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The use of chemical gel for decontamination during decommissioning of nuclear facilities

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HIGHLIGHTS

- A research study was developed for testing the decontamination using chemical gels.
- The purpose was realized by artificial contamination of eight types of materials.
- Decontamination gels are an efficient way to reduce the surface contamination.
- Minimize the potential for spreading contamination during decommissioning activities.

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ABSTRACT

A technical research study was developed for testing the decontamination using chemical gels. The study was realized for different type of samples, systems often encountered in the VVR-S nuclear research reactor from Magurele–Romania. The results obtained in the study have demonstrated that the decontamination gels could be an efficient way to reduce or to eliminate the surface contamination of buildings or equipment's, minimizing the potential for spreading contamination during decommissioning activities.

1. Introduction

The main reason for considering the use of the decontamination methodology in the nuclear installation decommissioning is the importance of removing the contamination from systems, structures, equipment's and components (SSEC) to reduce dose levels. The decontamination technique can be used for reducing the contamination of SSEC to such levels that most of them can be unconditionally released for recycling or reuse in the conventional industry or disposed of as waste exempt from regulatory concern. The selection of decontamination techniques is an important factor influencing the character and the amount of waste generated and should be carefully considered when planning waste minimization procedures (IAEA, 2001). Practical experience in decontamination has shown that a universally applicable decontamination process does not exist. As such, users should familiarize themselves with the characteristics of the proposed techniques, in order to make adequate choices based on site and facility specific requirements (IAEA, 1988; OECD, 1997; DOE, 1994; European Commission, 1995).

Due to the detergents widespread used in decontamination, there have been searched different products with absorbent properties that may partially or totally eliminate the detergents presented in the residual water after decontamination, reducing in this way the soil and water pollution with these substances. The chemical and/or mechanical process to remove and/or to neutralize chemically/biologically/radioactive must be done in terms of protection for all participants and workers. The decontamination is necessary to achieve when contamination affects the health of the population as well as operational capabilities of workers. The decontamination process is a progressive operation, and to be effective, needs to begin as soon as possible. The radioactive decontamination of equipment and/or nuclear facilities is a concern in many viewpoints. The chemical decontamination by applying a gel spray or brushing is an effective method in situations where it is necessary to minimize the radioactive waste.

The primary focus of this study is to evaluate the effectiveness and practical application of decontamination method by using easy and peelable environmentally friendly decontamination solution with a broad spectrum of uses. This is achieved by performing repeated radiological measurements on different type of materials encountered in the VVR-S nuclear research reactor from Magurele–Romania. For this purpose a program for testing and evaluation of radioactive decontamination is developed by artificial contamination of eight

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types of materials: pneumatic tire (A), copper (B), textolit (C), pertinax (D), aluminum (E), lead (F), galvanized sheet (G), teflon (H). The DeconGel™ 1101 agent (Cellular Bioengineering Inc.) is used for removing the deliberate contamination with ^{60}Co and ^{137}Cs radionuclides. The practical application will be realized by applying this decontamination method on KIP cupboard (contain auxiliary systems from the primary circuit of the VVR-S nuclear research reactor from Magurele; the differential pressure transducers are located in this place) that is going to be decommissioned.

2. Materials and methods

Two individual samples will be considered in this study for each type of material and each radionuclide, 1st and 2nd indicative code sample are for ^{60}Co and the 3rd and 4th indicative code sample are for ^{137}Cs.

(a) *The principles of operation*

The first step of the study was to clean the surface of the sample. After drying, an area of 7.065 cm^2 (round) was bordered in the center of the sample in order to be contaminated. The level of the background radiation was measured before the experiment; then, the radioactive solutions with ^{60}Co (chemical composition: $CoCl_2$ in HCl 0.1 N) and ^{137}Cs (chemical composition: CsCl in HCl 0.1 N) were uniformly spilled in the dedicated area for each sample type; then were left in a ventilated hood for 24 h. After drying, the measurements were performed for each sample involved in the study. In a next step, the DeconGel™ 1101 decontamination gel was applied with a device that can ensure the uniformity of the gel scattering in an area of about 6.5×6.5 cm^2 (larger than the surface contaminated with radioactive solution, for an easy peeling). After 24 h, the gel was completely dried and the measurements were performed on the sample surface after the decontaminated and on the peeling gel. A 2nd decontamination process was performed on the same sample using identical agent decontamination.

