

LAMPIRAN-LAMPIRAN



Lampiran. A

Perhitungan secara nisbi

Tabel 1. Hasil perhitungan sammarium dalam air sungai Semarang selama iradiasi 12 jam dan $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^{-2} \cdot \text{dt}^{-1}$, t cacah 600 detik dengan kadar standar 10 ppm.

Lokasi	(Cpso) Standar	(Cpso) Cuplikan	Kadar (ppm)
Simongan	15030,636	16,089	$1,375 \cdot 10^{-4}$
	15443,721	18,874	$1,527 \cdot 10^{-4}$
Bandarharjo	15030,636	48,017	$3,993 \cdot 10^{-4}$
	15443,721	25,502	$2,064 \cdot 10^{-4}$
Berok	15030,636	30,101	$2,503 \cdot 10^{-4}$
	15443,721	29,315	$2,373 \cdot 10^{-4}$

Tabel 2. Hasil perhitungan cerium dalam air sungai Semarang selama iradiasi 12 jam dan $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^{-2} \cdot \text{dt}^{-1}$, t cacah 600 detik dengan kadar standar 10 ppm.

Lokasi	(Cpso) Standar	(Cpso) Cuplikan	Kadar (ppm)
Simongan	6,632	0,144	$2,714 \cdot 10^{-3}$
	6,502	0,112	$2,153 \cdot 10^{-3}$
Bandarharjo	6,632	0,523	$9,857 \cdot 10^{-3}$
	6,502	0,357	$6,863 \cdot 10^{-3}$
Berok	6,632	0,270	$5,089 \cdot 10^{-3}$
	6,502	0,278	$5,344 \cdot 10^{-3}$

Tabel 3. Hasil perhitungan cobalt dalam air sungai Semarang selama iradiasi 12 jam dan $\phi = 5,85 \cdot 10^{10} \cdot n \cdot \text{cm}^2 \cdot dt^{-1}$, t cacah 600 detik dengan kadar standar 10 ppm.

Lokasi	(Cpso) Standar	(Cpso) Cuplikan	Kadar (ppm)
Simongan	8,184	0,002	$3,055 \cdot 10^{-4}$
	7,278	0,018	$3,091 \cdot 10^{-4}$
Bandarharjo	8,184	0,227	$3,467 \cdot 10^{-3}$
	7,278	0,152	$2,611 \cdot 10^{-3}$
Berok	8,184	0,147	$2,245 \cdot 10^{-3}$
	7,278	0,165	$2,834 \cdot 10^{-3}$

Keterangan :

ppm = $\mu\text{g/mL}$



Perhitungan secara nisbi

Tabel 4. Hasil perhitungan dalam samarium sedimen sungai Semarang selama iradiasi 12 jam dan $\phi = 5,85 \cdot 10^{10} \cdot n \cdot cm^{-2} \cdot dt^{-1}$, t cacah dengan kadar standar 6,7 ppm.

Lokasi	(Cpso) Standar	(Cpso) Cuplikan	Kadar (ppm)
Simongan	772,129	728,886	6,325
	850,080	742,960	5,856
Bandarharjo	772,129	635,703	5,516
	850,080	640,426	5,047
Berok	772,129	526,934	3,968
	850,080	457,326	4,353
Tanah Mas	772,129	552,378	4,562
	850,080	525,723	4,153

Tabel 5. Hasil perhitungan cerium dalam sedimen sungai Semarang selama iradiasi 12 jam dan $\phi = 5,85 \cdot 10^{10} \cdot n \cdot cm^{-2} \cdot dt^{-1}$, t cacah dengan kadar standar 72 ppm.

Lokasi	(Cpso) Standar	(Cpso) Cuplikan	Kadar (ppm)
Simongan	4,311	7,139	119,232
	4,541	7,112	112,764
Bandarharjo	4,311	6,595	110,146
	4,541	7,514	119,136
Berok	4,311	7,760	129,670
	4,541	7,685	121,849
Tanah Mas	4,311	2,157	36,025
	4,541	3,805	60,330

Tabel 6. Hasil perhitungan cromium dalam sedimen sungai Semarang selama 12 jam dan $\phi = 5,85 \cdot 10^{10} \cdot n \cdot \text{cm}^2 \cdot \text{dt}^{-1}$, t cacah 600 detik dengan kadar standar 135 ppm.

Lokasi	(Cpso) Standar	(Cpso) Cuplikan	Kadar (ppm)
Simongan	2,096	0,225	14,492
	1,485	0,235	21,364
Bandarharjo	2,096	0,567	36,519
	1,485	0,404	36,727
Berok	2,096	0,453	26,794
	1,485	0,485	41,182
Tanah Mas	2,096	0,560	31,238
	1,485	0,183	50,909

Tabel 7. Hasil perhitungan cobalt dalam sedimen sungai Semarang selama iradiasi 12 jam dan $\phi = 5,85 \cdot 10^{10} \cdot n \cdot \text{cm}^2 \cdot \text{dt}^{-1}$, t cacah 600 detik dengan kadar standar 14 ppm.

Lokasi	(Cpso) Standar	(Cpso) Cuplikan	Kadar (ppm)
Simongan	0,664	1,442	30,404
	0,815	1,497	25,715
Bandarharjo	0,664	1,241	26,166
	0,815	1,260	21,644
Berok	0,664	1,011	21,316
	0,815	0,738	12,677
Tanah Mas	0,664	0,434	9,151
	0,815	0,557	9,568

Keterangan : ppm = $\mu\text{g/g}$

Perhitungan secara absolut

Tabel 8. Hasil perhitungan samarium dalam air sungai Kali Semarang selama iradiasi 12 jam dan $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^{-2} \cdot \text{dt}^{-1}$, Efisiensi = 12%, $\pi = 206$ barn, $T_{1/2} = 47,1$ jam dan yield = 0,834.

Lokasi	(Cps0) Cuplikan	Kadar (ppm)
Simongan	16,089	$6,538 \cdot 10^{-4}$
	18,874	$7,669 \cdot 10^{-4}$
Bandarharjo	48,017	$1,951 \cdot 10^{-3}$
	25,502	$1,037 \cdot 10^{-3}$
Berok	30,101	$1,223 \cdot 10^{-3}$
	29,315	$1,191 \cdot 10^{-3}$

Tabel 9. Hasil perhitungan cerium dalam air sungai Kali Semarang selama iradiasi 12 jam, $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^{-2} \cdot \text{dt}^{-1}$, efisiensi = 9,7%, $\sigma = 0,578 \cdot 10^{-24} \text{ cm}^2$, $T_{1/2} = 32,5$ hari dan yield = 0,48.

Lokasi	(Cps0) Cuplikan	Kadar (ppm)
Simongan	0,144	0,024
	0,112	0,018
Bandarharjo	0,523	0,087
	0,357	0,059
Berok	0,270	0,045
	0,278	0,046

Tabel 10. Hasil perhitungan cobalt dalam air sungai Semarang selama iradiasi 12 jam, $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^2 \cdot \text{dt}^{-1}$, efisiensi = 0,007, $\sigma = 37,2 \cdot 10^{-24} \text{ cm}^2$, $T_{1/2} = 5,24$ tahun, yield = 0,999 dan $\rho = 100\%$.

