EPZDose, An Evaluation Code for Radioactive Materials Dispersion And Dose Consequences in Nuclear Emergency Situations

Yi-Hsiang Cheng  
(Formerly with Inst. of Nuclear Engineering and Science, National Tsing-Hua University, Hsinchu, Taiwan 30013)  
Material and Chemical Research Labs, Industrial Technology Research Inst.  
Bldg 52, 195 Chung-Hsing Rd., Sec. 4, Chutung, Hsinchu, Taiwan, 310  
yhcheng@itri.org.tw

Wei-Cheng Wang, Chia-Ying Chang, Shao-Shuan Chen, Chunkuan Shih  
Inst. of Nuclear Engineering and Science, National Tsing-Hua University  
101, Sec. 2, Kuang-Fu Rd., Hsinchu, Taiwan, 30013  
ckshih@ess.nthu.edu.tw

ABSTRACT

EPZDose, developed by National Tsing-Hua University, is an evaluation code that can compute the dispersions of radioactive materials and their dose consequences during nuclear emergency situations. The code is built up on Visual Basic programming language and runs under Windows-based environment at speeds much faster than the real-time. The state-of-the-art EPZDose is a standalone evaluation code that can read in dose data that contain the amounts of release in Curies of different radioactive nuclides as a function of time. The code allows users to set up a series of sets of meteorological conditions (wind direction, wind velocity and atmospheric Pasquill's stability). Furthermore, users can observe dose level distributions at the site location of interest. The calculated dose level distributions are dose rates and accumulated doses of thyroid and whole body. The dose level distributions are refreshed at every pre-determined calculation time and are shown on the map with colored shaded plots. EPZDose has been demonstrated in our domestic plant emergency exercises and well accepted.

KEYWORDS

Nuclear emergency planning, modified Gaussian puff model, off-site dose evaluations, Pasquill’s stability, emergency exercises.

1. INTRODUCTION

When nuclear emergency occurs, radioactive materials could be released from a nuclear power plant or some unexpected locations. The radioactive materials are released as puffs or plumes and disperse through its way of propagation under the action of meteorological conditions, such as wind direction and velocity and atmospheric stability. External and internal exposures of these radioactive materials could cause health problems on the local habitants. Therefore, the authorities (nuclear emergency response center) have to evaluate and predict the most probable dose consequences of the emergency situations and the dose levels to the public. Such information should be provided as soon as possible for the authorities to establish effective plans to protect the general public, including necessary evacuation or sheltering.
Developing an effective tool that can evaluate nuclear accident transient and its dose consequences during the nuclear emergency is important. Therefore, National Tsing-Hua University continues developing and improving the simulation software that can be applicable to the nuclear emergency response. Initially, the radioactive effluent dispersion model was embedded into the nuclear power plant transient and accident analysis software, PCTRAN [1]. However, the calculation speed of PCTRAN may slow down due to the closely linked calculation processes of nuclear power plant transient and dose consequences. To resolve this problem, we separated the radioactive effluent dispersion model out from PCTRAN and encoded the model to a user-friendly Windows PC-based software, EPZDose, as seen in Fig. 1 [2, 3]. Currently, the state-of-the-art EPZDose is a standalone evaluation code that provides practical functions applicable to computing the dispersions of radioactive materials and their dose consequences during nuclear emergency situations.

PCTRAN is responsible for nuclear power plant transient and accident analysis, and EPZDose is responsible for the calculation of dose distributions on the power plant off-site map. The data, or source term, of what and how many radioactive nuclides are released when a nuclear accident evolves are generated from PCTRAN [1]. These data can be saved in Microsoft Access format. With the use of graphical user interface (GUI), user can operate EPZDose to (1) read in the radioactive nuclides being released, (2) set up the meteorological conditions, and (3) choose the site map of interest. Then, EPZDose evaluates the dose distributions under the action of wind direction and velocity and atmospheric stability. User can decide to run EPZDose and PCTRAN at the same time. He can also run EPZDose at any later times for any
source term histories generated by PCTRAN. As a result, the speed performances of both codes are much improved.

2. IMPLEMENTATION OF MODIFIED GAUSSIAN PUFF MODEL

We have described in detail on the formulation of modified Gaussian puff model in [2, 3]. Interested readers should consult the articles for more detail information. In summary, the modeling of the release of radioactive materials during a nuclear power plant accident is done by grouping the continuous released activities into series of puffs at a predetermined length of time (for example, 60 sec) apart. The code follows the motion of the centers of all puffs until their centers travel outside the calculation radius. To save the computer memory, the calculation radius is reasonable within the emergency planning zone. The motions of all puffs are determined from the wind direction and wind velocity. The code allows for variations in meteorological conditions, e.g. wind direction, wind velocity, and stability category. No limitations are imposed on how many times and what meteorological conditions are to be changed. However, the direction changes are limited to ±45 degrees from the original wind direction in the current version of EPZDose for best calculation performance. As the puff travels downwind, dispersion takes place. Dose conversion factors are applied to evaluate the dose consequences of the puff. The complete dose level distributions in emergency planning zone are calculated from the superposition of contributions of all tracking puffs and shown with colored shaded plots. The dose consequences include dose rates and accumulated doses of thyroid and whole body.

3 EXAMPLES

Fig. 2 shows a result of thyroid dose rate distributions from a hypothetical radioactivity release accident. The figure covers 10 km by 10 km region around Kuosheng nuclear power plant. Wind was blowing from the east initially and changed to north-east later on. Fig. 3 shows another result in which Pasquill’s stability condition was changed from B (moderately unstable) to F (moderately stable). Fig. 3 covers a region of 2 km by 2 km. There are four nuclear power plants in Taiwan, three are cooperating and one is near completion. They all can use the same EPZDose for offsite dose consequences evaluations during nuclear emergencies.

Should there is a real nuclear emergency, system code such as PCTRAN could predict the courses of transients of the accident and amount of radioactive material release as a function of time from the plant. Based on such information along with meteorological conditions, EPZDose could then quickly evaluate the dose consequences in the affected area under nuclear emergency planning. Such evaluations can be done faster than real-time and the results are refreshed along with the evolutions of the plant accident.

4. CONCLUSIONS

We have developed EPZDose which is a standalone evaluation code that can read in dose data that contain the amounts of release in Curies of different radioactive nuclides as a function of time. The code allows users to set up a series of sets of meteorological conditions (wind direction, wind velocity and atmospheric Pasquill’s stability). Furthermore, users can observe dose level distributions at the site location of interest. The calculated dose level distributions are dose rates and accumulated doses of thyroid and whole body. The dose level distributions are
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![Map Illustration](image1.png)

Fig. 2 Illustrations of dose level distributions within 5 km radius in EPZDose, with wind direction change from east to north-east.

![Map Illustration](image2.png)

Fig. 3 Illustrations of dose level distributions within 1 km radius in EPZDose, with Pasquill's stability condition change from B (moderately unstable) to F (moderately stable).

REFERENCES

