Quality Policy of CMI OI Prague

The Czech Metrology Institute (CMI) – Regional Branch (RB) Prague is possessor of the national standard of unit of radioactivity - Bq. It is in the system of metrology of radioactivity the top facility in the Czech Republic. Working of the laboratory of absolute measurements is verified by system of international comparisons, which guarantees highest level of quality control.

To secure of metrological linking-up on radioactivity standard, RB manufactures wide scale of secondary standards, covering comprehensive spectrum of needs of labs for radioactivity measurement, labs of nuclear medicine, hygienic labs and for needs of legal metrology. Our aim is by means of secondary standards of highest class to improve system of metrology of radioactivity and in the highest possible degree to satisfy the client's requirements and aim at increase in quality and technical level of products. At response on market requirements we are able to develope and produce completely new types of standards.

CMI IIR, Department of Production of Radioactive Standards is holder of the Quality System Certificate DNV No. 174048-2015-AQ-CZS-RvA (ISO 9001:2008).

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CATALOG OF ČMI - RB RADIOACTIVE STANDARDS

PRODUCER
Český metrologický institut,
Oblastní inspektorát Praha
Czech Metrology Institute,
Regional Branch Prague

Standards for alpha spectrometry	EA
Standards for X and gamma spectrometry	EFF, EFX, EFS
Standards for checking and calibration gamma spectrometers	EG, MBSS
Standards for checking and calibration devices for measurement of area contamination	EM, EZ
Standards of mass ^{226}Ra	EB, EP
Standards in solution for general use	ER
Simulator ^{125}I for checking and calibration RIA measuring devices	ESI
Standards for use in nuclear medicine	ENM, ED
Standards for checkin ionization chambers	ENK
Standards type filter	FILTER
Methyl iodide labelled with ^{131}I	EMEI
Standards of rare gases	EVP
Phantom BOMAB	Phantom
Flow through sources of ^{222}Rn	RF
Simulator of radioactive contaminated steel	ES
Silicon dosimetric diodes for fast neutrons dose measurement	Si - 1,2

Vysvětlivky:
Uncertainty is an abbreviation for combined standard uncertainty (P = 68,3 %).
^{90}Sr is in radioactive equilibrium with ^{90}Y.
^{137}Cs is in radioactive equilibrium with ^{137m}Ba.
Half-lifes were taken from tables “**Laboratorie National Henry Beckquerel Recommended Data”** a **“Table of Nuclides Korea Atomic Energy Research Institute”.**

STANDARDS FOR ALPHA SPECTROMETRY

Description

The radioactive substance in thin layer on the Pt foil is squeezed to the duraluminium casing with dimensions
25 x 5 mm (diameter x height). The casing has front window with diameter 6 mm. The active area must be carefully protected against moisture, dust and abrasion.

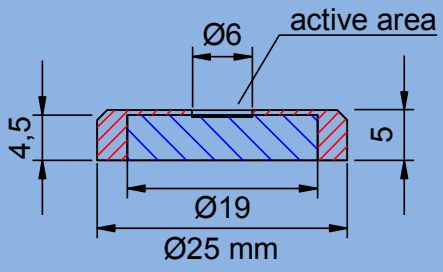
Application

They are widely used as control sources in comparative measurements, for energy and efficiency calibration of
α -spectrometers, determination of efficiency of window and windowless counters of α particles.

Measurement

Flux of α particles to spatial angle 2 π sr is determined by 2 π windowless proportional counter. Activity is calculated from flux using correction on back scattering, spatial angle and self-absorption.

Nuclide	Half-life days	Particle energy,keV	Type	Particle flux in 2π sr, s^{-1}	Uncertainty of flux, %	Activity kBq	Code
^{239}Pu	$8{,}802.10^{6}$	5244,43	EA 13	57	0,8	0,1	PUA 13
			EA 14	570	0,8	1,0	PUA 14
^{241}Am	$1{,}580.10^{5}$	5578,28	EA 13	57	0,8	0,1	AMA 13
			EA 14	570	0,8	1,0	AMA 14
			EA 15	5700	0,8	10	AMA 15
$^{241}Am + ^{239}Pu$	-	-	EA 14	570	0,8	1,0	AMPU 14



EFF AND EFX STANDARD SOURCES OF PHOTON FLUX

Description

Standards of X and γ photon flux type EFF and EFX are the point sources with minimum self-absorption emitting homogeneously to angle near 4π sr. The activity is deposited between two welded polyethylene foils with square weight 3,6 ± 0,3 mg.cm^{-2}. The foils are located in the metal ring with outer diameter 40 mm. The active material is located in the centre of the foil.

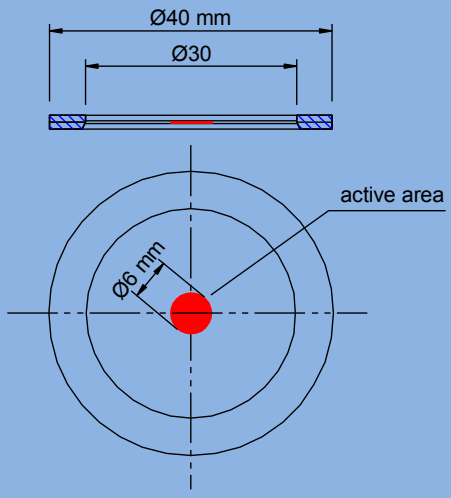
Application

Standards EFF and EFX are designed for energy and efficiency calibration of counters and spectrometers of X and γ photons. The activity of the standard gives the source strength approximately ~10^4 s^{-1} .

Measurement

The source strength of the EFX standard is determined by means of a suitable 4 π counter. For the standards EFF (emitting photons γ) source emission is calculated from the activity and the known photon yields.

Nuclide	Half-life days	Photon energy, keV		Particle flux in 4 π sr		Uncertainty %	Code
		X - K	γ	keV	s^{-1}		
^{55}Fe	1003,3	5,898		5,888	10^4	1,5	FMFX
^{57}Co	271,80	6,403	122,06065	122,06	10^4	1,5	CTFF
			136,4735	136,47			
^{65}Zn	244,01	8,047	1115,53	8,03	10^4	1,7	ZNFX
^{85}Sr	64,85	13,395	514,004	13,4	10^4	2,2	SAFX
^{109}Cd	461,9	22,16317	88,0336	22	10^4	1,5	CDFX
^{241}Am	158000	11,89-22,2	26,3446	59,5409	10^4	1,9	AMFF
			59,5409				



EFS STANDARD SOURCES FOR GAMMA SPECTROMETRY

Description

Standards of γ photon flux EFS are the point sources with minimum self-absorption emitting homogeneously to angle near 4 π sr. The activity is deposited between two welded polyethylene foils with thickness less than 0,2 mm. Foils are mounted in the metal ring with outer diameter 35 mm. The active material is located in the centre of the foil.

