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The Concentration Analysis of CO_2 Using ALOHA Code for Kuosheng Nuclear Power Plant

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Abstract**—**Not only radiation materials, but also the normal chemical material stored in the power plant can cause a risk to the residents. In this research, the ALOHA code was used to perform the concentration analysis under the CO_2 storage burst or leakage conditions for Kuosheng nuclear power plant (NPP). The Final Safety Analysis Report (FSAR) and data were used in this study. Additionally, the analysis results of ALOHA code were compared with the R.G. 1.78 failure criteria in order to confirm the control room habitability. The comparison results show that the ALOHA result for burst case was 0.923 g/m^3 which was below the criteria. However, the ALOHA results for leakage case was 11.3 g/m^3.

Keywords**—**BWR, ALOHA, habitability, Kuosheng.

I. Introduction

TAIWAN has four NPPs. The second NPP is Kuosheng plant. Kuosheng NPP locates in the north of Taiwan. In addition, Kuosheng is a BWR/6 NPP which is designed and manufactured by General Electric (GE).

In order to maintain NPPs operation and safety, some chemicals are used to perform these requests, for example: CO_2. Therefore, these chemicals are stored in NPPs. However, these chemicals may affect the habitability of control room if the burst or leakage of chemicals occurs. Additionally, Atomic Energy Council (AEC) requires Taiwan Power Company to confirm the control room habitability for all NPPs after the disaster of Fukushima Daiichi NPP occurred.

According the ALOHA manual [1], ALOHA code can estimate the spatial extent of volatile and flammable chemicals for the short-term accidental release. ALOHA can calculate the human health hazards for toxic chemical vapors, thermal radiation from fires, and the effects of the pressure wave of vapor-cloud explosions. ALOHA can provide a threat zones in the range from 100 to 10,000 meters according to the analysis results.

The maximum storage for chemicals is CO_2 in kuosheng NPP. The storage amount of CO_2 in Kuosheng NPP is 48000 kg. Therefore, the purpose of this study is to evaluate the control room habitability for Kuosheng under the CO_2 storage burst or leakage conditions. The data from FSAR [2], R.G. 1.78 [3], R.G. 1.23 [4], and report [5] were used to perform the analysis.

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II. The Analysis of Aloha

Two cases are in this research. Case 1 is the CO_2 storage burst and Case 2 is the CO_2 storage leakage. Table I shows the ALOHA input parameters for Case 1. Table II presents the ALOHA input parameters for Case 2. The stock of CO_2 is 48000 kg in Kuosheng NPP. The atmospheric conditions include that the wind speed is 3.11 kg/s, air temperature is 30 °C, humidity is 55%, and atmospheric stability classification is “C’. According to R.G. 1.23 [4], the atmospheric stability classification is divided into “A” ~ “G” level. Table III shows the definition of level. The extremely unstable is “A” level and the extremely stable is “G” level. The data are used in the following steps.

TABLE I
KUOSHENG ALOHA INPUT PARAMETERS (CASE 1)

Parameters	Values
CO_2 initial mass (kg)	48000
Wind speed (m/s)	3.11
Atmospheric stability classification	C
Air temperature (°C)	30
Humidity (%)	55

TABLE II
KUOSHENG ALOHA INPUT PARAMETERS (CASE 2)

Parameters	Values
CO_2 initial mass (kg)	48000
Wind speed (m/s)	3.11
Atmospheric stability classification	C
Air temperature (°C)	30
Humidity (%)	55
CO_2 release rate (kg/sec)	13.33

TABLE III
THE STABILITY CLASSIFICATION [5]

Stability classification	Pasquill stability category
Extremely unstable	A
Moderately unstable	B
Slightly unstable	C
Neutral	D
Slightly stable	E
Moderately stable	F
Extremely stable	G

There are four main steps for the ALOHA analysis in this study. First, the location data are input to ALOHA which includes elevation, latitude, longitude, etc. Fig. 1 presents the operation screen for location data. Second, the building data are input to ALOHA. In this study, the building is the control room of Kuosheng NPP. Therefore, the air intake rate of control room is input to ALOHA (see Fig. 2). Third, the atmospheric data are input to ALOHA which includes wind speed, air temperature, humidity, etc. Fig. 3 presents the operation screen for atmospheric data. Finally, the source data are input to ALOHA. This step can define the chemical burst or leakage. The left side for Fig. 4 is the operation screen for chemical burst. The right side for Fig. 4 is the operation screen for chemical leakage.

