Shielding Assessment for Container Inspection System at Busan Newport Using Monte Carlo Method

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1. Introduction

As the container inspection system at Busan Newport has been introduced, it needs to carry out shielding assessment for the facility in order to ensure safety of workers and public. In this study, Monte Carlo method was used in the shielding assessment for the container inspection system to secure high accuracy instead of the classical assessment method (NCRP51).

After the detailed modeling of the whole facility and container using MCNPX code [1], dose calculations were performed at the various points around the inspection system.

2. MCNP Modeling and Calculation Method

2.1 Modeling of Concrete Structure

The container inspection facility is described in Figures 1 and 2. All of the walls in this facility were made of normal concrete, and the length and width of the tunnel which the container passes through are 50.48m and 7.40m, respectively. In this facility, two x-ray generators are located horizontally and vertically individually.

In this work, the geometrical shape of freight car onto which container is loaded was simplified as rectangular one whose size is 20m × 2.5m × 4.6m × 1.6mm (length × width × height × thickness).

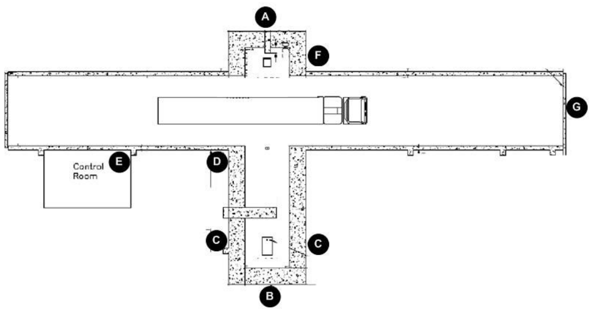

Figure 1. Horizontal View of the Container Inspection Facility

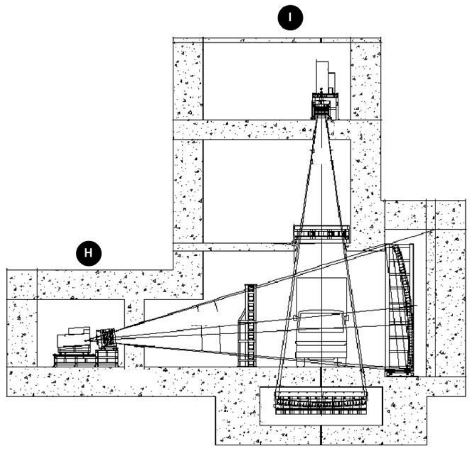

Figure 2. Vertical View of the Container Inspection Facility

2.2 Modeling of Radiation Source

A fan x-ray beam, such as is produced by employing a collimator with a rectangular slit, was established in the MCNPX modeling as shown in Figure 4. Maximum energy of the x-ray spectrum is 9MeV, but, in this work, source energy was assumed to have mono-energy of 9MeV for conservative calculation.

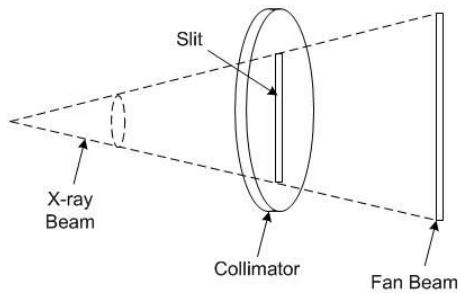

Figure 4. MCNP Modeling of Fan X-ray Beam

2.3 Calculation Method

Various positions at which shielding assessments are to be made, from A to I, are also shown in Figures 1 and 2.

In this work, dose calculations were separately pursued for the two x-ray sources at the entire surfaces of the walls located adjacent to the positions. Total dose rates were obtained by summing up the two results.

Gamma dose rates were calculated as flux multiplied by flux-to-dose conversion factor. ANSI/ANS-6.1.1-1991 photon dose function for A-P direction (Anterior-Posterior) was employed to convert the gamma flux into dose.

3. Results and Discussions

The MCNP modeling result of the inspection system was represented in Figure 3 using SABRINA program.

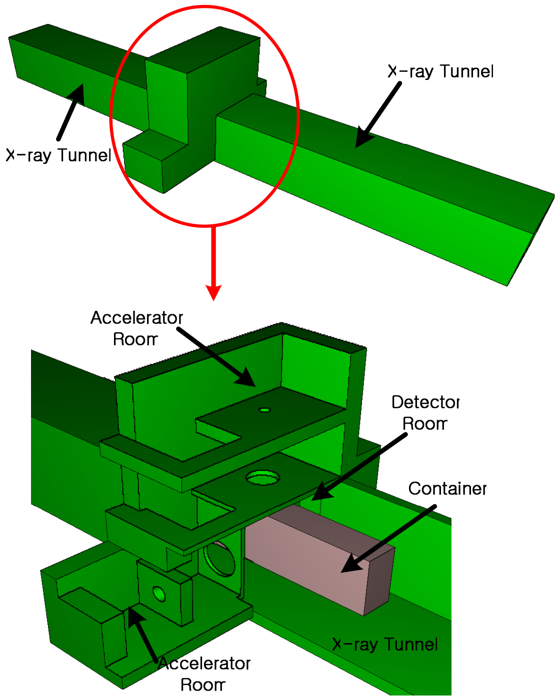

Figure 3. MCNP Modeling of Inspection System

Dose rates at the 9 positions, from point A to point I, were tabulated in Table 1. From the results, maximum dose was expected to be observed at Point I (Roof). This might be caused by gamma leakages from vertical x-ray generator since the thickness of concrete wall near the vertical x-ray generator is very thin compared to other wall thickness.

It is found that all the calculation results were sufficiently satisfied with the dose limit of 2.5 mrem/hr based on the design criterion of Korea Customs Service.

Table 1. Dose Rate Calculation Results

Position	Dose Rate
A (Back of Detector)	1.56E-02 mrem/hr
B (Back of Accelerator)	2.88E-04 mrem/hr
C (Side of Accelerator)	7.94E-04 mrem/hr
D	0.0 mrem/hr
E (Control Room)	0.0 mrem/hr
F (Side of Detector)	0.0 mrem/hr
G (Door)	1.39E-04 mrem/hr
H (Upside of Accelerator)	8.15E-04 mrem/hr
I (Roof)	3.71E-01 mrem/hr

4. Conclusions

In this work, shielding assessment was carried out for the container inspection system with MCNPX Code. All the calculation results were satisfied with the design criterion to be requested. It is, therefore, noted that the container inspection system at Busan Newport will be operated safely.

The results of this work can be applied as a validation tool for the safety regulation and approval for the system.

Acknowledgment

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REFERENCES

[1] Laurie Waters, Ed., “MCNPX User’s Manual, Version 2.4.0,” LA-CP-02-408, Los Alamos National Laboratory, September 2002.