Lokasi	(Cps) Cuplikan	Kadar (ppm)
Simongan	0,020	$9,136 \cdot 10^{-3}$
	0,018	$8,223 \cdot 10^{-3}$
Bandarharjo	0,227	0,104
	0,152	0,069
Berok	0,147	0,067
	0,165	0,075

Keterangan:

ppm = $\mu\text{g/mL}$



Perhitungan secara absolut

Tabel 11. Hasil perhitungan samarium dalam sedimen Semarang selama iradiasi 12 jam, $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^2 \cdot \text{dt}^{-1}$, efisiensi = 12%, $\sigma = 206 \text{ barn}$, $T_{1/2} = 47,1 \text{ jam}$ dan yield = 0,834

Lokasi	(Cps) Cuplikan	Kadar (ppm)
Simongan	728,886	23,695
	742,960	24,152
Bandarharjo	635,703	20,666
	640,426	20,819
Berok	457,326	14,867
	552,378	17,957
Tanah Mas	525,723	17,090
	526,934	17,130

Tabel 12. Hasil Perhitungan cerium dalam sedimen Semarang selama iradiasi 12 jam, $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^2 \cdot \text{dt}^{-1}$, efisiensi = 9,7%, $\sigma = 0,578 \cdot 10^{-24} \text{ cm}^2$, $T_{1/2} = 32,5 \text{ hari}$ dan yield = 0,48.

Lokasi	(Cps) Cuplikan	Kadar (ppm)
Simongan	7,139	1131,912
	7,112	1127,631
Bandarharjo	6,595	1045,658
	7,514	1191,369
Berok	5,467	866,811
	5,127	812,902
Tanah Mas	2,157	341,999
	3,805	603,295

Tabel 13. Hasil perhitungan cromium dalam sedimen Kali Semarang selama iradiasi 12 jam, $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^2 \cdot \text{dt}^{-1}$, efisiensi = 4,3%, $\sigma = 15,9 \cdot 10^{-24} \text{ cm}^2$, $T_{1/2} = 27,8$ hari dan yield = 0,0983, $P = 4,35\%$.

Lokasi	(Cps) Cuplikan	Kadar (ppm)
Simongan	0,225	96,727
	0,235	101,027
Bandarharjo	0,567	243,751
	0,404	174,079
Berok	0,416	178,837
	0,453	194,743
Tanah Mas	0,485	208,499
	0,560	240,742

Tabel 14. Hasil perhitungan cobalt dalam sedimen Kali Semarang selama iradiasi 12 jam, $\phi = 5,85 \cdot 10^{10} \text{ n.cm}^2 \cdot \text{dt}^{-1}$, efisiensi 0,9%, $\sigma = 37,2 \cdot 10^{-24} \text{ cm}^2$, $T_{1/2} = 5,24$ tahun dan yield = 0,999, $P = 100\%$.

Lokasi	(Cps) Cuplikan	Kadar (ppm)
Simongan	1,442	525,515
	1,497	545,615
Bandarharjo	1,241	452,426
	1,260	459,369
Berok	1,011	368,007
	0,738	268,605
Tanah Mas	0,434	157,874
	0,557	202,824

Keterangan : ppm = $\mu\text{g/g}$

Lampiran B.

Contoh Perhitungan Unsur air sungai secara nisbi

1. Menghitung (Cps)_o cuplikan Samarium dalam cuplikan :

Diketahui :

$$\text{Netto Cupl} = 142$$

$$t \text{ cacah} = 600 \text{ detik}$$

$$(Cps)_{o \text{ cupl}} = \frac{\text{Netto cupl}}{t \text{ cacah}}$$

$$= \frac{142}{600}$$

$$= 0,237$$

$$t \text{ funda} = 286,67 \text{ jam}$$

$$t_{12} = 47,1 \text{ jam}$$

$$(Cps)_{o \text{ cupl}} = (Cps)_{\text{cupl}} \times e^{0,693 t_{12}/t \text{ funda}}$$

$$= 0,237 \times e^{0,693 \cdot 286,67 / 47,1}$$

$$= 16,089$$

2. Menghitung (Cps)_o Samarium dalam standar :

Diketahui :

$$\text{Netto} = 130424$$

$$t \text{ cacah} = 600 \text{ detik}$$

$$(Cps)_{\text{std}} = \frac{\text{Netto}}{t \text{ cacah}}$$

$$= \frac{130426}{600}$$

$$= 217,37$$

$$t \text{ funda} = 287,92 \text{ jam}$$

$$t_{12} = 47,1 \text{ jam}$$

$$(Cps)_{o \text{ std}} = (Cps)_{\text{std}} \times e^{0,693 t_{12}/t \text{ funda}}$$

$$= 217,37 \times e^{0,693 \cdot 287,92 / 287,92}$$

$$= 15030,636$$

3 Menghitung Kadar Samarium dalam cuplikan

Diketahui :

$$(Cps) \circ \text{ cupl} = 16,089$$

$$(Cps) \circ \text{ std} = 15030,636$$

$$\text{Kadar Sm std} = 10 \text{ ppm}$$

$$\begin{aligned}\text{Kadar Sm dalam cuplikan} &= \frac{16,089 \times 10 \text{ ppm}}{15030,636} \\ &= 0,011 \text{ ppm}\end{aligned}$$

Karena 1L dipekaikan menjadi 25 cc dan diambil 2 cc, maka :

$$\begin{aligned}\text{Kadar Samarium dalam cupl} &= 0,011 / 80 \text{ ppm} \\ &= 1,375 \cdot 10^{-4} \text{ ppm.}\end{aligned}$$

Contoh Perhitungan unsur air sungai secara absolut

Diketahui : $(Cps)_0 \text{ Sm} = 16,089$

$$\epsilon = 0,18$$

$$\phi = 5,85 \cdot 10^{10} \cdot n \cdot \text{cm}^{-2} \cdot \text{dt}^{-1}$$

$$\sigma = 206 \cdot 10^{-24} \cdot \text{cm}^2$$

$$t_{1/2} = 47,1 \text{ jam}$$

$$\text{Tiradiasi} = 12 \text{ jam}$$

$$\text{Yield} = 0,834$$

$$\rho = 26,7\%$$

Jawaban :

$$A_0 = \frac{(C_{ps0}) Sm}{yield \times \varepsilon} = \frac{16,089}{0,834 \times 0,18} = 107,174 \text{ dps}$$

$$N_{Sm} = \frac{\rho \phi \sigma (1 - e^{-0,693 \cdot T_{irr}/\tau})}{107,174} \\ = \frac{0,2675,85 \cdot 10^{10} \times 206 \cdot 10^{-24} \times (1 - e^{-0,693 \cdot 12/47,1})}{0,2675,85 \cdot 10^{10} \times 206 \cdot 10^{-24} \times (1 - e^{-0,693 \cdot 12/47,1})}$$

$$= 2,057 \cdot 10^{14}$$

$$W = \frac{N \times M}{6,02 \cdot 10^{23}} \text{ gr}$$

$$W = \frac{2,057 \cdot 10^{14} \times 153 \times 10^6}{6,02 \cdot 10^{23}} \mu\text{gr} \\ = 52,304 \cdot 10^{-3} \mu\text{gr}$$

Karena 1 L dipekatkan menjadi 25 cc dan diambil 2 cc, maka

$$= 52,304 \cdot 10^{-3} / 80 \text{ ppm}$$

$$= 6,538 \cdot 10^{-4} \text{ ppm}$$

Contoh Perhitungan unsur sedimen secara nisbi

1. Menghitung (Cps) o cuplikan Samarium dalam cuplikan

Diketahui :

$$\text{Netto cupl} = 39258$$

$$t \text{ cacah} = 600 \text{ detik}$$

$$\begin{aligned} (\text{Cps}) \text{ cupl} &= \frac{\text{Netto cupl}}{t \text{ cacah}} \\ &= \frac{39258}{600} \\ &= 65,43 \end{aligned}$$

$$t \text{ tunda} = 163,83 \text{ jam}$$

$$t_{1/2} = 47,1 \text{ jam}$$

$$\begin{aligned} (\text{Cps}) \circ \text{cupl} &= (\text{Cps}) \text{ cupl} \times e^{0,693 \cdot 163,83 / 47,1} \\ &= 65,43 \times e^{0,693 \cdot 163,83 / 47,1} \\ &= 728,88 \end{aligned}$$

