ISOCS for the 2024 and 2025 Proficiency Tests

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Abstract

Accurate and traceable radionuclide activity determination is essential for ensuring high quality gamma spectrometric measurements across the international radiological community. As part of Mirion's continued engagement with the International Atomic Energy Agency (IAEA), Mirion has participated in the proficiency test (PT) program to assess laboratory performance in quantifying a suite of gamma emitting radionuclides. In this program, the In Situ Object Counting System (ISOCS) mathematical efficiency calibration methodology is applied to calculate efficiency calibrations. This approach enables flexible characterization of diverse sample geometries while maintaining robust metrological traceability.

This poster will present results from the past two years of PT exercises, highlighting measured radionuclide activities obtained via ISOCS based efficiency calibrations. These results will be analyzed in the context of the broader distribution of participant outcomes from the full international test campaigns, enabling comparison of Mirion's measurements to the collective reporting laboratories. Further, measured values will be benchmarked against the IAEA's assigned reference activities to evaluate accuracy, systematic trends, and potential sources of interlaboratory variation. Together, these results and collaborative initiatives underscore the continued commitment of Mirion and the IAEA to advancing global measurement consistency, strengthening technical capabilities, and supporting high quality radiometric practices across the international nuclear science community.

Introduction

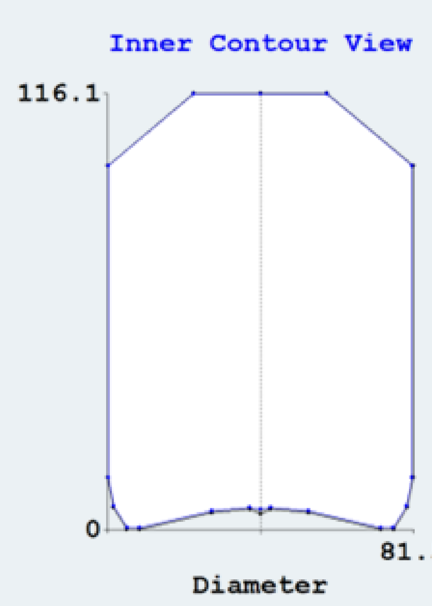
The IAEA Proficiency Test Program

The International Atomic Energy Agency (IAEA) proficiency test (PT) program plays a critical role in supporting the quality, consistency, and comparability of radiochemical and gamma spectrometric measurements worldwide. Through periodic interlaboratory exercises, participating laboratories analyze unknown samples containing anthropogenic and naturally occurring radionuclides and report identified nuclides, activities, and uncertainties. Laboratory performance is evaluated by comparison with assigned reference values and with the collective results of other reporting participants.

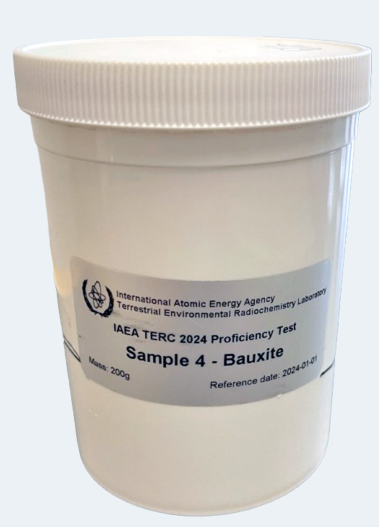
These PT campaigns serve multiple purposes: they provide external verification of laboratory measurement capabilities, identify systematic biases or methodological challenges, and promote the agreement of analytical practices across the international radiological community. As such, participation in IAEA PT exercises is widely regarded as an essential component of laboratory quality assurance and technical capability development.

