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Standard Test Method for Determination of Radon Decay Product Concentration and Working Level in Indoor Atmospheres by Active Sampling on a Filter[1]

This standard is issued under the fixed designation D6327; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method provides instruction for using the grab sampling filter technique to determine accurate and reproducible measurements of indoor radon decay product (RDP) concentrations and of the working level (WL) value corresponding to those concentrations.

1.2 Measurements made in accordance with this test method will produce RDP concentrations representative of closed-building conditions. Results of measurements made under closed-building conditions will have a smaller variability and are more reproducible than measurements obtained when building conditions are not controlled. This test method may be utilized under non-controlled conditions, but a greater degree of variability in the results will occur. Variability in the results may also be an indication of temporal variability present at the sampling site.

1.3 This test method utilizes a short sampling period and the results are indicative of the conditions only at the place and time of sampling. The results obtained by this test method are not necessarily indicative of longer terms of sampling and should not be confused with such results. The averaging of multiple measurements over hours and days can, however, provide useful screening information. Individual measurements are generally obtained for diagnostic purposes.

1.4 The range of the test method may be considered from 0.0005 WL to unlimited working levels, and from 40 Bq/m^3 to unlimited for each individual radon decay product.

1.5 This test method provides information on equipment, procedures, and quality control. It provides for measurements within typical residential or building environments and may not necessarily apply to specialized circumstances, for example, clean rooms.

1.6 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* See Section 9 for additional precautions

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D1605 Practices for Sampling Atmospheres for Analysis of Gases and Vapors (Withdrawn 1992)[3]

D3631 Test Methods for Measuring Surface Atmospheric Pressure

E1 Specification for ASTM Liquid-in-Glass Thermometers

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D1356.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *grab sampling, n*—the act and all procedures involved with obtaining a short term sample through the use of an operating air pump.

3.2.2 *radon, n*—the particular isotope radon-222.

[1] This test method is under the jurisdiction of ASTM Committee D22 on Air Quality and is the direct responsibility of Subcommittee D22.05 on Indoor Air.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] The last approved version of this historical standard is referenced on www.astm.org.

3.2.3 *radon decay products (RDP), n*—any or all of the particular isotopes polonium-218, bismuth-214, lead-214, and polonium-214.

3.2.4 *working level, n*—quantity of short-lived decay products that will result in 1.3×10^6 MeV of potential alpha energy per litre of air. The working level is the common unit for expressing environmental RDP exposure.

4. Summary of Test Method (1)[4]

4.1 Grab sampling measurements of RDP concentrations in air are performed by collecting the RDP from a known volume of air on a filter and subsequently counting the activity on the filter following collection. The counting is performed at specified times for specified periods. The energy from radioactive decay of the particles collected on the filter is converted to light pulses by a zinc sulfide phosphor in contact with the filter. The light pulses are detected and converted to counts. Analysis of the number of counts in each counting interval determines the concentrations of the RDP. The two counting methods which have found the most general use are the Kusnetz and the modified Tsivoglou procedures (**2**).

5. Significance and Use

5.1 The test method provides a relatively simple method for determination of the concentration of RDP without the need for specialty equipment built expressly for such purposes.

5.2 Using this test method will afford investigators of radon in dwellings a technique by which the RDP can be determined. The use of the results of this test method are generally for diagnostic purposes and are not necessarily indicative of results that might be obtained by longer term measurement methods.

5.3 An improved understanding of the frequency of elevated radon in buildings and the health effect of exposure has increased the importance of knowledge of actual exposures. The measurement of RDP, which are the direct cause of potential adverse health effects, should be conducted in a manner that is uniform and reproducible; it is to this end that this test method is addressed.

6. Interferences

6.1 Interferences may be caused by any alpha-emitting particle capable of inducing a light pulse in the phosphor screen used for alpha-counting. In general, the only significant interference source is that of the decay products of radon-220, thoron, which may be considerable in certain geographical regions. The direction of the interference is always positive. The extent to which thoron decay products interfere can be estimated or measured through alpha-spectroscopy or serial type measurements (**3**).

