The Radiation Streaming Calculation for Air Gap of the Shielding Door

Y.S. Min *, G.P. Jeon , K.J. Mun, J. M. Nam, J.S. Cho, J. H. Cho, Jun Yeon Kim
PEFP, KAERI, P.O. Box 105 Deok-Jin Dong, Yu-Seong Gu, Dae-Jeon 305-353,
**Corresponding author:ysmin@kaeri.re.kr*

1. Introduction

There are many penetrations and the thin air filled clearance gaps in accelerator facility, such as a cable, a cooling water pipe or an air conditioning duct as well as an air gap of between the wall and the shielding door. The estimation of the radiation streaming through these penetrations or the air filled gaps is one of the most difficult parts in shielding design. The Shin's semi-empirical formula describing energy-space distributions of neutrons and gamma-rays streaming in ducts or labyrinths is very useful for application to accelerator facility.[1] A streaming calculation code DUCT-III is based on the Shin's formula with the albedo data up to 3GeV.[2]

In this paper, the source term was calculated by MCNPX[3] and the radiation streaming through the air gap of between the wall and the shielding door by DUCT-III. The DUCT-III code is based on the Shin's semi-empirical formula. The formula, which describes the direct and albedo components, is derived in generic straight duct geometry. It is expressed by the product of spatial distributions which are represented by twice and eight-time reflected components, and power of an albedo matrix. This formula was then extended to bent ducts. The inflow of radiations to downstream at a corner of multi-bent ducts is formulated with the flux in the upstream leg. Using the obtained inflow current as the source term to downstream, the formula predicts the radiation flux in the downstream leg.

2. Calculation Method

2.1 Dose Conversion Coefficient

The ambient dose conversion coefficient of ICRP 74 was regeneration with the neutron energy group band width of DUCT-III by MCNPX. Table 1 is shown the dose conversion coefficient.

Neutrons and photons with the 12 groups of energy structures are dealt with in the DUCT-III. Neutrons in the energy range of DUCT-III are 12 groups as shown in the table 1. Because the proton beam energy of Korea proton accelerator facility is upto 100 MeV, the conversion coefficient is shown upto that.

Table 1: Dose Conversion Coefficient regenerated by MCNPX for DUCT-III input

Group	Upper Energy [MeV]	Dose Conversion Factor [Sv/hr/Source Intensity]
1	3.00E+03	-
2	1.50E+03	-
3	8.00E+02	-
4	4.00E+02	-
5	1.00E+02	1.65E-06
6	2.00E+01	1.52E-06
7	1.35E+00	9.85E-07
8	8.65E-02	1.14E-07
9	3.35E-03	2.90E-08
10	1.01E-04	3.66E-08
11	5.04E-06	4.57E-08
12	4.14E-07	4.80E-08
	1.00E-10	

2.2 Preparing the Source term (using MCNPX)

MCNPX was used to obtain neutron source terms for DUCT-III and PKN-H codes. Fig. 2 shows the simple geometry for source term calculation. Proton beam impinges at the center of a Ag target of which shape is a hexahedron. The length of each side is 1.5 cm. The beam power is assumed 30kW and beam energy is 100 MeV. Table 2 shows the neutron source term for DUCT-III code input.

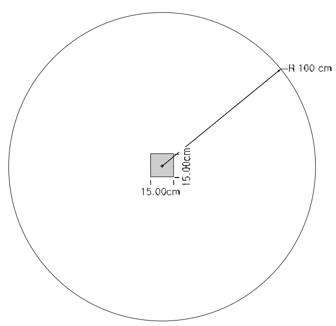

Fig. 1. Geometry model for the source term calculation in MCNPX

Table 2: Source Term calculated by MCNPX for DUCT-III input

Group	Upper Energy [MeV]	Average Surface Flux [#/cm2/proton]	Relative Error
1	3.00E+03	-	-
2	1.50E+03	-	-
3	8.00E+02	-	-
4	4.00E+02	-	-
5	1.00E+02	8.01E-11	5.95E-02
6	2.00E+01	4.59E-09	7.70E-03
7	1.35E+00	6.31E-08	2.10E-03
8	8.65E-02	1.70E-08	3.80E-03
9	3.35E-03	2.38E-09	1.00E-02
10	1.01E-04	2.32E-10	3.16E-02
11	5.04E-06	2.29E-11	8.63E-02
12	4.14E-07	2.50E-12	2.31E-01
	1.00E-10		

