INTERNATIONAL

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Standard Test Method for Application and Analysis of Radiometric Monitors for Reactor Vessel Surveillance, E 706 (IIIA)[1]

This standard is issued under the fixed designation E1005; 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 method describes general procedures for measuring the specific activities of radioactive nuclides produced in radiometric monitors (RMs) by nuclear reactions induced during surveillance exposures for reactor vessels and support structures. More detailed procedures for individual RMs are provided in separate standards identified in 2.1 and in Refs **11, 24-27**. The measurement results can be used to define corresponding neutron induced reaction rates ~~which~~that can in turn be used to characterize the irradiation environment of the reactor vessel and support structure. The principal measurement technique is high resolution gamma-ray spectrometry, although X-ray photon spectrometry and Beta particle counting are used to a lesser degree for specific RMs **(1-29).**[2]

1.1.1 The measurement procedures include corrections for detector background radiation, random and true coincidence summing losses, differences in geometry between calibration source standards and the RMs, self absorption of radiation by the RM, other absorption effects, ~~and~~ radioactive decay corrections, and burn out of the nuclide of interest **(1-10, 12-22).**

1.1.2 Specific activities are calculated by taking into account the time duration of the count, the elapsed time between start of count and the end of the irradiation, the half life, the mass of the target nuclide in the RM, and the branching intensities of the radiation of interest. Using the appropriate half life and known conditions of the irradiation, the specific activities may be converted into corresponding reaction rates **(24-30).**

1.1.3 Procedures for calculation of reaction rates from the radioactivity measurements and the irradiation power time history are included. A reaction rate can be converted to neutron fluence rate ~~(flux density)~~ and fluence using the appropriate integral cross section and effective irradiation time values, and, with other reaction rates can be used to define the neutron spectrum through the use of suitable computer programs **(24-30).**

1.1.4 The use of benchmark neutron fields for calibration of RMs can reduce significantly or eliminate systematic errors since many parameters, and their respective uncertainties, required for calculation of absolute reaction rates are common to both the benchmark and test measurements and therefore are self cancel~~l~~ing. The benchmark equivalent ~~flux,~~ fluence rates, for the environment tested, can be calculated from a direct ratio of the measured saturated activities in the two environments and the certified benchmark ~~flux~~fluence rate **(24-30).**

1.2 ~~This method is intended to be used in conjunction with ASTM Guides E 706 (IIC) and E 844E 844~~This method is intended to be used in conjunction with ASTM Guide E844. The following existing or proposed ASTM practices, guides, and methods are also directly involved in the physics-dosimetry evaluation of reactor vessel and support structure surveillance measurements:

~~E 706 (O) Master Matrix for Light-Water Reactor Pressure Vessel Surveillance Standards[3]~~
~~E 706 (IA), E 853 Analysis and Interpretation of Light-Water Reactor Surveillance Results[3]~~
~~E 706 (IC), E 560 Practice for Extrapolating Reactor Vessel Surveillance Dosimetry Results[3]~~
~~E 706 (ID), E 693 Practice for Characterizing Neutron Exposures in Ferritic Steels in Terms of Displacements Per Atom (DPA)[3]~~
~~E 706 (IE) Damage Correlation for Reactor Vessel Surveillance[3]~~
~~E 706 (IF), E 185 Practice for Conducting Surveillance Tests for Light-Water Nuclear Power Reactor Vessels[3]~~
~~E 706 (IG) Surveillance Tests for Nuclear Reactor Support Structures[3]~~
~~E 706 (IH), E 636 Practice for Conducting Supplemental Surveillance Tests for Nuclear Power Reactor Vessels[3]~~
~~E 706 (IIA), E 944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance[3]~~
~~E 706 (IIB), E 1018 Application of ASTM Evaluated Nuclear Data File (ENDF/A)—Cross Section and Uncertainty File[3]~~
~~E 706 (IID), E 482 Guide for Application of Neutron Transport Methods for Reactor Vessel Surveillance[3]~~

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[1] This method is under the jurisdiction of ASTM Committee ~~E-10~~ 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 the list of references appended to this method.

