www.lea-sources.com

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Sources & radioactivity standards

Catalog AN

SPE.COM.20.057
REV 02

Laboratoire d'Etalons d'Activité

orano
Donnons toute sa valeur au nucléaire

Orano at a glance

As a recognized international operator in the field of nuclear materials, Orano delivers solutions to address present and future global energy and health challenges.

Its expertise and mastery of cutting-edge technologies enable Orano to offer its customers high value-added technologies and services throughout the entire fuel cycle.

Every day, the Orano group's 16,500 employees draw on their skills, unwavering dedication to safety and constant quest for innovation, with the commitment to develop know-how in the transformation and control of nuclear materials, for the climate and for a healthy and resource-efficient world, now and tomorrow.

Our values

Customer satisfaction

Continuous improvement

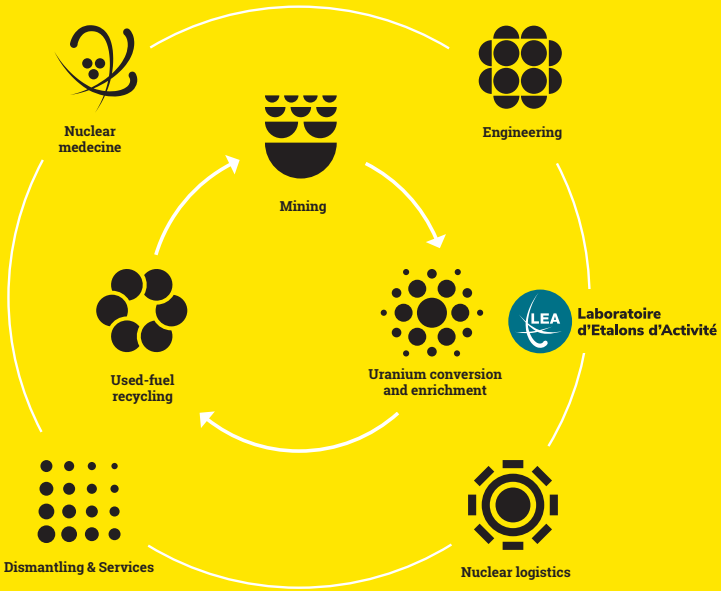
Respect and people development

Cohesion and team spirit

Exemplarity, integrity and responsibility

LEA within Orano

Wholly-owned by Orano since 2017, LEA has been located since 1999 at the heart of the Tricastin industrial platform in the South of France, where Uranium chemistry (fluorination, defluorination, denitration) and enrichment (centrifugation) operations are conducted for French nuclear power plants and international nuclear customers.

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T4


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T2
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T1

LEA at a glance
(Laboratoire d'Étalons d'Activité)

Our mission : valorize radioactive isotopes to protect lives

Founded at CEA before its transfer to Tricastin in late 1990s, LEA produces and distributes radioactive sources for control and calibration of equipment in the fields of radiodiagnostic, radiation protection and metrology.

Accredited COFRAC* Calibration for the measurement of ionizing radiation, LEA produces a wide range of calibration sources, sealed and unsealed, and distributes foreign-made sources from multiple partners in order to provide the most suitable solution to its customers.

In addition, thanks to its strong roots in the French nuclear industry, LEA has developed capabilities and services on high-activity sources (supply and recovery of sources for irradiators, radiography, primary neutron sources for the start-up of nuclear reactors…)

Hence, by utilizing radioactive isotopes on cutting-edge applications, in a secure and responsible way throughout the sources' life cycle, LEA is very well aligned with Orano's mission.

What makes us unique: Technicity and Reactivity

The men and women at LEA are committed to providing high-quality service and a reactivity adapted to its customers' needs, both users and distributors.
Hence LEA is keen to develop tailor-made standard sources (specific activity levels, matrix or geometries) in a fast and responsive way or identify relevant supply options.
To that end, LEA can rely on its experience (tens of thousands of radioactive sources supplied in France and abroad over the last 20 years), its network of international partners, and its own technical and human resources strengthened by Orano's.

This catalog aims at providing you clear and relevant information about sources and solutions we can provide you with. Direct communication remains the best option though, contact-us at : contact@lea-sources.com

* portée N°2-6386 disponible sur www.cofrac.fr ou sur demande.

