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Radioactive Standards Laboratory ININ as a reference laboratory in Mexico

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HIGHLIGHTS

- Reference laboratory in the field of radioactivity measurements.
- HPGe gamma-ray detector system ranging from 50 keV to 2000 keV.
- Standard beta-gamma emitting radionuclide sources of different geometries.
- Measurement uncertainties of 5% or better.
- Calibration of radionuclide dose calibrators.

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ABSTRACT

The Radioactive Standards Laboratory of the National Institute of Nuclear Research is the National reference laboratory for the measurement of radioactivity in Mexico. It has a gamma-ray spectrometry system with a high-purity Ge-detector for measurements from 50 keV to 2000 keV, and develops standardized radioactive (beta-particle and gamma-ray emitting) sources in different geometries with uncertainties less than or equal to 5% for applications such as the calibration of radionuclide calibrators (clinically used dose calibrators), Ge-detectors and NaI(Tl) detectors.

1. Introduction

The Radioactive Standards Laboratory (RSL), as part of the Metrology Radiation Department of the National Institute of Nuclear Research (ININ), was designated the reference laboratory for radioactivity measurements with the signing of the International Committee for Weights and Measures Mutual Recognition Arrangement (CIPM MRA) by the Metrology Nacional Center (CENAM) of Mexico. As the Designated Institute (DI) for radioactivity measurements in Mexico, RSL maintains the National standards for radioactivity supporting applications in health, environment, industry, food and nuclear energy. In particular, the RSL is active in providing measurement traceability for the quality assurance programs of accredited laboratories that must meet regulatory requirements to support nuclear medicine centers, research institutes, nuclear power-stations, hospitals and calibration laboratories.

The RSL has been working diligently to meet the requirements for acceptance of its calibration and measurement capabilities (CMCs) in the frame of the CIPM MRA. In addition to active participation with the metrology working group for ionizing radiation in the Inter-American Metrology System (SIM), the Regional Metrology Organization (RMO) for the Americas, the RSL has developed measurement capabilities, participated in measurement comparisons, and has hosted external technical reviewers of its programs.

Among the main services provided by the laboratory, the development of beta-particle and gamma-ray emitting radioactive source standards in different geometries for different applications requiring 5% (or better) uncertainty enable the laboratory to meet the needs of its customers. In particular, customers will often use these sources for the calibration of radionuclide dose calibrators. They are also used to calibrate the gamma-counting equipment (consisting of several NaI(Tl) detectors) that are often used in radioimmunoassay (RIA), a very sensitive and specific technique used to quantify very small amounts of substances in the presence of other molecular species.

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2. Capabilities

The technical capabilities established at the RSL enables it to provide services and further development in fields such as medicine, industry, research and education. In its role as the DI for radioactivity measurements, the RSL maintains the National radioactivity standards, which are developed and maintained principally through use of a well-calibrated gamma-ray spectrometer, with a high-purity germanium detector coupled to a multichannel analyzer, covering a range (from 50 keV to 2000 keV; Fig. 1) of gamma-ray energies, according to international standards (ANSI N.42.14-1999). The detector has demonstrated a stable response and has provided reproducible and reliable results since 1998 (Figs. 2 and 3).

The RSL has also developed methods and procedures for the preparation, measurement and calibration of radioactive reference sources, such as liquid in vials, point sources, bottles of different sizes, ampoules, Marinelli beakers of different sizes, circular planar sources, square, rectangular and activated carbon cartridges, circular point, and square thermosealed plastic (Fig. 4). As the only reference laboratory in the country, the RSL provides measurement traceability for activity measurements nationwide. Calibration and verification of gamma-ray emitting sources to the National measurement standards, with certification indicating traceability to international standards, are performed.

2.1. Development of radioactive sources

The preparation of radioactive source standards in various geometries for calibration of equipment used in environmental monitoring, radiological protection and safety, and in research centers, is performed at the RSL as described above and in the laboratory's quality management system (QMS) documented procedures (P.LPR-04, 2014; P.LPR-06, 2013). The majority of applications using these standards require an uncertainty on their activity measurement of 5% or better. Sources are prepared gravimetrically from a stock solution of a radionuclide, the specific activity of which has been determined with gamma-ray spectrometry methods (ANSI N42.14-1999) using the laboratory's HPGe-detector.

