

Design and validation of a measurement facility adapted to the radiological characterization of mercury-containing waste

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The aim of the PROMETEUS project is to develop a qualified method for the characterization, decontamination, conditioning and disposal of mercury-containing waste, which will be experimentally validated by the collaboration partners Forschungszentrum Jülich GmbH (Institute of Energy and Climate Research - Nuclear Waste Management) and Aachen Institute for Nuclear Training GmbH (AiNT).

Mercury is used, for example, as a sealing material in hot cells where it might be contaminated during the decommissioning and must be treated as radioactive waste accordingly. Moreover, mercury is also used as a spallation target in research accelerator facilities, where it is also activated by neutron capture.

Radiological characterization of the waste quotas

In the first phase of the PROMETEUS project, an identification and quantification of national as well as international waste mercury quotas is carried out.

To assign a disposal route for the mercury quotas, they must be radiologically characterized. This process is divided into two steps, downscaling and upscaling. After a representative sampling of the waste, the nuclide vector is determined by α -, β - and gamma spectrometry. The nuclide vector contains information about the specific activities of nuclides and total specific activity of the sample (step one: downscaling). To quantify the whole batch, gamma spectrometric measurements of batches or waste packages are performed and compared with the nuclide vector (step two: upscaling).

There might be the option to free release the mercury from the scope of the Atomic Energy Act, if the clearance procedure according to § 29 Radiation Protection Ordinance (StrlSchV) [1] is possible. That depends on the activity inventory of each batch. If the mercury cannot be cleared after radiological characterization, due to its activity inventory, it has to be iteratively decontaminated.

If the decontamination process is not successful and the activity exceeds clearance values, the mercury batch must be disposed as radioactive waste. During the conditioning process, the mercury has to be converted or immobilized to a stable form. The aim of conditioning and packaging is to produce a waste product, which can be stored in containers according to the waste acceptance criteria of the final disposal Konrad [2].

Design of a PROMETEUS measurement facility and simulation studies

As part of the radiological characterization, a measurement facility for the mercury quotas based on gamma spectroscopy will be designed and validated. The PROMETEUS measurement facility consists of two semi-planar p-type HPGe detectors with a diameter of 59 mm and a nominal relative efficiency of 20 % (see Fig. 1). The measurement concept was modeled in MCNP and a parameter study as a function of the matrix effect was conducted. As a result of the simulation studies detection limits according to DIN ISO 11929 [3] for different radionuclides, distributed in the mercury matrix, will be obtained. The determined detection limits will be compared with the clearance values in the appendix III table 1 of the Radiation Protection Ordinance (StrlSchV).

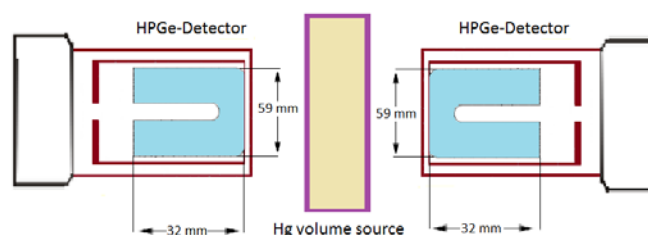


Figure 1: PROMETEUS measurement facility.

The concept takes into account the detection of homogeneity due to the use of two detectors. Moreover, a further advantage is the possibility of varying the distance between sample and two detectors to measure samples with different thicknesses.

In order to validate the design of the PROMETEUS facility the results of the simulation studies will be compared with experimental measurements using a point source of ¹⁵²Eu that will be placed in between of the two semi-planar HPGe detectors. After the validation phase, the facility will be used to characterize real batches of contaminated mercury.

- [1] Ordinance on the Protection against Damage and Injuries Caused by Ionizing Radiation (Radiation Protection Ordinance- StrlSchV), 2014.
- [2] P. Brennecke, Requirements on Radioactive Waste for Disposal (Waste Acceptance Requirements)-Konrad repository, 2014.
- [3] Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation. Fundamentals and application (ISO 11929:2010), 2011.