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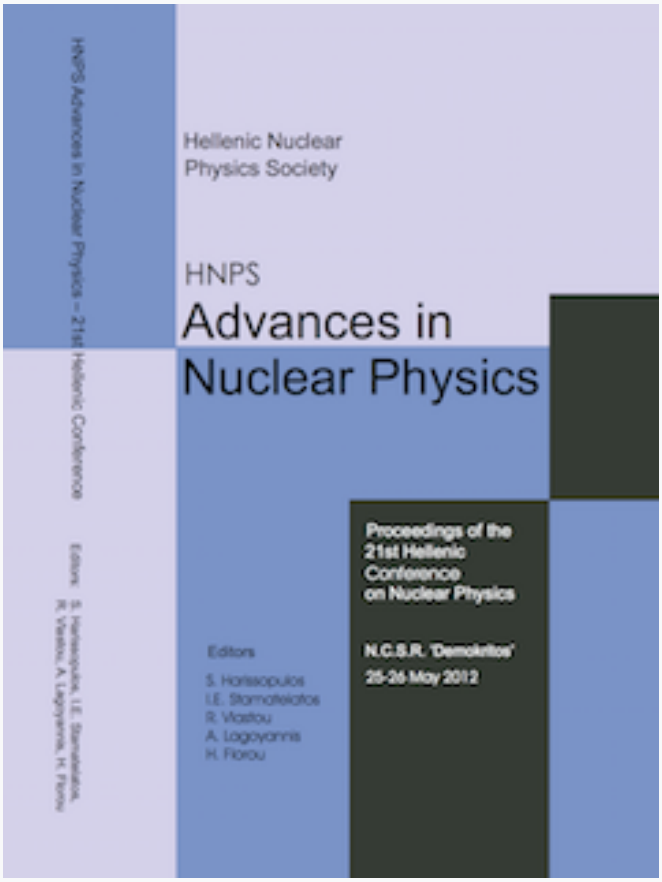

Techniques Used for Clearance of Radioactive Waste

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Techniques Used for Clearance of Radioactive Waste

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Introduction

Clearance of radioactive waste is an important management practice in the framework of the minimization principle of waste. The reduction of the volume of radioactive waste following a clearance procedure reduces substantially the cost of management and final disposal.

The present work concerns the techniques that were developed at NSCR "Demokritos' for verification of compliance with the clearance limits before removal of radioactive waste items or drums from regulatory control.

The estimates of total radioactivity present in waste items are derived directly from field radiological measurements, supplemented by analytical data and in some cases through computational models. These estimates include:

- Limited sampling and analyses to determine radionuclides present in radioactive waste
- No-destructive gamma spectroscopy measurements to support computational methodologies for determination of radionuclides.
- Direct measurement of β-γ contamination

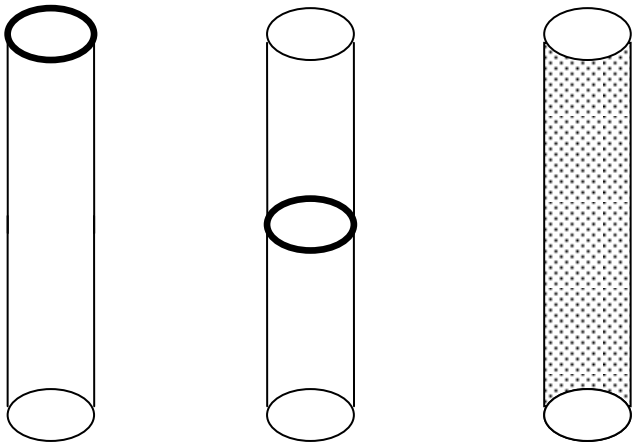
The applied practice in Greece for release of materials from regulatory control is the compliance with the general clearance levels in Bq/g that are mentioned in the Greek Radiation Protection Regulation [1]. These limits are in accordance with the EU publication RP 122 (Part I) [2]. The adopted strategies in EU for removal of materials from regulatory control are either compliance with the mass specific general clearance levels mentioned in RP122 and the surface specific for direct reuse of metals RP89 [3] or with the mass and surface specific conditional clearance criteria for recycling of metals mentioned in RP89. At NCSR 'Demokritos', the mass specific general clearance criterion is followed. In case of metals, additionally the surface specific clearance criterion mentioned in RP89 should be satisfied.