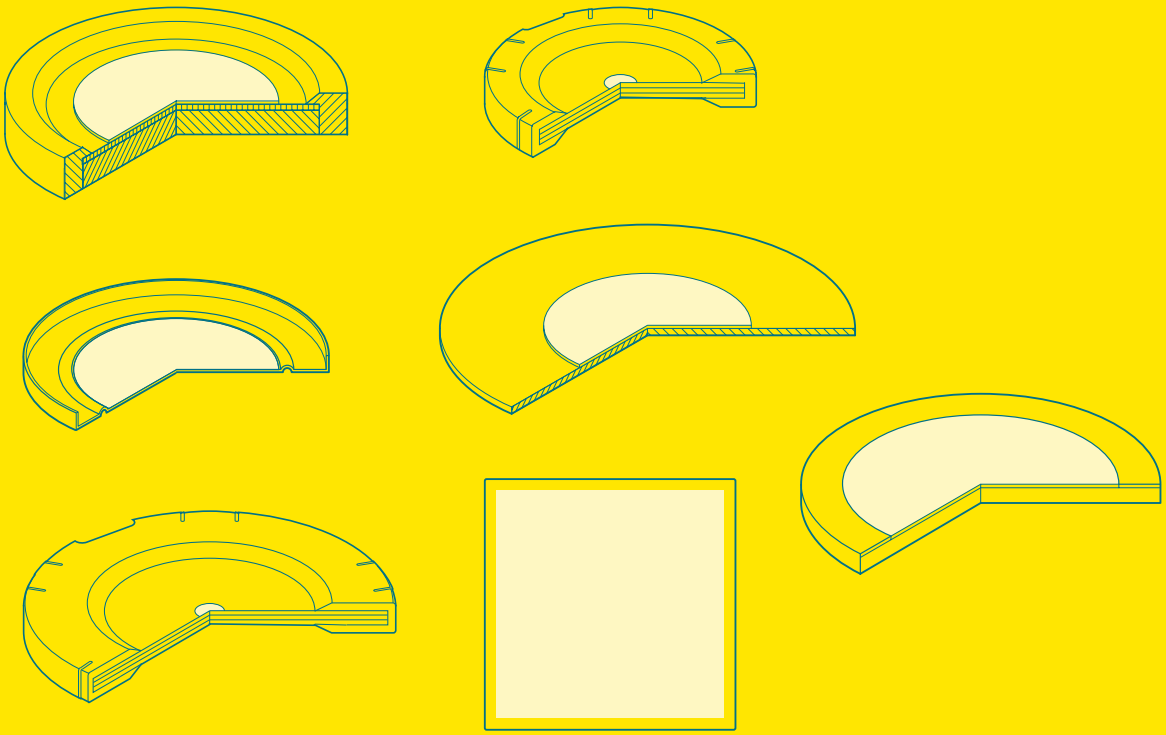
Sources

Sources

Accessories & services

Appendices

Sources solides α et β



Key applications

α or β sources are mostly used in:

- **Laboratories** (environmental measurements, process monitoring...): calibrations and metrological verifications of alpha spectrometers using PIPS (Passivated Implanted Planar Silicon) semiconductor detectors
- **Radiation protection :** calibrations, functional checks and periodic verifications of area and air contamination monitoring devices: airborne and area monitors, alpha and beta probes, polyradiameters, hand foot monitors, whole body monitors, ...
- **Training and education :** teaching how to choose the type of radiation protection probe adapted to the radiation, experimental validation of the mean free path of the charged particles in the air
- **Security:** verification of correct operation (external sources), real-time automatic correction of electronic gain of spectrometers (embedded sources)

Laboratories

Radiation protection

Training and education

Security

❶ LB SERIES © MIRION Technologies
❷ WPC-1050 © ORTEC
❸ HANDFOOT-FIBRE™ XLMED © MIRION Technologies
❹ ARGOS © MIRION Technologies
❺ BAB © BERTIN Technologies
❻ Contaminamètre/ polyradiameters © BERTIN Technologies
❼ Contrôle de non contamination © LEA
❽ SpiR-Id © MIRION Technologies
❾ IdentiFINDER R440 © FLIR Systems

Handling Precautions

Alpha and beta sources are considered as sealed sources, with an ISO2919 classification of C11111 or higher.

However, precautions must be taken so that the active surface is not in contact with any other material. LEA recommends handling these sources with tweezers to avoid leaving grease on the surface of the source, which would degrade the spectrum and risk contaminating the user.

We recommend storing these sources in their original packaging, away from dust and more generally away from the ambient air. It is therefore not recommended cleaning these sources and scrubbing the active area to check for contamination, to avoid damaging and tearing off part of the active surface.

By respecting these precautions for use, the recommended working life of our alpha and beta sources is 10 years.

EAS point α sources

Technical Information

Alpha point sources (EAS) are in the form of a stainless steel disk, unmounted (Type C or D) or sealed on an aluminum ring (Type A or B), at the center of which the radionuclides are electroplated to ensure their sealing.

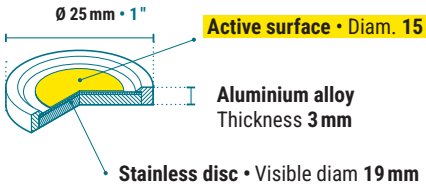
Radiological characteristics of the sources are measured with a calibrated grid cell detector.

Production range

Catalog references	On request
Active diameter	
15 mm	From 5 to 75 mm
External diameter	
25 mm	From 9 to 90 mm
30 mm	
38 mm	
Activity	
0.3 kBq	From 0.01 to 8 kBq
0.8 kBq	
3 kBq	
Radionuclide	
^{233}U, ^{238}Pu, ^{239}Pu, ^{241}Am, ^{244}Cm	–

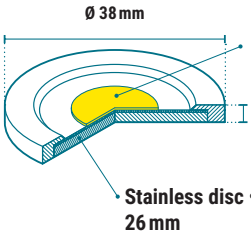
Standard geometries

Type A



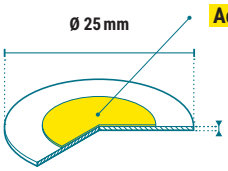
The distance between the active part and the height of the ring is 0,8 mm

Type B

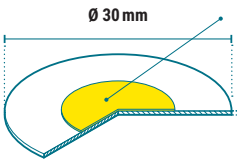


The distance between the active part and the height of the ring is 0,8 mm

Type C



Type D



Radionuclide	2π sr alpha flux		k=2 measurement uncertainty	Equivalent activity	Reference
	Under COFRAC* accreditation				
Mélange(1) • Mix(1) ^{239}Pu, ^{241}Am, ^{244}Cm	400	$\alpha.s^{-1}$	≤ 1.5%	0.8 kBq	9ML04 EAS [Type] 25
^{241}Am	150	$\alpha.s^{-1}$	≤ 1.5%	0.3 kBq	AM241 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 kBq	AM241 EAS [Type] 30
^{244}Cm	150	$\alpha.s^{-1}$	≤ 1.5%	0.3 kBq	CM244 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 kBq	CM244 EAS [Type] 30
^{238}Pu	150	$\alpha.s^{-1}$	≤ 1.5%	0.3 kBq	PU238 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 kBq	PU238 EAS [Type] 30
^{239}Pu (1)	150	$\alpha.s^{-1}$	≤ 1.5%	0.3 kBq	PU239 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 kBq	PU239 EAS [Type] 30
^{233}U (1)	150	$\alpha.s^{-1}$	≤ 1.5%	0.3 kBq	U233 EAS [Type] 20
^{241}Am	150	$\alpha.s^{-1}$	≤ 1.5%	0.3 kBq	Am241 EAS ICAM 20

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification: C11111

1) Source subject to export control on dual-use goods in accordance with CE Regulation 428/2009 from council of 5 May 2009 : an end user certificate will notably be requested from the customer.