2 Menghitung (Cps) o Samarium dalam standar

Diketahui :

$$\text{Netto} = 40909$$

$$t \text{ cacah} = 600 \text{ detik}$$

$$\begin{aligned} (\text{Cps}) \text{ std} &= \frac{\text{Netto std}}{t \text{ cacah}} \\ &= \frac{40909}{600} \\ &= 68,182 \end{aligned}$$

$$t \text{ tunda} = 164,95 \text{ jam}$$

$$t_{1/2} = 47,1 \text{ jam}$$

$$\begin{aligned} (\text{Cps}) \circ \text{std} &= (\text{Cps}) \text{ std} \times e^{0,693 \cdot 164,95 / 47,1} \\ &= 68,182 \times e^{0,693 \cdot 164,95 / 47,1} \\ &= 772,129 \end{aligned}$$

3 Menghitung Kadar Samarium dalam cuplikan

$$(Cps) \circ \text{cupl} = 728,88$$

$$(Cps) \circ \text{std} = 772,129$$

$$\text{Kadar Sm std} = 6,7 \text{ ppm}$$

$$\text{Kadar Sm dalam cuplikan} = \frac{728,88 \times 6,7}{772,129}$$

$$= 6,325 \text{ ppm}$$

Contoh perhitungan unsur sedimen secara absolut

Diketahui : $(Cps) \text{ Sm} = 728,886$

$$s = 0,18$$

$$\phi = 5,85 \cdot 10^{10} \cdot n \cdot \text{cm}^2 \text{dt}^{-1}$$

$$\sigma = 206 \cdot 10^{-24} \cdot \text{cm}^2$$

$$t_{1/2} = 47,1 \text{ jam}$$

$$T \text{ iradiasi} = 12 \text{ jam}$$

$$\text{yield} = 0,834$$

$$\rho = 26,7\%$$

Jawaban :

$$A_0 = \frac{(C_{pso}) Sm}{yield \times \epsilon} = \frac{728,886}{0,834 \times 0,18} = 4855,355 \text{ dps}$$

$$N Sm = \frac{4855,355}{\rho \cdot \phi \cdot \sigma (1 - e^{-0,693 \cdot 1 \text{ hr} / 117^2})}$$

$$= \frac{4855,355}{0,2675,85 \cdot 10^{10} \times 206 \cdot 10^{-24} \times (1 - e^{-0,693 \cdot 12 / 147,1})}$$
$$= 93,232 \cdot 10^{14}$$

$$W = \frac{N \times BA}{6,02 \cdot 10^{23}}$$

$$= \frac{93,232 \cdot 10^{14} \times 153 \times 10^6}{6,02 \cdot 10^{23}} \mu\text{gr}$$

$$= 2,369 \mu\text{gr}$$

Karena berat cuplikan yang digunakan 0,1 gr, maka :

$$= \frac{2,369 \mu\text{gr}}{0,1 \text{ gr}}$$

$$= 23,695 \text{ ppm}$$

Contoh perhitungan untuk akurasi

$$\text{Akurasi} = \frac{|K_{cupl} - K_{ser}|}{K_{ser}} \times 100\%$$

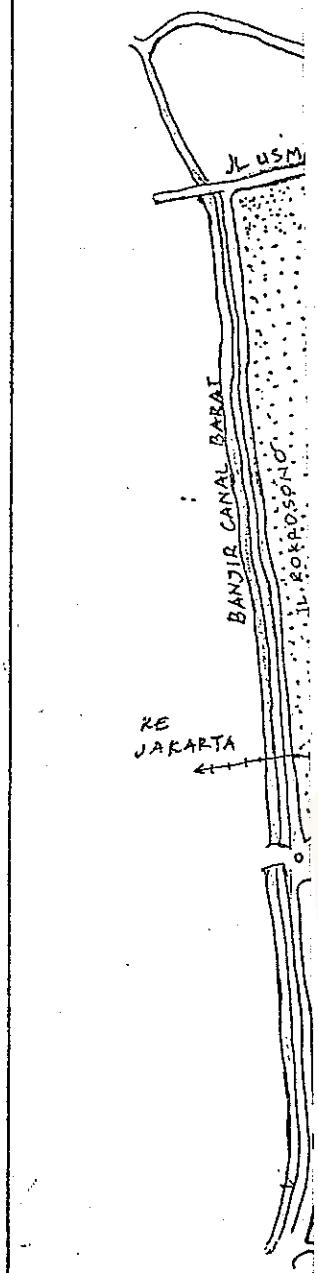
$$K_{cup} = \frac{C_{ps0} \text{ Buffalo river} \times \text{Berat std (B)}}{C_{ps0} \text{ std (B)}}$$

Untuk Samarium-153 :

$$K_{cupl} = \frac{772,129 \times 10 \text{ ppm}}{15030,636} = 0,6 \text{ ppm} \pm 0,005$$

$$\text{akurasi} = \frac{|0,6 - 6,7|}{6,7} \times 100\% = 91,04\%$$





National Institute of Standards & Technology
Certificate of Analysis
Standard Reference Material 2704
Buffalo River Sediment

This Standard Reference Material (SRM) is intended primarily for use in the analysis of sediments, soils, or materials of a similar matrix. SRM 2704 is a freeze-dried river sediment that was sieved and blended to achieve a high degree of homogeneity.

The certified elements for SRM 2704 are given in Table 1. The values are based on measurements using two or more independent and reliable analytical methods. Noncertified values for a number of elements are given in Table 2 as additional information on the composition. The noncertified values should not be used for calibration or quality control. Analytical methods used for the characterization of this SRM are given in Table 3 along with analysts and cooperating laboratories. All values (except for carbon) are based on measurements using a sample weight of at least 250 mg. Carbon measurements are based on 100 mg samples.

Notice and Warnings to Users: This certification is valid for 5 years from the shipping date. Should any of the certified values change before the expiration of the certification, purchasers will be notified by NIST.

Stability: This material was radiation sterilized (^{60}Co) at an estimated minimum dose of 2.8 megarads to reduce the rate of any biodegradation. However, its stability has not been rigorously assessed. NIST will monitor this material and will report any substantive changes in certification to the purchaser.

Use: A minimum sample weight of 250 mg (dry weight - see Instructions for Drying) should be used for analytical determinations relating to the certified values on this certificate.

Sample preparation: Sample preparation procedures should be designed to effect complete dissolution. If volatile elements (i.e., Hg, As, Se) are to be determined, precautions should be taken in the dissolution of SRM 2704 to avoid volatilization losses.

Statistical consultation was provided by S.B. Schiller and K.R. Eberhardt of the Statistical Engineering Division.

The overall direction and coordination of the analyses were under the chairmanship of M.S. Epstein and B.L. Diamondstone of the Inorganic Analytical Research Division.

The technical and support aspects involved in the preparation, certification, and issuance of this Standard Reference Material were coordinated through the Standard Reference Materials Program by T.E. Gills.

Gaithersburg, MD 20899

July 9, 1990

(Revision of certificate dated 6-1-88)

William P. Reed, Acting Chief
Standard Reference Materials Program

(over)

Instructions for Drying: When nonvolatile elements are to be determined, samples should be dried for 2 hours at 110 °C. Volatile elements (i.e., Hg, As, Se) should be determined on samples as received; separate samples should be dried as previously described to obtain a correction factor for moisture. Correction for moisture is made to the data for volatile elements before comparing to the certified values. This procedure, which was developed for the certification of volatile elements, ensures that these elements are not lost during drying. The approximate weight loss on drying has been found to be 0.8%.

Source and Preparation of Material: The river sediment for this SRM was collected from the Buffalo River in the area of the Ohio Street Bridge, Buffalo, N.Y. The U.S. Army Corps of Engineers, under contract to NIST, collected and screened approximately 908 kg of river sediment and placed it in six 55-gallon, Teflon-lined drums. The drums were loaded onto a refrigerated truck and transported to the Technimed Corporation, Fort Lauderdale, Florida, for freeze-drying of the contents. The freeze-dried sediment was shipped to an NIST contractor's laboratory where it was screened and passed through a 100 mesh sieve (nominal sieve opening of 150 µm) and retained on a 10 mesh sieve (nominal sieve opening of 38 µm). The sieved sediment was returned to NIST, radiation sterilized, packed, and bottled into 50-g units.

