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Decontamination of Metal Specimens by the PFC Spray Method

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1. Introduction

Korea Atomic Energy Research Institute is developing the dry decontamination technologies applicable to the decontamination of the highly radioactive surfaces loosely contaminated with radioactive particles. The technologies are the carbon dioxide pellet spray decontamination technology and the PFC decontamination technology. As a part of the project, PFC ultrasonic decontamination technology development was performed in 2004[1]. The PFC spray decontamination technology development has been performed since 2005.

2. Methods and Results

In this section experimental procedures and the test results of decontamination and distillation tests are described

2.1 Methods

After the weighing of the test specimen, it was contaminated with the ethyl alcohol containing Eu_2O_3 powders and the radioactive solution. Dried in a shadow place and photographed. It was weighed again and the radioactivity of the specimen was measured. After the application of the PFC spray decontamination method, the test specimen was dried and its radioactivity was measured.

The spray pressure was 41 kgf/cm^2, orifice diameter was 0.2 mm and spray velocity was 0.2 L/min. To investigate the decontamination surface, it was photographed again. To investigate the recovery and purification efficiency on the contaminated PFC solution, the solution containing Al_2O_3 powders was distilled at 80 ℃ and condensed near -80 ℃. The particle diameters used were 0.05, 0.3, 1, 3 and 10 mm, respectively. Before and after distillation, turbidity of the solution was measured (Model, DRT 15-CE HF Scientific, Inc.). The UV absorption spectrum of the PFC solution containing anionic surfactant was obtained (Model Cary 4000, Varian Co.). Pure perfluoroheptane was used as a blank solution.

2.2 Decontamination

In order to examine the characteristics of PFC spray decontamination process on the several shapes of the metal specimens, the decontamination tests were performed in the hot cell of the radioactive waste drum examination facility in KAERI.

Figure 1 is the photograph of showing the application of the PFC spray decontamination process on the disc type specimen. The manipulator is holding a spray part of the decontamination equipment. Disc specimen is held by the specimen cradle. During the application, the manipulator was holding a spray part well and most of the contaminants were satisfactorily removed. After 5 minutes' of application, the specimen was separated from the specimen cradle and its radioactivity was measured by MCA.

Figure 1. Decontamination test in a hot cell.

The radioactivity of specimens before decontamination is in the range from 732.4 to 931.5 Bq/1000 cm^2 for Co-60 and is in the range from 386.2 to 942.2 Bq/1000cm^2 for Cs-137. From the test results, we found that the decontamination factor was in the range from 9.6 to 62.4. When the decontamination efficiency of Co-60 was high, then the decontamination efficiency of Cs-137 was also high. As the surface roughness of the specimen increases, the PFC spray decontamination efficiency decreases.

In a Sonatol process, they applied the PFC ultrasonic wave to the several kinds of materials for one hour. 99.7 % of the contaminants were removed by the Sonatol process. The decontamination efficiency of the PFC spray decontamination is comparable to the decontamination efficiency of the Sonatol process [2].

2.3 Distillation

As a result of the multiple applications, PFC solution becomes to dirty. When the contaminants in a solution are removed, the solution can be recycled. As there is no water supply in the IMEF (Irradiated Material Examination Facility), we can not use water. We, therefore, use the dry ice as a coolant of the vaporized PFC. The merits of the dry ice as a coolant are as followings; 1) the recycle efficiency is high

compared with that of water. The temperature at which condensation of vaporized PFC occurs is near -80 ^{0}C, 2) it is safer than the water. When the incident happens, there will be no spills.

Figure 2 shows the variation of turbidity under various particle sizes of Al_2O_3. As shown in Fig. 2, all sizes of the particles are satisfactorily removed by distillation. We use the 0.2 ㎜ filtration column. Even smaller than 0.2 ㎜ of particles are also removed. If the particles in the hot cell of the IMEF are highly radioactive and the size is very small, we may use the distillation method.

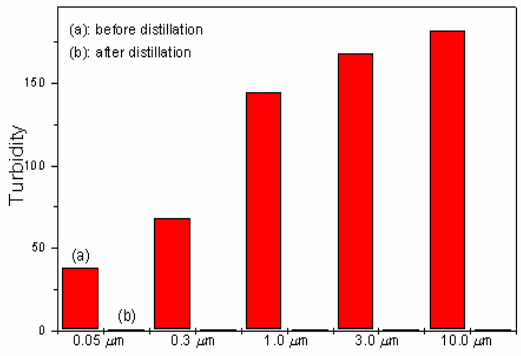

Figure 2. Turbidity of the PFC solution according to the particle size of Al_2O_3.

3. Conclusion

The PFC spray decontamination efficiency on the surrogate metal specimens was investigated. For all the shapes of specimens, we found that the PFC spray decontamination was satisfactorily applicable. Especially, the contaminants in the groove of the screw were also removed by the PFC spray decontamination. The characteristic of PFC spray method was comparable to the PFC ultrasonic decontamination method. From the feasibility test of using the dry ice as a coolant, we found that the recycle of the PFC solution by distillation in the no water supply area was possible. Decontamination work will be performed with a little loss of a main decontamination agent.

Acknowledgment

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