Improvement of Off-site Dose Assessment Code for Operating Nuclear Power Plant

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1. Introduction

Dose assessment codes for gaseous and liquid effluent from an operating nuclear power plant (i.e. GASDOS and LIQDOS, respectively) were developed by Nuclear Safety Center (currently Korea Institute of Nuclear Safety) in 1989. They were modified in accordance with ICRP (International Commission on Radiological Protection) 60 by KINS and integrated into INDAC (Integrated Dose Assessment Code Package) in 1999. In addition, XOQDOQ code which calculates atmospheric dispersion factor was included into INDAC also.

A research on the improvement of off-site dose assessment system for an operating nuclear power plant was performed by KINS in 2011 [1]. As a result, following improvements were derived:

- Separation of dose assessment for new and existing facilities
- Update of food ingestion data
- Consideration of multi-unit operation and so on

In order to reflect the results, INDAC is under modification.

2. Improvements

2.1 Overall

The user interface has been improved with the tree structure menu and multi tab (Fig. 1). Thus, a user can access each module easily and does not need to change the screen for each option.

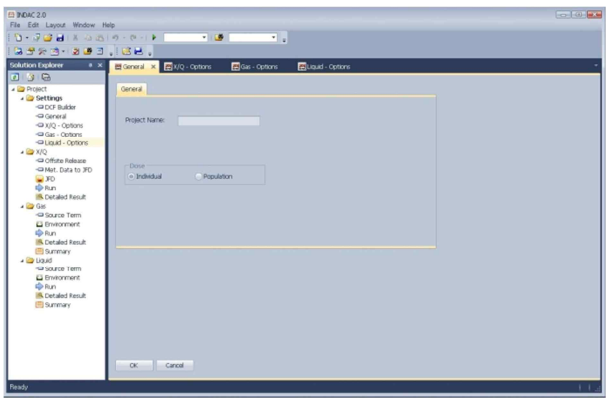

Fig. 1. Layout of improved INDAC

A module for JFD (Joint Frequency Distribution) calculation of meteorological data was developed and it is a submenu of XOQDOQ module. When a user selects the height of meteorological data and loads the meteorological data file (MS Excel format), the module automatically calculates JFD by wind direction, wind speed class and atmospheric stability (Fig. 2). The wind speed class is divided by user inputted criteria and atmospheric stability is calculated from the temperature of two levels.

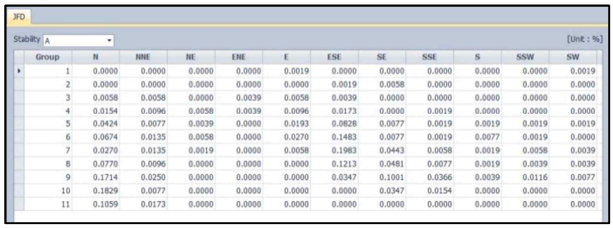

Fig. 2. Result of JFD calculation

A module for calculating multi-unit dose assessment points was developed. When a user enters center coordinate and radius of EAB (Exclusion Area Boundary) for each unit, the module calculates the coordinate of assessment points by sixteen directions for each unit on the site boundary (Fig. 3).

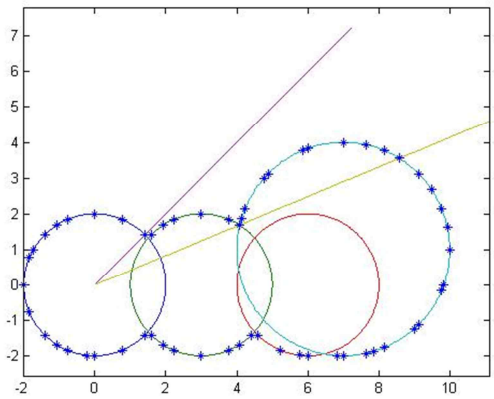

Fig. 3. Result of multi-unit dose assessment point calculation

The library of DCF (Dose Conversion Factor) has been updated. The format of library is MS Access file and the library contains more than 20,000 internal DCFs and 5,000 external DCFs for each nuclide. When a user runs the 'DCF Builder' module, the module extracts following DCF data files from the library automatically:

- Inhalation DCF
- Ingestion DCF
- Ground External DCF
- Water Immersion External DCF

2.2 XOQDOQ

A user can select the release mode: ground release, elevated release or mixed release (Fig. 4). According to U.S. NRC Regulatory Guide 1.111 [2], the ground release means that effluents are released from the height less than the height of adjacent structures. On the other hand, the elevated release is considered when effluents are released from the height which is higher than two times of the height of adjacent structures. When a user selects the mixed release, the ratio between ground and elevated release is calculated from the vertical exit velocity of the plume and the horizontal wind speed at the release height [3].