* Scope N°2-6386 available on www.cofrac.fr or upon request.

How to compose the reference ?

Replace ***[Type]*** with the letter ***A, B, C or D*** according to the required geometry. For example: ***U233 EAS C 20.***

EBS point β sources

Technical Information

Radionuclides are deposited between two hot-sealed polyester foils (approximately 75µm thick each). Each face of the source is gold vacuum-coated for optimum measurement efficiency. They are then mounted in a steel ring.

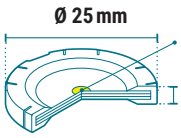
Radiological characteristics of the sources are measured with a calibrated gas flow proportional counter.

Production range

Catalog references	On request
Active diameter	
3 mm	From 3 to 30 mm
30 mm	
External diameter	
25 mm	From 25 to 60 mm
38 mm	
50 mm	
Activity	
0.08 kBq	From 0.05 to 4 kBq
3 kBq	
Radionuclide	
^{22}Na, ^{36}Cl, ^{60}Co, $^{90}Sr/^{90}Y$, $^{137}Cs/^{137m}Ba$, ^{147}Pm, ^{134}Cs, ^{89}Sr, ^{99}Tc	^{32}P, ^{35}S, ^{204}Tl, ^{99}Tc

Standard geometries

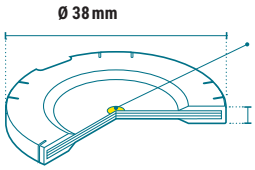
Type A



Active surface • Diam. **3 mm**

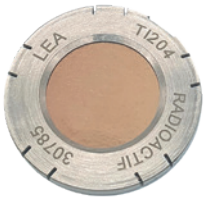
Metal ring
Thickness **3 mm**

Type B

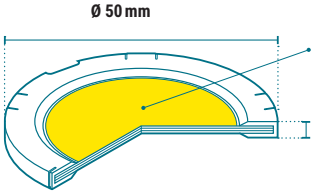


Active surface • Diam. **3 mm**

Metal ring
Thickness **3 mm**



Type C



Active surface • Diam. **3 mm**

Metal ring
Thickness **3 mm**

Radionuclide	4π sr beta flux		k=2 measurement uncertainty	Equivalent activity	Reference
	Under COFRAC* accreditation				
^{36}Cl	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	CL36 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	CL36 EBS [Type] 30
^{60}Co	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	CO60 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	CO60 EBS [Type] 30
^{134}Cs	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	CS134 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	CS134 EBS [Type] 30
^{137}Cs	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	CS137 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	CS137 EBS [Type] 30
^{22}Na	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	NA22 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	NA22 EBS [Type] 30
^{147}Pm	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	PM147 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	PM147 EBS [Type] 30
^{89}Sr	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	SR89 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	SR89 EBS [Type] 30
$^{90}Sr + ^{90}Y$	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	SR90 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	SR90 EBS [Type] 30
^{204}Tl	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	TL204 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	TL204 EBS [Type] 30
Tc99	80	$\beta.s^{-1}$	≤ 1.5%	0.08 kBq	Tc99 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 kBq	Tc99 EBS [Type] 30

Standard manufacturing tolerance: ± 30%
IAEA Category: 5 • ISO2919 Classification: C11111

* Scope N°2-6386 available on www.cofrac.fr or upon request.

How to compose the reference ?

Replace ***[Type]*** by the letter ***A, B or C*** according to the required geometry. For example :
TL204 EBS A 30.

Kits

EBS A and EBS B sources are also available in kit form. Radionuclides supplied are 147Pm, 134Cs, 137Cs, 90Sr+90Y, 204Tl and 22Na with an activity of 0.002 µCi (80 Bq) or 0.08 µCi (3 000 Bq). Other activities of EBS sources are available on request.

ESA wide area α and β sources
Discs

Technical Information

The radionuclides are deposited on a 0.01 in (0.3 mm) thick aluminum substrate (anodized surface), fixed on a stainless steel support of thickness 0.1 in (2.6 mm) ensuring the rigidity of the assembly.

The radiological characteristics (emergent flux) of the sources are measured with a calibrated absolute proportional 2π sr counter.

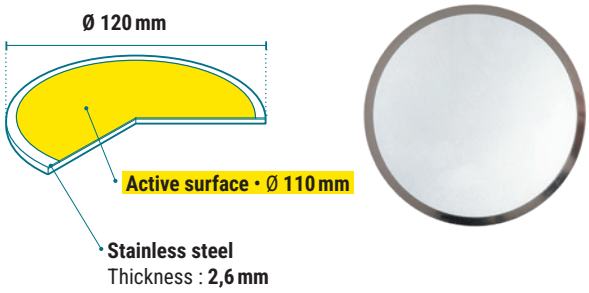
It should be noted that the size of a calibration source should be adapted to suit the size of the detector to be controlled or calibrated : **it is recommended not to use wide area sources to control detectors of a significantly different size from the detector itself.** LEA does not provide any guarantee on results for other uses than those recommended.

