



Standard Test Method for Alpha Particle Radioactivity of Water ¹

This standard is issued under the fixed designation D1943; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the measurement of alpha particle activity of water. It is applicable to nuclides that emit alpha particles with energies above 3.9 MeV and at activity levels above 0.02 Bq/mL (540 pCi/L) of radioactive homogeneous water. This test method is not applicable to samples containing alpha-emitting radionuclides that are volatile under conditions of the analysis.

1.2 This test method can be used for either absolute or relative determinations. In tracer work, the results may be expressed by comparison with a standard that is defined to be 100 %. For radioassay, data may be expressed in terms of alpha disintegration rates after calibration with a suitable standard. General information on radioactivity and measurement of radiation has been published ² and summarized in Practice D3648.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:³

D1129 Terminology Relating to Water

D1193 Specification for Reagent Water

¹ This test method is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.04 on Methods of Radiochemical Analysis.

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² Friedlander, G., et al., *Nuclear and Radiochemistry*, 3rd Ed., John Wiley and Sons, Inc., New York, NY, 1981.

Price, W. J., *Nuclear Radiation Detection*, 2nd Ed., McGraw-Hill Book Co., Inc., New York, NY, 1964.

Lapp, R. E., and Andrews, H. L., *Nuclear Radiation Physics*, 4th Ed., Prentice-Hall Inc., New York, NY, 1972.

Overman, R. T., and Clark, H. M., *Radioisotope Techniques*, McGraw-Hill Book Co., Inc., New York, NY, 1960.

³ 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.

D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water
D3370 Practices for Sampling Water from Closed Conduits
D3648 Practices for the Measurement of Radioactivity

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D1129. For terms not defined in this test method or in Terminology D1129, reference may be made to other published glossaries. ⁴

4. Summary of Test Method

4.1 The test sample is reduced by evaporation or a suitable chemical method to the minimum weight of material having measurable alpha activity. Alpha radioactivity is measured by an instrument composed of a detecting device, amplifier, power supply, and scaler—the most widely used being proportional and scintillation counters. In the proportional counter, which may be of the windowless or thin window type, alpha particles entering the sensitive region of the detector produce ionization of the counting gas. The negative ion of the original ion pair is accelerated towards the anode, producing additional ionization of the counting gas and developing a voltage pulse at the anode. In the scintillation detector, alpha particles interact with the material of the phosphor, transferring some of their energy to electrons. These electrons subsequently lose part of their energy by excitation rather than ionization of atoms, and the excited atoms revert to the ground state by re-emitting energy in the form of light quanta. A suitable light-sensitive device, usually a multiplier phototube, transforms the resulting flashes of light into voltage impulses. By use of suitable electronic apparatus, the pulse is amplified to a voltage sufficient for operation of the counting scaler. The number of pulses per unit time is related to the disintegration rate of the test sample. The efficiency of the system can be determined by use of a suitable alpha standard having equivalent residual plated solids.

5. Significance and Use

5.1 This test method was developed for the purpose of measuring gross alpha radioactivity in water. It is used for the

⁴ American National Standard Glossary of Terms in Nuclear Science and Technology (ANSI N1.1) available from the American National Standards Institute, 1430 Broadway, New York, NY 10018.

analysis of both process and environmental water to determine gross alpha activity which is often a result of natural radioactivity present in minerals.

6. Measurement Variables

6.1 The relatively high absorption of alpha particles in the sample media affects the counting rate of the measurement. Effects of geometry, back-scatter, source diameter, as well as the purity, pressure variation, and type of counting gas used shall also be considered. Thus, for reliable relative measurements, the variables shall be held constant while counting all test samples and standards. For absolute measurements, appropriate efficiency factors shall be applied. If a windowless proportional counter is employed, the sample mount shall be electrically conducting.

6.1.1 In tracer studies or tests requiring only relative measurements, in which the data are expressed as being equivalent to a defined standard, the above correction factors can be simply combined into a counting efficiency factor. The use of a counting efficiency factor requires that sample mounting, material of mounting dish, and weight of residue (milligrams per square centimetre), in addition to conditions affecting the above described factors, remain constant throughout the duration of the test and that the comparative standard be prepared for counting in the same manner as the test samples. The data from comparative studies between independent laboratories when not expressed in absolute units are more meaningful when expressed as percentage relationships or as equivalent of a defined standard.

6.2 The limit of sensitivity for both scintillation and proportional counters is a function of the background counting rate which should be as low as is feasible. Massive shielding is not used for alpha counters. The maximum activity for this test method is 1600 Bq.

7. Interferences

7.1 Solids content in the sample containing the alpha emitter produces significant losses in sample counting rates of about 10 to 15 % loss at 1 mg/cm². Liquid samples shall be evaporated to dryness onto dishes that allow the sample to be counted directly by the detector. Solids on the dish shall remain constant in amount between related test samples, and should duplicate the density of the solids of the plated standard.

7.2 Most alpha counters are insensitive to beta, gamma, and X radiations.²

8. Apparatus

8.1 *Alpha Particle Counter*, consisting of either a proportional detector or a scintillation detector, and a scaler conforming to the following requirements:

8.1.1 *Proportional Detector*—This may be one of several types commercially available. The material used in the construction of the detector should contain a minimal amount of detectable radioactivity. To establish freedom from undesirable characteristics, the manufacturer shall supply voltage plateau and background counting rate data. Voltage plateau data shall show the threshold voltage, slope, and length of plateau for a particular input sensitivity.

8.1.2 *Scintillation Detector*—This may be one of several types commercially available. It shall consist of an “activated” zinc sulfide phosphor having a minimum effective diameter of 36.5 mm and a superficial density of 10 to 15 mg/cm². The phosphor shall be mounted so that it can be attached and optically coupled to a multiplier phototube. Extraneous light shall be excluded from the phosphor either by its being covered with a thin (less than 1 mg/cm²) opaque window or by enclosing the assembly in a lightproof sample changer. The material used in the construction of the detector shall be free from detectable radioactivity. To establish freedom from undesirable characteristics, the manufacturer shall supply voltage plateau and background counting rate data. Voltage plateau data shall show the threshold voltage, slope, and length of a plateau for a specified scaler sensitivity.

8.1.3 *Scaler*—Often the scaler, mechanical register, power supply, and amplifier are contained in a single chassis, generally termed the scaler. The power supply and amplifier sections shall be matched with the type of detector to produce satisfactory operating characteristics and to provide sufficient range in adjustments to maintain controlled conditions. The manufacturer shall provide resolving time information for the counting system. The scaler shall have capacity for storing and visually displaying at least 10⁶ counts with a resolving time no greater than 5 μs. The instrument shall have an adjustable input sensitivity that can be matched to the detector and a variable high voltage power supply with indicating meter.

8.2 *Sample Mounting Dish*—Dishes having a flat bottom of a diameter slightly less than the inside diameter of the detector. Flat dishes are preferred, but dishes may be used that have 3.2-mm high side walls with the angle between dish bottom and side equal to or greater than 120°. Dishes shall be of a material that will not corrode under the plating conditions and shall be of uniform surface density; platinum and stainless steel have been used for this purpose.

9. Reagents

9.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.⁵ Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity and free from radioactivity to preclude detrimental effects. Some chemicals, even of high purity, contain naturally occurring radioactive elements, for example, uranium, actinium, and thorium. Consequently, when carrier chemicals are used in the analysis of low-radioactivity samples, the radioactivity of the carriers shall be determined under identical analytical conditions of the sample including

⁵ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.