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Development of Transfer Calibration Standards for Radon Measurements

J.M.R. Hutchinson, P. A. Mullen, and R. Collé
Center for Radiation Research
National Bureau of Standards
Washington, DC 20234

The national standard for radon measurement is embodied in a primary radon measurement system which has been maintained, for nearly 40 years, to accurately measure radon against both national and international radium standards. Readily available transfer calibration standards which are based on, or which have been compared directly with, this national standard are needed as a measurement reference basis by all laboratories performing radon measurements.

At present, the only transfer standards that are available are NBS ^{226}Ra solution standard reference materials which are used by some laboratories as their "primary" standard for radon. Although better laboratories can be expected to utilize this transfer standard with success, it is not practical for laboratories which do not maintain a large internal calibration capability. The use of this type of standard requires an indirect calibration based on a very careful quantitative extraction and collection of the radon from a solution. Many laboratories and users have encountered problems in using these solution standards and have encouraged NBS to provide more convenient and directly useable transfer standards.

NBS has recently initiated a modest program to address some of the needs for these standards and has sought additional external funding. Three program elements will be described.

Radon-in-Water Transfer Standard

With support provided by the U.S. Environmental Protection Agency, NBS has been developing and testing a regenerative radon-in-water transfer standard. At the present time, the most promising prototype consists of a source of ^{226}Ra attached to an ion exchange resin which is incorporated into a porous filter substrate. This source is then encapsulated into thin polyethylene. The polyethylene is relatively impervious to water, but ^{222}Rn diffuses through it. By immersing the source in a closed water system, constant concentrations of radon in water can be obtained from aliquants. Development of a suitable water sampling and transfer apparatus is also underway. Many variations in the type of ion-exchange resin, substrate and encapsulating plastic film have been tested. The results to date suggest that the detailed mechanisms for release of the radon from the resin filter source through the plastic and into the water are very complex and require greater understanding. Additional work must be done on testing the long-term stability of the standards and their performance under a variety of field conditions.

Radon-in-Air Transfer Standards

NBS has requested joint funding by the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission for the program to develop transfer calibration standards for measurement of radon concentration in air. The proposed program would consist of investigating the feasibility, performing exploratory research, and developing and testing two distinctly different types of transfer standards.

One alternative type of transfer standard may be a flow-through device using a solid ^{226}Ra source. A source of this type is available commercially. Several informal reports, however, have suggested that these commercial sources are not reliable. Furthermore, there is some reason to suspect that the nature of these commercial solid sources precludes their use as constant standards. (It is not known for certain since the form of the solid ^{226}Ra source and the fabrication details are considered proprietary information and have not been reported.) Little, if any, research has been performed to test the efficacy of the commercial solid sources, or to investigate the feasibility of other, possibly more promising solid forms. Our preliminary work on the solid-source regenerative radon-in-water standard is directly applicable for developing a solid-source radon-in-air standard.

An instrument-based transfer standard is an alternative to any type of source-based standard using radioactive material (liquid or solid). The usual method of calibrating instruments for many types of radiation measurements (e.g., x-rays) is to use a reference-class transfer instrument which is calibrated at NBS or at an intermediate calibration laboratory and transferred back to the user who then calibrates field instrumentation by making parallel measurements. By extension, an instrument-based transfer standard could be similarly employed for calibrating radon-measuring instruments at the field level, and would have advantages of simplicity and convenience over radioactive material standards. It is a rather simple matter for most users to obtain sufficiently high, but unknown radon concentrations (from any radium source, from drums of ore tailings, or even the soil). The difficult aspect of obtaining constant and <u>known</u> radon concentrations is obviated with an instrument-based transfer standard. Simple, well-designed and constructed ionization chambers may prove to be satisfactory.

Both the solid-source and instrument-based approaches to a radon transfer standard appear to be nearly equally worthy of consideration, and exploratory research on their development would hopefully be pursued simultaneously.

The proposed approaches may be summarized as follows:

1. Solid-Source Transfer Standard

    a) Perform exploratory research to select appropriate solid-source forms. Most promising approach appears to be incorporation of ^{226}Ra into highly selective ion-exchange resins which release radon. One variation is to use resin beads, and another is to use filter substrates either impregnated with or internally incorporating the ion exchange resin. The latter may have the advantage of providing a porous support medium that has a rigid pore structure. The radon emanation rate from a solid source is highly dependent on the solid's internal pore structure. Sources such as precipitated fatty-acid salts (e.g., radium stearates) or MnO_2 colums that have large emanation rates have pore structures that continually change with time.

b) Develop suitable prototype standards based on the exploratory research.

c) Test prototypes for delivering standardized quantities of radon, their constancy for intermittent use over long-time intervals, and the influence of external factors such as flow rate, temperature, pressure, and relative humidity.

d) If development is successful, adopt the transfer standard as an NBS standard reference material, and produce and distribute under the SRM program.

2. Instrument-Based Transfer Standard

a) Investigate suitability of air-filled or flow-through gamma-compensated, dual central-wire ionization chambers.

b) Design and construct prototype transfer standards (perhaps up to three ion-chamber variations).

c) Test prototypes for suitability as transfer standards, particularly the severity of ion-recombination effects, over a wide dynamic range of atmospheric variables.

d) Develop a calibration protocol, and test the transfer mechanism with several laboratories.

e) Disseminate instrument design and calibration protocol to commercial instrument manufacturers and interested laboratories.

Radon Test and Calibration Facility

This facility consists of an existing exposure chamber which is being adapted and modified. It will primarily be used to develop and test suitable radon transfer standards; and possibly in the future it will be used to provide direct measurement support services for external users.

The existing chamber is a 650 liter stainless steel (SS) vessel which is provided with sampling ports and equipped with a SS recirculation bellows pump and an all SS sampling and recirculation plumbing system. The system has the capability for measuring air flow rate (mass flow) at two locations and for monitoring ambient temperature, relative humidity and pressure. A continuous, flow-through radon concentration monitor (using a ZnS(Ag) scintillation cell) is partially complete. It is envisaged that the system will eventually incorporate additional controls and monitors to obtain environmentally controlled and regulated atmospheres.