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Using RASCAL and ALOHA Codes to Establish an Analysis Methodology for Hydrogen Fluoride Evaluation

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Abstract**—**In this study, the RASCAL and ALOHA codes are used to establish an analysis methodology for hydrogen fluoride (HF) evaluation. There are three main steps in this study. First, the UF_6 data were collected. Second, one postulated case was analyzed by using the RASCAL and UF_6 data. This postulated case assumes that fire occurring and UF_6 is releasing from a building. Third, the results of RASCAL for HF mass were as the input data of ALOHA. Two postulated cases of HF were analyzed by using ALOHA code and the results of RASCAL. These postulated cases assume fire occurring and HF is releasing with no raining (Case 1) or raining (Case 2) condition. According to the analysis results of ALOHA, the HF concentration of Case 2 is smaller than Case 1. The results can be a reference for the preparing of emergency plans for the release of HF.

Keywords**—**RASCAL, ALOHA, UF_6, hydrogen fluoride.

I. Introduction

THE analysis methodology of HF evaluation is established by using the RASCAL and ALOHA codes in this study. The RASCAL code can calculate the doses of radioactive materials from building, nuclear power plant, spent fuel storage pool and cask, fuel cycle facility, etc. [1], [2]. The Radiological protection computer code Analysis and Maintenance Program (RAMP) international cooperation program is led by U.S. NRC. The RASCAL is one of RAMP codes. The RAMP main research area is the plant decommissions, atmospheric dispersion factor, radiation dose calculation, control room habitability, and so on. Our group (Tsing-Hua University, Taiwan) joined the RAMP program in 2016 and got the RASCAL code.

According to the ALOHA manual [3], ALOHA code can calculate the spatial extent of volatile and flammable chemicals for the short-term accidental release. In addition, ALOHA can present a threat zone of chemicals according to the results.

Institute of Nuclear Energy Research (INER) stores the UF_6 in a building. The amount UF_6 of is about 34770 kg. UF_6 is a hazardous chemical and can react with water. This reaction can form HF and uranyl fluoride (UO_2F_2) and is an exothermic reaction. The UO_2F_2 is very toxic, and the HF is a highly corrosive chemical. Therefore, this study used the RASCAL and ALOHA codes to perform the postulated cases for the HF evaluation. Therefore, according to some reports and our previous studies [1]-[6], the RASCAL and ALOHA codes are used in this research to establish an analysis methodology for HF evaluation. Three main steps are used in this study. First, the INER UF_6 data were collected. Second, one postulated case under UF_6 fire accident condition was analyzed by using the RASCAL code and UF_6 data. Third, the predictions of RASCAL for HF mass were as the input data of ALOHA. Two postulated HF cases with the different meteorology conditions were analyzed by using ALOHA code and the RASCAL results.

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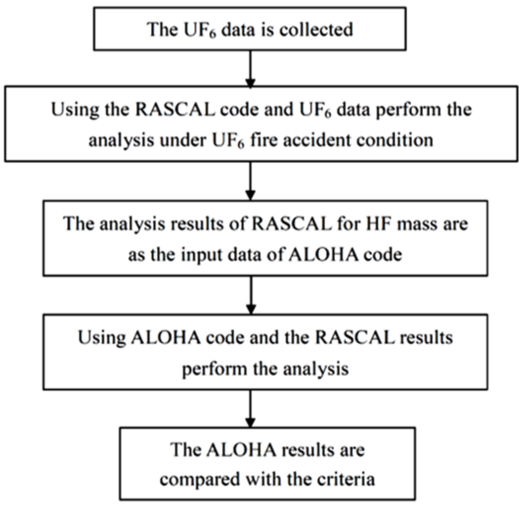


Fig. 1 The RASCAL/ALOHA analysis methodology

II. The Analysis Methodology of Rascal and Aloha

The flowchart of the analysis methodology of RASCAL and ALOHA is shown in Fig. 1 and as follows:

- The UF_6 data of INER were collected in the first step.
- Using the RASCAL code and UF_6 data performed the analysis of one postulated case under UF_6 fire accident condition in the second step.
- The analysis results of RASCAL for HF mass were as the input data of ALOHA code.
- Using ALOHA code and the RASCAL results performed the analysis of two postulated HF cases with the different meteorology conditions.