Reference sources with a specific geometry (P.LPR-06, 2013) are produced by depositing a suitable amount of stock solution to obtain the desired activity. The precise determination of the deposited mass is obtained through use of a microbalance (P.LPR-02, 2013). Inactive carrier is added to stabilize solutions and uniformity is ensured by stirring the liquid source on a stirring plate (P.LPR-03, 2014). Point sources are prepared by depositing a drop of 0.01 g of the radioactive solution on a plastic or other heat-sealable support within a region or cavity of 3 mm. Drying is carried out under a lamp placed in a plastic box to prevent any contamination (P.LPR-04, 2014).

Fig. 1. Gamma-ray spectrometry system located at ININ's RSL. The picture shows the HPGe-detector, Dewar, shield, electronic items and computer with Gamma-vision software.

2.2. International committee for weights and measures Mutual Recognition Arrangement

The RSL has worked to meet the requirements for acceptance of its calibration and measurement capabilities (CMCs) as described by the CIPM MRA. The first requirement, participation in international comparisons, was undertaken between the RSL and the BIPM, the results of which show the ability of the RSL to measure radioactivity. The results of comparisons CCRI(II).K2.Am-241 and CCRI(II).K2.Ir-192 have been published in the KCDB, and those for CCRI(II).K2.Mn-54 and CCRI(II).K2.I-125 are in Draft A form.

The second requirement, to demonstrate that the RSL is able to provide measurement services in a systematic way, is through the implementation of a QMS in accordance with the requirements such as those found in the ISO/IEC 17025 (2005), "General Requirements for the Competence of Testing and Calibration Laboratories." Recently, the laboratory has undergone two peer reviews: an administrative review by its parent NMI, the CENAM, and a technical review by a peer visit by the NIST. Modifications and improvements to the measurement traceability and radiation protection procedures were made, including improving control charts and uncertainty budgets, establishing intermediate calibration checks, and activating all the administrative parts of the QMS. To implement the QMS, additional equipment was acquired. The QMS was approved in October 2013 at a meeting of the Quality System Task Force (QSTF) of SIM, which took place in Querétaro City, Mexico (Fig. 5).

The RSL currently has 40 CMCs representing measurement capabilities for determining activity, activity per unit mass, gamma spectrometer efficiency versus energy, and efficiency of ionization chambers, all of which have been published in Appendix C of the Key Comparison Database (KCDB, http://kcdb.bipm.org/AppendixC/default.asp). This achievement has led to greater customer confidence in the services provided, as well as to improvements in the organization through expanded interactions internationally which have resulted in wider training opportunities for the measurement and calibration staff.

2.3. Application of capabilities to support customers

2.3.1. Calibration of radionuclide "dose calibrators"

In order to improve the calibration of well-type ionization chambers used in clinical settings (radionuclide "dose calibrators") and to establish measurement traceability for radioactivity determinations in nuclear medicine, measurements are carried out in Mexico in accord with the National Nuclear Activity Standard ININ-PNM-02, described in the Official Gazette, 1998. Characterization and control operations were performed with calibrated sources prepared at the RLS using a Capintec CRC-7BT model "Dose Calibrator" as a working standard (Fig. 6).

Characterization equipment and sources were based on recommendations in the ANSI N42.13-2004 standard concerning scale linearity, stability of readings, variation of readings due to the position of the source in the chamber well, repeatability, source geometry, accuracy, impurities and other potential sources of error as well as the calibration factor for each of the radionuclides used. Sources were prepared from radioactive solutions of radionuclides typically used in nuclear medicine (^{131}I, ^{153}Sm and ^{99}Mo with activities ranging from some hundreds of kBq to 3.7 GBq and ^{99m}Tc, ^{111}In, ^{201}Tl, ^{67}Ga with activities of about 3.7 GBq). Radionuclides