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Development of Calculation Module for Radionuclides Transport and Removal in the Dose and Accident Effects Analysis

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1. Introduction

RADTRAD is the typical calculation code for the evaluation of radiation dose and accident effects in DBA (Design Basic Accidents) of nuclear power plants [1].

This paper is focused on the development of the calculation module for "DBA and multiple failure" accident analysis.

In 2018, the intrinsic characteristic of RADTRAD has been deeply reviewed by KHNP-CRI [2]. This review includes calculation process, radiation dose results of some test case inputs and NRC estimation methodology.

In this study, the calculation module equivalent to RADTRAD is made as DLL file by Object Pascal programming language. Some parts of the module is made by FORTRAN 77.

The calculation module is consist of DLL files and OCX files. In this study, DLL development is needed to control the calculation function upgrade and more complex additional performance of this developed computer code. The upgraded complex function, the extended function and the extended performance would be very easily achieved after DLL calculation module is verified as the equivalent calculation function as RADTRAD.

The DLL calculation module development results are introduced by this paper.

2. Methodology

2.1. Calculation Process of RADTRAD

The calculation of RADTRAD is carried out as like Fig. 1[3].

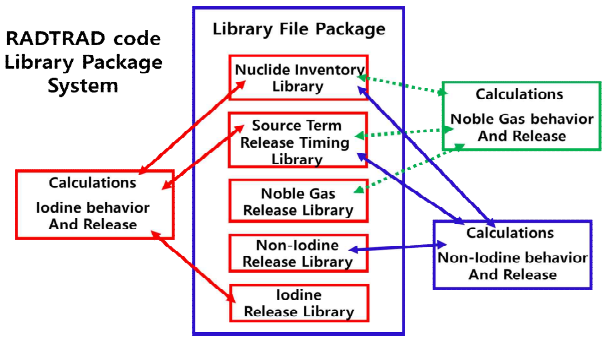

Fig. 1 RADTRAD Calculation Process of Design Basic Accidents (Example : LDLB radiological estimation)[3]

RADTRAD include the library packages such as source term inventory, release fraction timing and dose conversion factors.

The main body of RADTRAD controls library file packages, input module, calculation output and so on.

Library package and calculation parts interact with each other during radiological dose simulation. The work frame is shown in Fig. 1.

2.2. Creating Calculation Module

This purpose of this study is to make the calculation module with same performance against RADTRAD.

The main function is the control and interaction between library package and the main body. For this purpose, DLL file set is made.

DLL function requirement:

1. Recognition of library type
2. Release timing of radioisotope
3. Recognition of pipe break flow rate and atmospheric dispersion factors by input information.
4. Nuclide inventory file information and library matching

2.3. Compatibility with RADTRAD

The prepared input is used to verity the performance of the developed calculation module.

In 1989, "test case problem inputs" have been made by US NR to verify RADTRAD performance.

In order to verify the developed calculation module, "Test Case 1" of the "test case problem inputs" is used.

Compatibility verification of this calculation module is carried out by comparing with RADTRAD 3.03 calculations.

The condition of "Test case 1" is below:

Table1. Test Problem Case 1: Verification of DLL calculation module

Modeling Item	Inputs Information
Source Term	- TID-14844 pattern - Release start : 0.0hr - Iodine(element:0.91, organic:0.04, aerosol:0.05)
Plant Model	- Reactor Power 1932 MWth - Containment Volume :0.1730E+07 ft^3 - Leak-path: Containment to

	Environment - Containment leak rate : 0.12% per day
Dispersion Parameters	- EAB(X/Q) 0.0hr : 0.1000E-02 2.0hrs: 0.0000E+00 - LPZ(X/Q) 0.0hr : 0.1350E-03 8.0hrs: 0.1000E-03 24hrs : 0.5400E-04 96hrs : 0.2200E-04

3. RESULTS AND DISCUSSIONS

3.1. Generating of DLL Calculation Module

From FORTRAN and Object PASCAL, mixed programming is carried out. Compiled DLL is below in Fig.2
Specially, the visual interface has developed from this study in 2018. And the calculation module development has carried out by this study in February 2021.

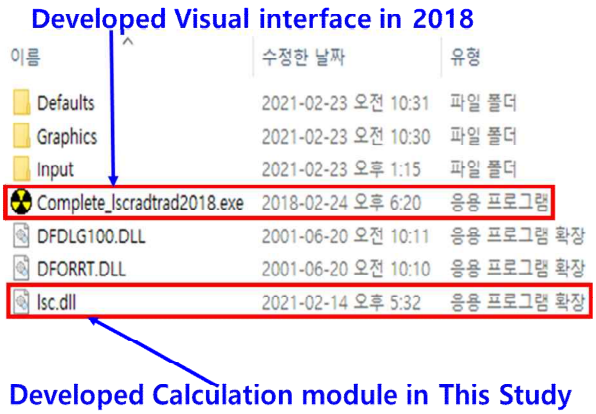

Fig.2 Developed calculation module in this study.

The developed DLL in this study is named as “lsc.dll”. The compiled “lsc.dll” was used to calculate “Test Case 1” of US NRC during RADTRAD estimation.

3.2. Results of DLL Performance Test as Calculation Module.

DLL performance is verified by comparing with US NRC’s RADTRAD 3.03 calculation results.
The comparison results between RADTRAD 3.03 module and developed DLL(lsc.dll) are shown in Table2.

Table2. DLL verification in “Test Case 1” of US NRC

Test Case 1	RADTRAD3.03 module	“lsc.dll” developed in this study
EAB(rem)	Thyroid : 444 TEDE:13.6 Whole Body: 0.079	Thyroid : 444 TEDE:13.6 Whole Body: 0.079
LPZ(rem)	Thyroid : 2991.8 TEDE:91.88 Whole Body: 0.798	Thyroid : 2991.8 TEDE:91.88 Whole Body: 0.798

From Table 2, the verification calculation of “Test Case 1” is carried out in both this study’s developed DLL module and US NRC’s RADTRAD 3.03 module.
The calculation results are compared with each other.
In every case of “EAB” and “LPZ”, the comparison results between the RADTRAD 3.03 and this study’s DLL calculation module are same in 0.0percent error.
The verification results are in good agreement with the RADTRAD 3.03.

4. CONCLUSIONS

The DLL calculation module equivalent to RADTRAD is developed in scope of calculation function.
The developed DLL calculation module is named as “lsc.dll” and is in good agreement with the RADTRAD 3.03. The difference of the comparison results between RADTRAD 3.03 and this study’s DLL module is in 0.0 percent error.

REFERENCES

[1] USNRC, “RADTRAD: A Simplified Model for RADionuclide Transport and Removal And Dose Estimation, April (1998).
[2] KHNP-CRI, Seung-Chan LEE, “The review document for RADTRAD intrinsic characteristics”, May(2018).
[3] KHNP-CRI, Seung-Chan LEE et al, “Study for Analyzing the Radiological Consequence of Small Line Break Outside of Containment in Design Basic Accident”, December(2020).