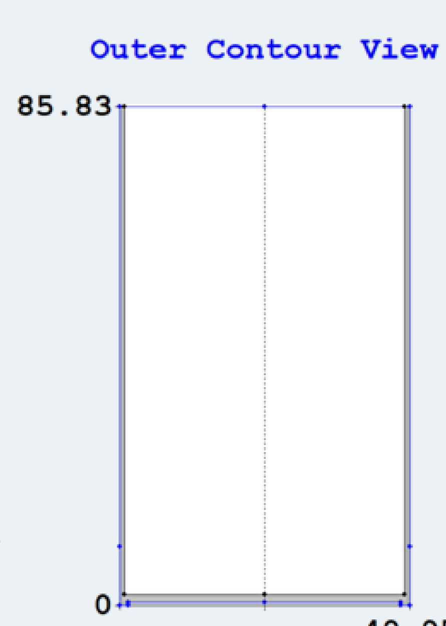
Samples and LabSOCs Beaker Files

Water sample and LabSOCS generated file

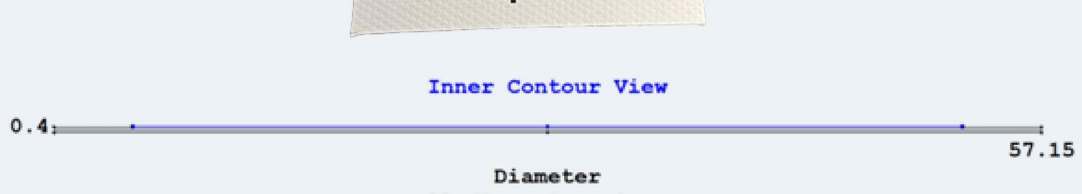


Bulk solid sample and LabSOCs generated file





Paper printed sample and LabSOCS generated file



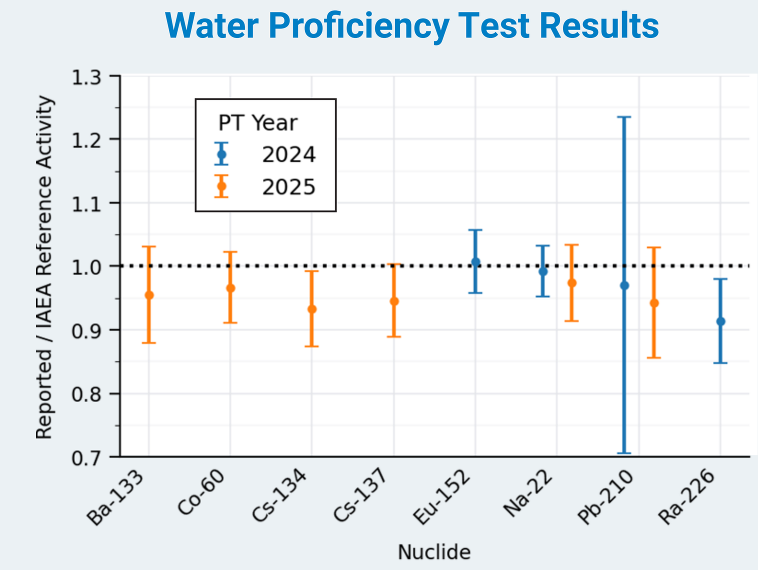
Objectives

The objectives of this study were to:

- Apply ISOCS based efficiency calibrations to IAEA PT samples spanning multiple geometries and source types.
- Identify and quantify gamma emitting radionuclides in unknown samples without source based calibrations.
- Evaluate measurement accuracy and precision by comparison with IAEA assigned reference values.
- Compare Mirion's reported results with overall interlaboratory performance statistics.
- Identify strengths, challenges, and methodological considerations relevant to proficiency testing using mathematical efficiency calibration.