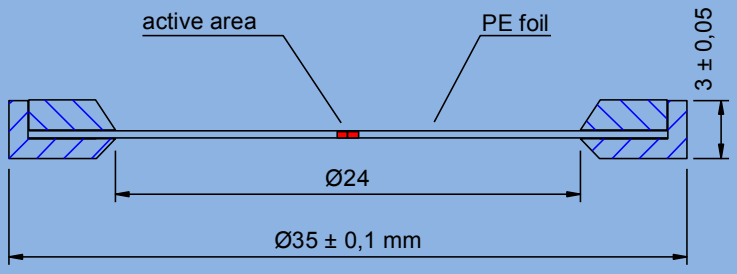
Application

The standards EFS are designed for energy and efficiency calibration of gamma spectrometers with Ge(Li) and HPGe detectors. Used radionuclides cover energy range 100 keV - 2 MeV.

Measurement

The activity of the standard is calculated from the mass and specific activity of the standard solution. The specific activity is determined by absolute measurement.

Nuclide	Half-life days	Energy keV	Photon yield %	Uncertainty		Activity kBq	Code
				activity, %	photon flux %		
^{57}Co	271,8	122,06065	85,51	1,2	1,2	50	CTS 01
		136,4735	10,71		2,2		
^{139}Ce	137,641	165,857	79,90	1,2	1,3	80	CCS 01
^{203}Hg	46,594	279,195	81,48	1,3	1,4	150	HGS 01
^{85}Sr	64,85	514,004	98,5	1,2	1,2	250	SAS 01
^{137}Cs	10976	661,657	84,99	1,2	1,2	400	CSS 01
^{54}Mn	312,19	834,848	99,9752	1,0	1,0	450	MNS 01
^{60}Co	1925,2	1173,22	99,85	0,8	0,8	700	COS 01
		1332,49	99,9826				
^{88}Y	106,626	898,036	93,90	1,5	1,5	700	YWS 01
		1836,052	99,32				
^{133}Ba	3849,7	53,1622	2,14	1,0	-	250	BAS 01
		79,6142	2,65		4,3		
		80,9979	32,9		5,3		
		160,6121	0,638		5,2		
		223,2368	0,453		-		
		276,3989	7,16		2,0		
		302,8508	18,34		1,8		
^{133}Ba	3849,7	356,0129	62,05		1,4	250	
		383,8485	8,94		1,8		
^{152}Eu	4938,8	121,7817	28,41	1,0	1,2	600	EUS 01
		244,697	7,55		1,2		
		344,2785	26,59		1,1		
		411,1165	2,238		1,1		
		443,965	2,80		1,2		
		778,9045	12,97		1,2		
		964,079	14,50		1,1		
		1085,837	10,13		1,1		
		1112,076	13,41		1,1		
		1408,01	20,85		1,1		


active area
PE foil
3 ± 0,05
Ø24
Ø35 ± 0,1 mm

EG REFERENCE SOURCES

Description

A weighed amount of the standard solution is dropped on the disc of filter paper in the polymethylmetacrylate capsule. The capsule is sealed up, when dried. The capsule and the reflector layer of common NaI(Tl) scintillators provide a sufficient filtering of β radiation of relevant radionuclide. For ^{144}Ce this filtration is not sufficient and for the types EG 1 and EG 3 layer of minimum 3,2 mm Al between the standard and the detector is necessary.

Application

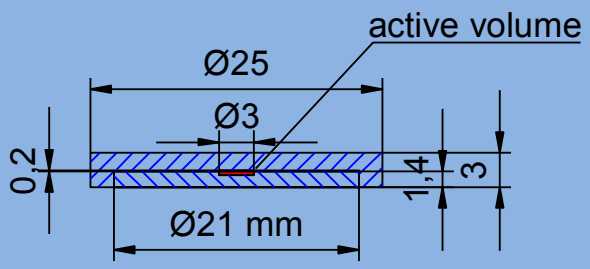
Energy and efficiency calibration of scintillation spectrometers and counters of γ and X radiation. They can serve as reference sources for relative measurements. Their activity is chosen so that: standard EG 1 in closed geometry with the NaI(Tl) 38 x 25 mm ; standard EG 2 inserted to the well of NaI(Tl) 45 x 50 mm and standard EG 3 located 10 cm from the forehead of NaI(Tl) 38 x 25 mm gives approx. 1700 counts per second for energy higher than 30 keV.

Measurement

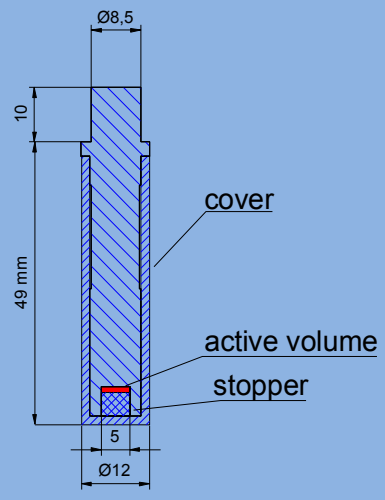
The activity of individual standards is calculated from the mass of the standard solution and is checked by relative measurements of γ photon flux. The specific activity is determined by absolute measurement
using $4\pi\ \beta-\gamma$, $4\pi\ \alpha-\gamma$ or 4π X- γ coincidence method or 4π proportional counter.

Nuclide	Half-life,days	Type	Activity kBq	Photon energy, keV	Photon yield, %	Uncertainty %	Code
^{22}Na	950,69	EG 1	5	511,0 1274,537	180,7 99,94	1,0	NAG - 1
		EG 2	3				NAG - 2
		EG 3	100				NAG - 3
^{54}Mn	312,19	EG 1	13	834,848	99,9752	0,7	MNG - 1
		EG 2	6				MNG - 2
		EG 3	300				MNG - 3
^{57}Co	271,80	EG 1	6	122,0606 136,4735	85,51 10,71	1,0	CTG - 1
		EG 2	2				CTG - 2
		EG 3	150				CTG - 3
^{60}Co	1925,2	EG 1	10	1332,492 1332,492	9,9826 99,9826	0,7	COG - 1
		EG 2	4				COG - 2
		EG 3	200				COG - 3
^{65}Zn	244,01	EG 1	40	1115,539	50,22	1,6	ZNG - 1
		EG 2	18				ZNG - 2
		EG 3	800				ZNG - 3
^{88}Y	106,626	EG 1	8	898,036 1836,052	93,90 99,32	1,2	YWG - 1
		EG 2	4				YWG - 2
		EG 3	200				YWG - 3
^{129}I	$5,88.10^{9}$	EG 1	15	39,578 29 - 35 X_K	7,42 > 70	0,7	IZG - 1
		EG 2	5				IZG - 2
^{133}Ba	3849,7	EG 1	3	80,9979 302,8508 356,0129	32,9 18,34 62,05	0,8	BAG - 1
		EG 2	2				BAG - 2
		EG 3	80				BAG - 3
^{137}Cs	10980	EG 1	16	661,657	84,99	0,9	CSG - 1
		EG 2	7				CSG - 2
		EG 3	300				CSG - 3

