



Designation: D1890 – 15 (Reapproved 2025)

Standard Test Method for Beta Particle Radioactivity of Water¹

This standard is issued under the fixed designation D1890; 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 U.S. Department of Defense.

1. Scope

1.1 This test method covers the measurement of beta particle activity of water. It is applicable to beta emitters having maximum energies above 0.1 MeV and at activity levels above 0.02 Bq/mL (540 pCi/L) of radioactive homogeneous water for most counting systems. This test method is not applicable to samples containing 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 which is defined to be 100 %. For radioassay, data may be expressed in terms of a known radionuclide standard if the radionuclides of concern are known and no fractionation occurred during processing, or may be expressed arbitrarily in terms of some other standard such as ¹³⁷Cs. General information on radioactivity and measurement of radiation may be found in the literature^{2, 3, 4, 5} and Practices D3648.

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

1.4 *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.*

1.5 *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:⁶

D1129 Terminology Relating to Water

D1193 Specification for Reagent Water

D2777 Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water

D3370 Practices for Sampling Water from Flowing Process Streams

D3648 Practices for the Measurement of Radioactivity

3. Terminology

3.1 Definitions:

3.1.1 For terms not defined in this standard or in Terminology D1129, reference may be made to other published glossaries.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *becquerel, n*—a unit of radioactivity equivalent to 1 nuclear transformation per second.

3.2.2 *beta energy, maximum, n*—the maximum energy of the beta-particle energy spectrum produced during beta decay of a given radioactive species.

3.2.2.1 *Discussion*—Since a given beta-particle emitter may decay to several different quantum states of the product nucleus, more than one maximum energy may be listed for a given radioactive species.

3.2.3 *counter background, n*—in the measurement of radioactivity, the counting rate resulting from factors other than the radioactivity of the sample and reagents used.

3.2.3.1 *Discussion*—Counter background varies with the location, shielding of the detector, and the electronics; it includes cosmic rays, contaminating radioactivity and electrical noise.

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.

Current edition approved Dec. 1, 2025. Published December 2025. Originally approved in 1961. Last previous edition approved in 2017 as D1890 – 15 (2017). DOI: 10.1520/D1890-15R25.

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

³ Price, W. J., *Nuclear Radiation Detection*, 2nd Ed., McGraw-Hill Book Co., Inc., New York, NY, 1964.

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

⁵ Overman, R. T., and Clark, H. M., *Radioisotope Techniques*, McGraw-Hill Book Co., Inc., New York, NY, 1960.

⁶ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.4 *counter beta-particle efficiency, n —in the measurement of radioactivity*, that fraction of beta particles emitted by a source which is detected by the counter.

3.2.5 *counter efficiency, n —in the measurement of radioactivity*, that fraction of the disintegrations occurring in a source which is detected by the counter.

3.2.6 *radioactive homogeneous water, n —water in which the radioactive material is uniformly dispersed throughout the volume of water sample and remains so until the measurement is completed or until the sample is evaporated or precipitating reagents are added to the sample.*

3.2.7 *reagent background, n —in the measurement of radioactivity of water samples*, the counting rate observed when a sample is replaced by mock sample salts or by reagent chemicals used for chemical separations that contain no analyte.

3.2.7.1 *Discussion*—Reagent background varies with the reagent chemicals and analytical methods used and may vary with reagents from different manufacturers and from different processing lots.

4. Summary of Test Method

4.1 Beta radioactivity may be measured by one of several types of instruments composed of a detecting device and combined amplifier, power supply, and scaler—the most widely used being proportional or Geiger-Müller counters. Where a wide range of counting rates is encountered (0.1 to 1300 counts per seconds), the proportional-type counter is preferable due to a shorter resolving time and greater stability of the instrument. The test sample is reduced to the minimum weight of solid material having measurable beta activity by precipitation, ion exchange resin, or evaporation techniques. Beta 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. By use of suitable electronic apparatus, the pulse is amplified to a voltage sufficient for operation of the counter scaler. The number of pulses per unit of time is related to the disintegration rate of the test sample. The beta-particle efficiency of the system can be determined by use of prepared standards having the same radionuclide composition as the test specimen and equivalent residual plated solids. An arbitrary efficiency factor can be defined in terms of some other standard such as cesium-137.

5. Significance and Use

5.1 This test method was developed for the purpose of measuring the gross beta radioactivity in water. It is used for the analysis of both process and environmental water to determine gross beta activity.

6. Measurement Variables

6.1 The relatively high absorption of beta particles in the sample media and any material interposed between source and sensitive volume of the counter results in an interplay of many variables which affect the counting rate of the measurement.

Thus, for reliable relative measurements, hold all variables constant while counting all test samples and standards. For absolute measurements, appropriate correction factors are applied. The effects of geometry, backscatter radiation, source diameter, self-scatter and self-absorption, absorption in air and detector window for external counters, and counting coincidence losses have been discussed^{2, 3, 4, 5} and may be described by the following relation:

$$cps = Bq_b(G_p)(f_{bs})(f_{aw})(f_d)(f_{ssa})(f_c) \quad (1)$$

where:

- cps = recorded counts per second corrected for background,
- Bq_b = disintegrations per second yielding beta particles,
- G_p = point source geometry (defined by the solid angle subtended by the sensitive area of the detector),
- f_{bs} = backscatter factor or ratio of cps with backing to cps without backing,
- f_{aw} = factor to correct for losses due to absorption in the air and window of external detectors. It is equal to the ratio of the actual counting rate to that which would be obtained if there were no absorption by the air and window between the source and sensitive volume of the detector. Expressed in terms of absorption coefficient and density of absorber, $f_{aw} = e^{-\mu x}$, where μ = absorption coefficient, in square centimetres per milligram, and x = absorber density in milligrams per square centimetre.
- f_d = factor to correct a spread source counting rate to the counting rate of the same activity as a point source on the same axis of the system,
- f_{ssa} = factor to correct for the absorption and scatter of beta particles within the material accompanying the radioactive element, and
- f_c = factor for coincident events to correct the counting rate for instrument resolving time losses and defined by the simplified equation, $f_c = 1 - nr$, where, n = the observed counts per second, and r = instrument resolving time in seconds. Generally, the sample size or source to detector distance is varied to obtain a counting rate that precludes coincident losses. Information on the effect of random disintegration and instrument resolving time on the sample count rate as well as methods for determining the resolving time of the counting system may be found in the literature.

For most applications, a detector system is calibrated using a single beta emitting radionuclide and an efficiency of detection, f_o , response curve generated for various sample residue weights. The efficiency of detection for each sample residual weight incorporates all the factors mentioned above so that:

$$f_o = cps/Bq = (G_p)(f_{bs})(f_{aw})(f_d)(f_{ssa})(f_c) \quad (2)$$

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, density of mounting dish, weight of residue in milligrams per square centimetre, and radionuclide composition, in addition to