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Radiochemical analysis of biological shielding of VVER-440 reactor for deep geological repository

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The decommissioning of nuclear facilities is connected with a huge amount of radioactive waste. The biological shielding of reactor vessel is an example of very heavy and voluminous part of NPP decommissioning waste. It is mainly composed of concrete which is long term exposed to gamma and neutron radiation.
ÚJV Řež a. s. owns one concrete block of biological shielding from NPP Greifswald's fifth reactor. This reactor was the same type VVER-440 as it is in NPP Dukovany. There is taken the advantage of experimental gamma analysis and destructive analysis of hard to detect nuclides (14C, 36Cl and 41Ca) in this work. The aim of this work is to compare experimental values with calculated ones.
The samples from the concrete block were taken with a special care to prevent release of volatile nuclides. Sampling was performed in 7 distances from 50 mm to 750 mm from the lining edge closer to the reactor. These 7 samples were analysed by Central analytical laboratory in ÚJV Řež, a. s. First of all, the high-resolution gamma spectrometry measurements were done using HPGe detector. Nuclides 60Co, 152Eu and 154Eu were identified in the samples. After gamma measurement, samples were decomposed by alkaline leaching. Content of 14C, 36Cl and 41Ca was analysed from the leachate.
14C was separated by precipitation from the leachate with solution of BaCl2. The precipitate was mixed with scintillation cocktail and measured with LSC Quantulus 1220. 36Cl was separated by extraction chromatography using Cl-resin produced by Eichrome. Small part of the eluate was used to calculate the yield of separation on ICP-MS and the rest was mixed with scintillation cocktail and measured with LSC. Evaluation of 41Ca was quite problematic. There was high content of calcium in the concrete so it was not possible to prepare thin layer sample for X-ray measurement, as a standard detection procedure. It was the reason to modify 41Ca detection from X-ray spectroscopy into LSC measurement. However the standard separation procedure used for X ray gamma spectroscopy was not good enough for LSC measurement even after some modifications. Then another separation procedure had to be used, where the procedure published by Xiaolin Hu (2005) was chosen and fit perfectly for this purpose. Finally, after separation the sample was mixed with scintillation cocktail and measured with LSC.
Obtained results were compared with theoretical values computed by Monte Carlo simulations. The comparison showed quite big differences between experimental and theoretical values. One of the possible explanations is that the differences come from approximations made in theoretical MCNP model based on available inadequate chemical and elemental/isotopic composition of analysed concrete, where missing elements had to be taken from the literature for similar (not the same) concrete. Especially the content of elements Eu and Cl is crucial to know likewise the content of hydrogen which moderates the neutron flux.

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