Nuclide	Half-life,days	Type	Activity kBq	Photon energy, keV	Photon yield, %	Uncertainty %	Code
^{141}Ce	32,503	EG 1	10	145,4433	48,29	0,9	CKG - 1
		EG 2	3				CKG - 2
		EG 3	250				CKG - 3
^{144}Ce	284,89	EG 1	30	133,5152	10,83	1,1	CEG - 1
		EG 2	8				CEG - 2
		EG 3	600				CEG - 3
^{152}Eu	4938,8	EG 1	30	od 121 do 1528 keV	závisí na energii	0,8	EUG - 1
		EG 2	15				EUG - 2
		EG 3	450				EUG - 3
^{203}Hg	46,594	EG 1	8	279,1952	81,48	1,1	HGG - 1
		EG 2	3				HGG - 2
		EG 3	200				HGG - 3
^{241}Am	158000	EG 1	15	59,5409	35,92	0,6	AMG - 1
		EG 2	5				AMG - 2
		EG 3	450				AMG - 3



Type EG 1 and EG 3



Type EG 2

MBSS STANDARDS IN MARINELLI BEAKERS

Description

Marinelli beakers are filled with silicone rubber containing uniformly distributed radionuclide or mixture of radionuclides. Default density of the active volume is 0,98 g.cm $^{-3}$ and mean atomic number approaches water. The standards are available in 3 types of polypropylene beakers with default volumes 450, 500 and 1000 ml. Other volumes, nuclides, activities or beakers are available on request.

Application

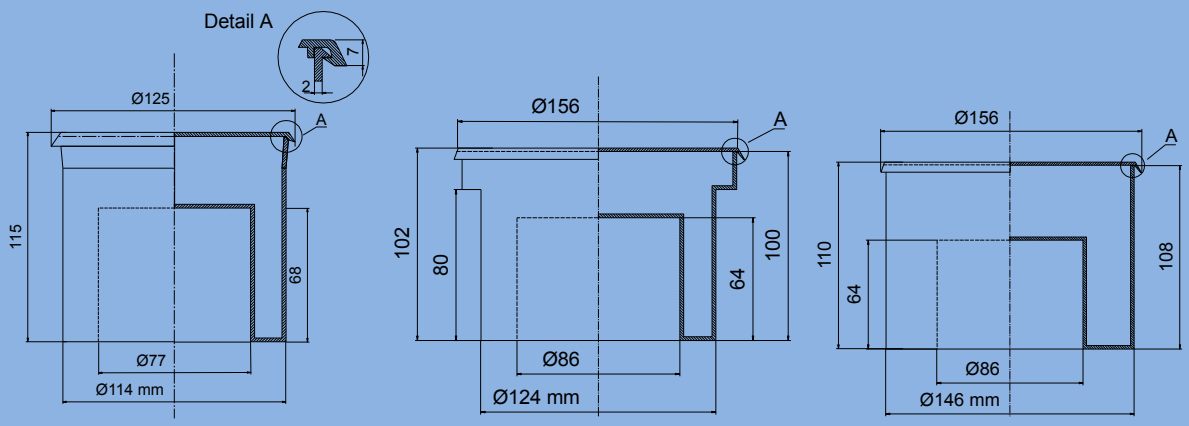
Energy and efficiency calibration of gamma spectrometers.

Measurement

The standards are prepared from the standard solutions ER(EB) whose activity is determined by absolute method. The final sources are checked by measurement on gamma spectrometer with HPGe detector. Combined standard uncertainty of activity is approx. 2 %.

Type	Nuclide	Half-life, days	Activity, kBq
MBSS 1	^{152}Eu	4938,8	3
MBSS 2	směs dle IEC 697/81	-	40
MBSS 3	^{134}Cs	754,01	*
MBSS 4	^{137}Cs	10980	3
MBSS 5	^{226}Ra	584400	3
MBSS 6	^{57}Co	271,80	*
MBSS 7	^{60}Co	1925,2	3
MBSS 8	^{241}Am	158000	10
MBSS 9	^{232}Th	$5,12.10^{12}$	1,5
MBSS 10	^{153}Gd	240,4	*
MBSS 12	^{133}Ba	3849,7	*
MBSS 13	^{109}Cd	461,9	20
MBSS 14	^{210}Pb	8119	*
MBSS 15	^{192}Ir	73,827	*
MBSS 16	^{85}Sr	64,850	*
MBSS 17	^{54}Mn	312,19	*
MBSS 18	^{88}Y	106,626	*
MBSS 19	^{139}Ce	137,641	*
MBSS 20	^{40}K	$4,567.10^{11}$	1,5

* - on request



Type 0530G **Type 0540G** **Type 1040G**

EM STANDARDS FOR CONTAMINATION MONITORS

Description
Standard radionuclide solution is deposited on a disc metal base in approx. 50 dots/cm ^{2}. Evaporated solution is overlayed with thermally cured layer of protective laquer and aluminium layer with square weight approx. 20 μg/cm^2 deposited in vacuum. Square weight of protective layer is less than 0,1 mg/cm^2. The active layer must be protected against dust, touch and corrosive atmosphere.

Application
Efficiency calibration in measurements of various radionuclides in thin layer particularly for checking of relative measurements in surface, water, air and personnel contamination with α and β emitting radionuclides. Likewise for checking of stability of contamination monitors. For measurements of contamination can be used also standards EZ with larger active area.

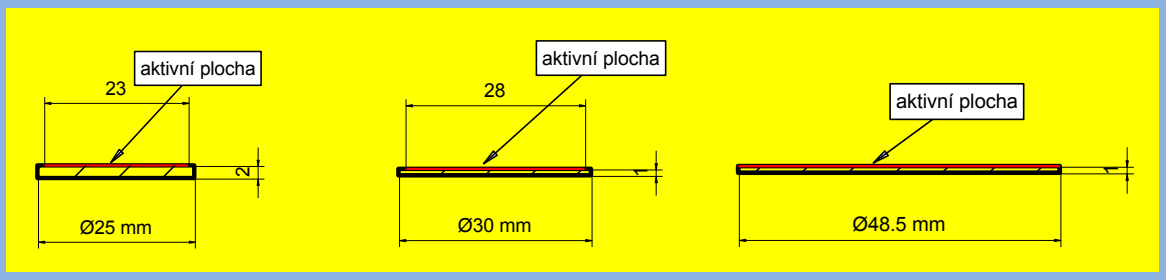
Measurement
The activity is calculated from mass and specific activity of standard solution, traceable to primary activity standard. Surface emission is measured with windowless proportional counter with uncertainty < 1 %. Both values are specified in associated documentation.

Dimension
Types EM 1, EM 2, EM 3 and EM 4 have diameter of the active area 23 mm, overall diameter 25 mm and thickness 1,5 mm.
Types EM 12, EM 22, EM 32 and EM 42 have diameter of the active area 28 mm, overall diameter 30 mm and thickness 1 mm.
Types EM 145 and EM 445 have diameter of the active area 48,5 mm, overall diameter 48,5 mm and thickness 1 mm. Another dimensions on request.