Clearance of contaminated pipe segments

Aluminium pipe segments contaminated by Ag108m [4] from the dismantling of the research reactor primary cooling system will be measured using an ExpluraniumTM GR-130 miniSPEC portable gamma ray spectrometer, equipped with a 38 mm in diameter, 57 mm in length NaI(Tl) scintillation detector. The detector efficiency for 614 keV photons (Ag108m) as a function of the detector-pipe distance was predicted by the use of the MCNP code considering homogeneous activity distribution.

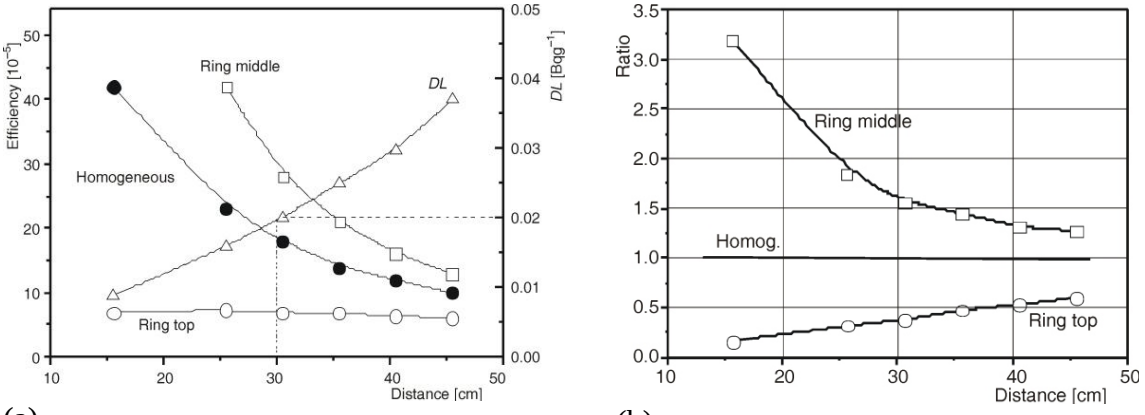
In order to define the optimum source-detector distance for the measurement, a standard aluminium pipe source (1 meter length, 20 cm diameter, 0.5 cm wall thickness) with known homogeneous Cs137 activity on the internal surface was used. The detector active centre was positioned at several distances from the geometrical centre and vertically to the pipe's main axis of symmetry. At each distance, the measurement was performed during the rotation of the pipe around its main axis of symmetry. The total duration of the measurement

was 60 min. Furthermore, two activity distributions were modelled; representing the worst envisaged cases of activity distributions in order to examine the effect of activity inhomogeneity on the accuracy of the technique. The detector efficiencies for 614 keV photons (Ag108m) as a function of the detector-pipe distance were predicted by the use of the MCNP code [5]. The results of inhomogeneous activity distribution were compared to the results obtained from the homogeneous distribution case (see figure 1). In figure 2 the results of these measurements are presented. It was showed that at the detector-pipe distance of 30 cm a minimum detectable activity of 0.02 Bq/g is achieved for 60 min counting time that is 5 times lower than the general clearance limit of 0.1 Bq/g for Ag108m. At this distance there is an over-estimation of 50 % in the case when all the activity is presented on the ring at the middle of the pipe and an under-estimation of 60 % if the ring is at the one edge of the pipe.



(a) (b) (c)

Figure 1. (a), (b): A ring of 1 mm width on the internal surface of the pipe at the top and at the middle of the pipe respectively; (c) Homogeneous distribution



(a) (b)

Figure 2. (a) Predicted detector peak efficiency for homogeneous and inhomogeneous distribution of Ag-108m (614 keV) as a function of source-to-detector distance and evaluated measurement detection limit for 60 min counting time. (b) Ratio of inhomogeneous to homogeneous activity distributions peak efficiency as a function of measurement distance for Ag-108m.

