Designation: E 481 – 03

Standard Test Method for Measuring Neutron Fluence Rates by Radioactivation of Cobalt and Silver[1]

This standard is issued under the fixed designation E 481; 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 suitable means of obtaining the thermal neutron fluence rate, or fluence, in well moderated nuclear reactor environments where the use of cadmium, as a thermal neutron shield as described in Method E 262, is undesirable because of potential spectrum perturbations or of temperatures above the melting point of cadmium.

1.2 This test method describes a means of measuring a Westcott neutron fluence rate (Note 1) by activation of cobalt- and silver-foil monitors (See Terminology E 170). The reaction $^{59}Co(n,\gamma)^{60}Co$ results in a well-defined gamma emitter having a half-life of 1925.5 days **(1)**.[2] The reaction $^{109}Ag(n,\dot{\gamma})^{110m}Ag$ results in a nuclide with a complex decay scheme which is well known and having a half-life of 249.76 days **(14)**. Both cobalt and silver are available either in very pure form or alloyed with other metals such as aluminum. A reference source of cobalt in aluminum alloy to serve as a neutron fluence rate monitor wire standard is available from the National Institute of Standards and Technology (NIST) as Standard Reference Material 953.[3] The competing activities from neutron activation of other isotopes are eliminated, for the most part, by waiting for the short-lived products to die out before counting. With suitable techniques, thermal neutron fluence rate in the range from 10^9 cm$^{-2}\cdot$ s^{-1} to 3×10^{15} cm$^{-2}\cdot$ s^{-1} can be measured. For this method to be applicable, the reactor must be well moderated and be well represented by a Maxwellian low-energy distribution and an (1/*E*) epithermal distribution. These conditions are usually met in positions surrounded by hydrogenous moderator without nearby strongly absorbing materials. Otherwise the true spectrum must be calculated to obtain effective activation cross sections over all energies.

NOTE 1—Westcott fluence rate = $v_0\int_0^\infty n(v)dv$.

1.3 The values stated in SI units are to be regarded as the 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 170 Terminology Relating to Radiation Measurements and Dosimetry[4]

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods[5]

E 181 Test Methods for Detector Calibration and Analysis of Radionuclides[4]

E 262 Test Method for Determining Thermal Neutron Reaction and Fluence Rates by Radioactivation Techniques[4]

3. Significance and Use

3.1 The pertinent data for these two reactions are given in Table 1. This test method uses one monitor (cobalt) with a nearly 1/*v* absorption cross-section curve and a second monitor (silver) with a large resonance peak so that its resonance integral is large compared to the thermal cross section. The equations are based on the Westcott formalism **(3, 4)** and determine a Westcott 2200 m/s neutron fluence rate nv_0 and the Westcott epithermal index parameter $r\sqrt{T/T_0}$. References **5, 6,** and **7** contain a general discussion of the two-reaction test method. In this test method, the absolute activities of both cobalt and silver monitors are determined. This differs from the test method in the references wherein only one absolute activity is determined.

3.2 The advantages of this test method are the elimination of three difficulties associated with the use of cadmium: (*1*) the perturbation of the field by the cadmium; (*2*) the inexact cadmium cut-off energy; (*3*) the low melting temperature of cadmium. In addition, the reactivity changes accompanying the rapid insertion and removal of cadmium may prohibit the use of the cadmium-ratio method. However, the self-shielding

[1] This test method is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.05 on Nuclear Radiation Metrology.

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[2] The boldface numbers in parentheses refer to references listed at the end of this test method.

[3] Standard Reference Material 953 is available from National Institute of Standards and Technology, U.S. Dept. of Commerce, Washington, DC 20234.

[4] *Annual Book of ASTM Standards*, Vol 12.02.

[5] *Annual Book of ASTM Standards*, Vol 14.02.

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