Development of Program equivalent to RADTRAD for DBA Safety Evaluation

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1. Introduction

RADTRAD code has been responsible for the evaluation of "radiation dose and accident effects" in all parts of DBA (Design Basic Accidents).

This code is very famous and well-known program in the scope of the dose and safety in FSAR chapter 15 since 1989 after NRC approval [1].

In this study, the development of another program equivalent to RADTRAD is introduced.

In 2018, GUI version of this study is made in KHNP [2].

In this study, the early version is developed and improved by imitating RADTRAD performance.

This study's results implement the exact same performance as RADTRAD.

The developed program from this study is named as "RADTRAD_LSC".

In this paper, the RADTRAD and the developed program package of this study are compared in calculating the NRC standard problem "Test Case 2".

And this study's developed program package shows the RADTRAD-like performance.

2. Methodology

2.1. Creating Source Code and Compiling

In order to make the RADTRAD-like program, FORTRAN77 and Object PASCAL Compilers are used [3].

In calculation module, 28 files are made by FORTRAN77.

In main body program, the 45files and 32 objects are made by PASCAL (Object PASCAL version 10.0).

FORTRAN files are used to compile the calculation module as DLL.

Object PASCAL's files are used to compile GUI program parts as main body program.

This study's key elements of source code development are in Table1.

Table 1. The developed source codes from this study (Object PASCAL)

Source Category	Main elements of PASCAL
File Handling	- FileHandles.pas - FileHandles.dcu
Interface Forms (general forms)	- Basic forms : frmAbout.dfm frmAbout.pas, frmCompart.dfm, frmCompart.pas,frmCalcOptions.pas and so on.
	- Calculation forms : frmData.dfm, frmData.pas, frmDoseLocation.pas, and so on
Interface Forms (Calculation)	- frmProgress.pas, frmProgress.dfm, - frmPowerSpray.pas, frmPowerSpray.dfm, and so on.
Others Forms (about 30forms)	- frmSourceTerm.pas, frmSourceTerm.dfm, and so on

2.2. Calculation Process of this Study's developed program

The calculation process of this developed program is very similar to RADTRAD.

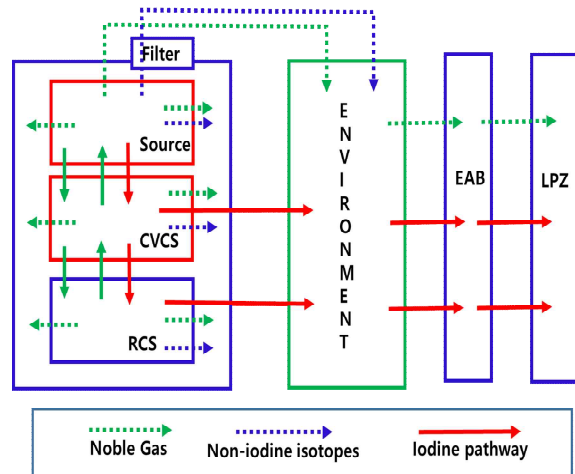As shown in Fig.1, the calculation progress and concept is same as RADTRAD.

Fig. 1 Calculation Process of Design Basic Accidents (Example : LDLB radiological estimation)[4]

2.3. Verification of RADTRAD_LSC as Developed Code

US NRC made the standard problem case to verify and test RADTRAD3.03.

In this study, Test Case 2 is used to verify RADTRAD_LSC.

And the code verification is carried out by comparing with RADTRAD 3.03 results in case of "Test Case 2".

The test condition is shown in Table2.

Table 2. Test Problem Case 2: Verification of RADTRAD_LSC

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 V:0.1730 ft3 - Leak-path: Containment to Environment - Containment leak rate : 0.18% 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. Compiling Developed Code and Execute

The calculation module is made from the developed Fortran files.
The GUI main program is and generated from the developed PASCAL files.
Fig. 2 shows the compiling process of PASCAL.
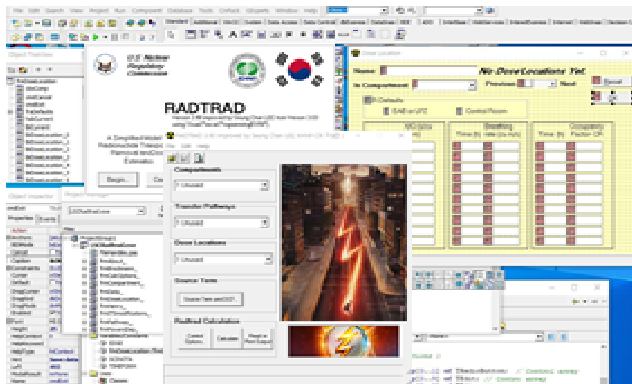Fig. 3 shows the work-start of RADTRAD_LSC in Windows 10 condition.

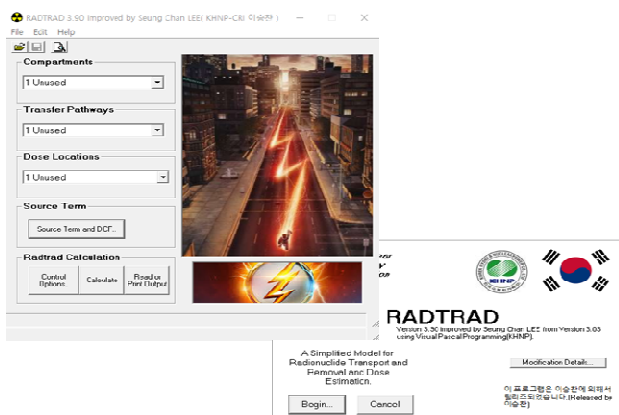Fig.2 Development of RADTRAD_LSC(Compiling Process in Object PASCAL).

Fig.3 Work-starting screen in the exe file of RADTRAD_LSC.

3.2. Verification of RADTRAD_LSC Performance

Using the Test Case2 of US NRC, RADTRAD_LSC is verified.
In order to verify RADTRAD_LSC, the cross–checking is carried out by RADTRAD3.03 calculation results.
The comparison results are shown in Table 3.

Table 3. Verification of comparing with each other : Test standard problem(Test Case2) of US NRC

Test Case 2	RADTRAD3.03	RADTRAD_LSC
EAB(rem)	Thyroid : 652 TEDE:28.76	Thyroid : 652 TEDE:28.76
LPZ(rem)	Thyroid : 4400 TEDE:220	Thyroid : 4400 TEDE:220

From Table 3, US NRC's "Test Case 2" is carried out by the developed RADTRAD-like program (RADTRAD_LSC).
In comparing with NRC's RADTRAD 3.03, the calculation results of RADTRAD_LSC (the developed code of this study) are perfectly matched in 0.0 percent error.
From these results, the development program (RADTRAD_LSC) is in good agreement with RADTRAD 3.03 of US NRC in scope of performance test.

4. CONCLUSIONS

The DBA safety calculation code equivalent to RADTRAD is developed.
The developed program package is named "RADTRAD_LSC" and the performance test results are in good agreement with RADTRAD 3.03 of US NRC.
In every case of "EAB" and "LPZ", the comparison results between the RADTRAD 3.03 and this study's developed program package (RADTRAD_LSC) are same. The developed program of this study is very useful to estimate DBA safety and radiation dose.

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]http://docs.embarcadero.com/products/rad_studio/cbuilder6/EN/CB6_ObjPascalLangGuide_EN.pdf, "Object Pascal Language Guide", (2002).
[4] 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).