2.3 Calculation Models for DUCT-III and PKN-H

The original dimension of the shielding door is shown as figure 2. To simplify the calculation model, one side of the air filled gaps of the door is only considered in modeling with DUCT-III. The figure 3 shows that the simplified calculation model.

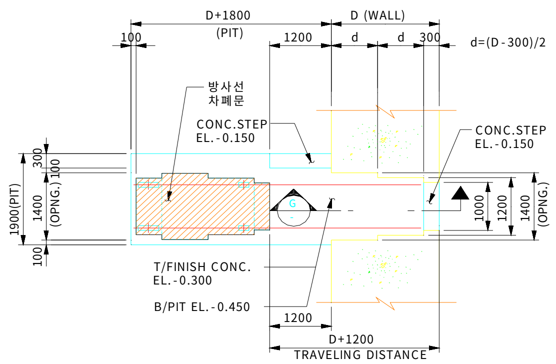

Fig. 2. The Shielding Door Configuration of the Target Room for Korea Proton Accelerator Facility

The length of the first, second and third legs are 30 cm, 85 cm and 85 cm respectively, and each bent angle is 90 degree. The length of each bent leg is only 10 cm.

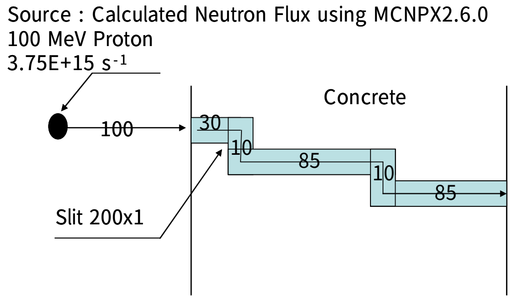

Fig. 3. The simplified model of the air filled gap between the Wall and the Door in DUCT-III

3. Calculation Results

Although the length of the bent leg is only 10 cm, equivalent dose rates are effectively reduced in that area. Figure 4 is given the results of the calculations along a distance of the air gap. The dose rate is 7.54 uSv/hr at the end of air gap. The comparison DUCT-iii calculations will be performed with experimental data and Monte Carlo calculations in future.

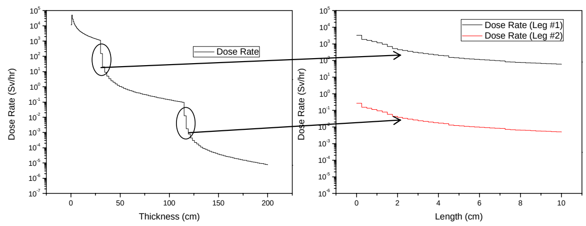

Fig. 4. The Dose Rate Curve along the Air Gap between the Wall and the Door

ACKNOWLEDGMENTS

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REFERENCES

[1] K. Shin, Evaluation Formula for Radiation Duct Streaming, J. Nucl. Sci. Technol., 26, 1067,1989.
[2] R. Tayama et al., DUCT-III: Simple Design Code for Duct-Streaming Radiations. KEK, 2001.
[3] D.B.Pelowitz, ed., MCNPX User's Manual, Version 2.6.0, LA-CP-07-1473, 2008.
[4] F. Masukawa et al., Analyses of High Energy Neutron Streaming Experiments Using DUCT-III, JNST, Supplement 2, p 1268-1271, 2002.
[5] A.H. Sullivan, "A Guide to Radiation and Radioactivity Levels near High Energy Particle Accelerators," Nuclear Technology Publishing, Ashford, kent, TN23 1JW, England.