- Finally, the ALOHA analysis results were compared with the criteria.

Table I presents one case conditions. The mass of UF_6 is 34770 kg (solid). The release rate of UF_6 is assumed to be 8 kg/sec. The release pathway and meteorology condition are also shown in Table I. Fig. 2 shows the operation screen of RASCAL and the RASCAL setting for the UF_6 analysis. The operation of RASCAL includes six main operation steps. The six main operation steps are event type, event location, source term, release path, meteorology, and calculation of doses. The RASCAL analysis result (HF mass, 3220 kg) was as the input data of ALOHA code in this study. Table II presents two postulated HF cases with the different meteorology conditions. Figs. 3 and 4 show the operation screen of ALOHA for the HF analysis. The operation of ALOHA includes atmospheric, source, and location setting. The input data for the HF analysis are from Table II. In addition, the human is assumed in a room which is located in the downwind distance 81 m. ALOHA can calculate the HF concentration in this room. The results compared with the criteria of hazardous levels for human health after the case analysis finished. The criteria of HF are following Emergency Response Planning Guideline (ERPG) [4]:

- ERPG -1: <2 ppm
- ERPG-2: 2~20ppm
- ERPG-3: 20~50ppm

The health effects for ERPG are presented in Fig. 5.

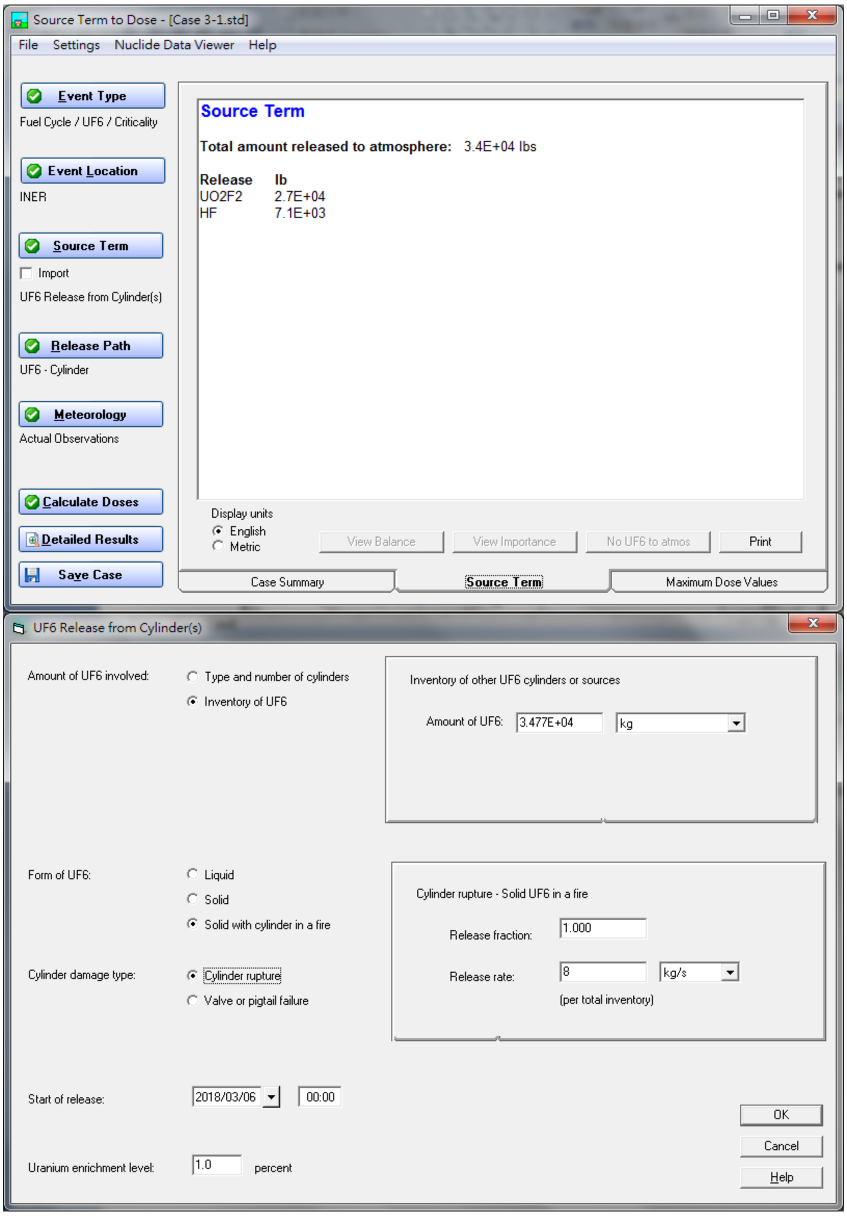


Fig. 2 The RASCAL setting for UF_6 analysis

TABLE I
CASES CONDITIONS FOR UF_6

Case	UF_6	Release pathway	meteorology
1	Mass: 34770 kg, solid Release rate: 8 kg/sec	Postulated fire occurring, UF6 is releasing from a building	West wind (1m/s), D stability 25°C, no raining

TABLE II
CASES CONDITIONS FOR HF

Case	HF	Release pathway	meteorology
1	Mass: 3220 kg, Release rate: 53.67 kg/min	Postulated fire occurring, HF is releasing directly	West wind (1m/s), D stability 25°C, no raining
2	Mass: 3220 kg, Release rate: 53.67 kg/min	Postulated fire occurring, HF is releasing directly	West wind (1m/s), D stability 25°C, raining

