Radioactive Sources in Metrology: Applications and Alternative Technologies

CCRI(II) Measurement of Radionuclides

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CCRI webinar
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The use of sources in Radionuclide Metrology

- Industries that rely on accurate and reliable radioactivity measurements
- The role of sources in development and maintenance of radionuclide standards
- International comparisons of radioactivity standards
- Dissemination of radioactivity standards
Accurate & reliable measurements to support health, trade, safety, environment

Diagnostic imaging (PET-CT, SPECT)
Nuclear medicine (therapy)
Radioisotope production
Nuclear power
Radiation protection
Environmental monitoring
Nuclear decommissioning
Nuclear forensics
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<td>Ge-68</td>
<td>In-111</td>
<td>Na-22</td>
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<td>Sb-124</td>
<td>Sr-90/Y-90</td>
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<td>Sb-125</td>
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Maintenance of radionuclide standards

Source dispensing
- Prepare counting sources for primary standardisation, calibration of secondary equipment & for customers

Secondary standard
- Ionisation chamber
  - Standards “saved” as radionuclide-specific calibration factors (pA/MBq)
  - Accuracy, reproducibility & stability < 0.1%

Keithley 6517A electrometer with SSIC
- $^{99m}$Tc linearity

Primary standardisation
- Source activity determined from first principles
- Independent of prior calibration of detectors
- Bq/mg

$^{226}$Ra sealed sources to account for
- Non-linearity between capacitor ranges
- Instability due to temperature fluctuations & gas leaks from pressurised IC, drifts in electronics

Gamma spectroscopy
- Calibrate gamma spec systems
- Identify & quantify radionuclides & impurities

Standards “saved” as radionuclide-specific calibration factors (pA/MBq)
Established by BIPM in 1976 to compare national standards of $\gamma$-emitting radionuclides
- Pressurised ionization chamber in lead shielding
- Participants send standardised ampoules to BIPM
- Current produced by ampoule compared to that produced by one of five reference $^{226}$Ra sources
- SIR provided 776 independent results for 72 different radionuclides

Operation relies on sealed $^{226}$Ra reference sources
- Sources are aging and indefinite use is not allowed by the regulator

Solutions:
- Fewer sources: New technology for improved current measurement linearity
- Different radionuclide: $^{166m}$Ho
SIR Transfer Instrument (SIRTI)

- Established in 2013 to compare national standards of short-lived γ-emitting radionuclides
- Calibrated against SIR for 5 radionuclides
- Well-characterised NaI(Tl) well detector with data acquisition system
- Stability monitored by $^{94}$Nb reference source
- Low-energy threshold set using $^{93m}$Nb X-ray peak

- SIRTI and reference source shipped to NMI
- Measurements taken by BIPM staff (or remotely)
- Limited to 2 participants per year
Large scale K2 key comparisons

- Aliquots of the same master solution distributed to participants by pilot laboratory
- Some participants submit standardised ampoules of the solution to the BIPM to provide a link to the SIR

- Intercomparisons rely on:
  - Shipping of sources around the world
  - Regulatory compliance
  - Time-bound shipping and customs clearance of short-lived radionuclides
Activity standards disseminated as certified sources

- Solutions in ampoules, vials, bottles
- Gases in ampoules, pressurized canisters
- Point sources
- Solid sources in various matrices
- Sources in natural matrices
- Sealed sources
- Large area sources

- Proficiency tests
- Onsite traceability measurements

Representative images were taken from the catalogues of a few NMIs. Please refer to the KCDB for details on radioactivity CMCs for all NMIs.
Activity standards disseminated through measurements

- Sources submitted by users and certified by NMI by primary or secondary measurement
- Calibration of radionuclide calibrators using certified reference sources
- Certification of short-lived radionuclide sources at production sites by:
  - portable primary standardisation system, or
  - using a transfer instrument with traceability to national standard