~~E 706 (IIE) Benchmark Testing of Reactor Vessel Dosimetry[3]~~

~~E 706 (IIIB), E 854 Test Method for Application and Analysis of Solid State Track Recorder (SSTR) Monitors for Reactor Vessel Surveillance[3]~~

~~E 706 (IIIC), E 910 Test Method for Application and Analysis of Helium Accumulation Fluence Monitors for Reactor Vessel Surveillance[3]~~

~~E 706 (IIID) Application and Analysis of Damage Monitors for Reactor Vessel Surveillance[3]~~

~~E 706 (IIIE) Application and Analysis of Temperature Monitors for Reactor Vessel Surveillance[3]~~

~~1.3The general procedures in this method are applicable to the measurement of radioactivity in RMs which satisfy the specific constraints and conditions imposed for their analysis. More detailed procedures for individual RM monitors are identified in~~

Master Matrix for Light-Water Reactor Pressure Vessel Surveillance Standards, E706 (O) [3]

E853 Analysis and Interpretation of Light-Water Reactor Surveillance Results, E706 (IA)[3]

E693 Practice for Characterizing Neutron Exposures in Iron and Low Alloy Steels in Terms of Displacements Per Atom (DPA), E706 (ID)[3]

E185 Practice for Conducting Surveillance Tests for Light-Water Nuclear Power Reactor Vessels, E706 (IF)[3]

E1035 Practice for Determining Radiation Exposure for Nuclear Reactor Vessel Support Structures, E706 (IG)[3]

E636 Practice for Conducting Supplemental Surveillance Tests for Nuclear Power Reactor Vessels, E706 (IH)[3]

E944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, E706 (IIA)[3]

E1018 Guide for Application of ASTM Evaluated Cross Section and Data File, E706 (IIB)[3]

E482 Guide for Application of Neutron Transport Methods for Reactor Vessel Surveillance, E706 (IID)[3]

E2005 Guide for the Benchmark Testing of Reactor Vessel Dosimetry in Standard and Reference Neutron Fields

E2006 Guide for the Benchmark Testing of Light Water Reactor Calculations

E854 Test Method for Application and Analysis of Solid State Track Recorder (SSTR) Monitors for Reactor Vessel Surveillance, E706 (IIIB)[3]

E910 Test Method for Application and Analysis of Helium Accumulation Fluence Monitors for Reactor Vessel Surveillance, E706 (IIIC)[3]

E1214 Application and Analysis of Temperature Monitors for Reactor Vessel Surveillance, E706 (IIIE) [3]

1.3 The general procedures in this method are applicable to the measurement of radioactivity in RMs that satisfy the specific constraints and conditions imposed for their analysis. More detailed procedures for individual RM monitors are identified in 2.1 and in Refs **11, 24-27** (see Table 1).

1.4 This method, along with the individual RM monitor standard methods, are intended for use by knowledgeable persons who are intimately familiar with the procedures, equipment, and techniques necessary to achieve high precision and accuracy in radioactivity measurements.

~~1.5*This standard does not purport to address all of the safety problems, 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.*~~

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.*

TABLE 1 Radiometric Monitors Proposed for Reactor Vessel Surveillance

Dosimetry Reactions	Residual Nucleus			Target Atom Natural Abundance[A] [31]	Detector Response[B]	ASTM Standard or Ref.
	Half-life[C,A,D]	E_γ[D] (keV)	Yield[D] (%) γ/Reaction			
$^{23}Na(n,\gamma)^{24}Na$	0.62356 (17) d	1368.633 2754.030	99.9936 99.855	1.00	NTR	**(24-30)**
$^{27}Al(n,\alpha)^{24}Na$	0.62356 (17) d	1368.633 2754.030	99.9936 99.855	1.00	TR	E266
$^{32}S(n,p)^{32}P$	14.262 (14) d	$\langle E_\beta \rangle$=694.9	100.	0.9502 (9)	TR	E265
$^{45}Sc(n,\gamma)^{46}Sc$	83.79 (4) d	889.277 1120.545	99.9844 99.9874	1.00	NTR	**(24-30)**
$^{46}Ti(n,p)^{46}Sc$	83.79 (4) d	889.277 1120.545	99.9844 99.9874	0.0825 (3)	TR	E526

[3] The reference in parentheses refers to Section 5 as well as Figs. 1 and 2 of Matrix E706.

