INTERNATIONAL

Designation: ~~E526 – 17~~ E526 – 17$^{\varepsilon 1}$

Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Titanium[1]

This standard is issued under the fixed designation E526; 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.

ε^1 NOTE—Editorial changes, such as removing extra spacing, correcting notation and a variable, were made in November 2017.

1. Scope

1.1 This test method covers procedures for measuring reaction rates by the activation reactions ^{46}Ti(n,p)^{46}Sc + ^{47}Ti(n, np)^{46}Sc + ^{47}Ti(n,d)^{46}Sc.

NOTE 1—The cross section for the ^{47}Ti(n,np+d) reaction is relatively small for energies less than 12 MeV and is not easily distinguished from that of the ^{46}Ti(n,p) reaction. This test method will apply to the composite ^{nat}Ti(n,X)^{46}Sc reaction that is typically used for dosimetry purposes.

1.2 The reaction is useful for measuring neutrons with energies above approximately 4.4 MeV and for irradiation times, under uniform power, up to about 250 days (for longer irradiations, or for varying power levels, see Practice E261).

1.3 With suitable techniques, fission-neutron fluence rates above 10^9 $cm^{-2}\cdot s^{-1}$ can be determined. However, in the presence of a high thermal-neutron fluence rate, ^{46}Sc depletion should be investigated.

1.4 Detailed procedures for other fast-neutron detectors are referenced in Practice E261.

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

1.6 *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.*

1.7 *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
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E181 Test Methods for Detector Calibration and Analysis of Radionuclides
E261 Practice for Determining Neutron Fluence, Fluence Rate, and Spectra by Radioactivation Techniques
E456 Terminology Relating to Quality and Statistics
E844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance
E944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance
E1005 Test Method for Application and Analysis of Radiometric Monitors for Reactor Vessel Surveillance
E1018 Guide for Application of ASTM Evaluated Cross Section Data File

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminologies E170 and E456.

---

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

Current edition approved Aug. 1, 2017. Published October 2017. Originally approved in 1976. Last previous edition approved in 2013 as E526 – 08(2013). DOI: ~~10.1520/E0526-17.~~10.1520/E0526-17E01.

[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.

4. Summary of Test Method

4.1 High-purity titanium is irradiated in a fast-neutron field, thereby producing radioactive ^{46}Sc from the ^{46}Ti(n,p)^{46}Sc activation reaction.

4.2 The gamma rays emitted by the radioactive decay of ^{46}Sc are counted in accordance with Methods E181 and the reaction rate, as defined by Test Method E261, is calculated from the decay rate and the irradiation conditions.

4.3 The neutron fluence rate above about 4.4 MeV can then be calculated from the spectral-weighted neutron activation cross section as defined by Test Method E261.

5. Significance and Use

5.1 Refer to Guide E844 for the selection, irradiation, and quality control of neutron dosimeters.

5.2 Refer to Test Method E261 for a general discussion of the determination of fast-neutron fluence rate with threshold detectors.

5.3 Titanium has good physical strength, is easily fabricated, has excellent corrosion resistance, has a melting temperature of 1668°C, and can be obtained with satisfactory purity.

5.4 ^{46}Sc has a half-life of 83.787 (16)[3] days(**1**).[4] The ^{46}Sc decay emits a 0.889271 (2) MeV gamma 99.98374 (35) % of the time and a second gamma with an energy of 1.120537 (3) MeV 99.97 (2) % of the time.

5.5 The isotopic content of natural titanium recommended for ^{46}Ti is 8.25 %. (**2**)

5.6 The radioactive products of the neutron reactions ^{47}Ti(n,p)^{47}Sc ($\tau_{1/2}$ = 3.3485 (9) d) (**1**) and ^{48}Ti(n,p)^{48}Sc ($\tau_{1/2}$ = 43.67 h), (**2**) might interfere with the analysis of ^{46}Sc.

5.7 Contaminant activities (for example, ^{65}Zn and ^{182}Ta) might interfere with the analysis of ^{46}Sc. See 7.1.2 and 7.1.3 for more details on the ^{182}Ta and ^{65}Zn interference.

5.8 ^{46}Ti and ^{46}Sc have cross sections for thermal neutrons of 0.59 ± 0.18 and 8.0 ± 1.0 barns, respectively (**3**); therefore, when an irradiation exceeds a thermal-neutron fluence greater than about 2 × 10^{21} cm^{-2}, provisions should be made to either use a thermal-neutron shield to prevent burn-up of ^{46}Sc or measure the thermal-neutron fluence rate and calculate the burn-up.

5.9 Fig. 1 shows a plot of the Russian Reactor Dosimetry File (RRDF-2002) cross section (**4**) versus neutron energy for the fast-neutron reactions of titanium which produce ^{46}Sc [that is, ~~Nat~~^{nat}Ti(n,X)^{46}Sc]. This cross section is identical, for energies up to 20 MeV, to what is found in the latest International Atomic Energy Agency (IAEA) International Reactor Dosimetry and Fusion File, IRDFF-1.05 (**5**). Included in the plot is the ^{46}Ti(n,p) reaction and the ^{47}Ti(n,np) contribution to the ^{46}Sc production, normalized per ^{46}Ti atom using the natural abundances (**2**). This figure is for illustrative purposes only to indicate the range of response of the ^{nat}Ti(n,p) ^{46}Sc reaction. Refer to Guide E1018 for descriptions of recommended tabulated dosimetry cross sections. Fig. 2 compares the cross section for the ^{46}Ti(N,p)^{47}Sc reaction to the current experimental database (**6, 7**).Fig. 3 compares the cross section for the ^{47}Ti(N, np+d) reaction to the current experimental database (**6, 7**).

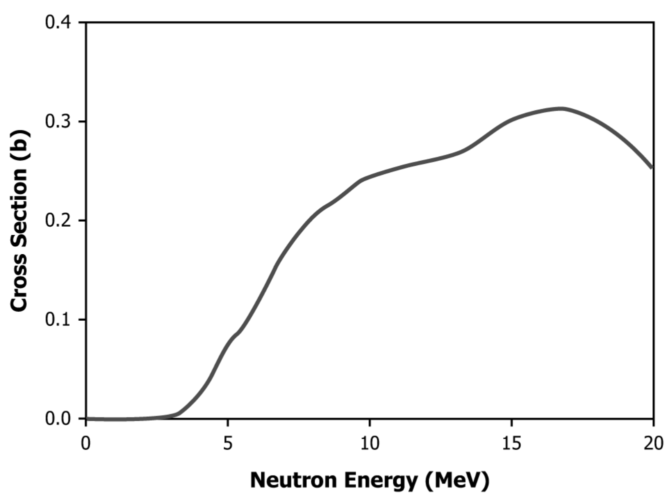

FIG. 1 ^{Nat}Ti(n,X)^{46}Sc Cross Section (Normalized per Ti-46 Atom Using Natural Abundance Data)

[3] The value of uncertainty, in parentheses, refers to the corresponding last digits, thus 14.958(2) corresponds to 14.958 ± 0.002.

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