Production range

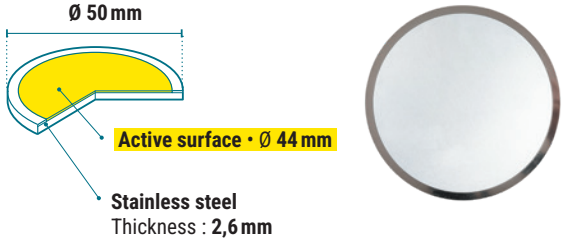
	Catalog references	On request
Active diameter		
α & β	15 mm	From 15 to 160 mm
	36 mm	
	44 mm	
	110 mm	
External diameter		
α & β	30 mm	From 20 to 170 mm
	47 mm	
	50 mm	
	120 mm	
Activity		
α	0.4 kBq	From 0.1 to 2 kBq
β	4 kBq	From 0.5 to 8 kBq
Radionuclide		
α	^{238}Pu, ^{239}Pu, ^{241}Am	^{233}U
β	^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{147}Pm	^{32}P, ^{35}S, ^{89}Sr, ^{99}Tc

Standard geometries

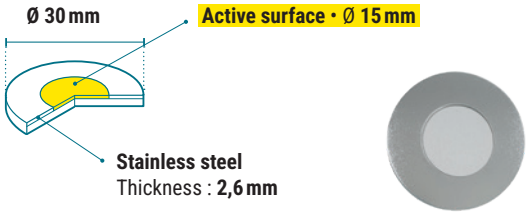
Type K



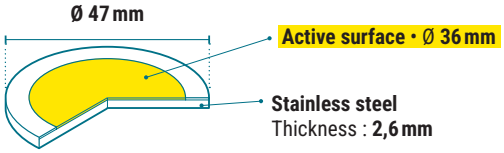
Type L



Type M



Type N



	Radionuclide	2π sr alpha flux 2π sr beta flux		k=2 measurement uncertainty	Equivalent activity	Reference
		Sous accréditation COFRAC*				
α	^{241}Am	200	$α.s^{-1}$	≤ 6%	0.4 kBq	AM241 ESA [Type] 20
	^{238}Pu	200	$α.s^{-1}$	≤ 6%	0.4 kBq	PU238 ESA [Type] 20
	^{239}Pu (1)	200	$α.s^{-1}$	≤ 6%	0.4 kBq	PU239 ESA [Type] 20
β	^{14}C	1 500	$β.s^{-1}$	≤ 6%	4 kBq	C14 ESA [Type] 20
	^{60}Co	1 900	$β.s^{-1}$	≤ 6%	4 kBq	CO60 ESA [Type] 20
	^{137}Cs	2 400	$β.s^{-1}$	≤ 6%	4 kBq	CS137 ESA [Type] 20
	^{147}Pm	1 900	$β.s^{-1}$	≤ 6%	4 kBq	PM147 ESA [Type] 20
	$^{90}Sr + ^{90}Y$	2 500	$β.s^{-1}$	≤ 6%	4 kBq	SR90 ESA [Type] 20
	$^{90}Sr + ^{90}Y$	2 500	$β.s^{-1}$	≤ 6%	4 kBq	SR90 ESA ICAM 20

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification: C11111

1) Source subject to export control on dual-use goods in accordance with CE Regulation 428/2009 from council of 5 May 2009 : an end user certificate will notably be requested from the customer.

* Scope N°2-6386 available on www.cofrac.fr or upon request.

How to compose the reference ?

Replace ***[Type]*** with the letter ***K, L, M or N*** according to the required geometry. For example : ***SR90 ESA K 20.***

ESA wide area α and β sources
Planchets

Technical Information

The radionuclides are deposited on a 0.01 in (0.3 mm) thick aluminum substrate (anodized surface), fixed on a stainless steel support of thickness 0.1 in (2.6 mm) ensuring the rigidity of the assembly.

The radiological characteristics (emergent flux) of the sources are measured with a calibrated absolute proportional 2π sr counter.

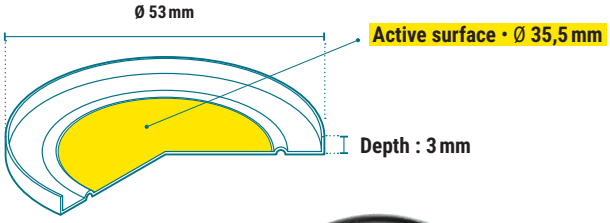
It should be noted that the size of a calibration source should be adapted to suit the size of the detector to be controlled or calibrated : **it is recommended not to use wide area sources to control detectors of a significantly different size from the detector itself.** LEA does not provide any guarantee on results for other uses than those recommended.

Production range

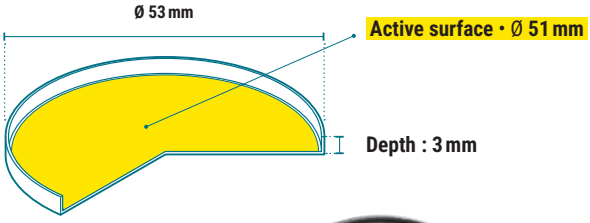
	Catalog references	On request
Diamètre actif		
α & β	35,5 mm	From 15 to 160 mm
	51 mm	
External diameter		
α & β	53 mm	From 20 to 170 mm
Activity		
α	0.4 kBq	From 0.1 to 2 kBq
β	4 kBq	From 0.5 to 8 kBq
Radionuclide		
α	^{238}Pu, ^{239}Pu, ^{241}Am	^{233}U
β	^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{147}Pm	^{32}P, ^{35}S, ^{89}Sr, ^{99}Tc

Standard geometries

Type I



Type J



	Radionuclide	2π sr alpha flux 2π sr beta flux		k=2 measurement uncertainty	Equivalent activity	Reference
		Sous accréditation COFRAC*				
α	^{241}Am	200	α.s^{-1}	≤ 6%	0.4 kBq	AM241 ESA [Type] 20
	^{238}Pu	200	α.s^{-1}	≤ 6%	0.4 kBq	PU238 ESA [Type] 20
	^{239}Pu (1)	200	α.s^{-1}	≤ 6%	0.4 kBq	PU239 ESA [Type] 20
β	^{14}C	1 500	β.s^{-1}	≤ 6%	4 kBq	C14 ESA [Type] 20
	^{60}Co	1 900	β.s^{-1}	≤ 6%	4 kBq	CO60 ESA [Type] 20
	^{137}Cs	2 400	β.s^{-1}	≤ 6%	4 kBq	CS137 ESA [Type] 20
	^{147}Pm	1 900	β.s^{-1}	≤ 6%	4 kBq	PM147 ESA [Type] 20
	^{90}Sr + ^{90}Y	2 500	β.s^{-1}	≤ 6%	4 kBq	SR90 ESA [Type] 20

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification: C11111

1) Source subject to export control on dual-use goods in accordance with CE Regulation 428/2009 from council of 5 May 2009 : an end user certificate will notably be requested from the customer.

