Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju HICO, Korea, October 27-28, 2016

Sensitivity Analysis of Onsite Atmospheric Dispersion Factor in Westinghouse type NPP in KOREA

Seung Chan Lee*, Duk Joo Yoon and Dong Soo Song
Korea Hydro Nuclear Power Electricity Co., KHNP Central Research Institute, Yuseong-daero 1312, Yuseong, Daejeon 305-343 Korea.
**Corresponding author: eitotheflash@khnp.co.kr*

1. INTRODUCTION

ARCON96 is a NRC licensed air dispersion model to evaluate onsite atmospheric relative concentration X/Q. The purpose of this paper is to provide some results for checking and testing the functionalities of ARCON96.

Specially, this code is optimized to estimate a habitability of control room. Since NUREG 0737 issue, the control room habitability has been studied for a FSAR (Final Safety Analysis Report). Some assumptions and methodology is used in this paper. Some methodology is introduced in this paper. This study includes onsite dispersion factor sensitivity analysis, dispersion model specific characteristics, and impact parameters in case of 2-loop Westinghouse NPP.

The reason of the selection of 2-loop Westinghouse NPP is because of carrying out the study project for the 2-loop Westinghouse NPP in the condition of the defueled NPP condition [1-3].

2. METHODOLOGY

2.1. Release Modes of ARCON 96 code

ARCON96 code has three possible release modes such as ground, vent and stack. If a release point is lower than 2.5times the height of the near structures, it is considered as a ground release. This modeling method is rather conservative comparing with the case of the vent height being lower than 2.5times the height of any adjacent structures.

ARCON96 does not use the plum rise mode and then a ground level release is used in the significant plum rise mode. This approach is more conservative than any other modeling case similar to plum rise[4-5].

2.2. Essential Keys of onsite dispersion factor.

For onsite dispersion factor, key input parameters are used as following.

a. Release height: Using NRC license method, onsite dispersion factor calculates a midpoint height between the lower and the upper wind instrumentation heights. If the release point is lower than this midpoint, X/Q is calculated using the lower wind data. If not that, the other point is used.
b. Wind direction: In this study, North wind is used as either 0 or 360 degrees. Specially, calm hours may be defined as hours with no wind or as very small value of wind speed.
c. Building area: The purpose of ARCON96 is estimate X/Q in the wake region, a directional-dependent building cross-sectional area which generate the wake impact area[4,5].
d. Wind speed : Wind speed category is distributed including 13 regions and each maximum value of these category is 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.

2.3. Default Parameters

Default parameters for the code include:

a. A surface roughness length : 0.2m
b. An angular width : 90 degree
c. A small threshold wind speed: 0.5m/sec – this wind direction is considered meaningless, and the input hourly meteorological conditions are routed to a calm-processing subroutine within the ARCON96.
d. A sector-averaged width is used only for averaging periods more than 8 hours. Here default values are 4 standard deviation of a Gaussian plume.
e. In dispersion coefficient, horizontal term and vertical term are calculated by using standard deviation of a Gaussian plume.
f. The set of averaging time period is ranged from 1 hour to 720 hour, in which averaging X/Q are calculated.

2.4. Meteorological Parameters

These include the number of meteorological data file set about 55,000. To calculate the onsite dispersion factor, this data set must read. In the heights above ground level, the meteorological data are measured, and the units is used for the input wind speeds such as meters per second.

The data scale is ranged from two years to five years. In this study, 2014 and 2015 is used to reflect the new current meteorological data set.

The lower and upper wind-speed is measured at heights of 10 m and 58m, respectively.

ARCON96 analyze the meteorological data file and can record the total number of hours of data and the hours of missed data.

2.5. Source Information

For the general basic analysis, only ground-level release mode is used. Other parameters are the height of source position, the building area (building wake effect), the radius of stack and the velocity and flow rate of plume.