6.2 Some depth penetration to the filter may occur. The extent of the penetration may be estimated using membrane filter types not suggested within this test method. The direction of interferences is always negative.

[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

7. Apparatus

7.1 *Collection Apparatus:*

7.1.1 Air pump capable of 10 to 12 L/min flow rate.

7.1.2 Bubble tube airflow calibration cell, 1 L or larger.

7.1.3 Calibrated dry gas meter.

7.1.4 Flow meter (optional).

7.1.5 Open-faced filter holder, 25 or 47-mm diameter.

7.1.6 Membrane filters, mixed cellulose ester, 25 or 47-mm diameter, 0.8-μm pore size.

7.1.7 Sharpened forceps, for removal of sample filters.

7.1.8 Stopwatch, accurate to 1 s.

7.2 *Decay Counting Apparatus:*

7.2.1 Zinc sulfide phosphor discs, 51-mm diameter.

7.2.2 *Scintillation Counter,* scaler and photomultiplier tube.

7.2.3 High voltage power supply.

7.3 Thermometer (see Specification E1).

7.4 Barometer (see Test Methods D3631).

8. Reagents and Materials

8.1 National Institute of Standards and Technology (NIST) traceable alpha calibration source, typically americium-241, to determine counter efficiency (**4**, **5**).

9. Hazards

9.1 Since radioactive material is being utilized, both in the form of calibration standards and particles collected on sample filters, wear disposable gloves during handling of these items.

9.2 If the atmospheres being measured are known to contain high concentrations of RDP, wear an HEPA half-mask respirator during sampling.

9.3 The calibration source from NIST must be shielded when not being used for calibration. Shield the source by returning the source to the original NIST storage container and placing the source in the original storage geometry within the container (**4**).

10. Preparation of Apparatus

10.1 Verify proper operation of the equipment prior to collection of the sample. Refer to equipment manuals for information.

10.1.1 Operate each counting system at the high-voltage (HV) and threshold settings that combines maximum stability, good counting efficiency, and low background counts. Each manufacturer's counting systems have different set-up requirements and optimization procedures. A general similar procedure is available (**6**).

10.2 Determine the counter efficiency and background for the sampling filter and phosphor screen pair prior to collection of the sample (see Section 11).

10.3 The air pump, filter assembly, and connecting tubing shall not leak.

10.4 A volume meter is needed for measuring total sample flow. A calibrated dry gas test meter is the most satisfactory total volume meter available for source test work. Calibrate the meter in the laboratory prior to use with a positive displacement liquid meter or a cylinder and piston flow calibrator, and determine a meter correction factor, C_M, as necessary.

10.5 Locate the scintillation counter to provide rapid access from the sampling site when the modified Tsivoglou counting procedure is utilized. This process is necessary due to the short time period between sampling and the start of counting.

11. Procedure

11.1 *Calibration of Scintillation Counter:*

11.1.1 Determine the efficiency of the scintillation counter through use of the NIST-traceable alpha-emitting calibration point source.

11.1.2 Deactivate the photomultiplier tube. Exposure of an activated photomultiplier tube to light while connected to power may permanently damage the photomultiplier tube.

NOTE 1—Although comments have been received indicating any light incident on the deactivated photomultiplier tube, even though completely disconnected from power, will result in spurious addition/deletions of light pulses. Tests conducted with four photomultiplier tubes of two designs at the Grand Junction DOE Facility Radon Chamber indicated no variation in background counts from photomultiplier tubes kept in the dark versus the same tubes with large mercury arc lamps over the tubes.

11.1.3 Place a fresh phosphor disc (phosphor side up) at the center of the photomultiplier lens.

11.1.4 Cover and activate the photomultiplier tube. The photomultiplier shall not be opened to light while activated or the electronics will be shocked. It is very important that there be no power to the opened photomultiplier.

11.1.5 Activate the scintillation counter for a defined counting interval in minutes, C_I. The counting interval shall be long enough to obtain at least 10 000 counts from the alpha-emitting source. The number of counts obtained from the phosphor is the background count, B_{cal}.