* Scope N°2-6386 available on www.cofrac.fr or upon request.

How to compose the reference ?

Replace ***[Type]*** with the letter ***I or J*** according to the required geometry. For example: ***SR90 ESA J 20.***

ESA wide area α and β sources
Rectangular and Square

Technical Information

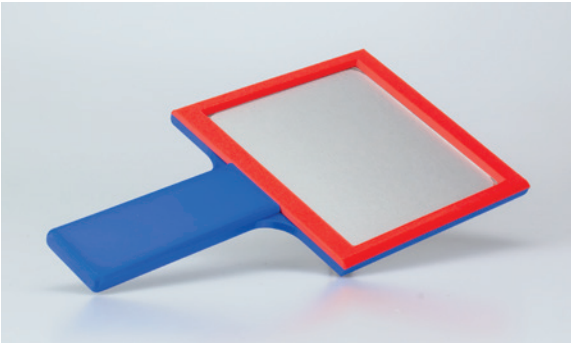
The radionuclides are deposited on a 0.01 in (0.3 mm) thick aluminum substrate (anodized surface), fixed on a stainless steel support of thickness 0.1 in (3 mm) ensuring the rigidity of the assembly.

The radiological characteristics (emergent flux) of the sources are measured with a calibrated absolute proportional 2π sr counter.

> It should be noted that the size of a calibration source should be adapted to suit the size of the detector to be controlled or calibrated : **it is recommended not to use wide area sources to control detectors of a significantly different size from the detector itself.** LEA does not provide any guarantee on results for other uses than those recommended.

Production range

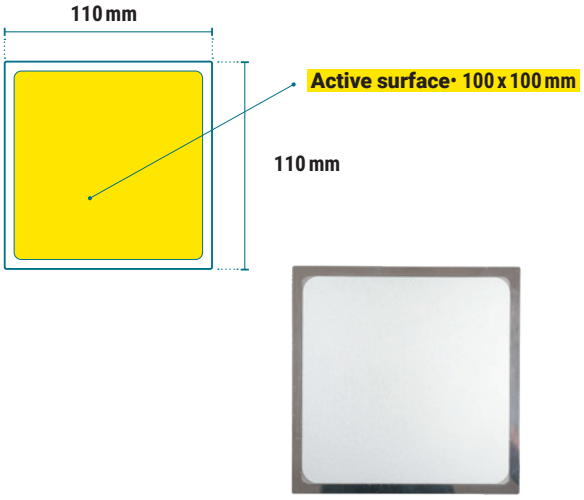
	Catalog references	On request
Actives dimensions		
α & β	100 x 100 mm	From 20 x 20 mm to 150 x 150 mm
	100 x 150 mm	
External dimensions		
α & β	110 x 110 mm	From 26 x 26 mm to 170 x 170 mm
	120 x 170 mm	
Activity		
α	0.4 kBq	From 0.1 to 2 kBq
β	4 kBq	From 0.5 to 8 kBq
Radionuclide		
α	^{238}Pu, ^{239}Pu, ^{241}Am	^{233}U
β	^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{147}Pm	^{32}P, ^{35}S, ^{89}Sr, ^{99}Tc



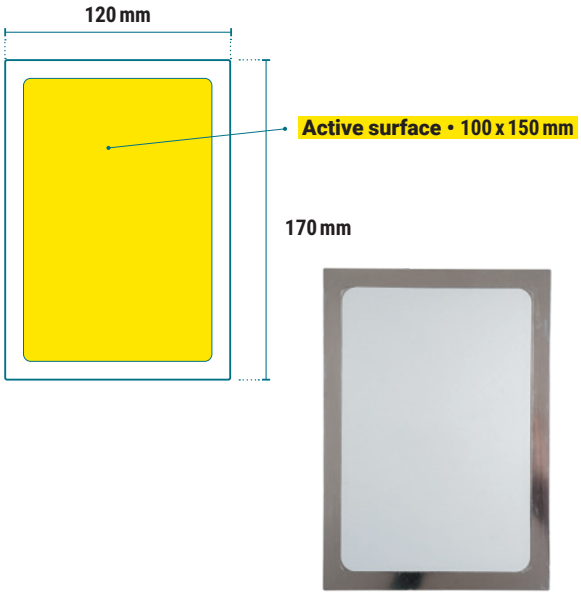
To facilitate your hand-foot controller checks, the LEA can provide you with rackets adapted to your sources and your HFC. The red face allows to quickly identify the active surface. The presence of edges prevents friction and possible degradation of the active part of the source on the walls of the HFC. The racket is suitable for all models of sources manufactured by the LEA. It can also be adapted to models of sources not manufactured by the LEA.