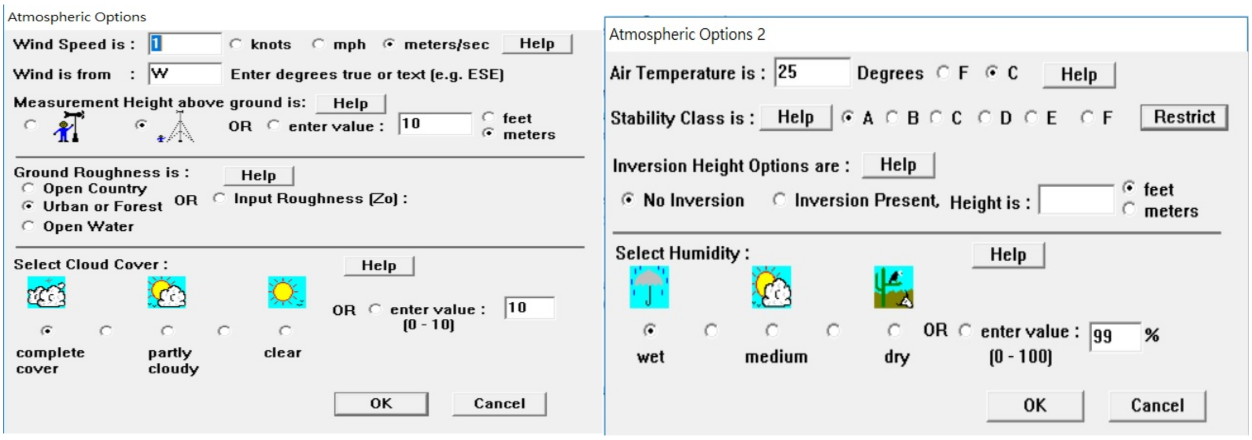


Fig. 3 The atmospheric setting of ALOHA for HF analysis

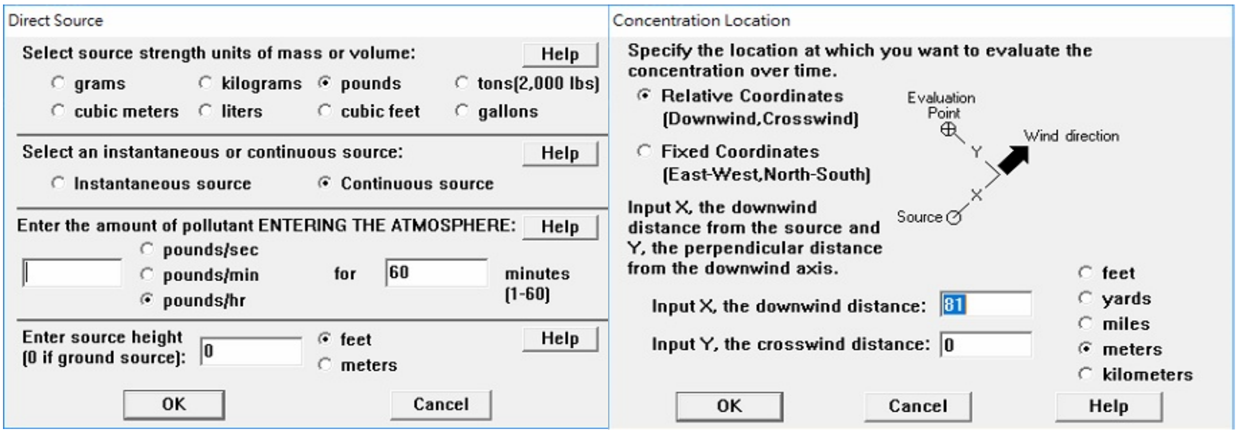


Fig. 4 The source and location setting of ALOHA for HF analysis

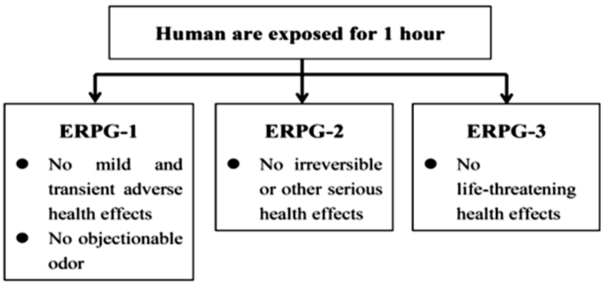


Fig. 5 The health effects for ERPG

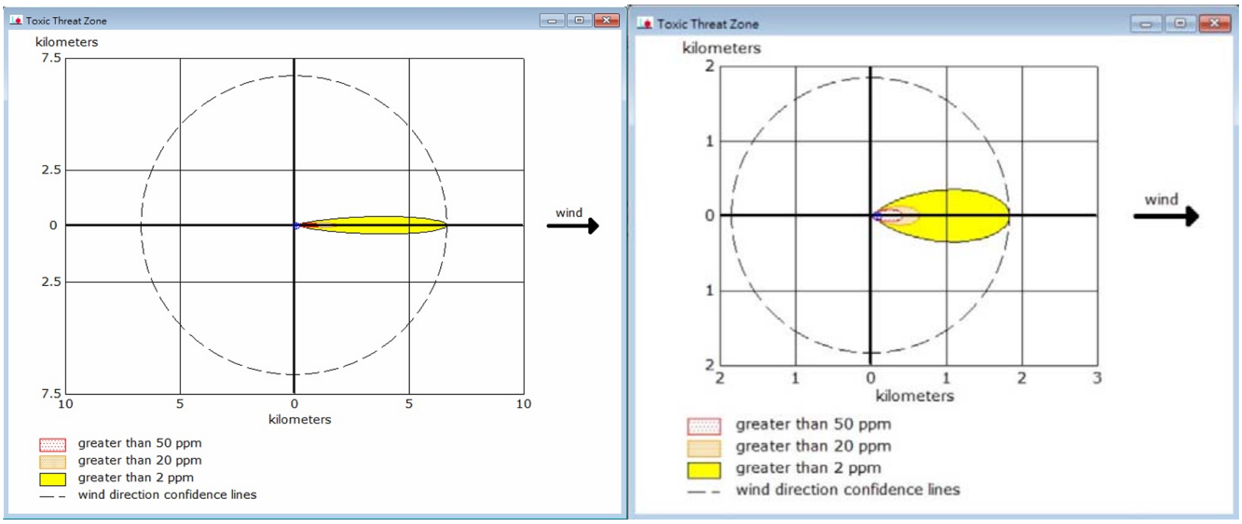
III. RESULTS

Table II shows the analysis result of RASCAL. The RASCAL result presents that the HF mass is 3220 kg under UF_6 fire accident condition. This HF mass result was as the input data of ALOHA code in this study. Table III presents the predictions of ALOHA for Case 1 and 2. The HF concentration in the room is 1190 g/m^3 and the HF concentration in the atmospheric is 8330 g/m^3 for Case 1. The HF concentration in the room is 222 g/m^3 and the HF concentration in the atmospheric is 1560 g/m^3 for Case 2. Therefore, the HF concentration of Case 2 is below Case 1 due to the raining.

ALOHA can show a threat zone of chemicals according to the results. Fig. 6 depicts the threat zone results of Case 1 and 2. The HF threat zone of Case 1 is larger than Case 2. Additionally, Fig. 6 also shows the criteria of ERPG. For Case 1, the distance which the HF concentration is above the ERPG-3 is below 1.1 km; the distance where the HF concentration is between