Designation: E263 – 18

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

This standard is issued under the fixed designation E263; 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 describes procedures for measuring reaction rates by the activation reaction $^{54}Fe(n,p)^{54}Mn$.

1.2 This activation reaction is useful for measuring neutrons with energies above approximately 2.2 MeV and for irradiation times up to about three years, provided that the analysis methods described in Practice E261 are followed. If dosimeters are analyzed after irradiation periods longer than three years, the information inferred about the fluence during irradiation periods more than three years before the end of the irradiation should not be relied upon without supporting data from dosimeters withdrawn earlier.

1.3 With suitable techniques, fission-neutron fluence rates above 10^8 $cm^{-2}·s^{-1}$ can be determined. However, in the presence of a high thermal-neutron fluence rate (for example, $>2 \times 10^{14}$ $cm^{-2}·s^{-1}$) ^{54}Mn depletion should be investigated.

1.4 Detailed procedures describing the use of 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]

D1193 Specification for Reagent Water

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

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 Terminology E170 for definitions of terms relating to radiation measurements and neutron dosimetry.

4. Summary of Test Method

4.1 High-purity iron is irradiated in a neutron field, thereby producing radioactive ^{54}Mn from the $^{54}Fe(n,p)^{54}Mn$ activation reaction.

4.2 The gamma rays emitted by the radioactive decay of ^{54}Mn are counted in accordance with Test Methods E181. The reaction rate, as defined by Practice E261, is calculated from the decay rate and irradiation conditions.

4.3 Radioassay of the ^{54}Mn activity may be accomplished by directly counting the irradiated iron dosimeter, or by first chemically separating the ^{54}Mn activity prior to counting.

[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.

Current edition approved Dec. 1, 2018. Published January 2019. Originally approved in 1965 as E263 – 65 T. Last previous edition approved in 2013 as E263 – 13. DOI: 10.1520/E0263-18.

[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.

4.4 The neutron fluence rate above about 2.2 MeV can then be calculated from the spectral-weighted neutron activation cross section as defined by Practice E261.

5. Significance and Use

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

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

5.3 Pure iron in the form of foil or wire is readily available and easily handled.

5.4 Fig. 1 shows a plot of cross section as a function of neutron energy for the fast-neutron reaction $^{54}Fe(n,p)^{54}Mn$ (**1**).[3] This figure is for illustrative purposes only to indicate the range of response of the $^{54}Fe(n,p)^{54}Mn$ reaction. Refer to Guide E1018 for recommended tabulated dosimetry cross sections.

5.5 ^{54}Mn has a half-life of 312.19 (3) days[4] (**2**) and emits a gamma ray with an energy of 834.855 (3) keV (**2**).

5.6 Interfering activities generated by neutron activation arising from thermal or fast neutron interactions are 2.57878 (46)-h ^{56}Mn, 44.494 (12) days ^{59}Fe, and 5.2711 (8) years ^{60}Co (**2,3**). (Consult the latest version of Ref (**2**) for more precise values currently accepted for the half-lives.) Interference from ^{56}Mn can be eliminated by waiting 48 h before counting. Although chemical separation of ^{54}Mn from the irradiated iron is the most effective method for eliminating ^{59}Fe and ^{60}Co, direct counting of iron for ^{54}Mn is possible using high-resolution detector systems or unfolding or stripping techniques, especially if the dosimeter was covered with cadmium or boron during irradiation. Altering the isotopic composition of the iron dosimeter is another useful technique for eliminating interference from extraneous activities when direct sample counting is to be employed.

5.7 The vapor pressures of manganese and iron are such that manganese diffusion losses from iron can become significant at temperatures above about 700°C. Therefore, precautions must be taken to avoid the diffusion loss of ^{54}Mn from iron dosimeters at high temperature. Encapsulating the iron dosimeter in quartz or vanadium will contain the manganese at temperatures up to about 900°C.

5.8 Sections 6, 7 and 8 that follow were specifically written to describe the method of chemical separation and subsequent counting of the ^{54}Mn activity. When one elects to count the iron dosimeters directly, those portions of Sections 6, 7 and 8 that pertain to radiochemical separation should be disregarded.

NOTE 1—The following portions of this test method apply also to direct sample-counting methods: 6.1 – 6.3, 7.4, 7.9, 7.10, 8.1 – 8.5, 8.18, 8.19, and 9 – 12.

6. Apparatus (Note 1)

6.1 *High–Resolution Gamma-Ray Spectrometer,* because of its high resolution, the germanium detector is useful when contaminant activities are present. See Test Methods E181 and E1005.

6.2 *Precision Balance,* able to achieve the required accuracy.

6.3 *Digital Computer,* useful for data analysis (optional).

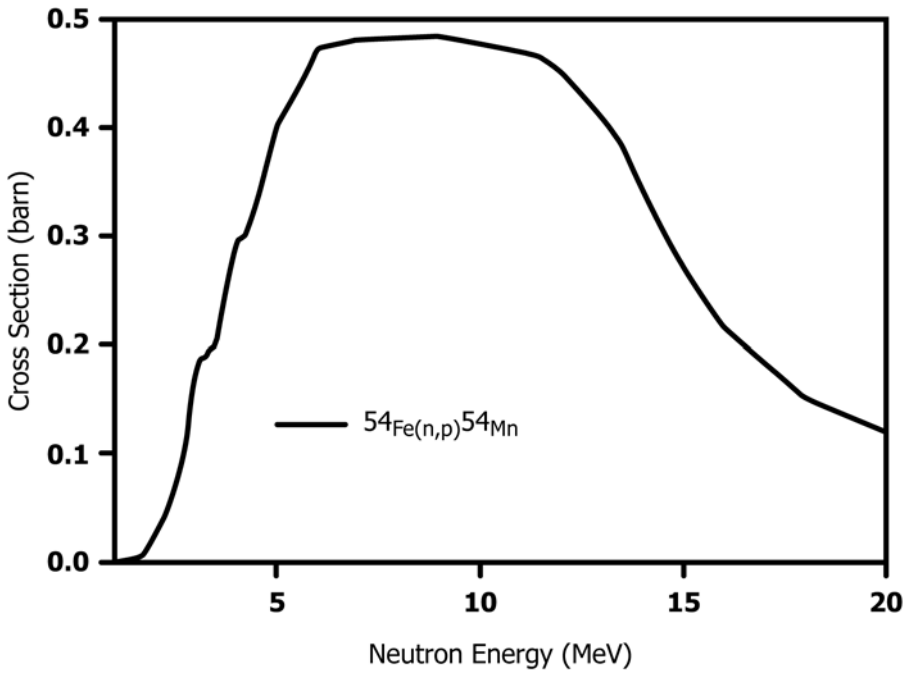

FIG. 1 $^{54}Fe(n,p)^{54}Mn$ Cross Section

[3] The boldface numbers in parentheses refer to the list of references located at the end of this test method.

[4] The un-bolded number in parenthesis after the unit indicates the uncertainty in the least significant digits. For example, 1.89 (2) keV would indicate a value of 1.89 keV ± 0.02 keV.