The gel applying process in safe and optimal working condition has required the use of a trowel, a palette knife and a paintbrush, and was simple and without release of odor. The drying time has depended on several factors: atmospheric moisture, temperature, substrate type and thickness of the gel applied. The gel removal was quick and uncomplicated for all cases. The evaluation of the activity was performed with the gamma-ray spectrometry equipment.

(b) *Gamma-ray spectrometry method*

The Ortec gamma-ray spectrometry system used in this study consist of a ScintiPack Photomultiplier Base with Preamplifier and High Voltage Supply type 296, a DigiDART Digital Portable Multichannel Analyzer and lead collimator. The most important characteristics of the spectrometric system are: operate with and without a PC (connection made through the USB cable); 23 spectra of 16,000 channels may be stored; a long life for battery. The NaI(Tl) detector specifications guaranteed by the producer are: the detector end cap diameter is 3×3 in., the crystal diameter is 8 cm, the energy resolution is 70.62 keV at 1332 keV (^{60}Co). The recommended operating bias is $+1000$ V.

The quality of the gamma-ray spectrometry measurements depends directly on the accuracy of detection efficiencies in specific conditions of measurement. Because the experimental efficiency calibration is restricted to several measurement geometries and cannot be applied directly to all measurement configurations, an approach using the experimental efficiency measured with point sources combined with theoretical procedures was applied for obtaining the peak efficiency for disk sources measured with the NaI(Tl) detector (Radu et al., 2009). The efficiencies results obtained were used for the evaluation of the surface activity. The task was complicated because in the case of extended sources measured close to the detector (like in the presented case) it is difficult to find appropriate calibration sources and the coincidence summing effects can be higher. The coincidence summing effects were evaluated using GESPECOR software (Sima et al., 2001) and were used to correct the experimental values of the efficiencies. Using these results an analytical procedure was implemented to calculate the efficiency for disk sources.

3. Results and discussions

In the 1st decontamination process, the radioactive solutions with ^{60}Co and ^{137}Cs were uniformly spilled in the area of interest for each sample type and were left in a ventilated hood for 24 h. After drying, the measurements were performed for each contaminated sample. In Fig. 1 are presented the values of the activity evaluated on the contaminated samples for each material involved in the developed study with DeconGel™ 1101. It can be observed that the level of activity is uniformly distributed on each sample. Then, the gel was peeled from the material and measurements were performed on the decontaminated sample and on the gel. A 2nd decontamination process was performed on the same sample using identical agent decontamination. The levels of the activity incorporated into DeconGel™ 1101 gel and the activity remained on sample, after the 1st and 2nd decontamination process were evaluated through gamma-ray spectrometry measurements. In Fig. 2 are

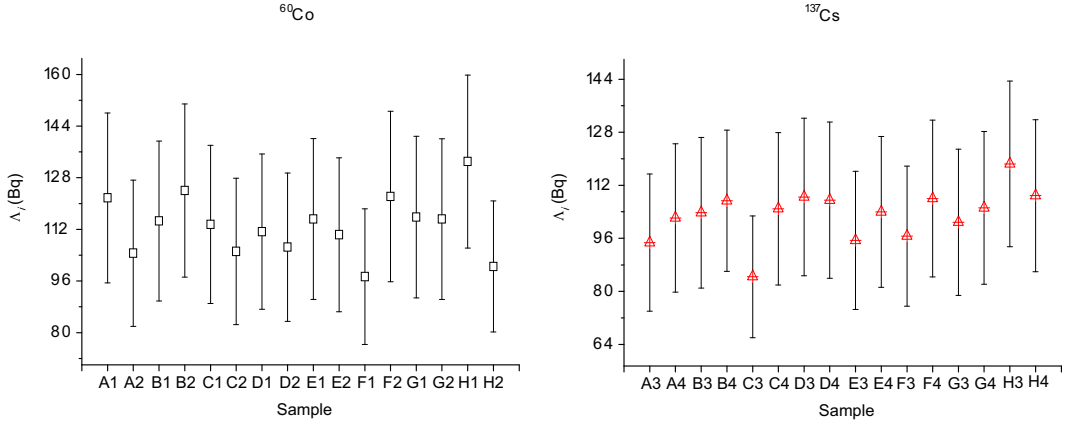

Fig. 1. The values of the initial activity.