Estimation of Mixed Nuclide Inventory Using MicroShield Computer Program

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1. Introduction

The methods for evaluating the gamma nuclide inventory present on the inner surface of component subject to decommissioning Nuclear Power Plant are LABSOCS (Laboratory SOurceless Calibration Software) that indirectly measures a sample that can demonstrate the representativeness of component subject to decommissioning, ISOCS (In Situ Object Counting System) that measures directly from the surface of a component subject to decommissioning, and MicroShield® computer program that estimates the nuclide inventory on the inner surface of component using the dose rate of component subject to decommissioning and the radioactivity of the sample. In this study, we estimated the nuclide inventory on the inner surface of the pipe using the dose rate of the pipe subject to decommissioning and the radioactivity concentration of the sample by MicroShield® ver. 10.03 computer program.

2. Materials and Methods

2.1 Point Kernel 16 fixed geometry

The MicroShield® computer program uses 16 fixed geometry models for radiation shielding evaluation of point sources, line sources, and volume sources using the Point Kernel method. The basic concept of the Point Kernel method is to divide the volume source into a large number of small point sources and regard each as a point source, and add up the respective contributions. The fixed geometry model approach reduces the effort required to express the geometry numerically for shielding evaluation, and can be applied to most problems, except when an accurate evaluation of complex geometry is required [1,2,3].

2.2 Gamma-ray fluence-to-dose factors

MicroShield® is now includes the reference gamma dose conversion factors from ANSI/ANI-6.6.1-1977: Neutron and Gamma-Ray Fluence-To-Dose Factors to support calculations for NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel".

MicroShield® calculates photon fluence rate at the dose point. This must be converted to more meaningful values for practical use. The fluence rate is converted to exposure in air, absorption in air, and effective dose equivalent to humans[3].

The general form of the analytic function is

$$\ln Dfg(E_p) = A + Bx + Cx^2 + Dx^3 \qquad (1)$$

where, $Dfg(E_p)$ = gamma flux to dose rate conversion factor (rem h^{-1})/(photon $cm^{-2}s^{-1}$)

E_p = gamma energy (MeV)

$x = \ln E$

The coefficient of the polynomial expression are given in ANSI/ANS6.6.1 Table A7.1-3[4].

2.3 Assumptions

Table 1 shows the radioactivity concentration of the system water samples to estimate the nuclide inventory on the inner surface of the pipe. It is assumed that the system water is 100% drained, the dose rate of the pipe is 120 mR/h, the inside is filled with air, and the parameters of the pipe are shown in Table 2.

Table 1. The radioactivity concentration in sample

Nuclide	Half life	Radioactivity concentration (μCi/cm^3)
Ag-110m	249.8 days	8.32E-03
Co-58	70.88 days	6.84E-04
Co-60	5.271 years	4.05E-04
Mn-54	312.1 days	1.33E-03
Nb-95	34.97 days	1.25E-03
Sb-124	60.20 days	2.24E-04

Table 2. Geometry model parameter

Source dimension		Dose points	
Height	200.0 cm	X	49.16 cm
Inner Diameter	78.0 cm	Y	100.0 cm
Radius	39.0 cm	Z	0.0 cm
Shield			
Shield No.	Dimension	Material	Density (g/cm^3)
Cyl. radius	39.0 cm	Air	0.00122
Shield 1	7.62 cm	Iron	7.86
Transition		Air	0.00122
Air gap		Air	0.00122

3. Results and Discussions

The dose rate-radioactivity conversion factor calculated by using MicroShield® ver. 10.03 computer program was estimated as follows:

▪ Conversion factor without build-up factor: 6.52E+01 mCi/mR h^{-1}

▪ Conversion factor with build-up factor: 7.69E+00 mCi/ mR h^{-1}

The nuclide inventory on the inner surface of the pipe considering Build-up factor was estimated as follows:

▪ Ag-110m: 6.29E-01 Ci or 1.28E+01 $\mu Ci/cm^2$
▪ Co-58: 5.17E-01 Ci or 1.05E+00 $\mu Ci/cm^2$
▪ Co-60: 3.06E-02 Ci or 6.25E-01 $\mu Ci/cm^2$
▪ Mn-54: 1.00E-01 Ci or 2.05E+00 $\mu Ci/cm^2$
▪ Nb-95: 9.44E-02 Ci or 1.93E+00 $\mu Ci/cm^2$
▪ Sb-124: 1.70E-02 Ci or 3.46E-01 $\mu Ci/cm^2$

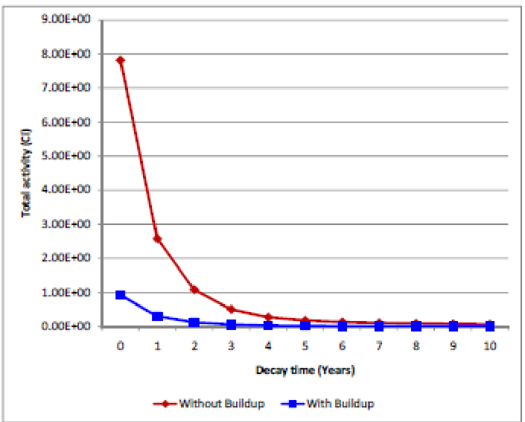

Fig. 1. Total activity vs. Decay time.

4. Conclusion

In this study, we estimated the nuclide inventory in the pipe according to the dose rate of pipe and the radioactivity concentration of the sample by using MicroShield® ver. 10.03 computer program. On the other hand, since the components subject to decommissioning have complicated shape and various materials, optimal modeling for this is important. In addition, for accurate error range and applicability, it is necessary to verify the validity of ISOCS and LABSOCS by performing radioactivity measurement and mutual comparison and analysis.

Acknowledgments

This study was conducted as part of the "Development of Decontamination Technology of Reactor Coolant System and Dismantled Equipment foe NPP Decommissioning" project supported by the MOTIE (Ministry of Trade, Industry and Energy) and the KETEP (Korea Institute of Energy Technology Evaluation and Planning (Project Number: 20141510300310).

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