



Standard Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Iron¹

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This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method describes procedures for measuring reaction rates by the activation reaction $^{54}\text{Fe} (n,p) ^{54}\text{Mn}$.

1.2 This activation reaction is useful for measuring neutrons with energies above approximately 2.2 MeV and for irradiation times up to about 3 years (for longer irradiations, see Practice E 261).

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

1.4 Detailed procedures for other fast-neutron detectors are referenced in Practice E 261.

1.5 *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:

D 1193 Specification for Reagent Water²

E 170 Terminology Relating to Radiation Measurements and Dosimetry³

E 181 Test Methods for Detector Calibration and Analysis of Radionuclides³

E 261 Practice for Determining Neutron Fluence Rate, Fluence, and Spectra by Radioactivation Techniques³

E 844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E 706(IIC)³

E 944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, (IIA)³

E 1005 Test Method for Application and Analysis of Radiometric Monitors for Reactor Vessel Surveillance, E 706(IIIA)³

E 1018 Guide for Application of ASTM Evaluated Cross

Section Data File, Matrix E 706(IIB)³

3. Terminology

3.1 Definitions:

3.1.1 Refer to ASTM Standard E 170 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 $^{54}\text{Fe} (n,p) ^{54}\text{Mn}$ activation reaction.

4.2 The gamma rays emitted by the radioactive decay of ^{54}Mn are counted in accordance with Methods E 181 and the reaction rate, as defined by Practice E 261, 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.

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 E 261.

5. Significance and Use

5.1 Refer to Guide E 844 for guidance on the selection, irradiation, and quality control of neutron dosimeters.

5.2 Refer to Practice E 261 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 $^{54}\text{Fe} (n,p) ^{54}\text{Mn}$. **(1)**⁴ This figure is for illustrative purposes only to indicate the range of response of the $^{54}\text{Fe} (n,p) ^{54}\text{Mn}$ reaction. Refer to Guide E 1018 for descriptions of recommended tabulated dosimetry cross sections.

5.5 ^{54}Mn has a half-life of 312.12 days **(2)**⁵ and emits a

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² Annual Book of ASTM Standards, Vol 11.01.

³ Annual Book of ASTM Standards, Vol 12.02.

⁴ The boldface numbers in parentheses refer to the list of references located at the end of this test method.

⁵ Reference **(3)** gives a value of 834.848 keV as the most precise value currently accepted for the ^{54}Mn decay gamma-ray energy.