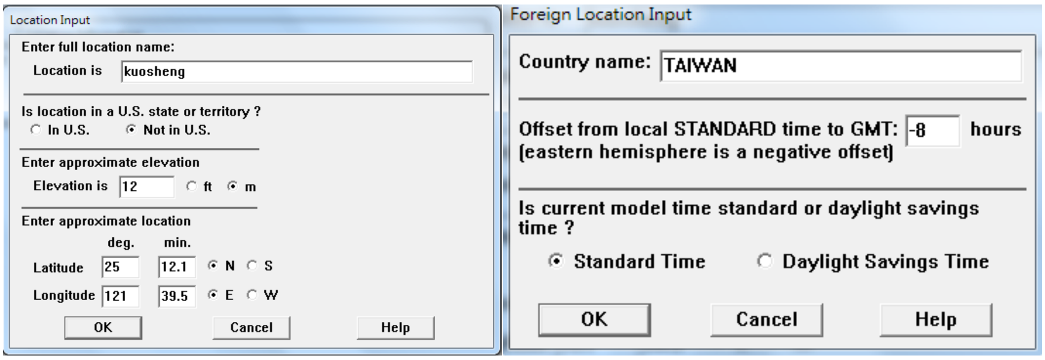


Fig. 1 The ALOHA operation screen for location data

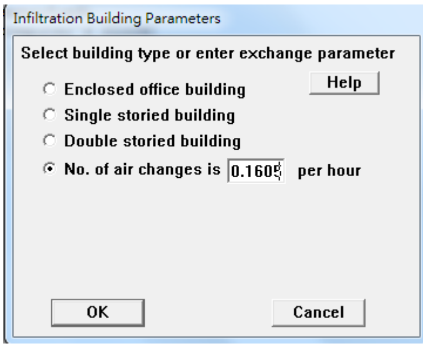


Fig. 2 The ALOHA operation screen for building data

III. Results

The CO_2 concentration dispersion and outdoor/indoor concentration for Case 1 are presented in Fig. 5. The CO_2 concentration dispersion is divided into three levels which are 7.36, 3.166, and 2.834 g/cm^3. These level areas are as follows:

- The area for 7.36 g/cm^3 locates the downwind distance 0~1.4 km.
- The area for 3.166 g/cm^3 locates the downwind distance 1.4~1.9 km.
- The area for 2.834 g/cm^3 locates the downwind distance 1.9~2.0 km.

The outdoor concentration in this analysis is the CO_2 concentration in the atmospheric. The indoor concentration in this analysis is the CO_2 concentration in the control room. The ALOHA result shows that the maximum outdoor concentration is 348 g/cm^3. The ALOHA result depicts that the maximum indoor concentration is 0.923 g/cm^3. In addition, the failure criterion is 7.36 g/m^3 according to R. G. 1.78 [3]. Table IV shows the comparison results. The ALOHA result for Case 1 is below the failure criterion. This indicates that the control room habitability for Kuosheng NPP can be maintained in this case.

The CO_2 concentration dispersion and outdoor/indoor concentration for Case 2 are shown in Fig. 6. The CO_2 concentration dispersion is also divided into three levels which are 7.36, 3.166, and 2.834 g/cm^3. These level areas are as:

- The area for 7.36 g/cm^3 locates the downwind distance 0~230 m.
- The area for 3.166 g/cm^3 locates the downwind distance 230~390 m.
- The area for 2.834 g/cm^3 locates the downwind distance 390~410 m.