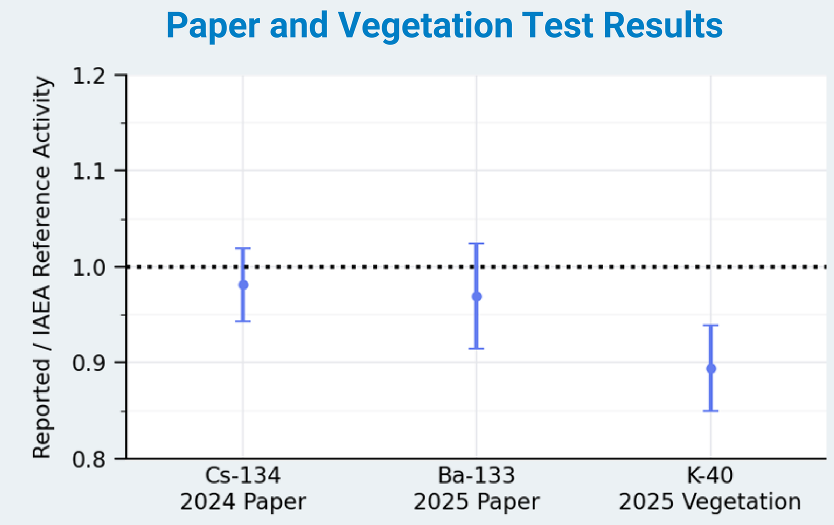
Performance vs Reference Values

Water Proficiency Test Results



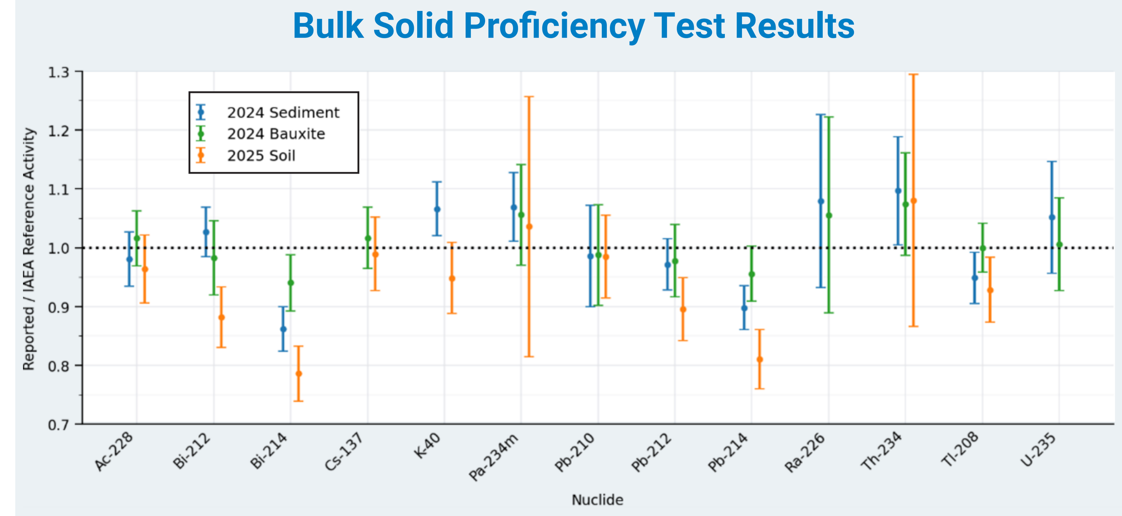
Ratios of the reported to the IAEA reference activities for water samples in the 2024 and 2025 PT exercises.

Paper and Vegetation Test Results



Ratios of the reported to the IAEA reference activities for paper and vegetation samples in the 2024 and 2025 PT exercises.

Bulk Solid Proficiency Test Results



Ratios of the reported to the IAEA reference activities for bulk solid samples in the 2024 and 2025 PT exercises.

Motivation for This Work

Accurate and traceable radionuclide activity determination is essential for high quality gamma spectrometric analysis, particularly when samples vary widely in geometry, composition, and activity. Traditional source based efficiency calibrations can be limiting in such contexts, requiring sample preparation or geometry matching that may not be practical for unknown or irregular samples.

In this work, Mirion participated in multiple IAEA proficiency testing exercises using the In Situ Object Counting System (ISOCS) mathematical efficiency calibration methodology. By applying ISOCS based efficiency models, activities for a diverse set of PT samples were determined without the use of source based efficiency calibrations. Results from two consecutive years of PT participation are presented and evaluated against IAEA reference values and interlaboratory performance distributions.

Overview of ISOCS Efficiency Calibration

ISOCS is a mathematical efficiency calibration approach based on factory characterized detectors and ray tracing calculations that account for geometry, attenuation, and material composition. Efficiency values can be calculated for arbitrary source geometries and photon energies without reliance on physical calibration sources. This provides flexibility for analyzing samples with non standard containers, unknown geometries, or where sample preparation is undesirable.

Samples and Measurement Approach

Across the reported PT exercises, samples included spiked water, sediment or bauxite based materials, vegetation, and contaminated surface (paper/ink) samples. Sample masses ranged from approximately 100–200 g for solids and approximately 500 g for liquids. All samples were measured in their original containers.

Key methodological features included:

- Direct modeling of container geometry, wall thickness, fill height, and sample mass.
- Use of ISOCS massimetric efficiencies (efficiency × mass) to report activities in Bq/kg.
- Close counting geometries to maximize efficiency and reduce statistical uncertainty.
- Application of true coincidence summing corrections using geometries defined in ISOCS and applied via Genie analysis software.
- Validation of ISOCS models using provided quality control samples, when available.

Selected Sample Highlights

Water Samples

Most gamma emitting radionuclides in the water samples (e.g., Co-60, Ba-133, Cs-134, Cs-137) were correctly identified and quantified. A notable improvement over the previous year was the successful identification and quantification of Pb-210 via its low energy 46.5 keV emission, a nuclide correctly quantified via gamma-ray analysis by 2% of reporting laboratories. Careful consideration of low energy interferences and coincidence summing effects was essential for accurate quantification.

Sediment / Bauxite Samples

Sediment based samples contained predominantly NORM radionuclides from natural decay chains. Despite incomplete material composition information, effective self attenuation modeling enabled accurate low energy quantification, including Pb-210. Most reported nuclides achieved high correctness and precision ratings relative to IAEA performance criteria.