11.1.6 Deactivate the photomultiplier tube.

11.1.7 Determine the calibration source count. Using forceps, place the calibration point source on top and in the center of the same phosphor disc as used in 11.1.3.

11.1.8 Cover and then activate the photomultiplier tube. The photomultiplier shall not be opened to light while activated or the electronics will be shocked. It is very important that there be no power to the opened photomultiplier.

11.1.9 Activate the scintillation counter for the counting interval, C_I, and the number counts obtained is the measured calibration count, M_{cal}.

11.1.10 Calculate the efficiency of the counter using the equation in 12.2.

11.2 *Sample Measurement:*

11.2.1 Deactivate the photomultiplier tube.

11.2.2 Place a fresh phosphor disc at the center of the photomultiplier lens. Select a sampling filter with the forceps, and inspect the filter to determine if any tears are present: if so, discard. Place an acceptable sampling filter on top at the center of the phosphor disc, making sure the sampling surface is toward the phosphor disc. Secure the filter to the phosphor disc, and ensure complete contact by placing a flat cover plate over the filter. The cover plate shall completely cover the filter and have been previously checked to ensure no count contribution.

11.2.3 Obtain a count measurement for 10 min. For every set of measurements, utilize a phosphor disc that no longer shows enhanced activity from previous sampling measurements. Use the same phosphor disc for a filter before and after collection of a sample with the filter. If the total count for 10 min is greater than 10, replace the filter and phosphor disc pair and recount. The number is the background count, B, and is recorded in counts.

11.2.4 Remove the filter from the phosphor disc with the forceps and place in the filter holder with the counted side exposed to the air.

11.2.5 Reassemble the filter holder with care to prevent tearing of the filter.

11.2.6 Obtain the initial dry gas meter reading.

11.2.7 Draw sample air through the filter for 5.00 min.

11.2.8 Obtain the final dry gas meter reading and record the volume of air sampled in litres, V.

11.2.9 Disassemble the filter holder, and carefully transfer the filter from the filter holder onto the phosphor disc with which the background was just previously measured (exposed sample filter side oriented toward the phosphor disc). During the transfer, inspect the filter for tears. If a tear is found, discard and begin again. Cover the filter with the cover plate. Cover and reactivate the photomultiplier tube.

11.3 *Sample Counting*—Two different counting techniques are described in this section, a modified Tsivoglou Technique (see 11.3.1) and a Kusnetz Technique (see 11.3.2). Each technique requires a unique set of counting intervals. Additionally, each technique requires a separate set of calculations as listed in Section 12.

11.3.1 *Modified Tsivoglou Technique*—Operate the scintillation counter for the following time intervals. The intervals are measured from the time the 5.00 min sampling period has ended.

Count Designation, $M_{(ab)}$	Time Interval, T
$M_{(2–5)}$	2 to 5 min (3 min)
$M_{(6–20)}$	6 to 20 min (14 min)
$M_{(21–30)}$	21 to 30 min (9 min)

Record the total number of counts during each time interval M_{ab}, [$M_{(2–5)}$, $M_{(6–20)}$, and $M_{(21–30)}$].

NOTE 2—Other counting techniques have been devised and are presently in use. However, the most generally used counting technique is the one presented here.

11.3.2 *Modified Kusnetz Technique*—Operate the scintillation counter over any 10 min interval between 40 and 90 min after the start of sampling. Record the total counts for the 10 min interval, *K*, and the time (in minutes after the end of sampling), *t*, at the *center* of the 10 min interval.

11.4 Obtain the temperature, s, and the ambient atmospheric pressure, *p*, at the sampling site (see ASTM Standards in 2.1).

12. Calculation

12.1 *Air Volume*—Convert the volume of air sampled to the volume at standard conditions of 25°C and 101.3 kPa as follows:

$$V_R = \left[V \frac{P}{101.3} \right] \left[\frac{293.15}{S} \right] \quad (1)$$