

Background

The decommissioning of the BR3 (Belgian Reactor 3) approaches its final phase, in which the building structures are being decontaminated and either denuclearized for possible reuse or demolished. Apart from the presence of naturally occurring radionuclides in building materials, other radionuclides might be present due to activation or contamination. The BR3 bioshield has been exposed to rather high neutron leakage fluxes during the reactor operation and is therefore activated. Building structure contamination usually results from leakages during reactor operation, releases due to maintenance works or even dismantling operations. In case of in-depth contamination in concrete it is important to know the exact in-depth profile before decontamination, in order to minimize the amount of radioactive waste that will be produced during the decontamination process and to optimize both the decontamination process and the final control measurements.

Objectives

Common non-destructive analyses used in decommissioning are usually based on the measurement of beta radiation, using e.g. hand-held plastic scintillators. This kind of measurement technique can not be used to determine in-depth contamination. Therefore, most of the decontamination specialists currently base themselves on the results of the radiological analysis of samples taken by core drilling. The use of such a destructive method implies a number of disadvantages: it is time consuming and therefore costly and the different sample preparation steps can conceivably lead to cross-contamination. Moreover, one only receives results of a limited number of points, while the in-depth contamination is usually very inhomogeneously distributed and the relationship between in-depth contamination and surface contamination and/or dose rate (hotspot detection) is generally rather poor.

The objective therefore is to test the use of the ISOCS (In Situ Object Counting System) for the determination of contamination depth.

Principal results

The overall process of dismantling/denuclearization of the BR3 building structure consist of:

- a preliminary characterization and determination of the contamination or activation depth;
- the determination of the decontamination method;
- the effective decontamination and clean up;
- a possible intermediate characterization followed by an additional decontamination step; and
- the characterization for clearance.

The more accurate the preliminary survey is performed, the less additional control/decontamination cycles are needed to reach clearance levels.

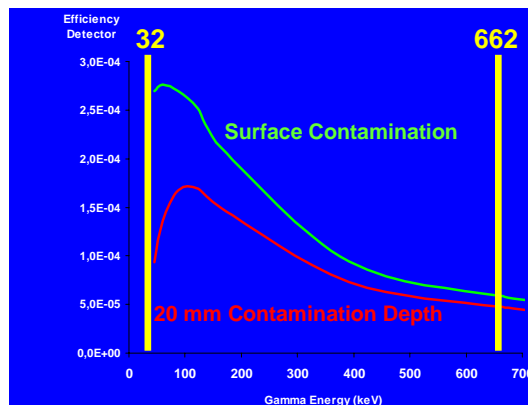
During the period 2005-2006 we selected an area of about 400 m², located in the auxiliary building cellars, in order to test the overall process of dismantling/denuclearisation. Within this case study we tested various methods for preliminary characterization, a number of decontamination methods and a clearance methodology consisting of three different types of measurements. The preliminary testing of the ISOCS for the determination of contamination depth took part of this case study.

The Canberra ISOCS (In Situ Object Counting System) is a mobile gamma spectroscopy unit based on a fully characterized (> 45 keV) HPGe (high purity germanium) detector accompanied with modelling tools.



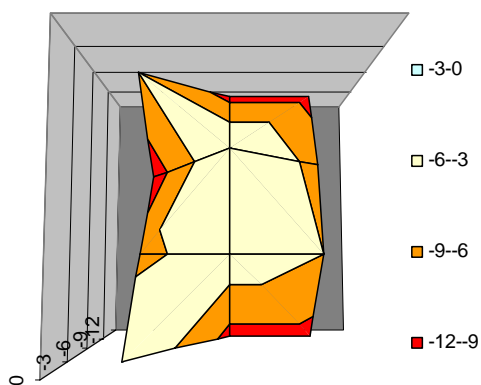
The ISOCS: a portable HPGe detector, Multi Channel Analyser and modelling tools

The radionuclide of main importance for contaminated BR3 structural elements is Cs-137. Cs-137 can be considered as a multi-energy X-ray/gamma-ray emitting radionuclide with energy lines at about 32, 36 and 662 keV (via its daughter Ba-137m). As shown in the figure (right-hand side) this property could be used in order to estimate the contamination depth. This method implies a number of uncertainties, such as possible background effects and potential X-ray interferences. The most important uncertainty however, is the fact that the detector is only calibrated from 45 keV onwards and that we have to extrapolate the efficiency curve down to lower energies.



Calculated ISOCS efficiency curves for 2 different activity distributions

Despite the various sources of uncertainty, the results obtained using the ISOCS are roughly in accordance with results obtained by destructive analysis and the final result of the various decontamination activities. The figures below give the example of the floor of room 18. The ISOCS measurements (total of 12) were carried out after removing the plinth and hammering the right hand side gutter. The results are averaged out over a surface of 1 m² and are expressed in mm Cs-137 contamination (left-hand side). The picture on the right-hand side gives a view of the present situation after decontamination.



In-depth Cs-137 contamination profile (ISOCS)



Floor of room 18: present situation after decontamination

Future work

The first results for the determination of Cs-137 in-depth contamination in concrete using the ISOCS are looking promising. In order to improve the quality of the results, we need to make a thorough validation study. We are as well considering organising an intercomparison test with an alternative technique based on the energy peak to Compton ratio (CEA, EDF).

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Main reference

Eric Cantrel, Sven Boden, "Pre decommissioning radiological survey of BR3 infrastructures", SCK•CEN Scientific Report, 2005.

Sven Boden, Eric Cantrel, "In-situ gamma measurements in view of building infrastructure denuclearization and dismantling: an appetizer", EPRI International Decommissioning and Radioactive Waste Workshop, Madrid, Spain, October 25-27, 2005