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Development of RADCON and Establishments of Its Related System

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Abstract

In a NPP (Nuclear Power Plant) severe accident, radionuclides are dispersed into the air. The official regulatory institute, KINS (Korea Institute of Nuclear Safety), has been authorized and developing Computerized technical Advisory system for the Radiological Emergency preparedness (CARE). In this paper, in line with the CARE system, we presented the result of a modularized intermediate-level emergency dose assessment computer code. The RADCON (RADiological CONsequence analysis) version 3.0, which is operable on PC, is developed for simulating emergency situation by considering continuous washout phenomena, and provide a function of effective emergency planning. The source files are coded by using C language in order to increase the compatibility with the other computer systems and modularized to adjust the functions and characteristics of each module for easy understanding and further modification.

1. Introduction

In a NPP severe accident, radionuclides are dispersed into the air by the mechanism of dispersion. External and internal exposure to the public must be estimated accurately. It will provide very useful and important information for the decision-makers of the emergency situation.

After a few NPP severe accidents occurred in other countries, the importance of developing the emergency dose assessment computer codes has been also realized in Korea. It is also very important to predict how much time it will take until the legal institutes and local government respond and take action to protect the public. By a large scale computer code, it usually takes a very long time to respond to the NPP severe accident. For a real-time dose assessment, sometimes it is as much necessary to develop an intermediate-level emergency dose assessment computer code as the larger one. The official regulatory institute, KINS, has been authorized and developing CARE system. In this paper, in line with the CARE system, the result of a modularized intermediate-level emergency dose assessment computer code which is operable on PC is presented.

2. Theoretical Background

2.1 Atmospheric Dispersion

In order to simulate the NPP emergency situation and calculate atmospheric dispersion in mesoscale range, Gaussian puff model is assumed. The derivation of the equation is discussed in many places including the works of Pasquill (1974)[1], Gifford(1968)[2] and Csanady(1973)[3]. There are three basic assumptions[4] : (1) Continuous plume can be approximated by a finite number of puffs released in succession. (2) Along-wind and cross-wind diffusions occur to the same extent. (3) The height of the puff center above ground level is constant.

For the washout rate calculation, Brenk and Vogt's[5] model is utilized and Sehmel's model[6] for a dry deposition velocity (0.01 m/s) for all radionuclides was adopted. In this work, the processes such as weathering and resuspension are ignored, so it is assumed that the only depletion process for the radionuclide deposited on the ground surface is a radioactive decay.

Brigg's formulation[7] and the NRC method[8] were adopted to RADCON 3.0 to calculate the horizontal and vertical diffusion coefficients. Puff release rate can be specified by user, however, the default value is set to 6 puffs per hour(i.e. each puff releases every 10 minutes).

2.2 Dose Calculation

The exposures considered in this code are shown in Table 1. Cloud shine is the major source for an external dose from a series of puffs. Its calculation is very time-consuming and contains lots of uncertainties compared with the other dose calculation procedures. It is due to the discrete gamma energies and the difficulty of considering the real distribution of the radionuclides in a puff. The semi-infinite cloud model calculates the cloud shine. Total whole body dose and thyroid dose are important in the emergency response and used as main criteria for the decision-making.

Table 1. Exposures considered in this code

External Exposure	Internal Exposure
External Dose From Puff (Cloud shine)	Internal Whole Body Dose
External Dose From Contaminated Ground (Ground Shine)	Internal Lung Dose
	Age-Dependent Thyroid Dose

2.3 Area Specification

A 40X40 square grid has been adopted into RADCON 3.0 as a default, however, the grid size and resolution are able to be adjusted by users. RADCON 3.0 is capable of simulating the heights of a series of moving puffs by adjusting topography around the release point.

3. Code Features

In our previous work[9], the code had been developed using C language to be operable on SUN-4 SPARC workstation. We have further modified and extended this code as it can be operable on PC(486 or 586) whose operating system is LINUX. It is operated in the protected mode. Basically RADCON 3.0 has been developed to be operable on the X-window system. We used hanterm to enable own Korean language input and output. We developed RADCON 3.0 with two versions : First one is for X-window system (with hanterm), and the other is WWW (World Wide Web) type which is operable at Netscape(TM). Anyone who gets WWW browsers such as Netscape(TM) and Mosaic can access this code. It performed best at Netscape(TM) version 2.0. RADCON 3.0 has provided the following improved advantages.

- it would be easy, portable, and still compatible with the network system.
- offer much improved user friendliness and compatibility with the CARE system.

3.1 Modularization

RADCON 3.0 is modularized to adjust the functions and characteristics of each module for easy understanding and further modification of the code. Each module consist of several subprograms. The function of each module is summarized in Table 2. The modularization was accomplished to make it easy for users to analyze and to modify the code in the future.

3.2 Output Display

The software, GNUPLOT, is applied to plot the results of simulation and the GHOSTVIEW code is used to see the actual graphs. These software is available freely through ftp. The lists of graph modules are showed in Table 3. Click the words to see the graphs of the following data. Each graphic file is produced with the form of postscript file.