Analysis: The homogeneity of the bottled units was assessed using x-ray fluorescence spectrometry. Duplicate 1-gram samples from 8 randomly selected bottles were analyzed for the following elements: Al, Si, K, Ca, Ti, Zn, Sr, P, Mn, Rb, and Zr. No statistically significant differences in the composition of samples within or between bottles were observed relative to the uncertainty of the XRF measurements, which is less than 0.4%. Sample inhomogeneity of about 4% for lead was observed in measurements on 250 mg samples by thermal-ionization atomic absorption mass spectrometry. Sample inhomogeneity for lead is reflected in the uncertainty limits placed on the certified value for lead.

Table 1. Certified Values

Element	Wt. %	Element	Wt. %
Aluminum	6.11 ± 0.16	Phosphorus	0.0998 ± 0.0028
Calcium	2.60 ± 0.03	Potassium	2.00 ± 0.04
Carbon	3.348 ± 0.016	Silicon	29.08 ± 0.13
Iron	4.11 ± 0.10	Sodium	0.547 ± 0.014
Magnesium	1.20 ± 0.02	Sulfur	0.397 ± 0.004
		Titanium	0.457 ± 0.018

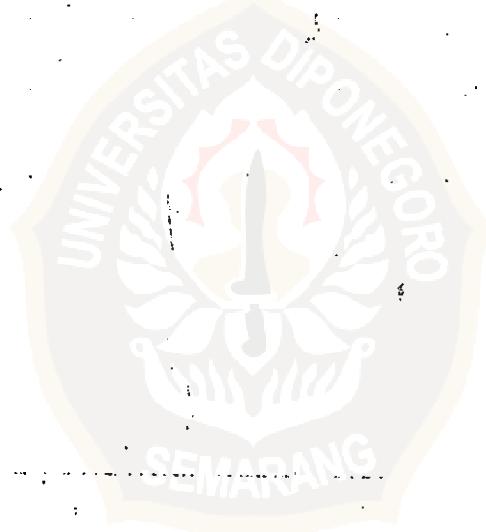
Element	µg/g	Element	µg/g
Antimony	3.79 ± 0.15	Manganese	555 ± 19
Arsenic	23.4 ± 0.8	Mercury	1.47 ± 0.07
Barium	414 ± 12	Nickel	44.1 ± 3.0
Cadmium	3.45 ± 0.22	Selenium	1.12 ± 0.05
Chromium	135 ± 5	Thallium	1.06 ± 0.07
Cobalt	14.0 ± 0.6	Uranium	3.13 ± 0.13
Copper	98.6 ± 5.0	Vanadium	95 ± 4
Lead	161 ± 17	Zinc	438 ± 12
Lithium	47.5 ± 4.1		

Certified Values and Uncertainty: The certified values are weighted means of results from two or more analytical methods. The weights for the weighted means were computed according to the iterative procedure of Paule and Marquardt (NBS Journal of Research 87, 1982, pp. 377-385). Each uncertainty is obtained from a 95% prediction interval plus an allowance for systematic error among the methods used. The allowance for systematic error is equal to the greatest difference between the weighted mean (certified value) and the component means for the analytical methods used. In the absence of systematic error, the resulting uncertainty limits will cover the concentration of approximately 95% of all samples of this SRM having a minimum size of 250 mg.

Table 2. Noncertified Values

<u>Element</u>	<u>Content, Wt. %</u>	<u>Element</u>	<u>Content $\mu\text{g/g}$</u>
Chlorine	(<0.01)	Bromine	(7)
		Cerium	(72)
		Cesium	(6)
		Dysprosium	(6)
		Europium	(1.3)
		Gallium	(15)
		Hafnium	(8)
		Iodine	(2)
		Lanthanum	(29)
		Lutetium	(0.6)
		Rubidium	(100)
		Scandium	(12)
		Samarium	(6.7)
		Strontium	(130)
		Tin	(9.5)
		Thorium	(9.2)
		Ytterbium	(2.8)
		Zirconium	(300)

Noncertified Values: Noncertified values are provided for information only. An element concentration value may not be certified, if a bias is suspected in one or more of the methods used for certification, or if two independent methods are not available. Certified values for some of these elements may eventually be provided in a revised certificate when more data is available.



Lampiran E.