Vegetation Sample

K-40 was correctly identified and quantified despite its high activity dominating the spectrum. Additional low activity NORM radionuclides (e.g., Pb-214, Bi-214) were also identified, demonstrating sensitivity to weak peaks in the presence of strong interfering activity.

Surface (Paper) Sample

The contaminated surface sample required particular attention to coincidence summing corrections. ISOCS derived geometries enabled reliable application of summing corrections, resulting in accurate Cs-134 activity determination without the need for source based calibration.

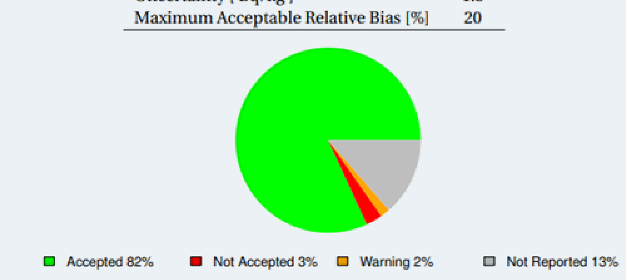
Discussion

Results from these PT exercises illustrate that ISOCS based efficiency calibrations can achieve performance comparable to, and in some cases exceeding, traditional source based approaches when applied carefully. Key factors influencing success included accurate geometric modeling, proper treatment of coincidence summing, and informed nuclide identification strategies, particularly for decay chain members and low energy emitters.

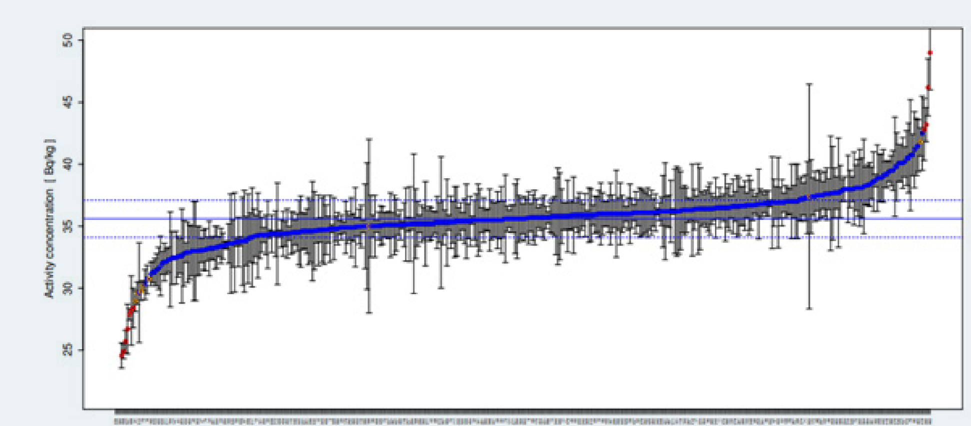
The samples provided had very low activity levels, with most requiring several days to a week of measurement directly on the endcap as well as a detector system with low background. Analytical challenges encountered—such as interferences involving Pb 210, Ra 226, and U 235—highlight the importance of spectral interpretation experience and decay chain knowledge in proficiency testing contexts. Participation in repeated PT exercises provided valuable feedback and contributed to improved performance over time, particularly for challenging radionuclides.

Interlaboratory Comparison Results

Parameter	Value
Activity concentration [Bq/kg]	35.6
Uncertainty [Bq/kg]	1.5
Maximum Acceptable Relative Bias [%]	20



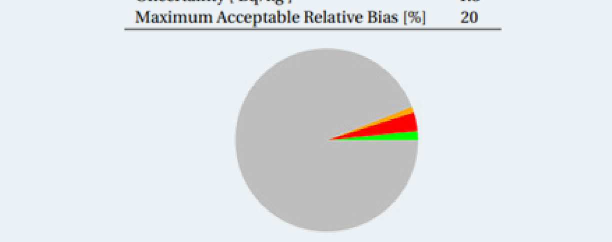
Accepted activity and uncertainty values for Co-60 quantification in the 2025 water sample. Percentages of Accepted vs Warnings vs Not Accepted vs Not Reported results across all participating laboratories.



