

Background

The decommissioning of the BR3 (Belgian Reactor 3) approaches its final phase, in which the buildings infrastructures are being decontaminated targeting either the reuse or the conventional demolition after denuclearisation. In a PWR with a significant operation lifetime, such as the BR3, maintenance operations, failure and/or leakages, incidents occurring in the different circuits of the plant result in the contamination of the buildings infrastructures at various activity levels with contaminants penetrating/migrating up to several cm inside the material bulk structure. Moreover, the BR3 bioshield has been exposed to rather high neutron leakage fluxes during the reactor operation and is therefore activated. The different radiological situations faced require the implementation of different characterization methodologies based on the use of an adequate combination of measurement devices and/or sampling devices. The non-destructive assay of activation depth using the ISOCS (In Situ Object Counting System) and a specific spectra analysis protocol has been tested in 2004. The first results obtained were encouraging and the qualification program for activated material is running. We are now investigating the possibilities to extend the methodology to building materials contaminated in-depth with ^{137}Cs .

Objectives

The overall process of dismantling/denuclearization of the BR3 building infrastructure consists 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. The pre-decommissioning characterization process includes a preliminary categorisation (see picture as per contra) of building surfaces based on a detailed analysis of the room history: identified contamination risks, reported incidents, processes applied during operation, etc. Specific characterization methodologies making use of destructive as well as non-destructive measurements have been defined for each category taking into account the implementation feasibility, the cost effectiveness and the ALARA principle. The main objective of the preliminary characterization is to measure the thickness

0 "Cold"	<ul style="list-style-type: none"> ➤ Location: outside controlled area ➤ Contamination risk: excluded ➤ Decontamination (& Characterization): not required 	0 mm
1 "Suspected"	<ul style="list-style-type: none"> ➤ Location: inside or outside controlled area ➤ Contamination risk: aerosols or dust (not confirmed) ➤ Decontamination: coating or base material removal 	1 mm
2 "Contaminated"	<ul style="list-style-type: none"> ➤ Location: inside controlled area ➤ Contamination: aerosols or dust (confirmed), no migration ➤ Decontamination: base material removal 	~5 mm
3 "Severely Cont."	<ul style="list-style-type: none"> ➤ Location: inside controlled area ➤ Contamination risk: liquids, possible migration ➤ Decontamination: case by case 	~20 mm
4 "Activated"	<ul style="list-style-type: none"> ➤ Location: close to RPV ➤ Contamination: activation ➤ Decontamination: case by case 	Several Dozen cm

Categorization of the BR3 surfaces

of the contaminated layer in order to define the most cost effective way to clean it down to clearance levels. Within this process we are using the traditional characterization methods, such as scanning of the surface using hand-held monitors (Selectra, Electra, Eberline), destructive analysis consisting of sampling by core drilling, sample treatment and gamma spectrometry but also, more recently, non-destructive assay using a mobile gamma spectrometry unit, the so-called ISOCS. The figure below presents the proposed methodology for category 3 surfaces. Core drilling and subsequent analysis of slices is a time consuming process and particular care must be taken to minimize cross contamination during sample preparation. We aim to use the ISOCS system to obtain quantitative information on contaminant in-depth distribution profile, but, for ^{137}Cs , the detector response in the X-Ray range (< 45 keV) still has to be modelled so that we can use the emission ratio 32/661 as an indicator of its penetration. Finally, all radiological data are gathered in the Concrete Management Database (CMD) which ensures, in particular, traceability of the radiological measurement, follow up and planning of the project.

Principal results

The controlled area of the BR3 plant represents a total surface area of 14000 m². The actual concrete radiological inventory estimates the total amount of contaminated concrete at 65 m³ and activated concrete at 150 m³. About 2000 m² of surfaces of different categories have already been characterized and are now waiting for treatment. The BR3 team, assisted by TECHNUBEL, has recently performed the decontamination of a large area (~ 400 m²) of the auxiliary building cellars where, in particular, the refuelling pool and decay storage pond demineralization circuits were located. Considering the high ambient dose rates and the history, the floors of the demineralization cells were classified in category 3, while floors of the adjacent rooms were assumed to belong to category 2 and walls and ceilings to category 1. Core drilling samples of the floor hot spots have been taken and the characterization of the rooms' walls was completed by successive grinding and on-line sampling of the dust. For the other category 1 surfaces, punctual ISOCS measurement allowed us to control the absence of contamination after removal of the coating/painting layer. The selected point were measured as follows: collimation on a 1 m² large surface, background acquisition with the detector blinded with a 5 cm lead shield, acquisition on a small sub-sample to control homogeneity of the residual activity distribution. For evaluation purposes, selected sampling points on category 2 surfaces have been both measured by *in situ* γ spectrometry and destructive analysis. When checking the categorization hypothesis (category 2 surfaces), a perfect agreement was found between the qualitative diagnoses issued by the ISOCS method (Has ¹³⁷Cs penetrated deeper than 5mm?) and the activity distribution measured