TABLE 1 *Continued*

Dosimetry Reactions	Residual Nucleus Half-life[C,A,D]	Residual Nucleus E_{γ}[D] (keV)	Residual Nucleus Yield[D] (%) γ/Reaction	Target Atom Natural Abundance[A] [31]	Detector Response[B]	ASTM Standard or Ref.
$^{47}Ti(n,p)^{47}Sc$	3.3492 (1) d	159.381	68.3	0.0744 (2)	TR	E526
$^{48}Ti(n,p)^{48}Sc$	43.67 (9) h	983.526	100.0	0.7372 (3)	TR	E526
		1037.522	97.5			
		1312.120	100.0			
$^{55}Mn(n,2n)^{54}Mn$	312.11 (5) d	834.843	99.9758	1.00	TR	E261, E263 **(24-30)**
$^{54}Fe(n,p)^{54}Mn$	312.11 (5) d	834.843	99.9758	0.05845 (35)	TR	E263
$^{54}Fe(n,\gamma)^{55}Fe$	2.73 (3) y	5.888	8.2	0.05845 (35)	NTR	**(24-30)**
		5.899	16.2			
		6.490	2.86			
$^{56}Fe(n,p)^{56}Mn$	2.5789 (1) hr	846.754	98.87	0.91754 (36)	TR	**(24-30)**
		1810.72	27.18925			
		2113.05	14.33615			
$^{58}Fe(n,\gamma)^{59}Fe$	44.472 (8) d	1099.251	56.5	0.00282 (4)	NTR	**(24-30)**
		1291.596	43.2			
		1481.7	0.059			
$^{59}Co(n,\gamma)^{60}Co$	1925.5 (5) d	1173.238	99.857	1.00	NTR	E262, E481
		1332.502	99.983			
	10.467 (6) m	58.603	2.01			
	(meta)	826.28	0.00768			
		1332.501	0.24			
		2158.77	0.00072			
$^{58}Ni(n,p)^{58}Co$	70.82 (3) d	810.775	99.45	0.68077 (9)	TR	E264
		863.959	0.69			
		1674.730	0.519			
	9.15 (10) h (meta)	24.889	0.0369			
$^{60}Ni(n,p)^{60}Co$	1925.5 (5) d	1173.238	99.857	0.26223 (8)	TR	**(24-30)**
		1332.502	99.983			
	10.467 (6) m	58.603	2.01			
	(meta)	826.28	0.00768			
		1332.501	0.24			
		2158.77	0.00072			
$^{63}Cu(n,\gamma)^{64}Cu$	12.700 (2) h	1345.77	0.47336	0.6917 (3)	NTR	**(24-30)**
$^{63}Cu(n,\alpha)^{60}Co$	1925.5 (5) d	1173.238	99.857	0.6917 (3)	TR	E523
		1332.502	99.983			
	10.467 (6) m	58.603	2.01			
	(meta)	826.33	0.0058			
		1332.501	0.25			
		2158.86	0.00088			
$^{93}Nb(n,n')^{93m}Nb$	5.89 (5) × 10^3 d	30.77	0.000549	1.00	TR	**(11, 24-30)**
		16.52 ($K_{\alpha 1,2}$)	9.25			
$^{103}Rh(n,n')^{103m}Rh$	56.114 (9) m	39.755	0.0684	1.00	TR	**(24-30)**
$^{109}Ag(n,\gamma)^{110m}Ag$	249.76 (4) d	116.48	0.00799	0.48161 (8)	NTR	E481
		884.685	72.192			
		937.493	34.1314			
		1384.300	24.1204			
		1505.040	12.9532			
		1475.788	3.96868			
$^{115}In(n,\gamma)^{116m}In$	54.29 (17) m	1293.54	84.4	0.9571 (5)	NTR	E261, E262
		1097.3	56.2104			
		818.7	11.4784			
		2112.1	15.5296			
$^{115}In(n,n')^{115m}In$	4.486 (4) h	336.241	45.9	0.9571 (5)	TR	**(24-30)**
		497.370	0.047			

