ 1000m Intake height : 0~5m Elevation difference : 0~2m Direction to source : 180 degree or 90 degree

4. RESULTS AND DISCUSSIONS

For 16 directional downwind distance of Table1, X/Q is calculated. Figure 1 shows the directional-independent 95 percentile values for 1-hour average, 24-hours average, 96-hours average, 192-hours average, 360-hours average and 720-hours average.
The average values are decreased by increasing distance and the decrease rate is more rapid at shorter distance than at longer distance.

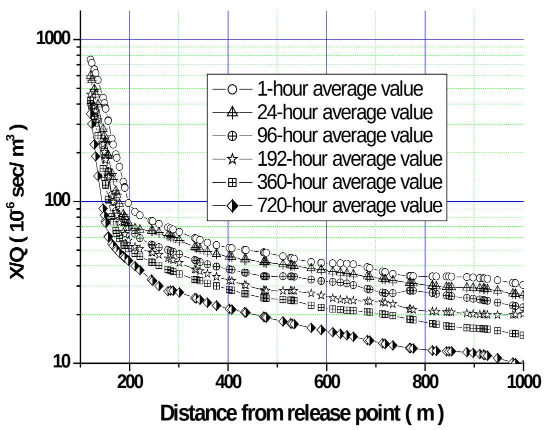

Fig. 1 Directional-independent X/Q in duration time average

In the 1000m^2 and the 30m^2 of building area, building wake effect sensitivity results are shown Fig. 2 and Fig. 3. In the wind speed less than 7m/sec, the building wake effect sensitivity is very small for building area of 1000m^2 and 30m^2 in Fig. 2.

The insensitive results are because of the low wind speed with sufficient stable condition and the small portion of unstable condition.

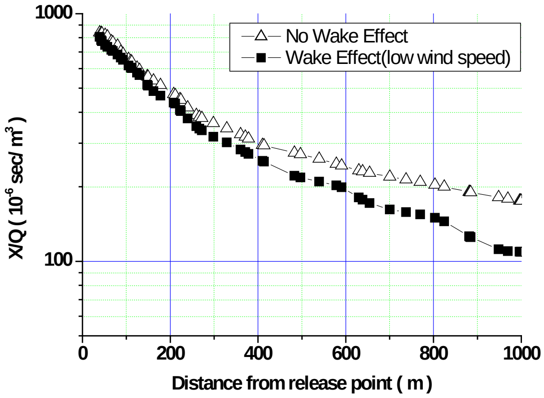

Fig. 2 Building Wake impact (low wind speed)

Finally, the low wind speed itself is the reason of the insensitivity of ARCON96 at building wake effect.

But comparable sensitivity analysis is shown in another condition. In the higher wind speed condition more than 7m/sec with unstable atmospheric condition, the results are shown in Fig. 3. Here, the effects are strongly appeared at the distance more than 200m.

The building wake effect must be affected by the atmospheric unstable condition and the accumulation effect by the downwind distance.

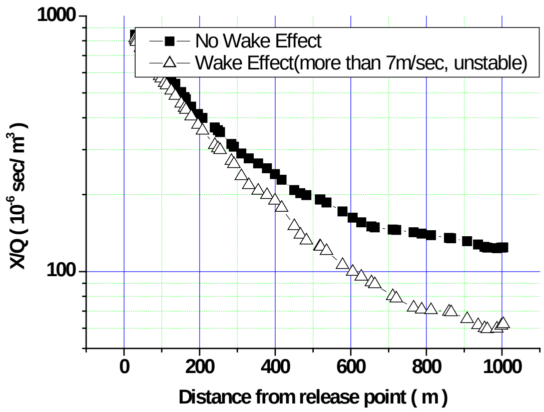

Fig. 3 Building Wake impact (more than 7m/sec)

ARCON96 can simulate plume meander rise effect with increased dispersion coefficients at the low wind speed condition.

The impact is appeared with reducing the X/Q values at low wind speed. The reducing factor is about 2.3 or 3.7. Therefore, more than 18% is reduced in X/Q values. This effect is strong when the plume meander rise duration time is accumulated. Also, the effect is strong when the distance from the release point is ranged from 700m to 850m. The impact is shown in Fig. 4.

In Fig. 4, the meander time accumulation effect is more than 37% between 4000 sec and 8000 sec at each distance condition. From Fig. 4, we know that the plume meander rise effect is accumulated by the distance length and the duration time.

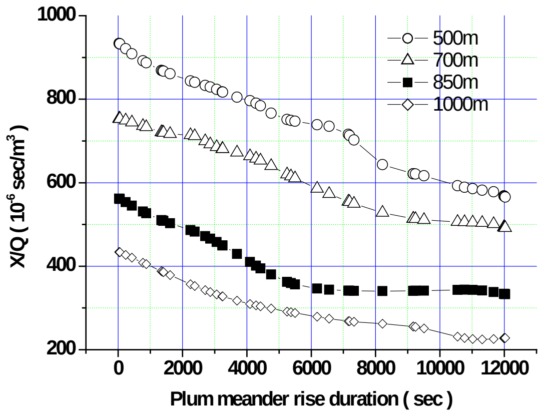

Fig. 4 Plume meander rise effects

5. CONCLUSIONS

Onsite atmospheric dispersion factor sensitivity is carried out for OPR 1000 NPP. Key impact factors are checked. From these results, we find some conclusions as below:

a. Duration time average effect of X/Q is timely increased.
b. Sensitivity analysis results are more conservative at the low wind speed conditions and the stable atmospheric conditions.
c. Building wake effect is strongly dependent on the unstable atmospheric class and higher wind speed conditions more than 7m/sec.
d. Plume meander rise effect is strong in the condition of 500 m and 850m release distance.
e. Generally, plume meander rise effect is accumulated by the release distance length and the duration time.
f. Plume meander rise effect is proportional to the release distance length and the duration time.

From some conclusions we know that ARCON96 is also suitable and efficient in the OPR 1000 site. Also these results seem to be in good agreement with NRC Regulatory Guide and positions.

REFERENCES

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