TABEL TENAGA RADIONUKLIDA

No	Isotop	Inten-sitas	Umur paro	Tenaga kov	Isotop	Inten-sitas	Umur paro	Tenaga kov	Isotop	Inten-sitas	Umur paro
1	Tb-161	30	7,2 h	136,5	Co-57	6	270 h	238,8	As-77	60	32,7 s
1	Rh-104m	-	4,4 m	137,0	Re-186	90	2,2 h	242,0	Pb-214	-	Ra-226 series
1	Bf-180m	30	5,5 j	139,0	Nd-151	12,0 m	245,4	Ag-111	10	7,4 s	
1	Co-60m	100	10,5 m	139,0	Os-193	20	31,5 j	Gd-111a	75	18 s	
1	Ir-192m	100	1,5 m	139,8	Ge-75m	100	49 d	245,4	In-111	50	2,01 h
1	Dy-159	100	124,4 h	140,6	Ho-99	90	66 j	Sa-155	6	21,9 s	
1	U-237	60	6,75 h	140,6	Tc-99m	100	6,04 j	As-77	10	38,7 s	
1	Sm-145	100	340 h	141,2	Sa-155	10	21,9 s	Sr-113	100	115 s	
1	Sb-122s	100	3,5 s	142,5	Ge-46m	100	20,0 d	Hg-151	-	12 s	
1	Yb-159	20	30,6 h	145,4	Ge-141	100	32,5 h	Ge-77	50	11,3 s	
1	Ta-182	14	115,1 h	146,7	Ta-182m	35	16,2 s	Se-75	30	121 s	
1	Gd-153	4	236 h	149,7	Tc-131	70	24,8 s	Ge-75	20	79 s	
1	Sm-153	20	47,1 j	150,3	Yb-177	50	1,9 j	Ba-135a	100	23,7 s	
1	U-239	100	23,54 s	150,8	Cd-111m	25	48	Cd-117z	-	3,0 s	
1	Tb-161	30	7,2 h	151,1	Sr-85m	-	70,0 m	Pm-151	10	27,5 s	
1	St-172s	100	3,5 s	151,7	Y-181	0,2	145 h	Se-81	60	18 s	
1	Rh-104s	-	4,4 m	153,7	Dy-165s	-	1,25 s	Ba-133s	100	38,9 s	
1	Hg-197	100	65 j	155,1	Re-128	70	16,7 i	Np-239	20	2,35 h	
1	PL-197	90	20,0 s	158,3	Mg-199a	-	42,0 m	Te-129	-	72 s	
1	Sc-166	90	26,9 s	158,3	Iu-199	80	3,15 h	Hg-203	100	46,9 h	
1	Sc-166s	20	30 s	158,4	Sr-117a	100	14 s	Pb-203	90	52,1 s	
1	Sm-133	20	7,5 t	158,4	Iu-117(1/2)	-	44 s	Se-75	14	121 s	
1	Ta-170	100	129 h	-	Tc-123a	100	104 h	Dy-165	15	2,36 s	
1	Zn-155	60	1,7 s	158,8	Tc-123a	100	282,6	Yt-175	30	101 s	
1	Tc-233	-	22,4 s	159,3	Ge-77a	50	54 d	Pm-149	90	53,1 s	
1	Pd-109	100	13,5 j	160,0	Sc-47	100	3,43 h	Sc-31	40	18 s	
1	Ag-109s	100	40 d	160,2	Sr-123	100	39,4 s	Ca-143	80	33,0 s	
1	Cd-109	100	470 h	160,6	Hf-179a	10	19,0 d	Pb-214	-	Ra-226 series	
1	Lu-176s	100	3,71 j	161,9	Se-77a	100	17,5 d	Er-171	2	7,8 s	
1	Hf-175	3	70,0 h	164,5	Y-131a	100	12,0 d	Ir-192	10	74,4 h	
1	Sd-147	50	11,1 h	164,6	U-257	10	6,75 h	Tb-160	20	73 s	
1	Re-158s	-	18,7 s	165,8	Ge-139	100	140,0 d	Pm-149	12	27,0 h	
1	Ta-180s	-	8,15 j	165,8	Ba-139	70	83 s	Ba-132	2	7,5 t	
1	Cu-67	40	61,6 i	168,1	Pm-151	20	27,5 j	Gd-159	1	18,0 s	
1	Ag-107s	100	43 d	171,1	In-111	50	2,81 d	Rb-105	-	35,1 s	
1	Dy-165	35	2,36 j	172,7	Ta-132a	40	16,2 s	Fe-161	50	11,0 s	
1	Sc-79s	100	3,91 s	172,1	Pd-111a	90	5,5 j	Er-171	50	7,8 s	
1	Rh-104m	-	4,4 s	175,3	Ga-70	30	21,1 s	Pm-149	10	13,5 s	
1	Gd-153	60	236 h	176,2	St-125	7	2,0 t	Pm-233	20	27,0 h	
1	Pt-195s	-	4,1 h	177,0	Yb-169	15	30,6 b	Gd-161	20	3,73 s	
1	Ta-182	10	115,7 h	180,9	Ko-99	10	66 j	In-117z	-	1,9 j	
1	Gd-161	10	3,73 s	182,4	Cu-67	60	61,6 s	In-192	-	74,1 h	
1	Sc-81a	100	36,8 s	184,3	Ho-166a	20	30 y	Pt-199	-	30,0 s	
1	Gd-153	40	236 b	184,9	Ta-182m	20	16,2 a	Ru-105	-	35,3 s	
1	Sm-153	90	47,1 j	185,9	Pt-199	-	30,0 s	Ru-127	6	11,00 s	
1	Ta-180s	-	8,15 j	186,2	Ru-226	-	320,0	Cr-51	100	27,8 s	
1	Sc-155	-	21,9 s	186,7	O-190m	20	10,0 s	Tl-51	90	5,79 s	
1	Eu-155	40	1,7 t	188,9	Pd-109s	100	4,75 s	Ru-97	10	2,88 s	
1	Re-188s	-	18,7 s	190,2	In-114a	100	50 h	Ir-194	50	19,7 s	
1	Hg-239	40	2,35 h	191,4	In-197	2	65 j	La-140	10	40,27 s	
1	Ba-131z	100	14,6 s	191,4	Pt-197	10	20,0 s	Sn-125	100	9,5 s	
1	Dy-165s	-	1,25 s	192,0	Mo-101	10	14,6 s	Hf-180s	20	5,5 s	
1	Ta-125s	100	58,0 h	192,5	Pt-59	2	45,1 h	Iu-196	26	6,2 s	
1	Er-171	20	7,8 j	197,8	Yb-169	20	30,6 h	In-115s	100	4,5 s	
1	Ta-177	15	6,75 h	198,3	Ta-168	20	85 d	Pm-151	30	27,3 s	
1	Lu-177m	-	155 h	198,6	Ge-75	10	79 s	Pm-233	3	23,0 s	
1	Yb-175	15	101 j	202,4	T-90m	50	3,14 j	Sn-125	100	9,5 s	
1	Nd-149	-	1,8 s	203,8	Hg-205	100	5,6 s	Hf-175	50	70,0 s	
1	Nd-151	-	12,0 s	208,0	U-237	30	6,75 h	Eu-152	20	9,35 s	
1	Eu-152a	20	9,35 j	208,2	Au-199	20	3,15 h	Hf-181	10	4,8 s	
1	Eu-152	10	12,2 t	208,4	Lu-177a	-	155 h	Pt-197s	100	88,0 s	
1	Zn-71	-	2,2 s	208,4	Lu-177	70	6,75 h	Pt-191	20	3,0 h	
1	Co-57	60	270 h	211,4	Ge-77	50	11,3 s	Pb-214	-	Ra-226 series	
1	Re-186	6	2,2 h	211,4	Nd-149	-	1,8 j	Zr-97	3	17,0 j	
1	Ba-131	30	11,5 h	212,3	Tc-121a	90	154 h	Eu-156	100	6,2 h	
1	W-185	100	70,0 h	214,3	Hf-179m	10	19,0 d	Ba-133	50	7,5 t	
1	Tc-101	2	14,0 s	215,3	Hf-180s	30	5,5 j	Se-83	100	25 s	
1	Co-134s	100	3,15 j	215,5	Ge-77m	50	54 d	Pt-191	20	3,0 h	
1	Xe-57	12	36,0 j	215,5	Ge-77	50	11,3 j	Sn-124	50	3,73 s	
1	Os-191	100	14,6 h	215,8	Ru-97	90	2,88 h	Gd-161	50	105 h	
1	Re-105s	100	45 d	216,1	Ba-131	20	11,5 h	Os-190s	25	10,0 s	
1	Hf-181	30	44,6 h	224,9	Se-83	50	25 s	Dy-165	20	2,36 s	
1	(Pr-114)	-	285 s	225,8	Gd-159	3	18,0 j	Gd-159	100	18,0 s	
1	Hg-197s	-	(17,3 s)	228,2	Up-239	20	2,35 h	I-131	80	8,03 h	
1	W-187	10	24,0 j	228,5	Lu-177a	-	155 h	Sn-85m	70 (s)	373,1 at UN	
1	Sc-75	30	121 h	235,7	Nb-95s	100	90 j	Ba-131	20	11,3 h	
1	V-181	0,1	145 h	256,6	Pb-212	-	Tc-232 series	Pd-111	---	42,0 s	