TABLE 1 *Continued*

Dosimetry Reactions	Residual Nucleus Half-life[C,A,D]	Residual Nucleus E_{γ}[D] (keV)	Residual Nucleus Yield[D] (%) γ/Reaction	Target Atom Natural Abundance[A] [31]	Detector Response[B]	ASTM Standard or Ref.
^{181}Ta(n,γ)^{182}Ta	114.43 (3) d	1121.3008 1189.0503 1221.4066	34.9 16.225 26.9777	0.99988 (2)	NTR	E262
^{197}Au(n,γ)^{198}Au	2.69517 (21) d	1087.6904 675.8874 411.804	0.159045 0.8038278 95.57	1.00	NTR	E261, E262 **(24-30)**
^{232}Th(n,γ)^{233}Th	22.3 (1) m	890.1 490.80 499.02 699.901 764.4	0.14 0.17 0.21 0.68 0.120	1.00	NTR	**(24-30)**
. . . .⇒^{233}Pa	26.967 (2) d	312.17	38.6			
FM(n,f)^{144}Ce	284.893 (8) d	133.515 80.120	11.09 1.36407 (see Table 2)	—[E]	NTR, TR	E704, E705 **(24-30)**
FM(n,f)^{140}Ba	12.752 (3) d	537.261	24.4 (see Table 2)	—[E]	NTR, TR	E393, E704, E705
^{140}Ba⇒^{140}La	1.6781 (3) d	1596.21 815.772 487.021	95.4 23.2776 45.5058 (see Table 2)			**(24-30)**
FM(n,f)^{137}Cs	30.07 (3) y	661.660	85.1 (see Table 2)	—[E]	NTR, TR	E320, E704, E705
^{137}Cs⇒^{137m}Ba	2.552 (1) m	661.660	90.11 (see Table 2)			**(24-30)**
FM(n,f)^{106}Ru	373.59 (15) d	—	— (see Table 2)	—[E]	NTR, TR	E704, E705 **(24-30)**
^{106}Ru⇒^{106}Rh	29.80 (8) s	511.8605	20.4 (see Table 2)			
FM(n,f)^{103}Ru	39.26 (2) d	497.084	91.0 (see Table 2)	—[E]	NTR, TR	E704, E705 **(24-30)**
FM(n,f)^{95}Zr	64.02 (5) d	756.729 724.199	54.46 44.1725 (see Table 2)	—[E]	NTR, TR	E704, E705 **(24-30)**
^{95}Zr⇒^{95}Nb	34.997 (6) d	765.807	99.81 (see Table 2)			

[A]The numbers in parentheses following some given values is the uncertainty in the last digit(s) of the value: 0.729 (8) means 0.729 ± 0.008, 70.8 (1) means 70.8 ± 0.1.
[B]NTR = Non-Threshold Response, TR = Threshold Response.
[C]The time units listed for half-life are years (y), days (d), hours (h), minutes (m), and seconds (s).
[D]The nuclear data has been drawn from several primary sources including References **(31)**, **(33)** and **(34)**. Reference **(32)** summarizes the source of the selected nuclear constants.
[E]FM = Fission Monitor: ^{235}U and ^{239}Pu (NTR) and ^{238}U, ^{237}Np, and ^{232}Th (TR) target isotope or weight fraction varies with material batch.

2. Referenced Documents

2.1 ~~ASTM Standards not identified in~~ ASTM Standards (some already identified in 1.2), including those for individual RM monitors:

2.2 *ASTM Standards:*

~~E170Terminology Relating to Radiation Measurements and Dosimetry~~

~~E177Practice for Use of the Terms Precision and Bias in ASTM Test Methods~~ [4]

[4] 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.