Nuclide	Half-life days	Energy, keV			Type	Square activity Bq.cm^{-2}	Uncertainty %	Code
		Particles α	Particles β	Photons γ				
^{14}C	2,082.10^6		156,476		EM 1	10	< 1,1	CWM 1
					EM 12			CWM 12
					EM 3	100		CWM 3
					EM 32			CWM 32
^{60}Co	1925,2		317,32	1173 1332	EM 1	10	< 1,1	COM 1
					EM 12			COM 12
					EM 3	100		COM 3
					EM 32			COM 32
^{90}Sr	10520		545,9 2278,7		EM 1	10	< 1,1	STM 1
					EM 12			STM 12
					EM 145			STM 145
					EM 3	100		STM 3
					EM 32			STM 32
^{137}Cs	10980		513,97 1175,63	661	EM 1	10	< 1,1	CSM 1
					EM 12			CSM 12
					EM 3	100		CSM 3
					EM 32			CSM 32
^{147}Pm	958,18		224,1		EM 1	10	< 1,1	PMM 1
					EM 12			PMM 12
					EM 3	100		PMM 3
					EM 32			PMM 32
^{204}Tl	1384		763,7		EM 1	10	< 1,1	TLM 1
					EM 12			TLM 12
					EM 3	100		TLM 3
					EM 32			TLM 32

Nuclide	Half-life days	Energy, keV			Type	Square activity Bq.cm^{-2}	Uncertainty %	Code
		Particles α	Particles β	Photons γ				
U_nat	+	4198 4774,6			EM 2	1	< 1,1	UWM 2
					EM 22			UWM 22
					EM 4	5		UWM 4
					EM 42			UWM 42
^{239}Pu	8,8023.10^{6}	5156,59			EM 2	1	< 1,1	PUM 2
					EM 22			PUM 22
					EM 4	10		PUM 4
					EM 42			PUM 42
^{241}Am	158000	5442,86 5485,56		59,5409	EM 2	1	< 1,1	AMM 2
					EM 22			AMM 22
					EM 445	10		AMM 445
					EM 4			AMM 4
					EM 42			AMM 42

\+ ^{238}U - 1,632.10^{12} days ^{235}U - 2,57.10^{11} days ^{234}U – 8,967.10^{7} days



Type EM 1, 2, 3, 4 **Type EM 12, 22, 32, 42** **Type EM 145, 445**

EZ LARGE AREA STANDARDS FOR CONTAMINATION MONITORING

Description

Standard radionuclide solution is deposited on a metal base with standard dimensions 200 x 140 x 1,5 mm (or dimensions on request) in approx. 50 dots/cm^2. Evaporated solution is overlayed with thermally cured layer of protective laquer and aluminium layer with square weight approx. 20 μg/cm^2 deposited in vacuum. Square weight of protective layer is less than 0,1 mg/cm^2. The active layer must be protected against dust, touch and corrosive atmosphere.

Application

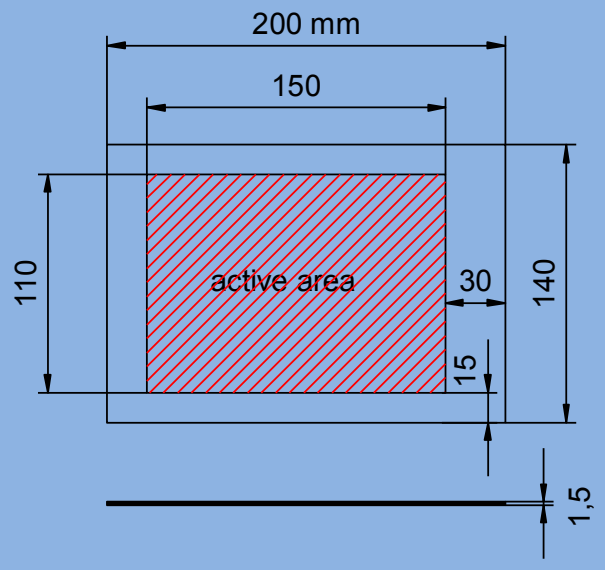
Efficiency calibration of instruments for monitoring the surface and personal contamination by α and β emitting radionuclides. Likewise they can be used for checking of contamination monitor stability.

Measurement

The activity is calculated from mass and specific activity of standard solution, traceable to primary activity standard. Surface emission is measured with windowless proportional counter with uncertainty < 1 %. Both values are specified in associated documentation.

Nuclide	Half-life days	Energy, keV			Type	Square activity Bq.cm^{-2}	Uncertainty %	Code
		Particles α	Particles β	Photons γ				
^{14}C	2,082.10^6		156,476		EZ 1	10	1,8	CWZ-1
^{60}Co	1925,2		317,32	1173,22 1332,492	EZ 1	10	1,6	COZ-1
^{90}Sr	10520		545,9 2278,7		EZ 1	10	1,6	STZ-1
^{137}Cs	10980		513,97 1175,63	661,657	EZ 1	10	1,6	CSZ-1
^{147}Pm	958,18		224,1		EZ 1	10	1,6	PMZ-1
^{204}Tl	1384		763,7		EZ 1	10	1,6	TLZ-1
U_{nat}	+	4198 4774,6			EZ 2	1	1,8	UWZ-1
^{239}Pu	8,8023.10^6	5156,59			EZ 2	1	1,8	PUZ-1
^{241}Am	158000	5442,86 5485,56		59,5409	EZ 2	1	1,6	AMZ-2

\+ ^{238}U - 1,632.10^{12} days ^{235}U - 2,57.10^{11} days ^{234}U – 8,967.10^7 days



^{226}Ra STANDARD SOLUTIONS

Description

Aqueous solution of the appropriate quantity of ^{226}Ra. Chemical composition of the solution: 1 g $BaCl_2$ /l and 10 g HCl/l. EB 00 is the aqueous solution of 1 g $BaCl_2$ /l and 10 g HCl/l with very low and determined mass fraction of ^{226}Ra.

Application

The standards are designed for efficiency calibration of activity (mass) determination of ^{226}Ra or ^{222}Rn. Standard solutions are used either in the form of sealed ampoules for calibration or weighed part of the solution can be added to the analysed sample as so called internal standard. After dilution by EB 00 solution is possible to prepare working standards with activities similar to measured samples. For emanometric determination of ^{226}Ra or ^{222}Rn in water, air and so on it is possible to transfer them to a washing bottle from which radon is expelled by a stream of gas.

Measurement

Standard solutions are prepared by dissolving of ^{226}Ra content of standard ES activity of which was determined by comparison of gamma photon flux of the standard with the flux of IIR primary radium standards. Comparison is carried out by means of the 4π–γ ionization chamber of IIR.

