~~Designation:E264–02~~ Designation: E 264 – 08

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

This standard is issued under the fixed designation E 264; 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 Department of Defense.

1. Scope

1.1 This test method covers procedures for measuring reaction rates by the activation reaction ^{58} Ni(n,p)^{58}Co.

1.2 This activation reaction is useful for measuring neutrons with energies above approximately 2.1 MeV and for irradiation times up to about 200 days in the absence of high thermal neutron fluence rates (for longer irradiations, see Practice E 261).

1.3 With suitable techniques fission-neutron fluence rates densities above 10^7 $cm^{-2}{\cdot}s^{-1}$ can be determined.

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

~~1.5~~

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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:* [2]

E 170 Terminology Relating to Radiation Measurements and Dosimetry

E 181 Test Methods for Detector Calibration and Analysis of Radionuclides

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

E 844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, ~~E706 (IIC)[2]~~ E 706(IIC)

E 944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, E 706 (IIA)

E 1005 Test Method for Application and Analysis of Radiometric Monitors for Reactor Vessel Surveillance, ~~E706 (IIIA)[2]~~ E 706(IIIA)

E 1018 Guide for Application of ASTM Evaluated Cross Section Data File, Matrix E 706 (IIB)

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology E 170.

4. Summary of Test Method

4.1 High-purity nickel is irradiated in a neutron field, thereby producing radioactive ^{58}Co from the ^{58}Ni(n,p) ^{58}Co activation reaction.

4.2 The gamma rays emitted by the radioactive decay of ^{58}Co are counted in accordance with Test Methods E 181 and the reaction rate, as defined by Practice E 261, is calculated from the decay rate and irradiation conditions.

4.3 The neutron fluence rate above about 2.1 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 the selection, irradiation, and quality control of neutron dosimeters.

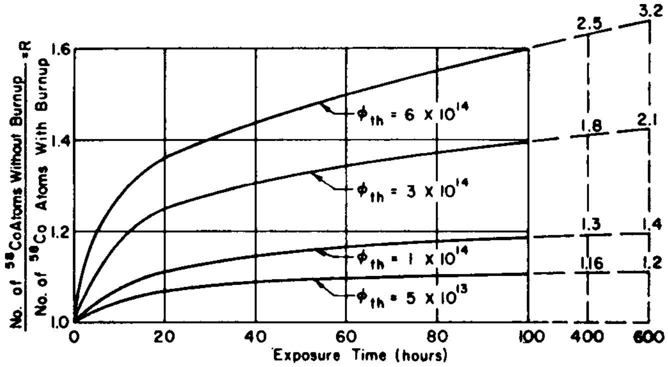
---

[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 June 10, 2002. Published September 2002. Originally published as E264–65T. Last edition E264–92(1996).~~

Current edition approved July 1, 2008. Published September 2008. Originally approved in 1965. Last edition approved in 2002 as E 264 – 02.

[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* ~~, Vol 12.02.~~ volume information, refer to the standard's Document Summary page on the ASTM website.



NOTE—The burnup correction Vals were computed us as a Fing effective burn-up cross sections of I 1650 b forradiati ^{58}Co(n Time,γ) and Neut 1.4E5 b for ^{58m}Co(n Flux,γ).

FIG. 1 *R* Correction Values as a Function of Irradiation Time and Neutron Flux

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 nickel in the form of foil or wire is readily available, and easily handled.

5.4 ^{58}Co has a half-life of 70.86 days and emits a gamma ray with an energy of 0.8107593-MeV.Co has a half-life of 70.86 days[3] and emits a gamma ray with an energy of 0.8107593-MeV.[4]

5.5 Competing activities ^{65}Ni(2.5172 h) and ^{57}Ni(35.60 h) are formed by the reactions ^{64}Ni(n,γ) ^{65}Ni, and^{58}Ni(n,2n)^{57}Ni, respectively.