TABLE 2 Recommended Fission Yield Data[A]

Fissionable Isotope	Reaction Product	Cumulative Fission Yield (Energy Dependent)		Independent Fission Yield (Energy Dependent)	
		0.5 MeV	Thermal	0.5 MeV	Thermal
^{232}Th(n,f)	^{95}Zr	5.67313 ± 2.8 %	—	3.84804×10^{-3} ± 64 %	—
	^{95}Nb	5.67313 ± 2.8 %	—	7.49008×10^{-7} ± 64 %	—
	^{103}Ru	0.156332 ± 4.0 %	—	6.12007×10^{-8} ± 64 %	—
	^{106}Ru	0.0537306 ± 11 %	—	1.05001×10^{-4} ± 64 %	—
	^{106}Rh	0.0537306 ± 11 %	—	1.33001×10^{-8} ± 64 %	—
	^{137}Cs	5.84355 ± 4 %	—	8.32609×10^{-3} ± 64 %	—
	^{137m}Ba	5.528 ± 4 %	—	7.63008×10^{-6} ± 64 %	—
	^{140}Ba	7.87647 ± 2.8 %	—	4.82795×10^{-2} ± 64 %	—
	^{140}La	7.87649 ± 2 %	—	2.71003×10^{-5} ± 64 %	—
	^{144}Ce	7.94699 ± 4 %	—	4.80505×10^{-3} ± 64 %	—
^{235}U(n,f)	^{95}Zr	6.42554 ± 1 %	6.49458 ± 1 %	2.93502×10^{-2} ± 64 %	1.2208×10^{-1} ± 16 %
	^{95}Nb	6.42557 ± 0.7 %	6.49471 ± 1 %	2.21002×10^{-5} ± 64 %	1.02003×10^{-4} ± 64 %
	^{103}Ru	3.26185 ± 1 %	3.03144 ± 1.4 %	2.35002×10^{-5} ± 64 %	2.31006×10^{-5} ± 64 %
	^{106}Ru	0.535398 ± 1 %	0.44108 ± 1.4 %	7.55005×10^{-3} ± 64 %	8.90023×10^{-7} ± 64 %
	^{106}Rh	0.535404 ± 1 %	0.400983 ± 1.4 %	6.06004×10^{-6} ± 64 %	0
	^{137}Cs	6.22335 ± 0.5 %	6.18682 ± 0.5 %	1.84879×10^{-1} ± 32 %	5.93635×10^{-2} ± 11 %
	^{137m}Ba	5.88768 ± 0.5 %	5.85286 ± 0.5 %	3.93003×10^{-4} ± 64 %	1.30003×10^{-4} ± 64 %
	^{140}Ba	5.98741 ± 1 %	6.19595 ± 1 %	4.72071×10^{-1} ± 64 %	4.64072×10^{-1} ± 32 %
	^{140}La	5.98872 ± 1 %	6.2012 ± 1 %	1.31401×10^{-5} ± 64 %	5.25214×10^{-3} ± 64 %
	^{144}Ce	5.26689 ± 1.4 %	5.49709 ± 0.7 %	4.35013×10^{-2} ± 64 %	6.27386×10^{-2} ± 64 %
^{237}Np(n,f)	^{95}Zr	5.68896 ± 2.8 %	—	6.1647×10^{-2} ± 64 %	—
	^{95}Nb	5.68907 ± 2 %	—	8.5×10^{-5} ± 64 %	—
	^{103}Ru	5.56212 ± 2.8 %	—	1.44×10^{-4} ± 64 %	—
