Development of preliminary MACCS2 input model for the Level 3 PSA on the KAERI Site

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1. Introduction

Facilities handling radioactive materials are in operation on the site of the Korea Atomic Energy Research Institute (KAERI). KAERI has been conducting deterministic radiological environmental impact assessments on the facilities handling radioactive materials in the KAERI site every year since 1995. There has been a need for an off-site consequence analysis of serious accidents in the facilities based on the probabilistic methodology.

The off-site consequence analysis of serious accidents is technically Level 3 Probabilistic Safety Assessment (PSA) area, and foreign countries have developed and used Level 3 PSA code suitable for their geography, humanities and social characteristics. Since Level 3 PSA code is currently under development in Korea, we will use the US MACCS2 code to conduct the off-site consequence analysis on the KAERI site. Preliminary MACCS2 input parameters for the off-site consequence analysis on the KAERI site were prepared by collecting and analyzing the vast amount of data in various areas such as weather data, population data, emergency plan.

2. MACCS2 input data

2.1 Source term data

When performing MACCS2 calculation, source term data will be generated by using MelMACCS code. MelMACCS code produces MACCS2 input file, which describes the source term, using the results calculated by MELCOR. Details of source term data are not covered in this paper.

2.2 Meteorological data

Wind direction, wind speed, temperature data for 10, 27, and 67 m height, and precipitation data for 2009-2019 measured at a meteorological tower in the KAERI site were obtained and used in this study. Meteorological data from the previous year at the time of the off-site consequence analysis will be used for MACCS2 calculation. Fig. 1 shows wind rose diagrams for wind direction and speed measured at 10 m height of the meteorological tower in 2018 and 2019.

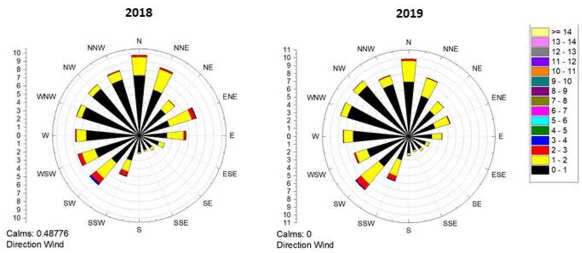

Fig.1. Wind rose diagrams for wind direction and speed measured at 10 m height of the meteorological tower at the KAERI site in 2018 and 2019

The release type is classified into ground level release and elevated (stack) release according to KINS Regulatory guide (RG) 1.03. Details on the release height are provided in KINS/RG-1.03. Atmospheric stability was calculated by applying a method based on the temperature lapse rate in accordance with the Nuclear Safety and Security Commission (NSSC) Notice 2017-26. NSSC Notice 2017-26 states that the data collection rate during the observation period should be at least 90%. The data collection rates from the meteorological tower satisfied this criterion. At this level of collection rate, the substituting method of missing meteorological data did not significantly affect the results when all weather sequences were applied to the calculation (Fig. 2). The missing meteorological data were replaced with data from one day before or after.

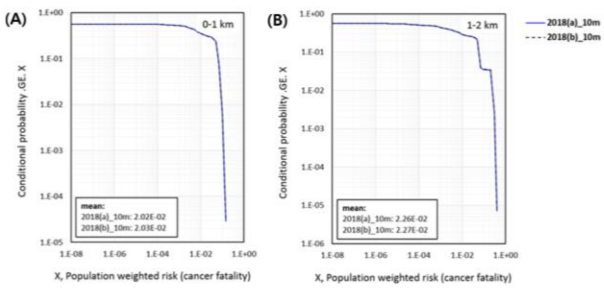

Fig. 2. Comparison of MACCS2 results according to the substituting method of missing meteorological data

As presented in Fig. 3, there was a difference between the results when METCOD2 (importance sampling method) was applied and when all weather sequences of a year (8,760 weather sequences) were used for calculation by applying METCOD5 (stratified random sampling from equally spaced intervals) as a meteorological sampling option. Therefore, METCOD5 will be applied to consider all weather sequences of a year although it takes a relatively long calculation time (Fig. 3).

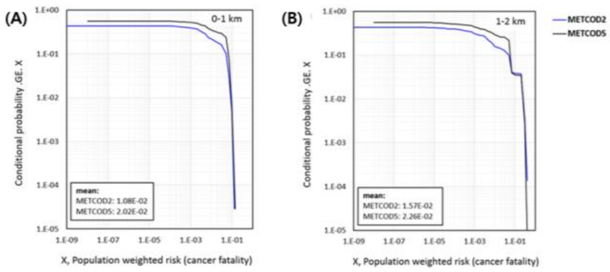

Fig. 3. Comparison of MACCS2 results according to a weather data sampling method

The results in Fig. 2 and 3 are not related to the case of an accident at the facilities on the KAERI site. A hypothetical source term was applied to analyze the input variables conditions related to the meteorological data.

2.3 Site data

The calculation area was divided into 16 compass directions and 35 grids within a 30 km radius of the KAERI site. A site data file was produced using KOSCA-POP program [1], which has been developed by KAERI. Population data in the site file was replaced with data generated by the GIS-Based Population Data Conversion Program (POPCON), and details of the program are presented in Jang et al. (2021) [2].

2.4 Emergency plan

According to NSSC Notice 2017-38, Emergency Planning Zone (EPZ) of HANARO and other nuclear facilities in the KAERI site were set to a radius of 1.5 km and site boundary, respectively. Based on the EPZ of HANARO, two emergency response scenario were considered for early phase (Table I).

Table I: Emergency response scenario for early phase

Scenario	EPZ (1.5 km)		Outside EPZ
	KAERI site (~800m)	Outside KAERI site (~1.5km)	
1	Not considered	Protective action x	Protective action x
2	Not considered	95% Evacuation, 5% sheltering	Protective action x

Data related to evacuation routes and time lines were referred to the emergency plan of KAERI [3].

2.5 Dose conversion coefficient and input parameter for health effect

FGR 13 Dose Coefficient Factor (DCF) file will be used for MACCS2 calculation. This file was created based on ICRP publication 60 (1990) and it is the most recent version of DCF file distributed by Nuclear Regulatory Commission (NRC.) Since DCF of FGR 13 were derived based on Biological Effects of Ionizing Radiation (BEIR) V, the input parameter for health effect were referred to BEIR V.

2.6 Input data for foodchain model (COMIDA2)

COMIDA2 is a food pathway model that estimates ingestion doses per unit of deposited activity from radionuclide. Since COMIDA2 was developed for the agricultural environment and dietary habits of United States, there are limitations in applying it to Korea. In order to reflect the characteristics of Korea, data derived under the Korean environment were applied as much as possible when generating the input file of COMIDA2. Statistical data for dietary habits and food production were referred to the latest officially published reports at Korea Rural Economic Institute (KREI) [4] and Ministry for Food, Agriculture, Forestry and Fisheries (MAFRA) [5]. For parameters derived based on experimental or measurement data related to radionuclide behavior and crop growth, the values from ECOREA, COMIDA2 and PATHWAY code, or the values presented in IAEA TRS-472 [6] were referenced.

2.7 Other input parameters

Among the input data not mentioned above, SOARCA project [7] was referenced for data that are not specific to the Korean environment.

3. Conclusion

Preliminary MACCS2 input model has been developed to conduct the off-site consequence analysis on a serious accident at nuclear facilities in the KAERI site. The currently constructed input data will be continuously updated to the latest data at the time of the MACCS2 calculation, and will be verified through sensitivity studies or literature review.

ACKNOWLEGEMENT

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