Nuclide	Half-life days	Type	Mass of solution g	Concentration of ^{226}Ra, ng/g	Mass of ^{226}Ra, ng	Uncertainty %	Packing	Code
^{226}Ra	584400	EB 6	1	1000	1000	0,5	glass ampoule 1 ml	RAB 6
		EB 7	1	100	100	0,5		RAB 7
		EB 8	1	10	10	0,5		RAB 8
		EB 9	1	1	1	0,6		RAB 9
		EB 10	1	0,1	0,1	0,7		RAB 10
		EB 65	5	1000	5000	0,5	glass ampoule 5 ml	RAB 65
		EB 75	5	100	500	0,5		RAB 75
		EB 85	5	10	50	0,5		RAB 85
		EB 95	5	1	5	0,6		RAB 95
		EB 105	5	0,1	0,5	0,7		RAB 105

^{226}Ra is in the radioactive equilibrium with its short life daughter products
Activity of 1 g ^{226}Ra is $3{,}657.10^{10}$ Bq

^{226}Ra SOLID STANDARDS EP

Description

A mixture of $RaSO_4$ and $BaSO_4$ is encapsulated in a cylindrical cell which is soldered, put in a tube or needle with length 13,5 - 25,5 mm and diameter 1,65 - 2,65 mm and soldered again. Both the cell and the outer capsule are made from alloy of 90 % Pt and 10 % Ir. The total wall thickness is 0.5 $\pm$ 0.05 mm which is sufficient to absorb all alpha and beta radiation.

Application

The standards are designed for calibration of dosimetric instruments, efficiency calibration in activity measurements of ^{226} Ra and other radionuclides. The calibration of dosimetric instruments is based on the knowledge that 1 g of ^{226}Ra with a 0,5 mm Pt filter has an exposure rate 59,12.10 $^{-9}$ A.kg $^{-1}$.

Measurement

Mass of ^{226}Ra is determined by comparison with IIR primary radium standards by means of $4\pi-\gamma$ ionization chamber. Radiation of primary standards is filtered with 0,5 mm Pt.

Nuklide	Half-life, days	Type [1)]	Mass of ^{226}Ra [2)], mg	Uncertainty, %	Code
^{226}Ra	584400	EP 10	20	0,5	RAP-22
		EP 9	10	0,5	RAP-12
		EP 8	5	0,5	RAP-53
		EP 1	1	0,5	RAP-13
		EP 14	0,1	0,5	RAP-14
		EP 15	0,01	0,6	RAP-15
		EP 16	0,001	0,7	RAP-16

[1] These standards are sealed sources and are tested for leakage
[2] Activity of 1 g ^{226}Ra is 3,657.10^{10} Bq

ER RADIOACTIVE STANDARD SOLUTIONS

Description

Approximately 1 or 5 g of the radioactive solution is sealed in a glass ampoule. Review of types and their parameters is in the table 1.

Application

The standards are designed for efficiency calibration of all kinds of detectors, type ER 2 is especially suitable for the calibration of proportional, scintillation and GM counters, types ER 3 and ER X for ionisation chambers. Standard solutions are used either directly or after dilution for preparation of working standards. Application for internal standards is also possible.

Measurement

The ER 2 and ER 25 standards are directly prepared from a standard solution, the specific activity of which was determined by absolute measurement using the 4π □ (α , β , X, e) - γ □ coincidence method or by a 4π proportional counter. The specific activity of the ER 3 and ER X standards is calculated from the dilution ratio and the specific activity of ER 2 standard solution. Some standards are denoted with suffix K, which means that their activities were determined by measurement on IIR 4π - γ ionisation chamber.

Table 1

Type	Mass, g	Specific activity MBq/g	Activity Mbq	Packing	Kód
ER 1 *	1	0,005	0,005	skleněná ampule 1 ml	IZR 1(^{129}I)
ER 2	1	0,100	0,100	skleněná ampule 1 ml	...R 2
ER 25	5	0,100	0,500	skleněná ampule 5 ml	...R 25
ER 3	1	5	5	skleněná ampule 1 ml	...R 3
ER X	1 - 5	do 50	do 50	skleněná ampule 1 nebo 5 ml	...R X

* it refers only to ^{129} I standards
In table 2 are assigned basic parameters and codes

Table 2

Nuclide	Half-life days	Chemical composition	Uncertainty %	Code
^{3}H	4496,9	H_2O	1,7	HWR
^{7}Be	53,22	30 mg $BeSO_4$ /l + 3 g HCl /l	1,0	BER
^{14}C	$2{,}082.10^{6}$	5 g Na_2CO_3 /l	1,5	CWR
^{22}Na	950,69	50 mg NaCl /l + 36 g HCl /l	0,8	NAR
^{24}Na	0,62325	50 mg NaCl /l + 36 g HCl /l	0,6	NKR
^{32}P	14,284	50 mg H_3PO_4 /l	0,6	PWR
^{35}S	87,25	50 mg Na_2SO_4 /l	1,3	SWR
^{42}K	0,51338	100 mg $KHCO_3$ /l	0,6	KWR
^{45}Ca	162,64	20 mg $CaCl_2$ /l + 3 g HCl/l	1,2	CAR
^{51}Cr	27,704	30 mg $CrCl_3$ /l + 3 g HCl /l	0,8	CRR
^{54}Mn	312,19	50 mg $MnCl_2$ /l + 3 g HCl/l	0,6	MNR
^{55}Fe	1003	50 mg $FeCl_3$ /l + 3 g HCl/l	2,7	FMR
^{56}Co	77,236	20 mg $CoCl_2$ /l + 3 g HCl/l	1,9	CBR
^{57}Co	271,80	20 mg $CoCl_2$ /l + 3 g HCl/l	0,8	CTR
^{58}Co	70,85	20 mg $CoCl_2$ /l + 3 g HCl/l	1,0	CYR
^{59}Fe	44,494	50 mg $FeCl_3$ /l + 3 g HCl/l	0,8	FER
^{60}Co	1925,2	20 mg $CoCl_2$ /l + 3 g HCl/l	0,4	COR
^{63}Ni	36000	20 mg $NiCl_2$ /l + 3 g HCl/l	1,5	NIR
^{64}Cu	0,529183	50 mg $CuCl_2$ /l + 3 g HCl/l	1,7	CUR
^{65}Zn	244,01	50 mg $ZnCl_2$ /l + 3 g HCl/l	1,5	ZNR