	^{106}Ru	2.18067 ± 11 %	—	6.0445×10^{-2} ± 64 %	—
	^{106}Rh	2.18077 ± 11 %	—	9.29×10^{-5} ± 64 %	—
	^{137}Cs	6.16977 ± 2.8 %	—	2.74311×10^{-1} ± 64 %	—
	^{137m}Ba	5.83804 ± 2.8 %	—	1.438×10^{-3} ± 64 %	—
	^{140}Ba	5.47246 ± 1.4 %	—	5.83709×10^{-1} ± 64 %	—
	^{140}La	5.47688 ± 2.8 %	—	4.421×10^{-3} ± 64 %	—
	^{144}Ce	4.12987 ± 2 %	—	9.1496×10^{-2} ± 64 %	—
^{238}U(n,f)	^{95}Zr	5.15126 ± 1 %	—	7.88021×10^{-4} ± 64 %	—
	^{95}Nb	5.15126 ± 1 %	—	8.34022×10^{-8} ± 64 %	—
	^{103}Ru	6.26113 ± 1 %	—	3.06008×10^{-7} ± 64 %	—
	^{106}Ru	2.48759 ± 1.4 %	—	3.8101×10^{-7} ± 64 %	—
	^{106}Rh	2.48759 ± 1.4 %	—	0	—
	^{137}Cs	6.02075 ± 1 %	—	9.28724×10^{-3} ± 64 %	—
	^{137m}Ba	5.69564 ± 1 %	—	4.10011×10^{-6} ± 64 %	—
	^{140}Ba	5.84596 ± 1 %	—	2.57317×10^{-2} ± 64 %	—
	^{140}La	5.84597 ± 1 %	—	1.38004×10^{-5} ± 64 %	—
	^{144}Ce	4.55034 ± 1.4 %	—	1.30603×10^{-3} ± 64 %	—
^{239}Pu(n,f)	^{95}Zr	4.65412 ± 1.4 %	4.80834 ± 1.4 %	7.94561×10^{-2} ± 64 %	1.25228×10^{-1} ± 64 %
	^{95}Nb	4.65431 ± 1.4 %	4.80904 ± 1.4 %	1.45002×10^{-4} ± 64 %	5.64006×10^{-4} ± 64 %
	^{103}Ru	6.85701 ± 1.4 %	7.0047 ± 2 %	4.41006×10^{-4} ± 64 %	1.01101×10^{-3} ± 64 %
	^{106}Ru	4.33807 ± 1.4 %	4.32901 ± 2 %	2.00083×10^{-1} ± 64 %	3.2276×10^{-1} ± 32 %
	^{106}Rh	4.33845 ± 1.4 %	4.32923 ± 2 %	3.76005×10^{-4} ± 64 %	2.23002×10^{-4} ± 64 %
	^{137}Cs	6.57917 ± 0.7 %	6.61591 ± 0.5 %	9.9008×10^{-1} ± 16 %	5.94641×10^{-1} ± 16 %
	^{137m}Ba	6.22844 ± 0.7 %	6.26233 ± 0.5 %	4.54506×10^{-3} ± 64 %	3.68004×10^{-3} ± 64 %
	^{140}Ba	5.31538 ± 1 %	5.37475 ± 2 %	9.4334×10^{-1} ± 64 %	1.51518×10^{-0} ± 23 %
	^{140}La	5.32713 ± 1 %	5.38286 ± 1.4 %	1.17572×10^{-2} ± 64 %	8.11109×10^{-3} ± 64 %
	^{144}Ce	3.67369 ± 0.7 %	3.74236 ± 1 %	1.56328×10^{-1} ± 64 %	1.06259×10^{-1} ± 64 %