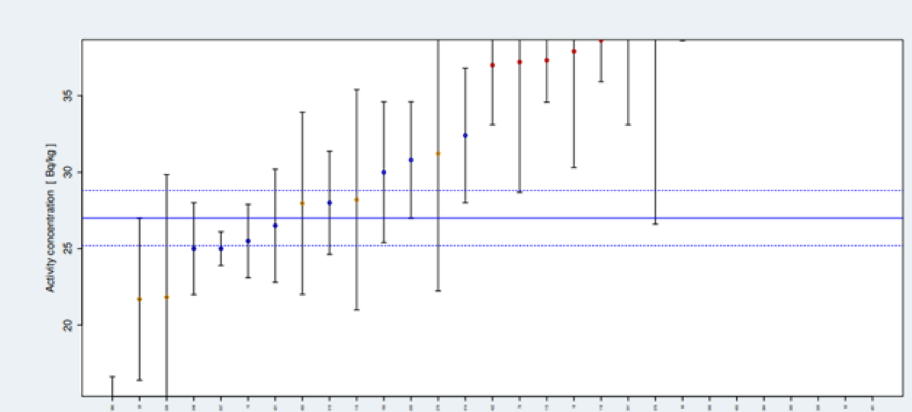
Reported results and evaluation parameters for Co-60 quantification in the 2025 water sample across all participating laboratories. Blue points represent reported activities within the maximum acceptable relative bias (accepted score).

Table 56. Target values

Parameter	Value
Activity concentration [Bq/kg]	27.0
Uncertainty [Bq/kg]	1.8
Maximum Acceptable Relative Bias [%]	20



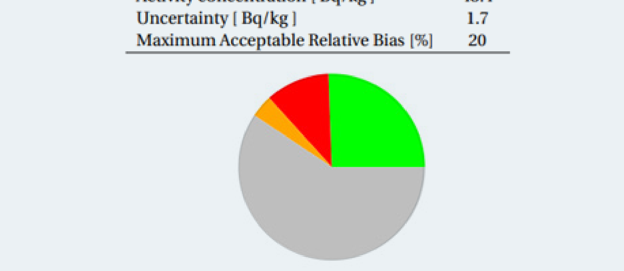
Accepted activity and uncertainty values for Pa-234m quantification in the 2025 soil sample. Percentages of Accepted vs Warnings vs Not Accepted vs Not Reported results across all participating laboratories.



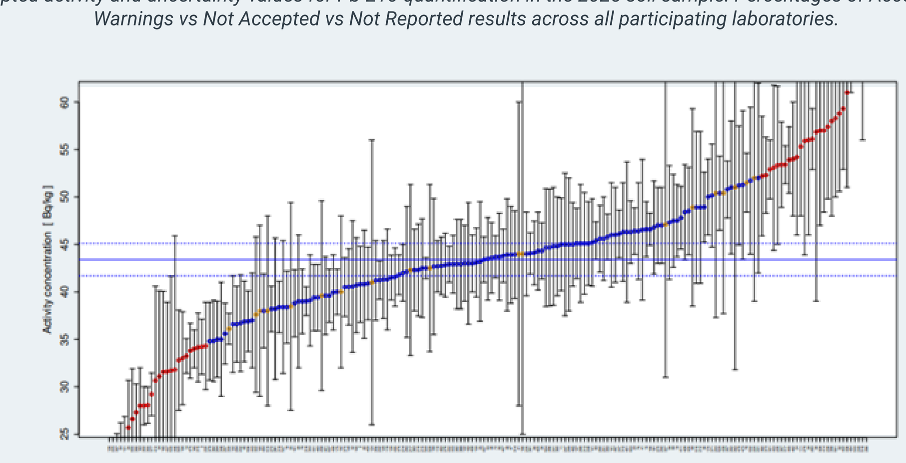
Reported results and evaluation parameters for Pa-234m quantification in the 2025 soil sample across all participating laboratories. Blue points represent reported activities within the maximum acceptable relative bias (accepted score).

Table 40. Target values

Parameter	Value
Activity concentration [Bq/kg]	43.4
Uncertainty [Bq/kg]	1.7
Maximum Acceptable Relative Bias [%]	20



Accepted activity and uncertainty values for Pb-210 quantification in the 2025 soil sample. Percentages of Accepted vs Warnings vs Not Accepted vs Not Reported results across all participating laboratories.



Reported results and evaluation parameters for Pb-210 quantification in the 2025 soil sample across all participating laboratories. Blue points represent reported activities within the maximum acceptable relative bias (accepted score).

Conclusions

- ISOCS based efficiency calibration is well suited for IAEA proficiency testing and unknown sample analysis.
- Accurate activity determinations were achieved across multiple sample types and geometries without source based calibrations or sample preparation.
- Low energy and decay chain radionuclides remain challenging but can be quantified successfully with appropriate modeling and interpretive strategies.
- Continued participation in international PT programs strengthens analytical capability and contributes to improved global measurement consistency.

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