Radiological characterization of drums with waste resin

The drums with waste resin from the research reactor were measured using the ExpluraniumTM GR-130 miniSPEC portable gamma ray spectrometer. The detector efficiencies for photon energy: 614 keV of Ag108m, 662 keV for Cs137 and 1330 keV for Co60 were predicted by the use of the MCNP code. The resin waste was assumed as a homogeneously distributed volume source within a cylindrical iron drum.

The detector active centre was positioned at 57 cm from the geometrical center of the drum. Three consequent measurements were performed for each drum one every 120° of drum rotation around its long axis. The duration of each measurement was 20 min. The minimum detectable activities of the radionuclides of concern were at least five times lower than the general clearance limits (0.1 Bq/g for Ag108m, 1 Bq/g for Cs137 and 0.1 Bq/g for Co60).

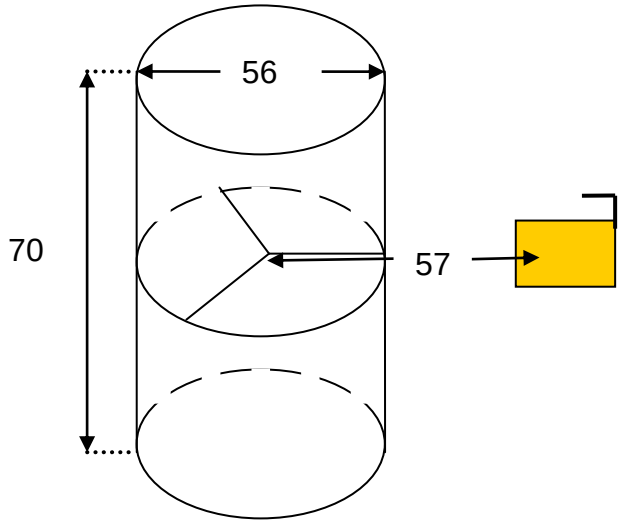


Figure 3. Measurement configuration of the resin waste drums

Six extreme activity distributions were modelled [6]:
(a) over the entire surface of the drum,
(b) over its side cylindrical surface,
(c) over one of its circular surfaces (top or bottom),
(d) over a circular surface at the central cross-plane,
(e) as a point source at the geometrical center of the drum, and
(f) as a line source along the main symmetry axis of the drum

The worst possible inhomogeneities for the energy range 100 to1500 keV were:
(i) case of a point source with an under-estimation of 30 % to 75 %; (ii) case of a line source with an under-estimation of 78 % to 38 %.

Because more than one radionuclides are presented, the summation formula is used:

$$\sum_{i=1}^{n} \frac{C_i + \delta C_i}{C_{Li}}$$

Where,
Ci : is the specific activity of radionuclide *i*

δCi : is the uncertainty for the specific activity of radionuclide *i* at 95% confidence level
CLi : is the clearance level of radionuclide *i*
n : is the number of radionuclides in the mixture.

If the sum of the above formula is less than one the material complies with the clearance requirements.

Clearance of an old delay tank segments

The mean surface activities of 10 samples collected from the interval surface of the tank after decontamination are given in the TableI. The results showed that the radionuclide of concern is the Cs137.

Table I

Mean surface activity of samples collected from the interval surface of the old delay tank

Isotope	Surface Specific Activity (Bq/cm^2)	Statistical uncertainty at 95% conf. level (Bq/cm^2)	Surface Specific Clearance Levels for Direct Reuse of Metal (Bq/cm^2)
Cs-137	0.64±0.03	0.12	10
Co-60	0.03±0.01	0.06	1
Ag-108m	0.01±0.01	0.01	1
Eu-152	0.05±0.03	0.07	1

For clearance procedure, the metal tank segments were measured by a portable beta/ gamma contamination monitor [7]. The average activity on an area of about 4000 cm^2 was determined by scanning. The detector was operated at the integral mode and the alarm was set at 4 kBq (1Bq/ cm^2) which corresponds to 1/10 of the surface specific clearance level for direct reuse of metals contaminated with Cs-137.

References

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