[A] All yield data is given as a percentage.

E181 ~~General Methods for Detector Calibration and Analysis of Radionuclides[4]~~

~~E219Test Method for Atom Percent Fission in Uranium Fuel (Radiochemical Method)[4]~~ Test Methods for Detector Calibration and Analysis of Radionuclides

E185 Practice for Design of Surveillance Programs for Light-Water Moderated Nuclear Power Reactor Vessels

E261 Practice for Determining Neutron Fluence, Fluence Rate, ~~Fluence,~~ and Spectra by Radioactivation Techniques

E262 Test Method for Determining Thermal Neutron Reaction Rates and Thermal Neutron Fluence Rates by Radioactivation Techniques

E263 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Iron

E264 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Nickel

E265 Test Method for Measuring Reaction Rates and Fast-Neutron Fluences by Radioactivation of Sulfur-32

E266 ~~Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Aluminum[4]~~

~~E267Test Method for Uranium and Plutonium Concentrations and Isotopic Abundances[4]~~ Test Method for Measuring

Fast-Neutron Reaction Rates by Radioactivation of Aluminum
E320 Test Methods for Cesium-137 in Nuclear Fuel Solutions by Radiochemical Analysis[4]
E321Test Method for Atom Percent Fission in Uranium and Plutonium Fuel (Neodymium-148 Method)[4]
E343Test Method for Measuring Reaction Rates by Analysis of Molybdenum-99 Radioactivity from Fission Dosimeters[4] Test Method for Cesium-137 in Nuclear Fuel Solutions by Radiochemical Analysis
E393 Test Method for Measuring Reaction Rates by Analysis of Barium-140 fromFrom Fission Dosimeters
E481 Test Method for Measuring Neutron Fluence Rate by Radioactivation of Cobalt and Silver[4] Test Method for Measuring Neutron Fluence Rates by Radioactivation of Cobalt and Silver
E482 Guide for Application of Neutron Transport Methods for Reactor Vessel Surveillance, E706 (IID)
E523 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Copper
E526 Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Titanium[4] Test Method for Measuring Fast-Neutron Reaction Rates by Radioactivation of Titanium
E636 Guide for Conducting Supplemental Surveillance Tests for Nuclear Power Reactor Vessels, E 706 (IH)
E693 Practice for Characterizing Neutron Exposures in Iron and Low Alloy Steels in Terms of Displacements Per Atom (DPA), E 706(ID)
E704 Test Method for Measuring Reaction Rates by Radioactivation of Uranium-238
E705 Test Method for Measuring Reaction Rates by Radioactivation of Neptunium-237
E844 Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E 706 (IIC)[4] Guide for Sensor Set Design and Irradiation for Reactor Surveillance, E 706 (IIC)
E853 Practice for Analysis and Interpretation of Light-Water Reactor Surveillance Results, E706(IA)
E854 Test Method for Application and Analysis of Solid State Track Recorder (SSTR) Monitors for Reactor Surveillance, E706(IIIB)
E910 Test Method for Application and Analysis of Helium Accumulation Fluence Monitors for Reactor Vessel Surveillance, E706 (IIIC)
E944 Guide for Application of Neutron Spectrum Adjustment Methods in Reactor Surveillance, E 706 (IIA)
E1018 Guide for Application of ASTM Evaluated Cross Section Data File, Matrix E706 (IIB)
E1035 Practice for Determining Neutron Exposures for Nuclear Reactor Vessel Support Structures
E1214 Guide for Use of Melt Wire Temperature Monitors for Reactor Vessel Surveillance, E 706 (IIIE)
E2005 Guide for Benchmark Testing of Reactor Dosimetry in Standard and Reference Neutron Fields
E2006 Guide for Benchmark Testing of Light Water Reactor Calculations

2.3 *ANSI Standard:*
N42.14 Calibration and Usage of Germanium Detectors for Measurement of Gamma-Ray Emission Rates of Radionuclides[5]

3. Terminology Definitions

3.1 *Definitions:*

3.1.1 *radiometric monitor (RM), dosimeter, foil*—a small quantity of material consisting of or containing an accurately known mass of a specific target nuclide. Usually fabricated in a specified and consistent geometry and used to determine neutron fluence rate (flux density), fluence and spectra by measuring a specific radioactive neutron-induced reaction product. A single RM may contain more than one target nuclide or have more than one specific reaction product.

3.2*calibration standard*

3.1.2 *calibration standard*—a calibrated radioactive source standardized using an absolute calibration method or by rigorous comparison to a national or certified radioactivity standard source.

3.1.3 *national radioactivity standard source*—a calibrated radioactive source prepared and distributed as a standard reference material by the U.S. National BureauInstitute of Standards and Technology (NIST).

3.1.4 *certified radioactivity standard source*—a calibrated radioactive source, with stated accuracy, whose calibration is traceable to a Nnational R radioactivity M measurements system.

3.1.5 *check source, control standard*—a radioactivity source, not necessarily calibrated, which is used as a working reference to verify the continuing satisfactory operation of an instrument.

3.1.6 *FWHM (full width at half maximum)*—a measure of detector/system gamma-ray energy resolution expressed as the width of the gamma-ray peak distribution, in units of energy, measured at one-half the maximum peak height above the background.

3.1.7 *FWTM (full width at tenth maximum)*—identical to FWHM except the width is measured at one tenth the maximum peak height above the background.

3.8*resolution, gamma-ray*

3.1.8 *resolution, gamma-ray*—usually expressed as the FWHM and often including a specification for the FWTM.

3.9*peak-to-compton-ratio*

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[5] Annual Book of ASTM Standards, Vol 14.02.
[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.