In addition, the building wake option has been added (Fig. 4). A user can select the consideration of building wake factor irrespective of the release mode. When a user turned off the building wake option and selected the ground release mode, the building wake factor, C, in related equations becomes zero.

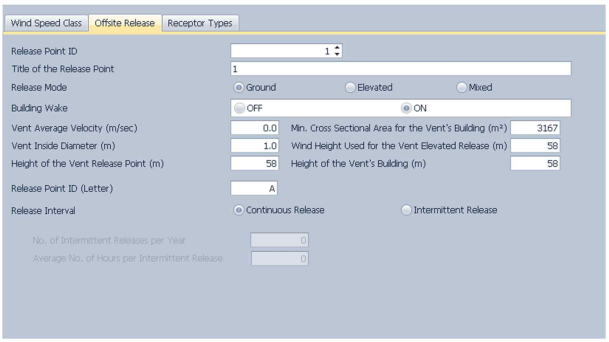

Fig. 4. Options for release mode and building wake factor

2.3 GASDOS

The old version of GASDOS considered 33 nuclides only for the source term. Thus, it was difficult to simulate with the real release data of nuclear power plant at the same time. In order to solve this problem, the number of source term nuclides has been increased up to 99 nuclides.

In addition, the old version considered 5 points for individual dose assessment only. With this number, it was impossible to get the result for sixteen directions. Therefore, the number of assessment points has been increased up to 30 points for each release point to consider the multi-unit assessment (Fig. 5). This number corresponds to the limit of XOQDOQ.

The format of DCF data file for noble gases has been modified in order to improve the usability. In the older version, a user could modify the effective dose DCF from external exposure only and other types of DCF such as gamma-air, beta-air, beta-skin and lung were fixed. As the DCF data file included DCF for gamma-air, beta-air, beta-skin and lung, a user can modify DCF data easily if necessary. DCF data were referred to IAEA (International Atomic Energy Agency) Safety Series No. 115 [4].

Selected	Point	Direction	Distance(m)	X/Q	X/Qd	X/Qdd	D/Q
✓	RESIDENCES	N	800	3.546E-05	3.528E-05	3.232E-05	4.777E-08
✓	RESIDENCES	NNE	800	5.457E-05	5.434E-05	4.977E-05	6.647E-08
✓	RESIDENCES	NE	800	3.050E-05	3.037E-05	2.782E-05	4.611E-08
✓	RESIDENCES	ENE	800	1.995E-05	1.987E-05	1.819E-05	4.189E-08
✓	RESIDENCES	E	800	1.474E-05	1.468E-05	1.343E-05	3.392E-08
✓	RESIDENCES	ESE	800	8.022E-06	7.981E-06	7.303E-06	1.698E-08
✓	RESIDENCES	SE	800	9.614E-06	9.568E-06	8.752E-06	2.470E-08
✓	RESIDENCES	SSE	800	1.126E-05	1.121E-05	1.024E-05	3.580E-08
✓	RESIDENCES	S	800	1.247E-05	1.241E-05	1.134E-05	3.697E-08
✓	RESIDENCES	SSW	800	1.047E-05	1.041E-05	9.522E-06	2.183E-08
✓	RESIDENCES	SW	800	8.564E-06	8.504E-06	7.792E-06	8.973E-09
✓	RESIDENCES	WSW	800	1.050E-05	1.043E-05	9.556E-06	1.007E-08
✓	RESIDENCES	W	800	8.980E-06	8.919E-06	8.165E-06	1.060E-08
✓	RESIDENCES	WNW	800	9.038E-06	8.988E-06	8.223E-06	1.659E-08

Fig. 5. Input of assessment point

2.4 LIQDOS

DCF data files for external exposure from ground and water immersion have been updated. DCF data were referred to ICRP 60 and results of DFEXT (Dose Factor EXTernal) code.

3. Conclusions

INDAC is an integrated dose assessment code for an operating nuclear power plant and consists of three main modules: XOQDOQ, GASDOS and LIQDOS. The modules are under modification in order to improve the accuracy of assessment and usability.

Assessment points for multi-unit release can be calculated through the improved code and the method on dose assessment for multi-unit release has been modified, so that the dose assessment result of multi-unit site becomes more realistic by relieving excessive conservatism.

Finally, as the accuracy of calculation modules has been improved, the reliability of dose assessment result has been strengthened.

REFERENCES

[1] Korea Institute of Nuclear Safety, Research on the Improvement of Off-site Dose Assessment System for an Operating Nuclear Power Plants, KINS/RR-808, 2011

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[4] International Atomic Energy Agency, International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, 1996