Homogeneity Survey of Advanced Spent Fuel Conditioning Process Hot Cell

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1. Introduction

The hot cell facility (ACPF) for research activities related to the advanced spent fuel conditioning process (ACP) [1] is being constructed. The hot cell construction work will be finished in May, 2005. Hot cell is designed to permit safe handling of radioactive materials up to 1,385 TBq and to keep gamma and neutron dose-rate lower than the recommended ones. The dose-rate limit values following the Korean nuclear laws are 0.01 mSv/h at operation area and 0.15 mSv/h at maintenance area.

The ACPF is a concrete structure with two rooms, and made its exterior walls of heavy concrete with density of 3.45 g/cm^3 and the wall thickness is more than 90 cm.

2. Shielding Wall Homogeneity Test

It is important to verify the hot cell wall being well constructed in according to design specification. In the concrete pouring process, voids or crack can be occurred in hot cell wall, because many plates or equipments are embedded such as lead plate for shield reinforcement, toboggan, penetration, s-shape curve, and etc. So if there are any voids or cracks occurred in hot cell wall, this causes to weaken the shielding performance of the wall.

To check the shielding wall homogeneity, the gamma scanning test as non-destructive method is used. After finishing the construction work for hot cell wall, the gamma scanning test is fulfilled to confirm the integrity of facility prior to hot cell start-up. Gamma scanning test is especially good at to detect any voids and cracks in heavy concrete wall and to find crevices between wall and devices frame.

3. Experimental

3.1 Source choice

In order to finish the gamma scanning test successfully and economically, it is important to choose the source strength reasonably. The selection of the high activity source is beneficial to get a good test result, but testing cost rises steeply and the exposure hazard on worker is also increased. If source strength is too low on the contrary, gamma scanning test would be failed. Because the shielding capability of hot cell wall is very high, it is difficult to discriminate between intact wall and failure parts of wall.

Using MCNP[2] code calculation for ACP source and cobalt-60 and comparing the previous testing results for IMEF in 1993, we choose source strength around 100 Ci for gamma scanning test.

Figure 1 and figure 2 shows the flux data for heavy concrete wall via concrete thickness. The flux data between ACP source and cobalt-60 shows the similar tendency except no flux data higher than 1.33 MeV gamma energy in cobalt case. The dose rate is around 2 μSv/h for ACP source and 1 μSv/h for Co-60 100 Ci.

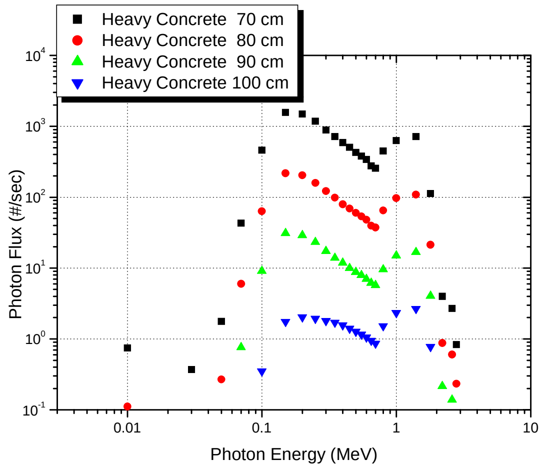

Fig. 1 Photon flux for ACP source via heavy concrete thickness.

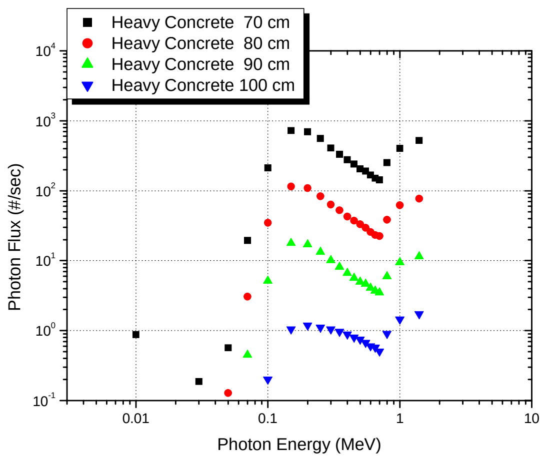

Fig. 2 Photon flux for 80 Ci of cobalt-60 via heavy concrete thickness.

3.2 Testing item

The shielding effectiveness and homogeneity of the hot cell wall, shielding window, rear door etc., shall be measured by reading the activity level of radiation at the outer surface of each component with a gamma source placed on the corresponding inside surface.

The item lists for the gamma scanning test are shown in table 1. The hot cell wall except back side and the most of interface between device frame and wall is divided by 250 mm x 250 mm square. The rests are mostly divided by 500 mm x 500 mm square.

Table 1 Determination of measuring points and interval distance between checking points for the principal equipment on hot cell wall

Equipment	The number of points and interval between checking points
Hot cell wall - Front and side - Back	900 mm to 2800 mm elevation from bottom: 250 mm x 250 mm 900 mm to 2800 mm elevation from bottom: 500 mm x 500 mm
Radiation shielding windows	2 or 4 points Window frame/wall interface: 250 mm
Rear doors	Inner frame region: 500 mm x 500 mm Door frame/wall interface: 250 mm
Wall tube	Wall tube/wall interface: 2 points per each Manipulator tube/wall gap: 4 points per each
Shielding screw	One points for shielding screw Shielding screw frame/wall gap: 2 points per each
Penetration assembly	2 points per each
Toboggan	2 or 4 points Toboggan frame/wall gap: 4 points per each

4. Results

The gamma scanning test is performed to whole area of hot cell and scanning data is compared to acceptance goals. The total test points are around 1,000. There are two kinds of detector used, survey meter and contamination survey meter. IMEF facility is on operation over 10 years, so background dose rate is slightly higher than environments. Because the concrete wall is thick and the cobalt source activity isn't much high, it is difficult to use survey meter only to discriminate the background and cobalt dose. After getting counts per minute data using contamination survey meter, it is converted to dose rate using experimental fitting curve converting cpm to dose rate for our cases.

The results show that most readings are in the acceptance values, but some high readings are detected. It may be occurred because a few regions didn't be filled out well in the concrete pouring process especially the wall cutting layer and shielding window frame. To fixing this problem, repairing work for abnormal regions is done using lead wire, lead plate, and heavy concrete.

References

1) S. W. Park, H. S. Park, C. S. Seo, J. M. Hur, and Y. S. Hwang, "Development of advanced spent fuel conditioning process", *Proc. of the 3rd Korea-China Joint Workshop on Management of Nuclear Wastes*, Shanghai (2002).

2) "MCNP4C monte carlo n-particle transport code system," *ORNL RSIC CCC-700*, Radiation Safety Information Computational Center, Oak Ridge National Lab.