Famma keV	Isotop	Inten- sitas	Usur paro	Tenaga keV	Isotop	Inten- sitas	Usur paro	Tenaga key	Isotop	Inten- sitas	Usur paro
388,2	I-126	40	13,1 h	602,1	Te-131	4	24,8 s	909,2	Zr-89	100	78
388,5	Sr-87m	100	2,84 j	602,6	Sb-124	50	60,9 h	910,1	Zn-71	-	2,2 i
391,4	In-113m	100	104	604,7	Cs-134	40	2,07 t	911,0	Ac-228	-	Th-232 series
396,1	Yb-175	50	101 j	608,4	Tl-51	1	5,79 s	928,5	Tl-51	4	5,79 s
401,4	Pb-203	4	52,1 j	609,3	Pb-214	-	Ra-226 series	934,1	Cd-115n	60	44 h
411,8	Au-198	100	2,70 h	610,2	Ru-103	10	38,9 h	934,6	Nb-92	90	10,1 h
417,0	In-116m	20	53,99 m	616,4	Os-190m	25	10,0 s	937,2	Ag-110m	10	253 h
417,4	Te-127m	70	105	617,0	Ru-80	100	4,5 i	938,4	Ir-194	6	19,7 j
423,6	Nd-149	-	1,8 j	619,0	Br-82	13	35,87 j	963,5	Eu-152n	30	9,35 j
426,1	Au-196	1	6,2 h	622,3	Ru-106	30	1,02 t	965,8	Tb-160	20	73,0 h
427,8	Sb-125	30	2,0 t	(Rh-106)	-	210	(30 d) h; 2,5 t	983,5	Ic-228	-	Th-232 series
432,8	Hf-175	2	70,0 h	628,3	Rh-102(m)	-	10	14,3 j	Sc-48	33	44 j
433,8	Kg-108	20	2,4 s	630,1	Ga-72	10	16,7 j	1005,5	Eu-154	20	16,0 t
438,7	Zn-69m	100	13,8 j	633,0	Re-188	10	2,42 s	1012,4	Ho-101	10	14,6 s
440,2	Tl-202	90	12,0 d	632,9	Ag-108	60	1037,6	Hg-27	30	9,45 s	
442,7	I-128	90	25,4 m	634,6	As-74	17	17,5 h	1039,0	Sc-48	33	44 j
443,1	Hf-180m	30	5,5 j	636,4	I-131	30	8,08 h	1039,4	Cu-66	100	5,1 s
447,1	Tm-168	10	85	640,4	Ru-80	30	17,6 s	1047,0	Rh-102(m)	10	21,1 s
452,4	Te-131	20	24,8 s	644,6	Ir-194	10	19,7 j	1050,5	Ga-70	30	21,1 s
459,2	Th-233	-	22,4 s	645,8	Os-185	80	93,6 b	1050,5	Ru-106	5	1,02 t
459,5	Te-129m	-	33,5 h	657,0	As-76	10	26,3 j	(Rb-106)	(30 d)	-	
459,5	Te-129	-	72	657,8	Ag-110m	30	253	1076,6	Rb-86	100	18,66 h
460,1	Os-193	20	31,5 j	658,1	No-97	100	72,1 s	1079,8	Yb-177	15	1,9 j
467,9	Ir-192	20	74,4 h	661,6	Ba-137m	100	2,6 s	1097,1	In-116m	20	53,9 s
469,6	Ru-105	20	4,5 j	663,6	Cs-137	100	26,6 t	1098,6	Fe-59	50	45,1 h
475,1	Rh-102(m)	70	210 h (2,5 t)	(Ba-137n)	-	(2,6 s)	1115,4	Zn-65	100	245 h	
478,0	Ra-188	6	16,7 j	664,4	Co-143	13	33 j	1115,5	Bi-54	30	2,56 s
479,3	W-187	20	24,0 j	665,7	Br-80	100	17,6 s	1120,0	Sc-46	50	83,9 h
479,3	Y-90m	50	3,14 j	666,3	I-126	40	13,1 h	1120,3	Ta-182	17	115,1 h
482,2	Hf-181	60	44,6 b	667,7	Ga-132	100	6,2 b	1121,2	Sb-122	1	2,75 h
484,9	Cd-115m	10	44 h	670,0	Th-233	-	22,4 s	1140,5	Zr-97	17,0 j	
486,8	Lu-140	20	40,27 j	676,0	Ru-105	10	4,5 s	1147,3	Co-60	100	5,24 t
491,2	I-126	7	13,1 b	685,7	W-187	40	24,0 j	1173,1	As-76	7	26,3 j
492,5	Cd-115	30	53 j	692,5	Sb-122	5	2,75 h	1215,8	Yb-177	14	115,1 d
497,0	Ru-103	90	38,9 b	695,8	Te-129m	-	33,5 h	1221,6	Fe-59	40	1,9 j
507,5	Ie-121	20	17,0 h	696,4	Cs-144	-	285 h	1240,9	Ar-41	100	2,62 s
507,9	Zr-97	-	17,0 j	(Pr-144)	-	(17,3 s)	1266,2	Eu-154	20	16,0 t	
509,8	Tl-202	3	12,0 h	697,4	Rh-102m	-	2,5 t	1273,0	Al-29	100	6,56 s
511,0	Cu-64	-	12,8 j	702,5	Nb-94	-	2,03 x 10 ⁴ t	1273,3	Na-22	100	2,53 t
	Zn-65	-	24,5 h	717,8	Se-83	20	25 s	1274,5	Cd-115m	20	44 h
	Br-80	-	17,6 s	721,6	Co-143	13	33 j	1289,9	Eu-64	100	12,8 s
	Co-58	-	71,3 b	722,1	I-131	30	8,08 h	1291,5	Ar-41	100	17,0 j
	Is-74	-	17,5 b	722,8	Sb-124	6	60,9 b	1293,6	Co-47	50	53,99 s
	Zr-89	-	78 j	723	Eu-154	10	16 t	1299,9	Sc-47	50	4,7 h
	Na-22	-	2,58 t	724,0	Zr-95	50	65 b	1300,0	In-114	1	72 d
	Ki-57	-	36,0 j	724,3	Ru-105	40	4,5 j	1311,8	Sc-48	33	44 j
	Rb-102	-	210 h	725,1	Io-114	14	72 d	1322,4	Co-59	1	19,5 s
511,6	Za-71	-	2,2 s	727,3	Di-212	-	Ra-226 series	1332,4	Co-60	100	5,24 t
511,9	Ru-106	90	1,02 t	729,9	No-99	2	66 j	1332,4	Eu-166	10	26,9 j
	(Rh-106)	(30 d)	724,3	Nb-97s	10	60 d	1345,5	Ho-166	10	36,0 j	
514,0	Sr-85	100	64 b	754,0	Co-139m	100	55 d	1362,3	Eu-152	20	12,2 t
515,5	Dy-165m	-	1,25 s	756,6	Zr-95	40	65 h	1368,4	Y-52	100	3,76 s
520,8	As-77	20	38,7 j	765,8	Nb-95	100	35 h	1378,1	K-40	100	1,25 x 10 ⁹ t
521,4	Br-83	-	2,33 j	768,1	Bi-214	-	Ra-226 series	1378,4	El-65	50	2,56 s
521,5	Tl-202	4	12,0 h	776,6	Br-82	30	35,87 j	1378,4	K-42	100	12,52 j
526,3	I-128	9	25,4 s	791,7	Re-184	30	38 h	1378,4	Pr-142	100	19,2 j
527,7	Cd-115	60	2,3 h	795,8	Ga-134	40	2,07 t	1378,4	Cd-117n	-	3,0 j
530,5	Br-83	-	2,33 j	810,3	Co-58	100	71,3 h	1380,5	Ho-166	3	26,9 j
531,0	Nd-147	20	11,06 h	810,3	No-166m	20	30 t	1388,1	Eu-152	100	26,9 j
533,0	Pt-191	30	3,0 b	815,7	Tm-168	15	85 h	1388,1	Al-28	100	2,31 s
542,8	Pt-192	-	30,0 m	828,0	Se-81	30	18 s	1397,0	Ho-166	3	26,9 s
544,9	Tc-101	7	14,0 s	834,1	Ga-72	40	14,3 j	1398,3	El-228	-	Th-232 series
552,9	In-117	-	44 s	834,8	Na-54	100	291 h	1399,4	La-140	50	40,27 j
554,3	Br-82	20	35,87 j	841,6	Eu-152m	30	9,35 j	1405,4	Cl-38	50	37,29 s
555,8	Rb-86m	100	1,02 m	844,0	Mg-27	70	9,45 m	1412,0	Sb-124	25	60,9 h
555,8	Rh-104	100	44 d	846,9	Na-56	70	2,58 j	1419,0	Al-28	100	2,31 s
557,7	Os-193	10	31,5 j	860,5	Tl-208	-	Ra-226 series	1427,8	Ho-56	20	2,58 j
558,2	Lu-114	14	72 d	871,1	Nb-94m	10	6,6 m	1430,7	Rb-88	50	17,8 s
559,2	As-76	75	26,3 j	871,1	Nb-94	50	2,03 x 10 ⁴ t	1436,1	Y-88	100	104 b
564,0	Sb-122	90	2,75 h	874,8	Os-185	7	93,6 h	1447,4	Cd-117m	-	3,0 j
569,3	Cs-134	14	2,07 t	879,4	Tb-160	20	73,0 h	1457,5	Na-56	80	2,58 j
572,9	Tc-121	80	17,0 h	880,0	Os-185	7	93,6 b	1462,0	Cl-38	40	37,29 s
580,0	Pd-111	24	22,0 m	884,5	Ag-110m	20	253 h	1469,0	Cl-38	40	280 h
583,1	Tl-208	-	Th-232 series	889,4	Sc-46	50	83,9 h	1475,8	(Pr-144)	(17,2 s)	
588,6	Zr-89m	90	4,4 m	894,2	Re-184	10	38 h	1481,4	Ga-72	14	14,3 j
590,8	Mo-101	10	14,6 m	898,0	Rb-88	30	17,8 s	1486,3	Tl-208	-	Th-232 series
595,8	As-74	80	17,5 h	898,0	Y-88	100	104 h	1491,3	Na-56	50	17,8 s
600,4	Sh-125	20	2 t	902,8	Re-184	40	38 h	1497,4	S-37	52	15 j
								1507,0	Ca-49	100	5,05 s
								1517,0		100	8,8 s

