



Designation: E496 – 14 (Reapproved 2022)

Standard Test Method for Measuring Neutron Fluence and Average Energy from $^3\text{H}(d,n)^4\text{He}$ Neutron Generators by Radioactivation Techniques¹

This standard is issued under the fixed designation E496; 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 covers a general procedure for the measurement of the fast-neutron fluence rate produced by neutron generators utilizing the $^3\text{H}(d,n)^4\text{He}$ reaction. Neutrons so produced are usually referred to as 14-MeV neutrons, but range in energy depending on a number of factors. This test method does not adequately cover fusion sources where the velocity of the plasma may be an important consideration.

1.2 This test method uses threshold activation reactions to determine the average energy of the neutrons and the neutron fluence at that energy. At least three activities, chosen from an appropriate set of dosimetry reactions, are required to characterize the average energy and fluence. The required activities are typically measured by gamma-ray spectroscopy.

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:*²

E170 Terminology Relating to Radiation Measurements and Dosimetry

E181 Test Methods for Detector Calibration and Analysis of Radionuclides

E261 Practice for Determining Neutron Fluence, Fluence Rate, and Spectra by Radioactivation Techniques

E265 Test Method for Measuring Reaction Rates and Fast-Neutron Fluences by Radioactivation of Sulfur-32

E720 Guide for Selection and Use of Neutron Sensors for Determining Neutron Spectra Employed in Radiation-Hardness Testing of Electronics

2.2 *International Commission on Radiation Units and Measurements (ICRU) Reports:*³

ICRU Report 13 Neutron Fluence, Neutron Spectra and Kerma

ICRU Report 26 Neutron Dosimetry for Biology and Medicine

2.3 *ISO Standard:*⁴

Guide to the Expression of Uncertainty in Measurement

2.4 *NIST Document:*⁵

Technical Note 1297 Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results

3. Terminology

3.1 *Definitions*—Refer to Terminology **E170**.

4. Summary of Test Method

4.1 This test method describes the determination of the average neutron energy and fluence by use of three activities

¹ This test method is under the jurisdiction of ASTM Committee **E10** on Nuclear Technology and Applications and is the direct responsibility of Subcommittee **E10.07** on Radiation Dosimetry for Radiation Effects on Materials and Devices.

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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 Available from the International Commission on Radiation Units, 7910 Woodmont Ave., Washington, DC 20014.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, <http://www.nist.gov>.

from a select list of dosimetry reactions. Three dosimetry reactions are chosen based on a number of factors including the intensity of the neutron field, the reaction half-lives, the slope of the dosimetry reaction cross section near 14 MeV, and the minimum time between sensor irradiation and the gamma counting. The activities from these selected reactions are measured. Two of the activities are used, in conjunction with the nuclear data for the dosimetry reactions, to determine the average neutron energy. The third activity is used, along with the neutron energy and nuclear data for the selected reaction, to determine the neutron fluence. The uncertainty of the neutron energy and the neutron fluence is determined from the activity measurement uncertainty and from the nuclear data.

5. Significance and Use

5.1 Refer to Practice E261 for a general discussion of the measurement of fast-neutron fluence rates with threshold detectors.

5.2 Refer to Test Method E265 for a general discussion of the measurement of fast-neutron fluence rates by radioactivation of sulfur-32.

5.3 Reactions used for the activity measurements can be chosen to provide a convenient means for determining the absolute fluence rates of 14-MeV neutrons obtained with $^3\text{H}(d, n)^4\text{He}$ neutron generators over a range of irradiation times from seconds to approximately 100 days. High-purity threshold sensors referenced in this test method are readily available.

