Methodology and techniques of early detection anomalies ^{85}Kr and ^{3}H in near bottom layer of sea water by water infiltration in spent nuclear fuel in dumpsites of the ship and submarine reactors

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Assessment of the future radioactive environmental contamination threat by releases from the dumped submarine and ship reactors with spent nuclear fuel (SNF) is a project goal. The methodology of search and detection of traces of noble gases (^{85}Kr, ^{222}Rn) and ^{3}H (which leaking the first from the SNF) on them plume on a bottom in dumpsites of ship nuclear reactors is advanced.

Investigation of releases from the dumped ship reactors with SNF of icebreaker "Lenin" in Kara Sea is launched (September 2003). Research has multilane character: experiments with SNF, creation of techniques and expeditions. Preliminary observation of current field and hydrological characteristics in zone of marked dumpsites on the shelf has been fulfilled.

For an estimation of a gas fission products release (including Kr-85) from the irradiated fuel during the corrosion in conditions a near-bottom layer of the sea in Arctic the special installation has been created in the RRC "Kurchatov Institute" hot laboratory. Then the following experiment (modeling the conditions a near-bottom layer of the sea in Arctic) was made:

First, samples of irradiated VVER-1000 type reactor fuel (UO_2) are loaded into capsules filled with pure sea water or sea water with the silt sampled in Kara Sea. The fuel samples have been selected due to similarity of its burnup level (62 MWd/kg) and other parameters to the one of icebreaker "Lenin" reactor, that had been buried (1965) in Kara sea. The average sample activity was about 1 GBq for ^{137}Cs. Second, the capsules and the vacuum system are pumped out and checked on tightness by the helium leak tester. Then capsules are filled with the artificial gas mixture without traces of ^{85}Kr. Temperature of capsules are maintained in a range 0÷1 °C.

Each 1-2 month gas samples are taken from the capsules into the previously pumped out flask, then capsules are refilled by the gas mixture. The measurements of ^{85}Kr concentration in the samples are carried out on low-background installation with the proportional counter in Institute for Nuclear Research RAS. At the end of the experiment the fission products inventory in water is also measured.

Installations for extraction and measurements ^{85}Kr in water are developed. They consist from two parts. The first part is intended for extraction of ^{85}Kr from 130 l seawater and includes 170 l tank and system of traps. The ^{85}Kr is extracted from seawater by bubbling with He flux, purified from the water by low temperature traps and captured from He flux in low temperature traps with charcoal. The bubbler with volume 170 l for full scale installation has been created from stainless and tested during expedition (September 2003, Barents and Kara seas) on the board of R/V "Akademik Boris Petrov".

The second part is intended for fine purification of Kr sample with high temperature getter and Toepler pump for transporting the gas sample in to a proportional counter for ^{85}Kr activity measuring. The construction of the super miniature proportional counter (volume 1 ml) is based on only quartz without any glue, that allows heating it up to 200°C and all the gases absorbed in the counter walls can be removed. The proportional counter is placed into anticoincidence system from cosmic rays and passive shielding from pure materials (Fe, W, and Hg) for lowering the background. On the current stage the counter background is about a few events per hour which corresponds the sensitivity of about 3×10^{-6} Bq/l of seawater (~1300 atoms of ^{85}Kr/l). The measurements of the rate of diffusion of ^{85}Kr from SNF and ^{85}Kr concentration in seawater samples have been started. Sensitivity of ^{3}H measurement with preliminary enrichment is 0.03 TE.