d = datik, m = menit, j = jam, h = hari, t = tahun

Reaction	Half-life of product	Cross sections		Activation products (decays/sec per 1 μ g element)					Main γ lines
		1 sec	1 min	1 hour	1 day	70 days	saturation		

μm Z = 61 unstable element

sterile neutrinos

isotopes

1.53 a) Pm-147	2.02 s	8400 ± 1080 b
2.52 a) Pm-148m ^{b)}	41.3 d	85 ± 5 b
Pm-148s	6.37 d	80.0 ± 1.8 b
Pm-148m ^{c)}	-	18 ± 7 b
		2300 ± 300 b
(41.3 d) Pm-149	53.1 h	22000 ± 2500 b
(5.37 d) Pm-149	53.1 h	2000 ± 1000 b
53.1 h) Pm-150	2.68 h	1400 ± 300 b
28.4 h) Pm-152 m ^{d)}	4.2 m ± 7.8 m <700 b ^{e)}	922.7 b ^{f)}
		+m ^{g)}

μm Z = 62 A = 150.4 $\sigma_{sb} = 5800 \pm 100$ b $t_{sh} = 1400 \pm 200$ b

sterile neutrinos		$\phi_h = 10^{13}, f_{\text{sp}} = 2 \cdot 10^{11} \text{ n cm}^{-2} \text{ sec}^{-1}$								
/3.1	Sm-145	340 d	~0.7 b		2.07E-6	1.24E-3	7.46E-2	1.79	36.1	878
	Pm-146	17.7 s	dau							38.7(112.6), 43.8(26.5), 61.4(12.7)
/16.0	Sm-148	stable	84 ± 6 b	714 ± 50 b ^{h)}						
	(n,d)Nd-144	stable	0.35 ± 0.05 mb							
/11.2	Sm-149	stable	2.7 ± 0.6 b ^{h)}	27 ± 14 b						
/13.8	Sm-150	stable	41000 ± 2000 b	3183 b ⁱ⁾						
	(n,d)Nd-146	stable	43.0 ± 0.8 mb							
0/7.4	Sm-151	83 s	102 ± 5 b	310 ± 18 b ^{j)}	7.7E-5	4.66E-3	0.273	8.66	131	3.21E5
2/28.7	Sm-153	46.6 h ✓	208 ± 8 b ✓	3141 ± 157 b ^{k)} 11.0	714	42600	8.64E5	sat	2.87E5	41.6(46), 47(11), 103.2(28.3)
4/22.8	Sm-155 ✓	22.2 m	5.5 ± 1.1 b	21 ± 1 b ^{l)}	28.1	1660	45800	sat	sat	54100
	Eu-155	4.96 s	dau		6.41E-7	2.22E-4	0.473	20.2	412	41.5(22.5), 86.6(32), 105.3(22.4)
closed nuclides										
45 (340 d) Sm-146	7 · 10 ⁷ s	~110 b								
51 (93 a) Sm-152	stable	16000 ± 1800 b	3300 ± 700 b							

notes Promethium

7 % IT

Association to p- or m-state reaction is uncertain

Footnotes Barium see page after the next

Reaction isotope and time	Half life of product	Cross section		Activation products [decays/sec per 1 μg element]						Main γ lines
		σ	σ	1 sec	1 min	1 hour	1 day	20 days	saturation	
$\text{um} \quad Z = 58 \quad A = 140.12 \quad \sigma_{\text{sb}} = 830 \pm 150 \text{ mb} \quad t_{1/2} = 3.0 \pm 0.8 \text{ h}$										
$\phi_{\text{th}} = 10^{13}, \phi_{\text{epi}} = 2 \cdot 10^{11} \text{ n cm}^{-2} \text{ sec}^{-1}$										
Reactor neutrons										
30/0.193	Ce-137m ^{b)}	34.3 h	0.05 ± 0.26 b		4.47E-4	2.08E-2	1.69	30.0	sat	79.8
	Ce-137g	9.0 h	8.3 ± 1.6 b		1.38E-2	0.018	47.3	566	sat	717
	Ce-137m+g	-	7.26 ± 1.8 b	70 ± 7 b	0	0	3.26E-8	1.12E-6	4.37E-4	717
	La-137	60000 s	dat							no γ
138/0.28	Ce-130m ^{b)}	58 s	1.6 ± 5 mb	1.21 ± 0.13 b ^{c)}	6.30E-2	2.3	sat	sat	4.38	34.7(6.2), 764.4(0.3)
	Ce-138g	137.6 d	1.1 ± 0.3 b		7.25E-6	4.39E-4	2.7E-2	0.648	12.3	33.4(14), 165.9(8.1)
	Ce-138g (cum)	-	1.1 ± 0.3 b							
140/ 8.48 8.48	Ce-141	32.61 d	V	570 ± 40 mb	V	430 ± 20 mb ^{d)}	5.43E-3	0.328	18.6	404
142/11.07	Ce-143 ^{c)}	33.0 h	950 ± 50 mb	1.1 ± 0.08 b ^{c)}	2.7E-2	1.82	98.1	1830	4620	36(6.7), 57.4(11.1), 293.3(46.6)
	Pr-143	13.68 d	dat		0	2.85E-6	0.103	49.8	2270	4630
										no γ
Initial nuclides										
-141 (32.51 d) Ce-142	stable	20 ± 3 b	0.48 b ^{a)}							
-143 (33.0 h) Ce-144 ^{c)}	284.4 d	6.0 ± 0.7 b	42.66 b ^{a)}							
-144 (284.4 d) Ce-145 ^{c)}	3.3 m	1.0 ± 0.1 b	2.6 ± 0.3 b							
$\phi = 10^{12} \text{ n cm}^{-2} \text{ sec}^{-1}$										
St. reactor neutrons										
>136/0.193	(n,p)La-138	9.87 m	800 (+800, 400) μb		7.64E-6	4.43E-4	5.44E-3	sat	sat	6.53E-3
	(n,p)Ce-133m+g ^{b)}	38.8 h	19 (+16, 9) μb		0	1.18E-3	2.03E-8	6.66E-7	1.65E-4	30.9(44), 81(32.8), 302.7(18.6), 36
	(n,2n)Ce-136m+g ^{b)}	10.4 s								
		20 ± 17.7 h	450 (+320, 180) μb							
	La-135	18.5 h	dat		-	-	2.63E-8	8.43E-4	sat	3.73E-3
>138/0.28	(n,p)La-138	stable	280 (+280, 140) μb							
	(n,p)Ba-135m+g ^{b)}	28.2 ±	7 (+8, 3) μb							
	(n,2n)Ce-137m+g ^{b)}	34.3h ± 9h	710 (+500, 280) μb							
>140/88.48	(n,p)La-140	40.23 h	5 (+8, -3) μb		8.1E-8	6.46E-6	3.25E-4	6.44E-3	sat	1.9E-2
	(n,p)Ba-137m+g ^{b)}	2.55 m	3 (+2.5, 1.5) μb							
	(n,2n)Ce-138m+g ^{b)}	stable	-1 (+0.7, -0.4) μb							
		137.5 d								
Ca-142/11.07	(n,p)La-142	92.4 m	2 (+3, -1) μb		1.19E-7	7.13E-6	3.46E-4	sat	sat	9.54E-4
	(n,p)Ba-139	83.3 m	0 (+0, -4) μb		6.79E-7	3.18E-6	1.5E-3	sat	sat	3.82E-3
	(n,2n)Ce-141	32.61 d	7.8 (+6.5, -3.2) mb		8.3E-7	5.58E-5	3.35E-3	7.35E-2	1.31	3.77