5.4 The neutron-energy spectrum must be known in order to measure fast-neutron fluence using a single threshold detector. Neutrons produced by bombarding a tritiated target with deuterons are commonly referred to as 14-MeV neutrons; however, they can have a range of energies depending on: (1) the angle of neutron emission with respect to the deuteron beam, (2) the kinetic energy of the deuterons, and (3) the target thickness. In most available neutron generators of the

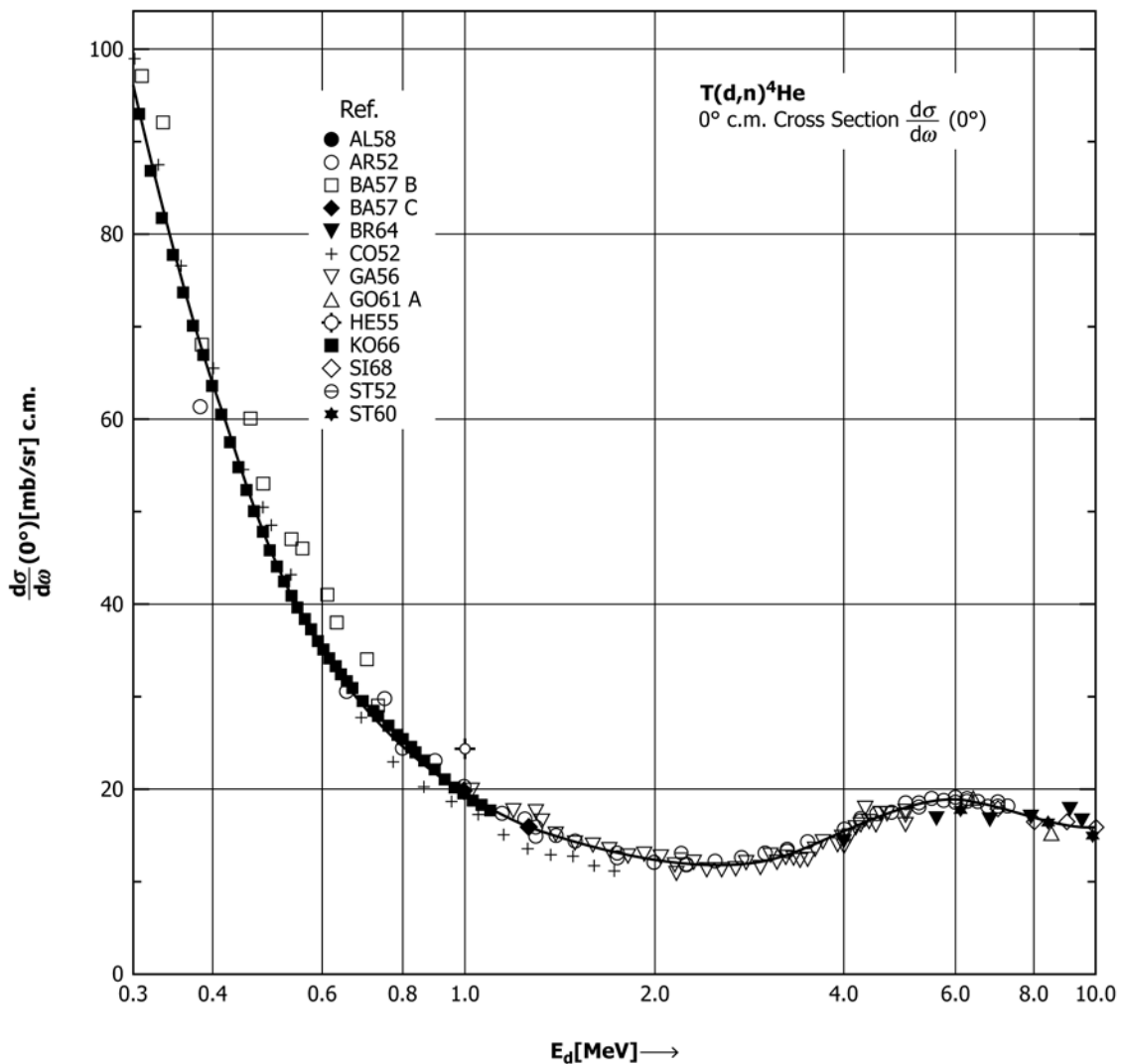


FIG. 1 Variation of 0 Degree $^3\text{H}(d, n)^4\text{He}$ Differential Cross Section with Incident Deuteron Energy (1)