on the drilled samples. Following the defined methodologies, the complete radiological survey of the mentioned area required 28 physical samples and 19 ISOCS measurements. After thorough decontamination of the area using adequate techniques, such as jack-hammer, floor-shaver, grinding and abrasive-blasting, only few significant radioactive sources remain. Deep penetration of ¹³⁷Cs in the lowest part of some walls of the demineralisation cells was unexpected. Removal of the plugs, wall anchorages and punctual hammering should be sufficient to complete the decontamination of these rooms. However control measurements using hand-held plastic scintillators remains challenging in high and/or variable γ background environment. Because of its higher cost *In-situ* γ spectrometry is only implemented in the frame of characterization for clearance survey when information on bulk activity is required (category 3 or 4) or when the surface is hardly reachable or of complex geometry (case of BR3 ventilation shaft).

Future work

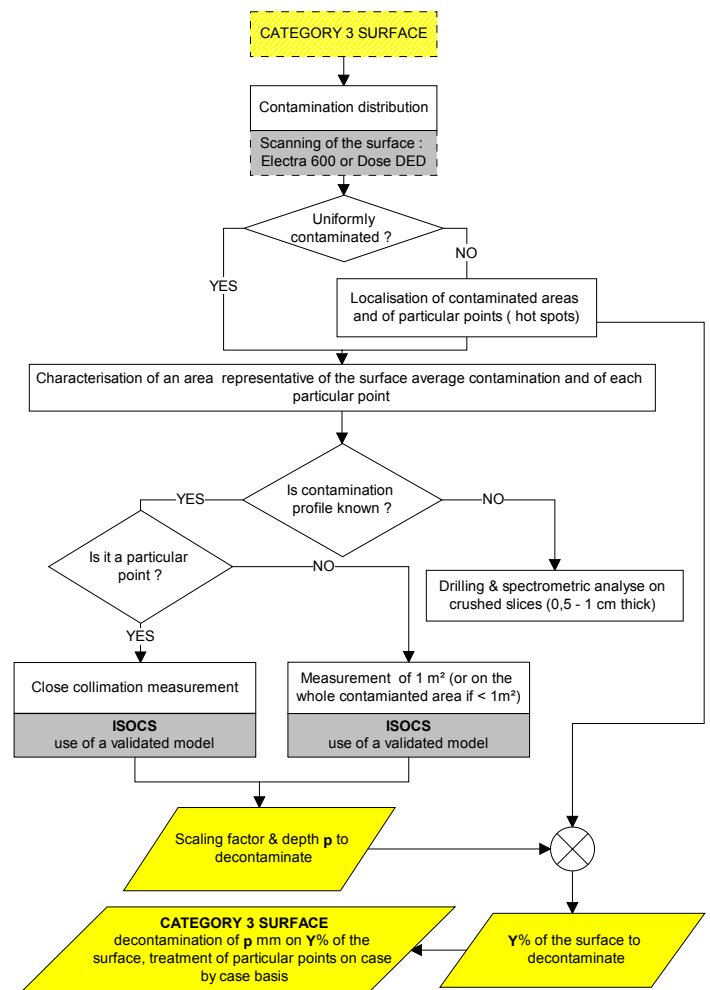
Strategies for the final clearance survey of BR3 infrastructures still has to be defined in agreement with the authorities. The methodologies applied must take into account radiological as well as historical data collected during the pre-decommissioning survey. The percentage of the surface to be controlled and the devices to be used are defined in accordance with the surface category. The use of existing plastic scintillators in the BR3 final denuclearization survey requires the development of an appropriate measurement methodology taking into account natural radioactivity (⁴⁰K, ²³²Th decay chain) and variable γ background.

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Main reference

S. Boden, E. 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



Characterization of category 3