Standard geometries

Type E



Type F



	Radionuclide	2π sr alpha flux 2π sr beta flux		k=2 measurement uncertainty	Equivalent activity	Reference
		Under COFRAC* accreditation				
α	^{241}Am	200	α.s^{-1}	≤ 6%	0.4 kBq	AM241 ESA [Type] 20
	^{238}Pu	200	α.s^{-1}	≤ 6%	0.4 kBq	PU238 ESA [Type] 20
	^{239}Pu (1)	200	α.s^{-1}	≤ 6%	0.4 kBq	PU239 ESA [Type] 20
β	^{14}C	1 500	β.s^{-1}	≤ 6%	4 kBq	C14 ESA [Type] 20
	^{60}Co	1 900	β.s^{-1}	≤ 6%	4 kBq	CO60 ESA [Type] 20
	^{137}Cs	2 400	β.s^{-1}	≤ 6%	4 kBq	CS137 ESA [Type] 20
	^{147}Pm	1 900	β.s^{-1}	≤ 6%	4 kBq	PM147 ESA [Type] 20
	^{90}Sr + ^{90}Y	2 500	β.s^{-1}	≤ 6%	4 kBq	SR90 ESA [Type] 20

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification: C11111

1) Source subject to export control on dual-use goods in accordance with CE Regulation 428/2009 from council of 5 May 2009 : an end user certificate will notably be requested from the customer.

* Scope N°2-6386 available on www.cofrac.fr or upon request.

How to compose the reference ?

Replace ***[Type]*** with the letter ***E or F*** according to the required geometry. For example: ***SR90 ESA E 20.***

Tailor-made α and β sources

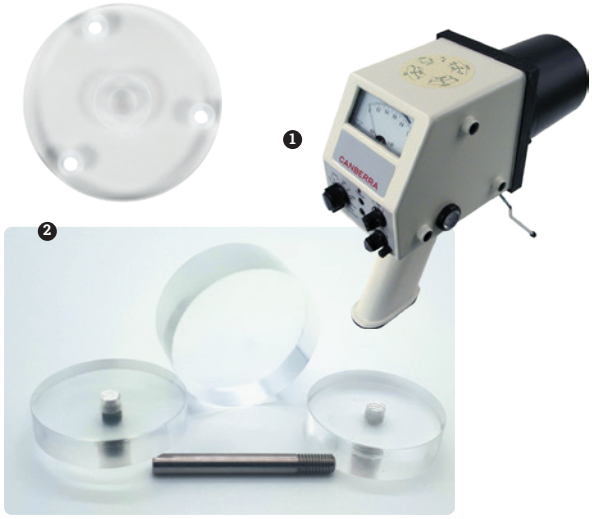
LEA can, on request, adapt the activity and the geometry of catalog sources to a specific need. **Here are six examples.**

#01

Babyline specific checks

To carry out Babyline checks (Babyline 81™ MIRION Technologies), LEA offers a source kit specially adapted to the operating range of this portable survey meter.

The kit is composed of 4 sources of 90Sr, with activity levels of 0.07µCi (2.5kBq), 0.81µCi (30kBq), 8.1µCi (300kBq) and 94.6µCi (3.5MBq). Other radionuclides and other activities are available on request.



❶ Babyline 81 © MIRION Technologies
❷ © LEA

#02

Verification of MIRION ICAM™ type fixed aerosol monitors

Self calibration of portable systems

The use of a radioactive source is one of the methods for correcting the gain of the on-board acquisition electronics in the portable systems used by the fire brigade or army to identify a possible radiological threat.

The radioactive source is chosen to generate a signal outside the region of interest.

For the NaI detectors,typically used source are point sources of 241Am or 137Cs, with a nominal activity of 0.002µCi (70Bq) or 0.2µCi (700Bq), mounted inside the scintillator. The system adjusts the electronic gain to maintain the peak position (generated by the 3 alpha rays of the 241Am between 5.4 and 5.5 MeV or the 137Cs gamma ray of 662 keV).

LEA can provide you with specific activities, tolerances and uncertainties : contact us to validate the feasability of your project.

SpiR-Id
© MIRION Technologies

#03

Verification of mobile aerosol monitors

Mobile monitors of atmospheric non-contamination are widely used in nuclear installations in operation during one-off maintenance actions or in dismantling nuclear installations.

Their periodic verification is typically done using 137Cs or 239Pu sources of low activity (a few µCi) deposited on a support specially adapted to the measurement geometry of the monitor.

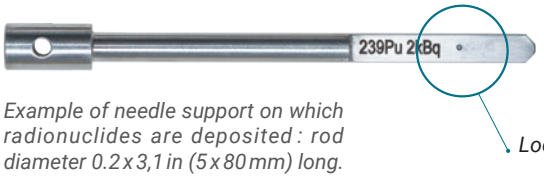
ABPM © MIRION Technologies

EDGAR © CEA

Exemple #03A

"Needle sources" for ABPM™ type

The needle sources are periodically inserted into a housing provided for this purpose in the monitor.



Example of needle support on which radionuclides are deposited : rod diameter 0.2 x 3,1 in (5 x 80 mm) long.

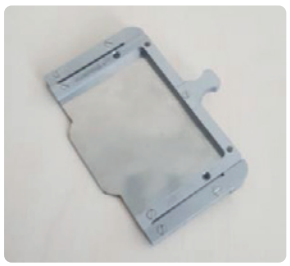
Location of the source

Exemple #03B

"Drawer sources" for EDGAR type

Drawer sources are fixed on the monitor and remain permanently in place. In routine operation, the drawer is closed. It is opened when periodic verifications are performed.

Drawer in open position. Position adopted during periodic verifications of the atmospheric contamination monitor.



Drawer in closed position. Position adopted during normal operation of the atmospheric contamination monitor. The tray is retracted, shielding against the flow of alpha particles generated by the source.

Tailor-made α and β sources

#04

Customer specific holder

In practice, samples measured by alpha spectrometry are often deposited in planchets before insertion into the measurement system.

LEA can manufacture sources adapted to your equipment by depositing the radionuclides to planchets of your own supply. The diameter of the active surface can vary from 0.6 in (15 mm) to 2.8 in (70 mm) and accommodate all alpha emitters proposed by LEA, for activities ranging from 0.003 µCi (100 Bq) to 0.05 µCi (2 kBq).

1.9 in (47 mm) diameter planchet provided by the customer

1.6 in (40 mm) active diameter source deposited in 1.9 in (47 mm) diameter customer planchet.