2.6. Receptors for evaluating

Here, some parameters are used as following:

a. The height of air intake at ground-level: The elevation difference between the source height the receptor height.
b. The directional α: the centerline of a sector of angular width.
c. The default parameter β : an angular width (90 degree).

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

3. APPLICATION OF POWER PLANT

3.1. Baseline Application

This chapter introduces the method to apply the ARCON96 code to the NPP.
In this study, we select the Westinghouse type NPP because of carrying out the study project of the Westinghouse NPP related to the safety issue for preparing the defueled condition.
A generic ground-level release from building or NPP is modeled to determine normalized concentrations at various distances from the building to apply in consequence screening analysis. ARCON96 generate the result of producing direction-independent 95 percentile values of X/Q for durations of 2-hours, 8-hours, 24-hours, 96-hours, 192-hours and 720-hours.
In this case, the value is averaged at 16 downwind distances from the source.

3.2. Baseline Input

The standard default parameters of ARCON96 code are used. Especially, in order to reflect the approach point described in RG 1.145, position3, the angular width, β is set to 360 degree in case of the directional-independent X/Q. Table 1 shows a summary of the input data used for each portion of the ARCON96 code.

Table1. Summary of input parameter

Input	Values
Default parameters	Surface roughness length : 0.1m Angular width : 360 degree Threshold wind speed : 0.5m/ Sector-average width : 4 or 90 degree σ-x, σ-z : 0, 0~2, 2 Averaged durations : 1 hour~ 720hours
Meteorological parameters	Wind Speed : 12 categories Stability class : 7 categories (delta T/deltaZ)
Source parameters	Release type, Release height : Ground, 0~2 m Building area : 50 m^2 ~ 1200 m^2 Velocity, Stack radius : default
Receptor parameters	Distance to receptor : 10m ~ 1000m Intake height : 0~2m Elevation difference : 0~2m Direction to source : 180 degree or 90 degree

4. RESULTS AND DISCUSSIONS

For 16 downwind distance of Table1 input, ARON96 code calculates the X/Q. Figure 1 shows the directional-independent 95 percentile values for 1-hour average, 24-hours average, 96-hours average, and 720-hours average.
As shown, the values are decreased with increasing distance and the rate of decrease is more rapid at the shorter distance than at the longer distance.

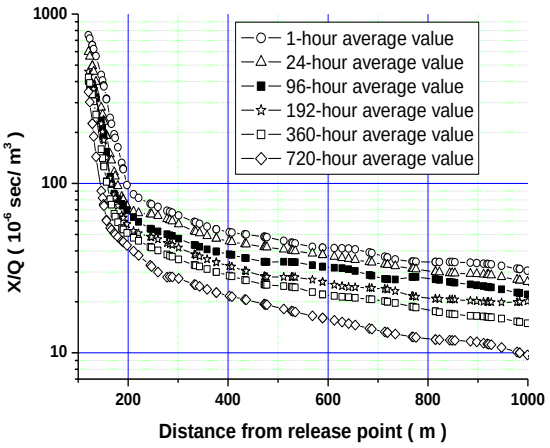

Fig. 1 Directional-independent X/Q in time average

In the 1200m^2 and the 50m^2 of building area, building wake effect sensitivity review is carried out. The results are shown Fig. 2 and Fig. 3. In the low speed condition less than 7m/sec, ARCON96 results are not sensitivity to the building area for 1200m^2 and the 50m^2. The effect of building wake is very small in Fig. 2.
In this condition, even though ARCON96 considers the ground-level release. The reason for the insensitivity is because of the meteorological data set related to 95 percentile value and the low wind speed with stable atmospheric class.