Footnotes see next page

Reaction nuclide	Half-life of product	σ	Cross sections		Activation products [disintegrations per 1 μg element]						Maximum limit				
					I sec		1 min		1 hour						
			1 sec	1 min	1 hour	1 day	20 days	saturation	1 sec	1 min					
alum Z = 24 A = 51.008 $\nu_{\text{abs}} = 3.1 \pm 0.2 \text{ b } t_{\text{abs}} = 1.7 \pm 0.2 \text{ h}$ (cont).															
b) V neutrons															
43E	(n,2n)Cr-40 V-40	42.0 m 331 d	10 ± 2 mb ^a doubt		2.03E-6 0	1.51E-4 1.14E-10	8.02E-3 3.05E-7	1.01E-6 1.01E-6	3.03E-4 2.27E-3	9.57E-3 8.67E-3	511(192), 62.3(20), 80.6(50), 162(7) no?				
83.78	(n,p)V-52 (n,2n)Cr-51	3.765 m 27.21 d	94 ± 10 mb 318 ± 20 mb		2.87E-3 8.04E-7	0.164 6.30E-6	9.61 2.27E-3	9.61 2.02E-2	9.61 1.72	0.012 3.09	1434.2(100) 370.1(9.8)				
9.6	(n,p)V-53 (n,2n)Cr-52	5.66 m stable	40 ± 4 mb ^a 810 ± 140 mb (14.7)		3.77E-4	1.60E-2	9.61	9.61	9.61	4.4E-2	1006(88.7), 1287(11.3)				
17.30	(n,2n)Cr-53	stable	1.17 ± 0.13 h (14.7)												
yttrium Z = 39 A = 64.0380 $\nu_{\text{abs}} = 13.3 \pm 0.2 \text{ b } t_{\text{abs}} = 14.0 \pm 0.4 \text{ h}$															
c) reactor neutrons															
5/100	Mn-56	2.582 h	13.3 ± 0.2 b	14.0 ± 0.4 b	111	6650	3.51E-6	sat	sat	1.49E0	846.6(99), 1811.2(30), 2112(16.5)				
selected nuclides															
I3 (3.7 ± 10 ⁶ a)	Mn-54	312.5 d	33 ± 5	16 b											
54 (312.6 d)	Mn-55	stable	< 10 b												
reactor neutrons															
55/100	(n,p)Cr-55 (n,d)V-52 (n,2n)Mn-54	3.60 m 3.755 m 312.6 d	302 ± 1450, 1801 pb ^a 11Q ± 30 pb 258 ± 13 pb ^a		1.07E-2 3.7E-3 2.26E-8	0.582 0.203 4.30E-6	3.29 3.21 2.61E-4	sat sat 5.27E-3	sat sat 0.125	3.29 1.21 2.03	1528.2(0.043) 1434.2(100) 834.8(100)				
f) MeV neutrons															
55/100	(n,p)Cr-55 (n,d)V-52 (n,2n)Mn-54	3.56 m 3.755 m 312.6 d	41 ± 5 mb ^a 37 ± 5 mb 890 ± 60 mb ^a		1.46E-3 1.08E-3 2.6E-7	7.95E-2 5.91E-2 1.6E-6	sat 0.051 9.02E-4	sat sat 2.10E-2	sat 0.432 0.432	0.449 0.351 8.76	1528.2(0.043) 1434.2(100) 834.8(100)				

selected Chromium

Other value 11.1 h^b
Other value 800 mb^b
Other value 700 mb^b
Other value 250 mb^b
Other value 11 (18.4) pb^b
Other value 600 (1,060, 330) pb^b
Other value 120 (1,180, 701) pb^b
Other value 8 (1,12, 8) pb^b
Other value 29.4 ± 1.0 mb (14.7)^c
Other value 352 ± 65 mb (14.7)^c

Fontnotes Manganese

a) Other value 180 (1,130, 701) pb
b) Other value 837 ± 67 mb (14.7)^c

Reaction	Half-life of product	σ	Cross sections		Activation products [literacy per 1 μb element]					Main γ lines			
			1 sec	1 min	Irradiation time	1 hour	1 day	20 days	saturation				
Z = 27 A = 68.0332 $v_{ab} = 37.2 \pm 0.2 \text{ b}$ $t_{ab} = 76.5 \pm 1.5 \text{ b}$													
radiation													
$\sigma_N \times 10^{13}, \sigma_{pp} = 2 \times 10^{-13} \text{ n cm}^2 \text{ sec}^{-1}$													
(n,p)Co-59	10.48 m	20 ± 2 b	36.8 ± 0.5 b ^{a)}	2330	1.30E6	2.00E8	3E1	3E1	2.17E0	58.0(2.1)			
(n,p)Mn-56	5.772 s	12 ± 2 b	30 ± 2 b ^{b)}										
(n,p)Iron-57	37.2 ± 0.2 b	✓	76.5 ± 1.5 b	2.8E-3	0.472	51.2	1410	28200	3.93E-8	1173.2(93.9), 5332.5(100)			
capture													
(1 h) Co-59	stable	136000 ± 10000 b											
(1.3 d) Co-59	stable	1880 ± 170 b	6890 b										
(0.48 m) Co-61	1.650 h	58 ± 8 b	230 ± 50 b										
(2.72 s) Co-61	1.060 h	2.0 ± 0.2 b	4.3 ± 1.0 b										
or neutron													
(n,p)Fe-59	44.0 d	1.47 ± 0.14 mb ^{c)}	2.61E-6	1.57E-4	0.30E-3	0.224	3.88	14.5	1099.3(56), 1291.6(44)				
(n,d)Mn-56	2.582 h	156 ± 9 mb ^{d)}	1.19E-4	2.12E-3	0.375	5E1	1.59	846.6(99), 1811.2(30), 2112.6(15.5)					
(n,2n)Co-58	70.78 d	400 ± 40 mb ^{e)}	--	--	--	0.722	4.09	511(30), 810.6(99.4)					
proton													
$\Phi 14.5 \text{ MeV} \times 10^6 \text{ n cm}^{-2} \text{ sec}^{-1}$													
(p,p')Fe-59	44.0 d	80 ± 23 mb	1.47E-7	8.82E-6	5.29E-4	1.26E-2	0.219	0.818	1099.3(56), 1291.6(44)				
(p,p')Mn-56	2.582 h	30 ± 2 mb	2.79E-6	1.37E-3	7.22E-2	0.300	5E1	0.307	846.6(99), 1811.2(30), 2112.6(15.5)				
(p,p')Co-58m ^{f)}	8.94 h	402 ± 41 mb	8.65E-5	5.18E-3	0.3	3.44	5E1	4.11	ray				
(p,p')Co-58	70.78 d	720 ± 50 mb ^{g)}	8.28E-7	4.07E-5	3.04E-3	9.26E-2	2.03	11.5	511(30), 810.6(99.4)				

% IT
 range between values above and below
 a value 1 (±3.5, 0.0) mb^{1,2)}
 b value 170 (±140, 20) mb^{1,2)}
 c value 160 (±110, 60) mb^{1,2)}
 d value 838 ± 22 mb^{1,2)} 22)