#05

Accessories to facilitate daily checks of radiation protection probes

To facilitate checks on radiation protection probes, LEA offers a racket-type source holder / wall support source holder, embedding one or more sources suited to the radiological work environment.

One of the most used source combinations consists of a 239Pu source of 0.01 µCi (400 Bq) and a 90Sr source of 0.01 µCi (400Bq).

Racket-type source holder / wall support are also available for all radionuclides and ESA type sources (see page 16).

Racket-type source holder /wall support can also be delivered with a summary document specifying the operating ranges associated with the radiation protection devices used in the installation.

#06

Vérification de balises aérosol fixes type MIRION ICAM™

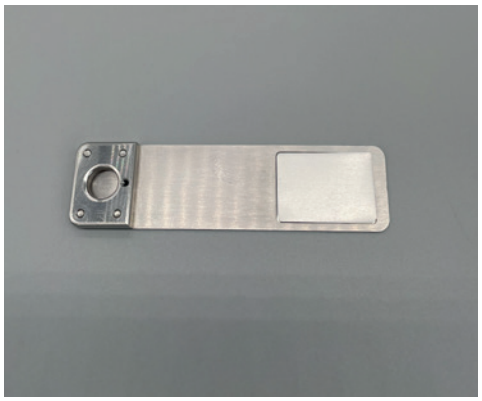
Exemple #06A

Atmospheric radiation monitoring systems are used in nuclear installations where there is a risk of internal contamination.
Their periodic verification is typically carried out using sources fixed to a support specially adapted to the measurement geometry of the system.
Non-exhaustive list of radionuclides and available activity range :
• 239Pu, 241Am: 100 Bq to 1 kBq • 14C, 60Co, 90Sr/Y, 137Cs, 147Pm: 500 Bq to 4 kBq

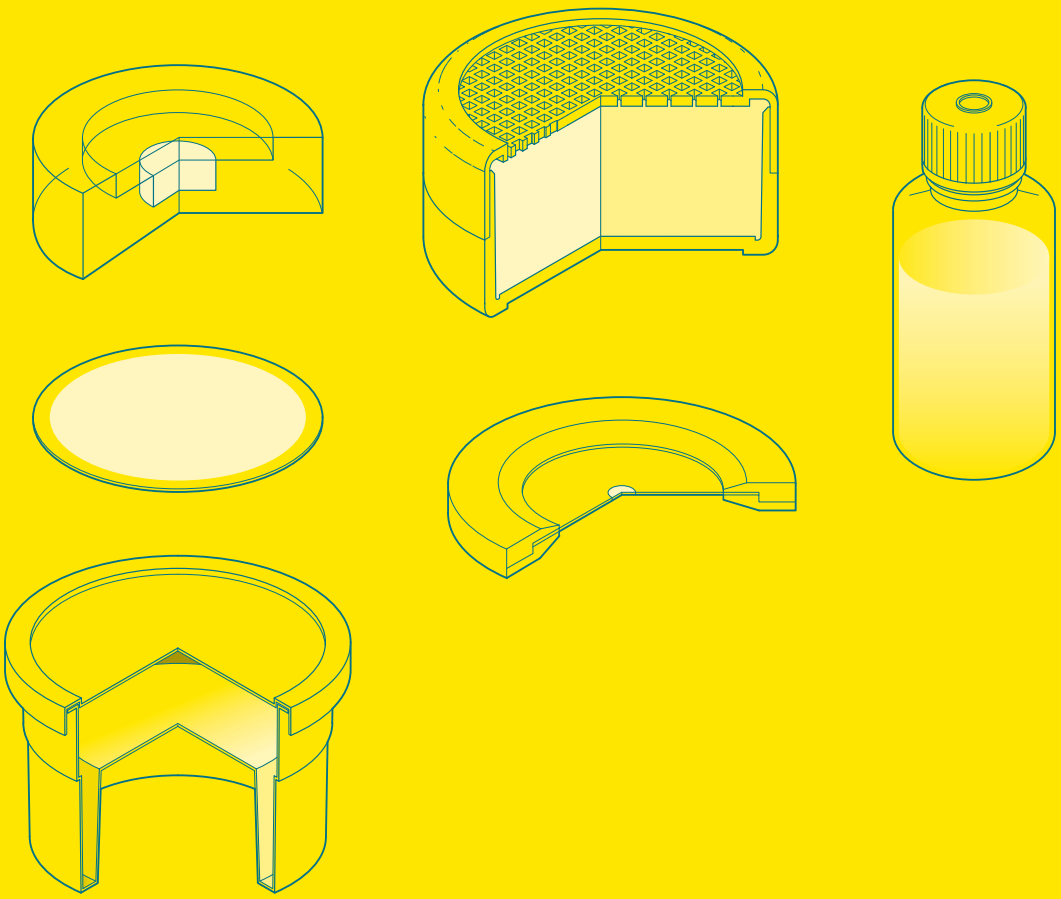
❶ Balise ICAM™ / ICAM™ monitor
© MIRION Technologies
❷ Sources Cartes / Card sources
source Icam Beta © LEA

Exemple #06B

The LEA offers Alpha and Beta sources adapted to the equipment type EAR (Radioactive Aerosol Recorder) of the MGPI range. This new geometry is designed specifically for this equipment. Radionuclides are deposited on an aluminum substrate with a 38 x 28 mm active surface. (same process as our ESA wide area source range).