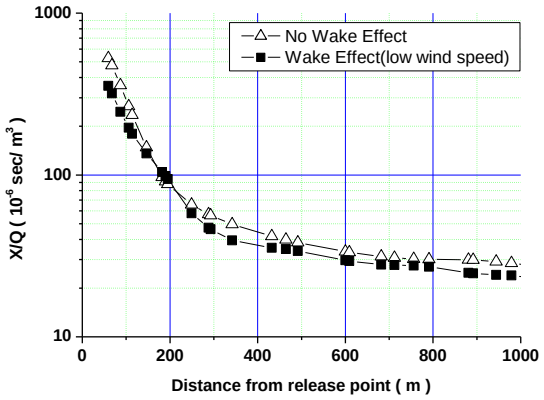

Fig. 2 Building Wake impact (low wind speed)

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

But comparable sensitivity analysis is carried out using another condition. In the condition of higher wind speed more than 7m/sec with unstable atmospheric condition, the performed results are shown in Fig. 3.

Here, the building size effects downwind positions appreciably as expected.

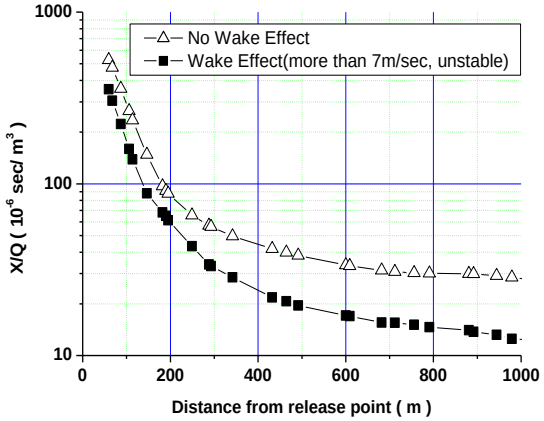

Fig. 3 Building Wake impact (more than 7m/sec)

ARCON96 treats 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 3 or 4. Therefore, more than 20% is reduced in X/Q values. This effect is strong when the plume meander rise duration time accumulated. Also, the effect is strong when the distance from the release point is very small. The impact is shown in Fig. 4.

In Fig. 4, the meander time accumulation effect is more than 30% between 2000 sec and 12000 sec at each distance condition. The other review point is the distance effect of plume meander rise. Fig. 4 shows that the plume meander rise effect is accumulated by the distance length. Because of that, the meander rise effect is stronger by the distance.

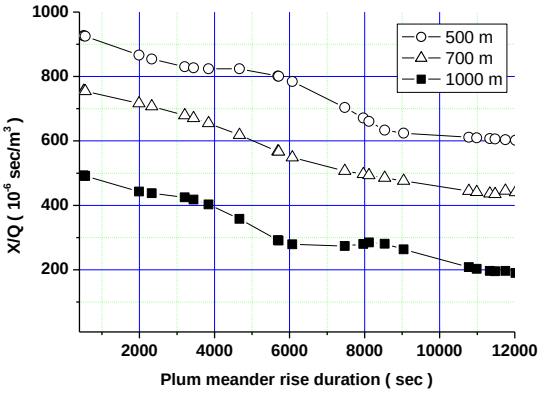

Fig. 4 Plume meander rise effects

5. CONCLUSIONS

Onsite atmospheric dispersion factor sensitivity is performed. Key impact factor is reviewed. Some results are below:

a. Time averaged effect of X/Q is timely increased.
b. ARCON96 code is more conservative at the low wind speed conditions.
c. Building wake impact is significant in the condition of unstable atmospheric class with more than 7m/sec of wind speed.
d. Plume meander effect is strong when the distance from the release point is small.
e. The other plume meander effect is strong when the meander duration time is accumulated

Finally, these results show that the appropriate conservation of ARCON96 is appeared in some conditions. Also these results seem to be in good agreement with NRC Regulatory Guide and positions.

REFERENCES

[1] Final Safety Analysis Report, Kori 1,2.
[2] NRC Regulatory Guide 1.194
[3] NRC Regulatory Guide 1.23
[4] NRC Regulatory Guide 1.145.
[5] NUREG/CR-6331, Atmospheric Relative Concentrations in Building Wakes, Rev.1(1997).