# A Study on Applicability of Evaluation Code for Calculation of Exposure Dose of Workers for NPPs Decommissioning

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## 1. Introduction

Along with deterioration of domestic NPPs, various technologies for NPPs decommissioning are currently being studied. Accessing NPPs for decommissioning is difficult due to high level of radiation. Therefore, in order to ensure efficient performance of work, decontamination and forecasting of highly radioactive area must be made in order to minimize the exposure dose received by the workers.

This study introduces various Monte Carlo assessment codes for calculating workers exposure dose and makes analysis to present applicability of such codes for calculating workers exposure dose upon NPPs decommissioning.

## 2. Main title

### *2.1 Considerations for NPPs decommissioning*

According to SCK·CEN considerations for workers upon NPPs decommissioning are as follows[1]

- Safety : Not increased radiological or classical hazards
- Efficiency : Sufficient DF to reach the objectives
- Cost Effectiveness : Should not exceed the cost for waste treatment and disposal
- Waste Minimisation : Should not rise large quantities of waste resulting in added costs, work power and exposure
- Feasibility of Industrialisation : Should not be laboure intensive, difficult to handle or difficult to automate

When working in a highly radioactive area in preparation of decommissioning, workers are highly likely to be exposed to radiation within a relatively short period of time. For such reasons, workers working times are sometimes controlled based on effective dose and equivalent dose.

### *2.2 Introduction of Monte Carlo assessment code*

Monte Carlo method is a method for solving statistical problems using random sample extraction that uses random number, and is useful for solving complex problems where measurement is not possible.

*2.2.1 EGS.* EGS computer simulation code is a universal Monte Carlo code that can simulate the behavior of electrons and photons in multiple KeV ~ TeV area of energy within various forms of substance that have been configured by the user. This code has a very high scope of application, is well-documented, and has been verified by many people in numerous areas of study. When using the code, programming using a high quantity of MORTRAN language is required.

*2.2.2 ITS.* ITS code that simulates behavior of electrons and photos in consideration of time within various forms and substances, and is is a set of various programs that share source code library for solving highly complex radiation transport equation. ITS code consists of TIGER code, CYLTRAN code, ACCEPT code, Standard code, P code, and M code. User can select and sue the appropriate code from the library. When using the code, programming using a high quantity of FORTRAN language is required.

*2.2.3 MCNP.* MCNP code is simulates the behavior of neutrons, photons, and electrons, in a various 3 dimensional structure of substances. For photons, simulations such as incoherent scattering, coherent scattering, photoelectric effect, annihilation radiation, braking radiation, and positron annihilation are available. The reason that MCNP code can be

applied for various purposes is that it has good applicability by including various data, such as high number of general sources, critical sources, area sources, geometrical structures, and floaters of output tally.

*2.2.4 GEANT4.* GEANT4 code was originally developed to simulate physical experiment with high energy, but is now being applied and used in areas such as medicine, biology, and radiation protection, Major area of application for GEANT4 code is experiment setting for detector response simulation and calculation of particle behavior through visualization of particle orbit [2].

*2.3 Analysis of Monte Carlo codes*

This introduces Monte Carlo codes of EGS, ITS, MCNP, and GEANT4 that have been discussed above. Table 1 below shows the comparisons and characteristics of the codes [3].

Table 1. Classification of Monte Carlo Code with Respect to Key Features

| Parameters | | General Purpose Code | | | |
|---|---|---|---|---|---|
| | | EGS4 | MCNP | ITS | GEANT4 |
| Accuracy Interactions | Photoelectric | Y | Y | Y | Y |
| | Compton Scatter | Y | Y | Y | Y |
| | Coherent Scatter | Y | Y | Y | Y |
| | Non-Colinearity | Y | Y | Y | Y |
| | Positron Range | Y | Y | Y | Y |
| Components | Crystal | Y | Y | Y | Y |
| | Collimator | Y | Y | Y | Y |
| | Septa | Y | Y | Y | Y |
| | Debugging | Y | Y | Y | Y |
| | Geometry Based | Y | Y | Y | Y |
| | Voxel Based | N | Y | N | N |
| | Plane | Y | Y | Y | Y |
| | Ring | Y | Y | Y | Y |
| | Single Unit | Y | Y | Y | Y |
| | Block Unit | N | Y | Y | N |
| Data | Energy Spectra | Y | Y | Y | Y |
| | Unscattered | Y | Y | Y | Y |
| | Scattered | Y | Y | Y | Y |
| | Randoms | N | Y | Y | N |
| | Singles | Y | Y | Y | Y |
| Easy of Use | Familiar Language | Fortran | Fortran 77+C | Fortran | C, C++ |
| | Public Domain | Y | Y | Y | Y |
| | Docum / Support | Y | Y | Partially | Y |

*2.4 Application of Monte Carlo code*

To study the applicability of assessment code, GEANT4 code that was introduced above, was selected. RCP sealing device of Kori unit 1 was modeled into the form of cylinder, and gamma-ray energy value Cobalt-60 was used.

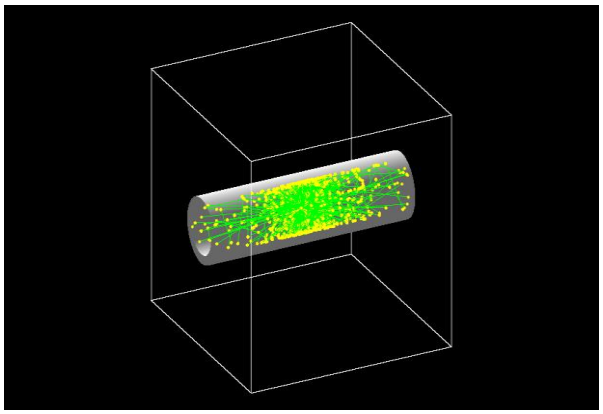

Fig. 1. Modeling of RCP Seal Using GEANT4 Code.

## 3. Conclusion

This study introduced assessment codes for calculating worker's exposure dose when decommissioning NPPs compared and analyzed the characteristics on applicability of assessment codes. Optimal assessment method out of the assessment codes that have been presented above may be considered to be used on exposure management for workers.

## REFERENCES


[1] Massaut Vincent.; Decontamination for Decommissioning Decontamination of Building and Nuclear Research Centre, (SCK·CEN).

[2] Choi, K.J. (2014) Study of the Simulation of GEM by Geant4.

[3] Chung, Y.H.; Beak, C.H.; Lee, S.J. (2008) Monte Carlo Simulation Codes for Nuclear Medicine Imaging. N.Med Soc.Vol.42, No.2: 127-136.