Table 2. Function of Each Module

Module	Function of Module
RADCON	Main Module
INIPUT	Initialization and Input Module
METOPO	Meteorological and Topographic Data Processing Module
SOTERM	Source Term Calculation Module
TRADIF	Transport and Diffusion Module
DOSCAL	Dose Calculation Module
CHECK	Dose Checking Module
WRITER	Output-Writer Module
FOODCH	Food Chain Module
SUPPLE	Supplementary Module
ISODOSE	Iso-dose line plotting Data Output Module
GRAPHIC	Graphic Tool Calling Module

Table 3. The Lists of graph modules

Word	Graph
AIRNDP	Ground-level Air Concentration (Without Depletion)
AIRDPL	*Ground-level Air Concentration (With Depletion)*
DEPOST	Surface-deposited Concentration
INHLNG	Inhalation Lung Dose
THYINF	Infant Thyroid Dose
INHWBD	Internal Whole Body Dose
EXTSIC	External Whole Body Dose from Semi-infinite Cloud
EXTGRD	External Whole Body Dose from Ground
EXTPLM	External Whole Body Dose from Puff
TOTWBD	Total Whole Body Dose
THYCHD	Child Thyroid Dose
THYADL	Adult Thyroid Dose

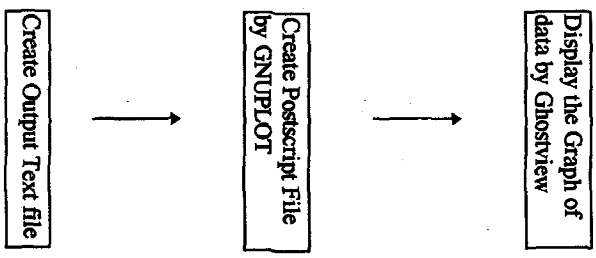

Figure 1. The Diagram of the Graphic Output

4. Relationship with CARE

KINS has developed CARE which is a nation-wide NPP emergency planning system such as ARAC (Atmospheric Release Advisory Capability) and SPEEDI (System for Prediction of Environmental Dose Information). It is composed of several models such as wind field atmospheric diffusion, and radiation exposure. A random-walk method has been adopted in atmospheric diffusion. In CARE system, FADAS which is developed by KAERI(Korea Atomic Energy Research Institute) is a real-time dose assessment system for nuclear emergencies. RADCON 3.0 is connected with CARE system through network to receive a meteorological input data and source terms. If the main utilized network system has some problem and CARE system is not operating properly, RADCON 3.0 can be independently as an intermediate level for a rough calculation.

5. Results and Discussion

We have analyzed the effects of source term, atmospheric stability, mixing layer lid-height, rainfall rate, wind speed and the height of release point. The effects of source term and meteorological data (wind speed and stability) are more dominant than the other parameters. It is also proved that the cloud shine and internal whole body exposure are important pathways for the short-term scale, while the ground shine become more important for the long-term scale in the emergency situation of the assumed NPP accident.

The simulated results were compared with those of the Radiological Assessment System for Consequence Analysis (RASCAL), version 2.1[10]. RASCAL is developed for NRC personnel by ORNL (Oak Ridge National laboratory) and utilized in 1989 as a federal emergency response tool. However it has adopted Gaussian plume model for the atmospheric dispersion . The comparison of RASCAL 2.1 and RADCON 3.0 is shown in Fig 2.

6. Conclusion

RADCON 3.0 has been developed as an intermediate level dose assessment computer code for the NPP severe accident and is operated on PC whose operating system is LINUX.

When we compared with RASCAL version 2.1 the same input data, RADCON 3.0 was turned out to give fairly good predictions. The dose-monitoring and decision-making capability, and the graphic tool added in the code is expected to make it easier to prepare an emergency situation effectively. It is expected that RADCON 3.0 can be adopted as a part of nation-wide emergency planning system, in order to support the main code system and obtain quite reasonable dose information in a relatively short time. If the network has some problem and CARE system is not operating properly, RADCON 3.0 can be operable independently to simulate the emergency situation.

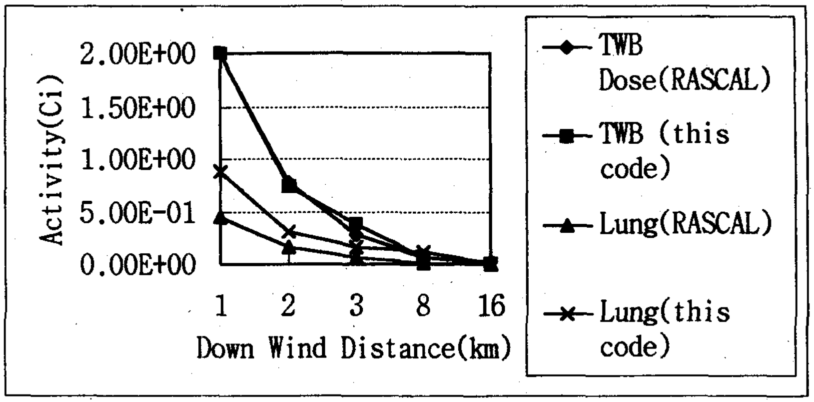

Fig 2. The Comparison of RASCAL 2.1 and RADCON 3.0

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