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#7-42 Commissioning and calibration of the MICADO passive and active neutron measurement system for the characterization of radioactive waste drums

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The accumulation of radioactive waste from legacy nuclear facilities presents a critical challenge for long-term environmental safety, as precise quantification of nuclear material within these waste drums is necessary to inform safe storage and disposal strategies. In this context, a passive and active neutron measurement system was developed within the MICADO H2020 project to estimate the nuclear material mass inside legacy waste drums with low and intermediate levels of radioactivity. The MICADO neutron system was installed in the CEA Danaides casemate at the Nuclear Measurement Laboratory, where measurements have been conducted. Calibration tests in passive neutron coincidence counting were performed using a Cf-252 neutron source, yielding a total neutron efficiency of 3.8%. Measurements in 12 different positions were conducted to account for source localization effects. Mock-up drums filled alternately with materials representative of real drums, such as stainless steel, wood, polyethylene, and PVC, were measured in neutron coincidence counting and in a transmission measurement to evaluate the impact of matrix effects on the neutron signal. Experimental and simulated transmitted signals showed good agreement, within 10%.

The measurement of real coincidences and the calculation of calibration coefficients using Monte Carlo simulations allowed for an estimation of nuclear material mass inside mock-up drums, with results agreeing within approximately 0–20% of the actual mass of the nuclear material. This validated both the simulation model and the experimental findings. In active neutron total counting, a neutron generator was used to induce fission in a Pu-239 neutron target located at the drum's center. The total neutron background measured in the prompt neutron time window showed agreement with simulations to within 10%. The estimated Pu-239 mass was within approximately 15–40% of the actual mass across most matrices, though larger discrepancies were observed with PVC, attributed mainly to uncertainties in matrix modeling. Finally, a matrix correction model was developed using an artificial neural network, achieving accurate calibration predictions for four test drums in both passive and active modes. This model was scaled up for 200 L drums and employed in the final demonstration at ENEA Casaccia (Italy) to improve nuclear material mass estimates.

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