5.6A second 9.04–h isomer,

5.6 A second 9.04 h isomer, ^{58m}Co, is formed that decays to 70.82-day70.86-day ^{58}Co. Loss of ^{58}Co and ^{58m}Co by thermal-neutron burnout will occur in environments[5,6] having thermal fluence rates of 3×10^{12} $cm^{-2} \cdot s^{-1}$ and above. The ^{58}Co(n,γ) 59Co and ^{58m}Co(n,γ) ^{59}Co cross sections have been measured at 1650 and 1.4×10^5 barns, respectively. Burnout correction factors, *and above. Burnout correction factors, R, are plotted as a function of time for several thermal fluxes in Fig. 1.. Tabulated values for a continuous irradiation time are provided in Hogg, et al.*[6]

5.7 Fig. 2 shows a plot of cross section[7] versus energy for the fast-neutron reaction ^{58}Ni(n,p) ^{58}Co. This figure is for illustrative purposes only to indicate the range of response of the ^{58}Ni(n,p) reaction. Refer to Guide E 1018 for descriptions of recommended tabulated dosimetry cross sections.

NOTE 1—The data is taken from the Evaluated Nuclear Data File, ENDF/B-VI, rather than the later ENDF/B-VII. This is in accordance with E 1018, section 6.1, since the later ENDF/B-VII data files do not include covariance information. For more details see Section H of reference 8.[8]

6. Apparatus

6.1 *NaI (T1) or High Resolution Gamma-Ray Spectrometer*. Because of its high resolution, the germanium detector is useful when contaminant activities are present (see Test Methods E 181 and E 1005).

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

[3] Evaluated Nuclear Structure Data File (ENSDF), a computer file of evaluated nuclear structure and radioactive decay data, which is maintained by the National Nuclear Data Center (NNDC), Brookhaven National Laboratory (BNL), on behalf of the International Network for Nuclear Structure Data Evaluation, which functions under the auspices of the Nuclear Data Section of the International Atomic Energy Agency (IAEA). The URL is http://www.nndc.bnl.gov/nndc/ensdf. The data quoted here comes from the database as of January 1, 2002.

[3] J. K. Tulti, "Nuclear Wallet Cards," National Nuclear Data Center, Brookhaven National Laboratory, Upton, New York, April 2005.

[4] Hogg, C. H., Weber, L. D., and Yates, E. C., "Isomers and the Effects on Fast Flux Measurements Using Nickel," *Atomic Energy Commission R and D Report* IDO-16744, 1962.

[4] Evaluated Nuclear Structure Data File (ENSDF), a computer file of evaluated nuclear structure and radioactive decay data, which is maintained by the National Nuclear Data Center (NNDC), Brookhaven National Laboratory (BNL), on behalf of the International Network for Nuclear Structure Data Evaluation, which functions under the auspices of the Nuclear Data Section of the International Atomic Energy Agency (IAEA). The URL is http://www.nndc.bnl.gov/nndc/ensdf. The data quoted here comes from the database as of January 1, 2002.

[5] ENDF-201, ENDF/B-VI Summary Documentation, edited by P. F. Rose, Brookhaven National Laboratory Report BNL-NCS-1741, 4th Edition, October 1991.

[5] Hogg, C. H., Weber, L. D., and Yates, E. C., "Isomers and the Effects on Fast Flux Measurements Using Nickel," *Atomic Energy Commission R and D Report* IDO-16744, 1962.

[6] J. K. Tulti, "Nuclear Wallet Cards," National Nuclear Data Center, Brookhaven National Laboratory, Upton, New York, January 2000.

[6] Hogg, C. H., Weber, L. D., Yates, E.C., "Thermal Neutron Cross Sections of the Co^{58} Isomers and the Effect on Fast Flux Measurements Using Nickel," IDO-16744 AEC Research & Development Report, Physics TID-4500, June 18, 1962.

[7] B. N. Taylor, C.E. Kuyatt, *Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results*, NIST Technical Note 1297, National Institute of Standards and Technology, Gaithersburg, MD, 1994.

[7] *ENDF-201, ENDF/B-VI Summary Documentation*, edited by P. F. Rose, Brookhaven National Laboratory Report BNL-NCS-1741, 4th Edition, October 1991.

[8] "Special Issue on Evaluated Nuclear Data File ENDF/B-VII.0," Nuclear Data Sheets, J. K. Tuli, Editor, Vol. 107, December 2006.