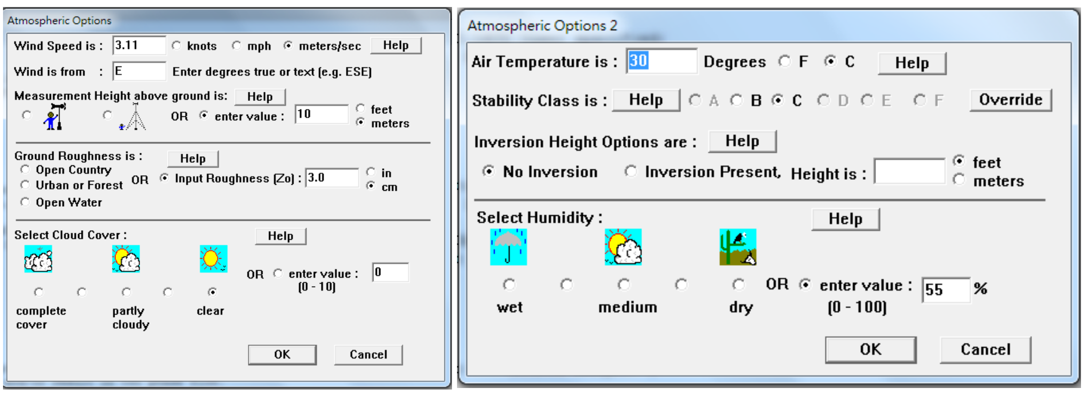


Fig. 3 The ALOHA operation screen for atmospheric data

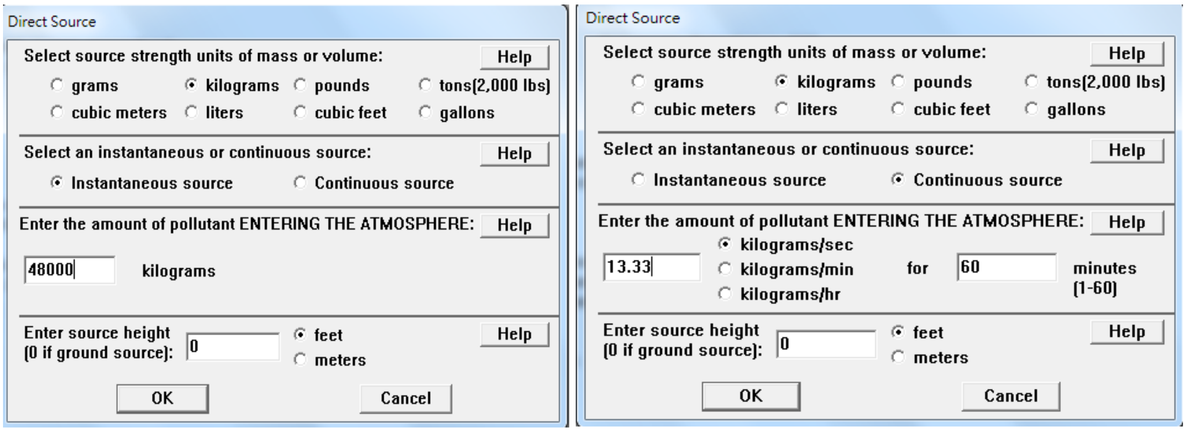
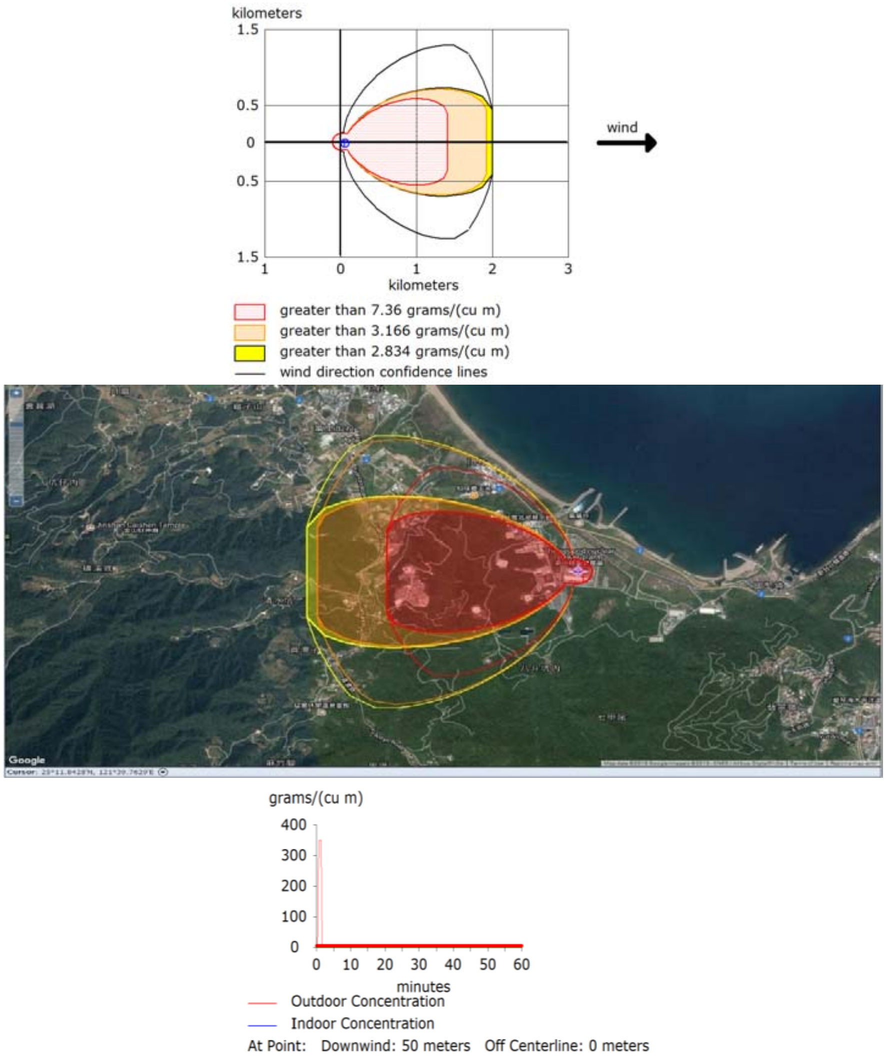