Nuclide	Half-life days	Chemical composition	Uncertainty %	Code
^{67}Ga	3,2613	12,6 mg $GaCl_3$ /l + 7 g HCl/l	1,2	GAR
^{75}Se	119,781	20 mg Na_2SeO_3 /l + 4 g NaOH/l	1,0	SER
^{76}As	1,0942	50 mg Na_3AsO_3 /l + 50 mg Na_2SO_3 /l + 1g NaOH/l	1,3	ASR
^{82}Br	1,4701	50 mg NH_4 Br/l	1,0	BRR
^{85}Sr	64,850	20 mg $SrCl_2$ /l + 3 g HCl/l	0,8	SAR
^{86}Rb	18,642	20 mg RbCl/l + 3 g HCl/l	0,8	RBR
^{88}Y	106,626	20 mg YCl_3 /l + 3 g HCl/l	1,2	YWR
^{89}Sr	50,57	20 mg $SrCl_2$ /l + 3 g HCl/l	0,6	SRR
^{90}Sr	10520	20 mg $Sr(NO_3)_2$ /l + 20 mg $Y(NO_3)_3$ /l + 3 g HNO_3 /l	0,6	STR
^{90}Y	2,6684	50 mg YCl_3 /l + 3 g HCl/l	0,6	YKR
^{95}Zr	64,032	12 mg $(NH_4)_4$ $Zr(C_2O_4)_4$/l + 12 mg $(NH_4)_3$ $NbO(C_2O_4)_3$/l + 0,5 g $H_2C_2O_4$ /l	1,0	ZRR
^{95}Nb	34,991	12 mg $(NH_4)_3$ $NbO(C_2O_4)_3$ /l + 0,5 g $H_2C_2O_4$ /l	0,6	NBR
^{99}Mo	2,7479	25 mg $(NH_4)_2$ MoO_4 /l + 0,3 g NH_4OH/l	1,0	MOR
^{99m}Tc	0,25028	3 g NH_4OH/l	1,5	TCR
^{103}Ru	39,247	50 mg $RuCl_3$ /l + 30 g HCl/l	1,2	RKR
^{106}Ru	371,5	50 mg $RuCl_3$ /l + 50 mg $RhCl_3$ /l + 30 g HCl/l	1,2	RUR
^{109}Cd	461,9	50 mg $CdCl_2$ /l + 3 g Hcl/l	1,3	CDR
^{113}Sn	115,09	50 mg H_2SnCl_6 /l + 216 g HCl/l	1,2	SNR
^{124}Sb	60,208	50 mg $SbCl_3$ /l + 70 g HCl/l	1,2	SBR
^{125}I	59,388	50 mg KI/l + 50 mg $Na_2S_2O_3$ /l	0,6	ITR
^{129}I	$5,880.10^9$	4 g KI/l + 10 g $Na_2S_2O_3$ /l	0,6	IZR
^{131}I	8,0233	50 mg KI/l + 50 mg $Na_2S_2O_3$ /l	0,6	IWR
^{131}I	8,0233	2 μg I_2/ml CCl_4	1,0	IER
^{132}Te	3,230	50 mg Na_2TeO_3 /l + 25 mg KI/l + 25 mg $Na_2S_2O_3$ /l	1,6	TER
^{133}Ba	3849,7	30 mg $BaCl_2$ /l + 3 g Hcl/l	0,6	BAR
^{134}Cs	754,01	20 mg CsCl/l + 3 g HCl/l	0,8	CGR
^{137}Cs	10980	20 mg CsCl/l + 3 g HCl/l	0,8	CSR
^{139}Ce	137,641	20 mg $CeCl_3$ /l + 3 g Hcl/l	0,8	CCR
^{141}Ce	32,503	30 mg $CeCl_3$ /l + 3 g Hcl/l	0,8	CKR
^{144}Ce	284,89	20 mg $CeCl_3$ /l + 20 mg $PrCl_3$ + 3 g HCl/l	1,0	CER
^{147}Pm	958,18	20 mg $PrCl_3$ /l + 20 mg $NdCl_3$ + 3 g HCl/l	1,5	PMR
^{152}Eu	4938,8	30 mg $EuCl_3$ /l + 3 g HCl/l	0,6	EUR
^{192}Ir	73,827	50 mg Na_2IrCl_6 /l + 3 g HCl/l	0,8	IRR
^{197}Hg	2,673	50 mg $Hg(NO_3)_2$ /l + 4 g HNO_3 /l + 50 mg H_2SO_4 /l	1,5	HKR
^{198}Au	2,6943	50 mg $KAu(CN)_4$ /l + 50 mg KCN/l	0,9	AUR
^{203}Hg	46,594	50 mg $Hg(NO_3)_2$ /l + 4 g HNO_3 /l + 50 mg H_2SO_4 /l	1,0	HGR
^{204}Tl	1384	30 mg Tl_2SO_4 /l + 3 g HNO_3 /l	1,3	TLR
^{210}Po	138,3763	25 mg TeO_2 /l + 63 g HNO_3 /l	1,3	POR
^{210}Pb	8119	20 mg $Pb(NO_3)_2$ /l + 20 mg $Bi(NO_3)_3$ /l + 25 mg TeO_2 /l + 63 g HNO_3 /l	1,3	PBR
^{239}Pu	$8,8023.10^6$	63 g HNO_3 /l	1,2	PUR
^{241}Am	158000	20 mg $Sm(NO_3)_3$ /l + 6,3 g HNO_3 /l	0,4	AMR
Unat	+	1,66 g $UO_2(NO_3)_2$ /l + 6,3 g HNO_3 /l	1,0	UER

+ ^{238}U - $1,632.10^{12}$ days ^{235}U - $2,57.10^{11}$ days ^{234}U – $8,967.10^7$ days

^{125}I SIMULATING RADIOACTIVITY STANDARD ESI

Description

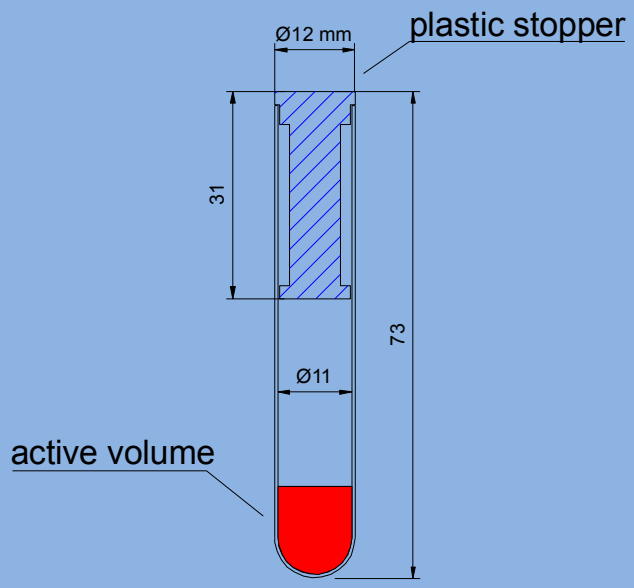
1 ml of polymerised mixture of epoxy resin containing ^{241}Am and ^{129}I in the plastic test tube with dimensions 12 x 73 mm (diameter x length). Activities of ^{241}Am and ^{129}I are in such a ratio that resulting spectrum γ on a well type NaI(Tl) detector corresponds as much as possible with ^{125}I γ spectrum. Test tube is closed by plastic stopper.

Application

The standards are designed for the calibration and checking of RIA gamma counters, especially for the measuring of kits with ^{125}I.

Measurement

The effective activity is determined by the comparison measurement with ^{125}I working standards using the gamma spectrometer with a well type NaI(Tl) detector 50 x 50. Nominal activity is 1500 Bq of ^{125}I.



ENM STANDARDS FOR NUCLEAR MEDICINE

Description
Standards in 10 ml penicillin vials in form of polyacrylamide gel, active volume is 5 ml. In case of breaking the vial , polyacrylamide gel prevents from larger contamination, which the radioactive solution would not.

Application
The standards are used for calibration and checking of measuring devices in nuclear medicine, e.g. activity calibrators.

Measurement
The activity is determined by measurement in 4π ionization chamber, which is the part of national standard of activity.

