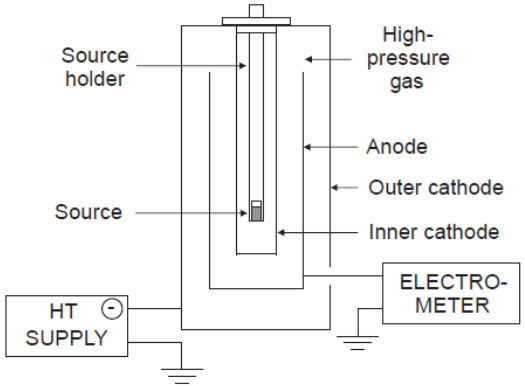
Proposal for a Joint CCRI and CCEM Working Group

Low current measurement for ionization chambers

Need: Radionuclide metrology relies heavily on pressurized ionization chambers. Applications of these instruments include disseminating national standards and measurements of radiopharmaceuticals in nuclear medicine clinics. The challenge is that ionization chambers require electrical current measurements with high precision / accuracy (better than 0.1 %) and linearity over a wide range (more than 5 orders of magnitude). The aim is to upgrade the electrical current measurement systems for these instruments in order to reduce the dependence on artifact-based standards and to provide accurate (stable) traceability to the SI for the next 30+ years.

Background: A calibrated well-type ionization chamber is used to measure the radioactivity (disintegrations per second, Bq) of samples of gamma-ray-emitting radionuclides. Such a chamber consists of a gas-tight vessel containing a gas at high pressure placed between two electrodes with a potential difference of approximately 500 V. The sample of the radionuclide is placed at the center of the well in the chamber, and then the gamma rays emitted from the sample ionize the gas, which results in a relatively low, but measurable, current generally on the order of 10^{-13} A to 10^{-8} A (with a relative uncertainty of < 0.1 %). A major advantage of ionization chambers is that their response has been, historically, very stable (better than 0.1 %) over long-time periods (several decades). They are the instrument of choice at NMIs for maintaining standards of gamma-ray emitters, avoiding the need to repeat time-consuming primary standardizations of radionuclides.



Schematic of well-type ionization chamber (overall electric screen not shown)

From S. Giblin et al., 2009, *Nuclear Instruments and* Methods *in Physics Research Section A*

Ionization chambers have been used in radionuclide metrology for more than 50 years, and the electrical current measurement systems often use now-obsolete electrometers (traditionally based on the "Townsend Balance"). Significantly, these electrometers tend to experience non-linearities over the wide current range expected from the variety of radionuclides and activity levels measured. Therefore, these metrology systems rely on sets of sealed, long-lived and well-characterized, radioactive sources as reference points (to enable ratios of measurements). However, reliance on such artifacts, especially as they age, presents potentially serious safety (source leakage, breakage, etc.) and security (theft) concerns.

The Proposed Working Group: A joint working group of experts from measurements in the field of electricity (especially measurement of current), and from ionizing radiation (especially radionuclide metrology) to define the application, is the ideal mix to define and propose innovative approaches to the improvement of current measurements at low currents such as applied in radionuclide metrology. The primary requirements of such a current measurement system would be:

- Of the same or improved accuracy compared to present systems
- Forward-compatible for the next 30, 40, or more years (traceable)
- Of adequate linearity to obviate the need for radioactive sources to be used for reference

A variety of approaches in improving the measurement of low current (e.g., better calibration of high-value resistors, and single-electron pumps to calibrate amplifiers) have been in development over the last few years. One such technology, ultrastable low-noise current amplifiers (ULCA), is being investigated at the BIPM as one potential evolution in low-current measurements for ionization chambers used in radionuclide metrology. The joint working group would be expected to inform these activities, as well as to use the experiences obtained during the BIPM's investigations, to further working group discussions and documentary outputs. The working group would likely continue for the next few years until developments and implementation of new approaches in electrical metrology as applied to radionuclide metrology are well-established.

Chairperson

To be appointed by the CCEM and CCRI Presidents in consultation with CCEM and CCRI members

Members

- Representatives from CCEM
- Representatives from CCRI
- Executive Secretaries of the CCEM and the CCRI

Activities of the proposed Working Group

- To advise the CCEM and the CCRI on the measurement of low electrical currents for ionizing radiation metrology
- To provide input to the BIPM's technical program in this field
- To share information between electrical metrology and ionizing radiation metrology

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