Fig. 4 The ALOHA operation screen for source data

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THREAT AT POINT:
  Concentration Estimates at the point:
  Downwind: 50 meters                    Off Centerline: 0 meters
  Max Concentration:
     Outdoor: 348 grams/(cu m)
     Indoor:  0.923 grams/(cu m)
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Fig. 5 The ALOHA results for Case 1

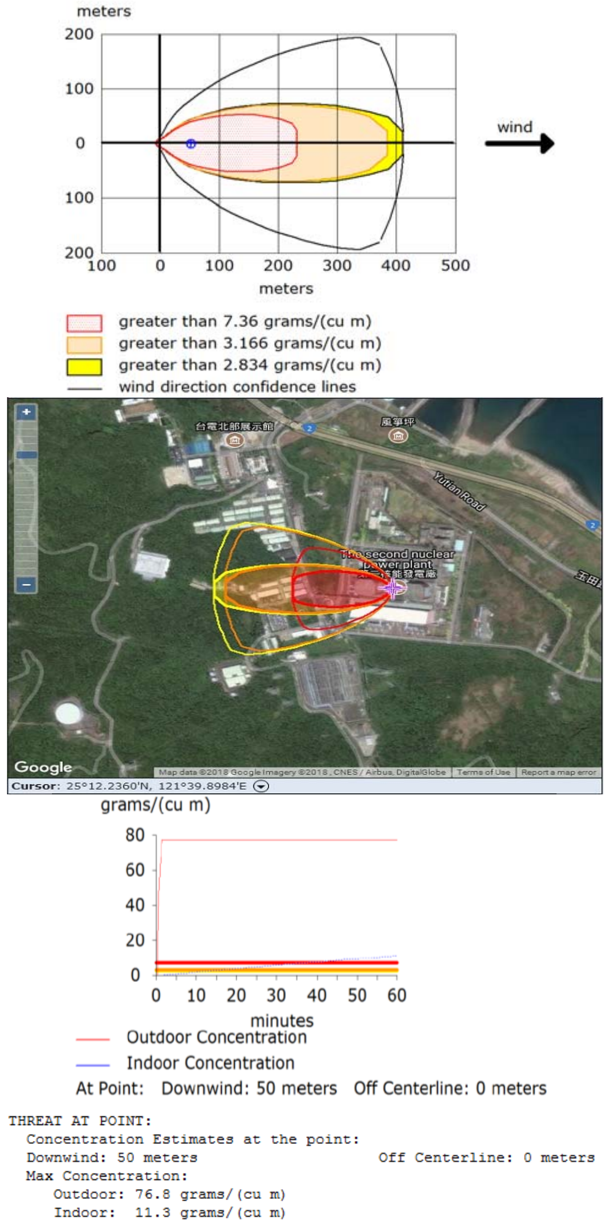

Fig. 6 The ALOHA results for Case 2

The ALOHA result shows that the maximum outdoor concentration is 76.8 g/cm^3. The ALOHA result shows that the maximum indoor concentration is 11.3 g/cm^3. Table V shows the comparison results for the ALOHA result and failure criterion. The ALOHA result for Case 2 is over the failure criterion. This indicates that the control room habitability for Kuosheng NPP may not be maintained in this case.

TABLE IV
THE ALOHA RESULTS FOR THE CO_2 STORAGE BURST CASE

	Max. concentration (g/m^3)
ALOHA	0.923
R.G. 1.78 failure criteria	7.36

TABLE V
THE ALOHA RESULTS FOR THE CO_2 STORAGE LEAKAGE CASE

	Max. concentration (g/m^3)
ALOHA	11.3
R.G. 1.78 failure criteria	7.36

IV. CONCLUSION

The main purpose of this research is to use the ALOHA code to perform the concentration analysis under the CO_2 storage burst (Case 1) or leakage (Case 2) conditions for Kuosheng NPP. The analyses result of ALOHA for the CO_2 burst case is below the R.G. 1.78 failure criteria. It indicates that the control room habitability for Kuosheng NP can be maintained for this case. However, the analyses result of ALOHA for the CO_2 leakage case is over the R.G. 1.78 failure criteria. This implies that the control room habitability for Kuosheng NP may not be maintained for this case.

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