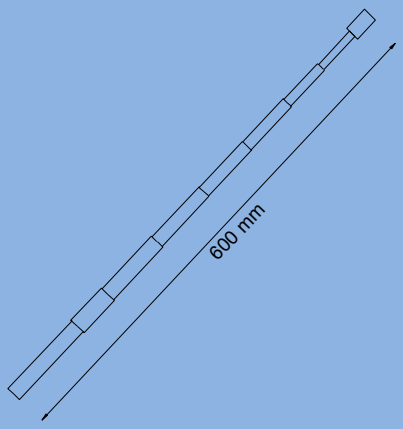
Nuclide	Half-life days	Photon energy keV	Photon yield, %	Activity MBq	Uncertainty %	Code
^{57}Co	271,80	122,06065	85,51	5	1,5	CTNM
		136,4735	10,71			
^{60}Co	1925,2	1173,22	99,85	5	0,8	CONM
		1332,49	99,9826			
^{133}Ba	3849,7	53,1622	2,14	5	1,2	BANM
		79,6142	2,65			
		80,9979	32,9			
		160,6121	0,638			
		223,2368	0,453			
		276,3989	7,16			
		302,8508	18,34			
		356,0129	62,05			
		383,8485	8,94			
^{137}Cs	10980	661,657	84,99	5	1,2	CSNM
^{241}Am	158000	59,5409	35,92	5	2,3	AMNM

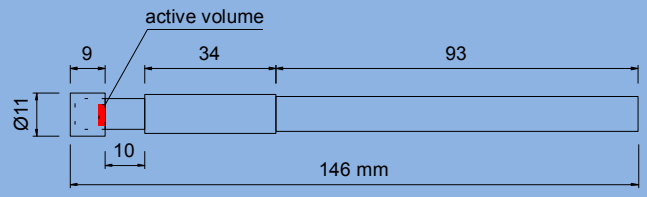
PEN POINT MARKER SOURCE ED

Description
Dried weighed part of standard solution of ^{57}Co is closed in a cylindrical plastic capsule with dimensions 11 x 9 mm (diameter x length). The source is installed on the top of the telescopic holder. Nominal activity is 5 MBq.

Application
The source is used mainly as a marker in nuclear medicine.

Measurement
The activity is calculated from the mass and specific activity of the standard solution.





STANDARDS TYPE ENK

Description
Control source for checking of stability of ionization chambers, altermative the type of ENM. It is sealed source in duralumin casing. Radioactive material is sorbed on a ceramic carrier in a sealed brass capsule. The capsule is crimped into the duralumin case shape of 10 ml peniciline vial.

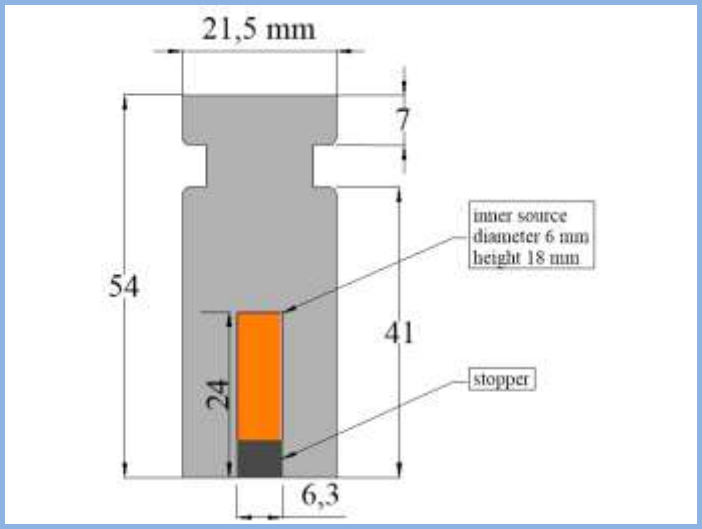
Application
For checking of instruments for measuring activity in nuclear medicine.

Measurement
The activity is calculated from the weight and specific activity of the standard solution, the equivalent activity is determined by measuring at $4\pi\,\gamma$ RB Prague ionization chamber, which is part of the state activity standards.

Nuclide	Half-life days	Photon energy keV	Photon yield, %	Aktivita MBq	Nejistota %	Kód
^{137}Cs	10980	661,657	84,99	5	1,2	CSNK

outer case

inner source



BOMAB PHANTOM

Description

The Bottle Manequin Absorber Phantom (BOMAB) is the model of the human body 170 cm tall, separated into ten discrete parts, which can be independently filled. It is made from high density polyethylene, 4.8 – 5 mm thick, internal volume is approximately 55 dm^3 . It is supplyed either empty or filled with non active silicone resin with specific density near 1 $g.cm^{-3}$ or filled with the same material containing activity, usually ^{152}Eu. The overall dimensions comply with requirements of Reference Man described in ICRP 23.

Application

BOMAB provides a functional simulation for the scattering of radiation in an adult human figure, to calibrate and check of whole body counters used for *in vivo* determination of deposited γ emitting radionuclides.

Measurement

The activity is calculated from the specific activity and the mass of used standard solutions and from mass of filler.

Description	Number pcs	Shape	Profile, cm	Height, cm	Volume dm^3
head	1	ellipse	19 x 14	20	3,50
neck	1	circle	13 - diameter	10	1,00
thorax	1	ellipse	30 x 20	40	15,00
lumbar	1	ellipse	36 x 20	20	9,00
thigh	2	circle	15 - diameter	40	5,90
leg	2	circle	12 - diameter	40	3,60
arm	2	circle	10 - diameter	60	3,60

^{222}Rn FLOW THROUGH SOURCES RF

Description

Accurate and long term stable sources of defined activity of ^{222}Rn in gas phase. Radon is released from thin layer of a plastic foil with emanation power approaching 1. The source is constructed as a stainless steel cylindrical case supplied on the ends with the two ball valves and the two aerosol filters connected on the output aperture of the valves. All parts are made from stainless steel or Teflon. The sources are produced in activity range 20, 100, 200, 500, 1000 a 2000 kBq of ^{226}Ra with commercial label RF 20, RF 100, ... RF 2000.

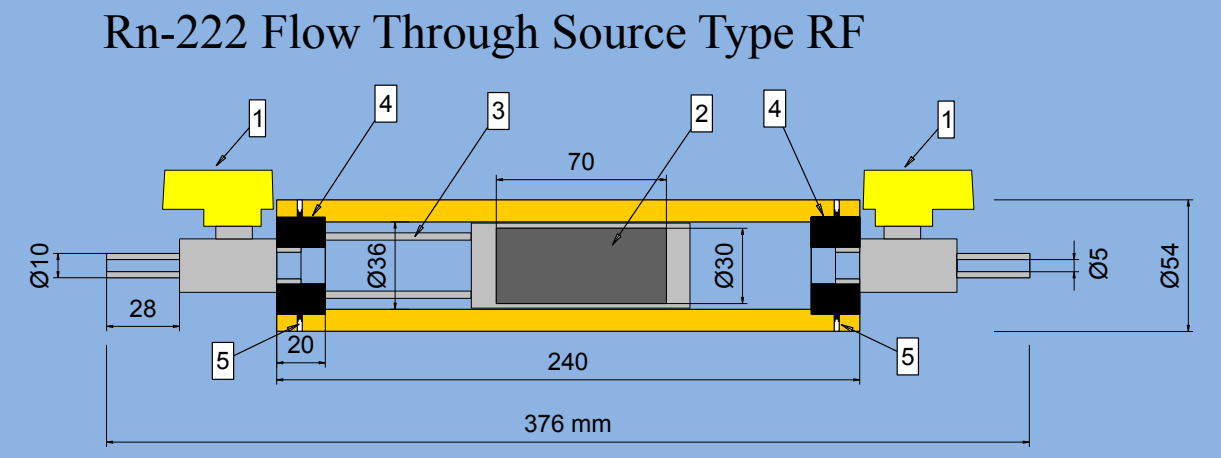
Application

The sources are designed for laboratory and field conditions. The main application is calibration of devices and detectors for activity measurements of ^{222}Rn and ^{226}Ra in environmental research. The user can apply the source in batch or flow through mode.