the ERPG-2 and ERPG-3 is between 1.9 and 1.1 km; the distance which the HF concentration is between the ERPG-1 and ERPG-2 is between 6.7 and 1.9 km. For Case 2, the distance which the HF concentration is above the ERPG-3 is below 0.43 km; the distance where the HF concentration is between the ERPG-2 and ERPG-3 is between 0.65 and 0.43 km; the distance where the HF concentration is between the ERPG-1 and ERPG-2 is between 1.8 and 0.65 km. In addition, the threat zone of chemicals can be shown in the Google map. Fig. 7 shows the threat zone of HF for Cases 1 and 2 which are using ALOHA results and Google map function.

TABLE III
THE ALOHA RESULTS

	Room Concentration (g/m^3)	Atmospheric Concentration (g/m^3)
Case 1	1,190	8,330
Case 2	222	1,560



(a) Case 1 (b) Case 2

Fig. 6 The HF analysis result of ALOHA (a) Case1 (b) Case 2

(a) Case 1 (b) Case 2

Fig. 7 The HF analysis result of ALOHA with Google map (a) Case1 (b) Case 2

IV. Conclusion

By using RASCAL and ALOHA codes, an analysis methodology is established successfully in this study. One postulated case under UF_6 fire accident condition was analyzed by using RASCAL. The HF predictions of RASCAL were as the input data of ALOHA code. The ALOHA code with the RASCAL results performed two postulated cases analysis for HF