Measurement

The activity of ^{226}Ra is determined by comparison with IIR standards, the emanation power by gamma spectrometry on a HPGe detector.

Specifications	
Combined standard uncertainty of ^{226}Ra activity	1,5 %
Emanation power	near 1, typical value 0,998
Internal volume	200 cm^3
Maximum flow of carrier gas	10 l/min.
Working temperature and relative moisture	0 - 40 ^{o} C, 0 - 100 %
Dimensions	376 x 54 mm
Weight	1,32 kg



STANDARDS TYPE ESCO AND ESCS

Description

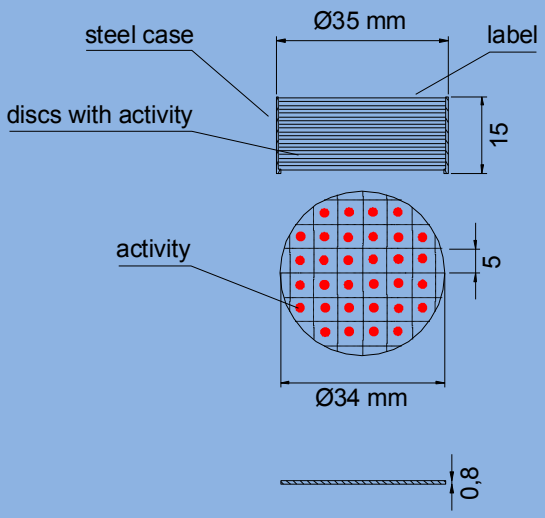
Cylinder shape standards type ESCO and ESCS consist of outer case with inserted discs with activity of ^{60}Co or ^{137}Cs. Activity is deposited in points in the net 5 x 5 mm. Discs putting together originate a cylinder with approximately homogeneously deposited activity. Disc and case are made from polished stainless steel. Standard dimension of cylinder is 35 x 15 mm , standard dimension of one disc is 34 x 0,8 mm (diameter x thickness). Other dimensions are made according to requirements of customer.

Application

Standards are designed for efficiency calibration of gamma spectrometers used for checking ^{137}Cs and ^{60}Co activity in steel. These radionuclides can occur in scrap iron as a result of liquidation of medical or industrial sources. According to customer requirements is possible to prepare standards with other radionuclides or with mixture of radionuclides.

Measurement

Activity of the standard is calculated from the mass and specific activity of the standard solution. The specific activity is determined by suitable absolute method. Produced sources are checked by comparison with IIR by standards gamma spectrometry with HPGe detector.



STANDARDS TYPE FILTER

Description
Filter type are standards of radionuclides evaporated on the filters of materials (paper, textiles, paper captive charcoal, carbon cartridges etc.) used in air monitors.

Application
They are intended to calibrate monitoring devices by direct measurement or after separation of the radionuclide from filter in the manner prescribed for the monitoring system. They are manufactured according to requirements and after consultation with the customer (dimensions, materials, radionuclides and activity).

Measurement
Activity is determined by calculation from the weight and specific activity of the standard solution.

METHYL IODIDE LABELLED WITH ^{131}I

Description
Set of 10 pieces of 5 ml glass ampoules containing 30 kBq $CH_3{}^{131}I$ each, absorbed in 0,1 g sorbent for gas chromatography. After opening ampoule, methyl iodide can be released by heating on 200 - 250 ^{o} C in stream of carrier gas (air, nitrogen). Content of CH_3I in ampoule is 2 μg (nominal values).

Application
For checking of gas monitors in nuclear facilities, especially in nuclear power plants.

Measurement
Activity is determined by gamma spectrometry with HPGe detector.

STANDARDS OF RARE GASES

Description
Standards of radioactive rare gases ^{41}Ar, ^{85}Kr, ^{133}Xe are designed for calibration and checking of monitors of outlets from nuclear facilities especially nuclear power plants. Known activity of radioactive gas is closed in the steel pressure bottle in mixture with air under pressure up to 100 bar. Declared quantity is volume activity at normal conditions.

Application
Radioactive gas is blew off to the monitor systems of nuclear facilities.

Measurement
Activity of ^{41}Ar is determined by gamma spectrometry with HPGe detector, activities of ^{85}Kr and ^{133}Xe by measurement with calibrated ionization chamber.

Note: normal conditions are p = 101,3 kPa and t= 0 ^{o}C

DOSIMETRIC DIODES Si-1 AND Si-2

Description

The diodes Si-1 and Si-2 are long base silicon diodes (LBSD) developed for measurement of kerma from heavy particles, particularly fast neutrons. The main physical effect, which is used for kerma measurement, is the change of t as the minor charge carriers lifetime in silicon after irradiation due to radiation damage in the crystal lattice. Because of the difficulties in lifetime measurement, the forward bias voltage drop on the diode is measured. The change of this voltage □U i.e. the difference between the voltage U after irradiation and the initial voltage U_0 is taken as a measure of the radiation damage and is approximately linear function of kerma from fast neutrons. Both types has very low sensitivity for gamma irradiation and so they can be used in mixed gamma – neutron fields. Diodes Si-1 and Si-2 differs in technical specifications, type Si-2 is more sensitive and therefore useful in personal dosimetry (see table).

Technical parameters of Si-1 and Si-2 diodes

Description	Type Si-1	Type Si-2
radiation detected	neutrons with energy > 300 keV	
dimensions	1,2x1,8x1,8 mm	2x2x2,5 mm
kerma range	0,1 30 Gy	0,01 5,0 Gy
kerma neutron energy dependence	less than ± 15 %	
fast neutron sensitivity	128 mV/Gy	1 V/Gy
gamma sensitivity	< 0,01 mV/Gy	< 0,4 mV/Gy
encasing	plastics	
initial voltage	0,9 1,1 V	1,8 2,5 V

Application

The main utilizations are: measurement of kerma from fast neutrons for purposes of personal and accidental dosimetry, military dosimetry, mapping of neutron beams.

Measurement

The constant current pulse (25 mA, 40 ms) is used for measurement of forward voltage. For this purpose CMI IIR is capable to supply special measuring device.
The dependence of the voltage change of Si-2 diode on the value of the neutron tissue kerma K_n for neutrons from unshielded ^{252}Cf.