evaluation. According to the analysis results of ALOHA, the HF concentration of Case 2 is below Case 1. In addition, the predictions of the analysis methodology can be a reference for the preparing of emergency plans which handle the release of HF.

References

[1] G. F. Athey, J. P. Rishel, J. V. Ramsdell, Jr., and J. J. Tomon, RASCAL 4.3: User's Guide, U.S. Nuclear Regulatory Commission, Washington, DC, 2015.
[2] J. V. Ramsdell, Jr., G. F. Athey, and J. P. Rishel, RASCAL 4.3: Description of Models and Methods, U.S. Nuclear Regulatory Commission, Washington, DC, 2015.
[3] R. Jones, W. Lehr, D. Simecek-Beatty, R. M. Reynolds, ALOHA (Areal Locations of Hazardous Atmospheres) 5.4.4 Technical Documentation, 2013.
[4] AIHA Guideline Foundation, 2016 ERPG/WEEL Handbook, 2016.
[5] W. S. Hsu, J. R. Wang, H. C. Chen, Y. Chiang, S. W. Chen and C. Shih, Evaluation of control room habitability in case of LOCA for Maanshan NPP using codes RADTRAD, HABIT and ALOHA, Kerntechnik, Vol. 83, 2018.
[6] W. S. Hsu, Y. Chiang, H. C. Chen, J. R. Wang, S. W. Chen, J. H. Yang, C. Shih, The Concentration Analysis of CO_2 Using ALOHA Code for Kuosheng Nuclear Power Plant, World Academy of Science, Engineering and Technology International Journal of Nuclear and Quantum Engineering Vol:12, No:4, 2018.