X and γ solid sources



Key applications

X and γ sources are mostly used in :

- **Laboratories :** calibrations and metrological verifications of gamma counters or spectrometers (HPGe, CZT, NaI, LaBr) used for environmental or process measurements
- **Radiation protection :** calibrations, functional checks and periodic verifications of radiation protection probes and systems (gas flow detectors or scintillators, exit portals, hand-foot or object controllers, ambient radioactivity monitors…)
- **Training and education :** experimental validation of the gamma flux decrease with several shields or the 1/d2 flux decrease law
- **Security :** functional checks and periodic verifications of portable devices used for identifying radiological threat, performing emergency exercises
- **NDA (Non Destructive Assay) devices :** calibrations, functional checks and periodic verifications of waste radiological characterization devices or on-line process monitoring systems

Samples' measurement & characterization labs

Examples of gamma measurement chains (detector+ cryostat + shield) used in laboratories

Waste characterization

❸

Example of automatic gamma measurement chain used for the characterization of radioactive waste.

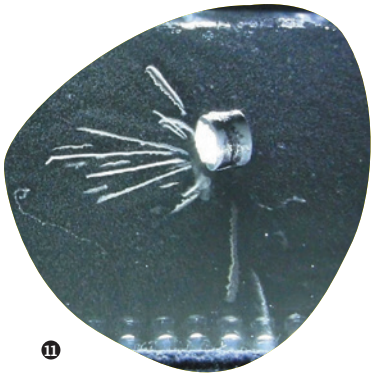
❹

Example of manual mobile gamma measurement chain, used for the measurement of radioactive waste or materials.

Training and education

❿

CRAB (Beta and gamma radiation counter)



⓫

Radioactive source in a cloud chamber

❶ & ❷ Mobius et ICS/ISC-E © ORTEC
❸ & ❹ © Baltic Scientific Instruments (BSI)
❺ © FLIR systems
❻ & ❼ © MIRION Technologies
❽ & ❾ © BERTIN Technologies
❿ © CEA/JEULIN
⓫ © Cloudylabs

Detection equipment

❺ ❻

Examples of mobile spectrometers, used during dismantling projects or by first responders (fire brigade)

❼

Object controller

❽

Environmental monitoring beacon

❾

Saphygate zone exit gantry

EGS point γ sources

Technical Information

Radionuclides are placed between 2 hot-sealed polyester foils approximatly 125 µm thick each, then mounted in a plexiglass ring.

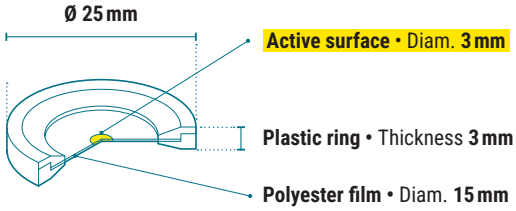
The radiological characteristics of the sources are measured with calibrated NaI scintillators or HPGe semi-conductors.

Production range

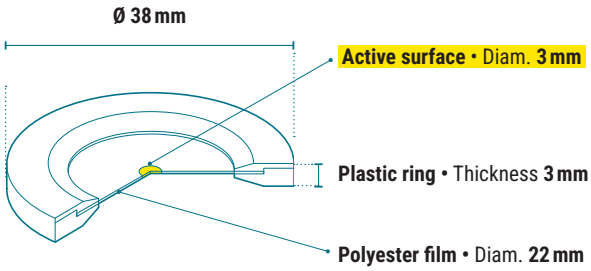
Catalog references	On request
Active diameter	
3 mm	From 3 to 50 mm
External diameter	
25 mm	From 25 to 75 mm
38 mm	
Activity	
4 kBq	From 2 to 1 000 kBq
40 kBq	
400 kBq	
700 kBq	
Radionuclide	
^{22}Na, ^{51}Cr, ^{54}Mn, ^{57}Co, ^{60}Co, ^{85}Sr, ^{88}Y, ^{133}Ba, ^{137}Cs, ^{152}Eu, ^{241}Am, ^{109}Cd, ^{139}Ce, ^{60}Co, ^{113}Sn, ^{65}Zn	^{110m}Ag, ^{139}Ce, ^{51}Cr, ^{134}Cs, ^{59}Fe, ^{54}Mn, ^{113}Sn (Non-exhaustive list)

Standard geometries

Type A



Type E



For A and E types, the distance between the active part and the height of the ring is 0.08 in.

Radionuclide	Activity	k=2 measurement uncertainty	Reference
	Under COFRAC* accreditation		
^{241}Am***	4 kBq	≤ 3.5%	AM241 EGS [Type] 10
	40 kBq	≤ 3.5%	AM241 EGS [Type] 15
^{133}Ba	4 kBq	≤ 2%	BA133 EGS [Type] 10
	40 kBq	≤ 2%	BA133 EGS [Type] 15
	400 kBq	≤ 2%	BA133 EGS [Type] 20
^{57}Co	4 kBq	≤ 2%	CO57 EGS [Type] 10
	40 kBq	≤ 1.9%	CO57 EGS [Type] 15
	400 kBq	≤ 1.9%	CO57 EGS [Type] 20
^{60}Co	4 kBq	≤ 2%	CO60 EGS [Type] 10
	40 kBq	≤ 1.5%	CO60 EGS [Type] 15
	400 kBq	≤ 1.7%	CO60 EGS [Type] 20
^{51}Cr	4 kBq	≤ 3,5%	CR51 EGS [Type] 10
	40 kBq	≤ 2%	CR51 EGS [Type] 15
	400 kBq	≤ 1.5%	CR51 EGS [Type] 20
^{137}Cs	4 kBq	≤ 2.5%	CS137 EGS [Type] 10
	40 kBq	≤ 2%	CS137 EGS [Type] 15
	400 kBq	≤ 2%	CS137 EGS [Type] 20
^{152}Eu***	4 kBq	≤ 3%	EU152 EGS [Type] 10
	40 kBq	≤ 3%	EU152 EGS [Type] 15
^{54}Mn	4 kBq	≤ 2%	MN54 EGS [Type] 10
	40 kBq	≤ 2%	MN54 EGS [Type] 15
	400 kBq	≤ 2%	MN54 EGS [Type] 20
^{22}Na	4 kBq	≤ 2%	NA22 EGS [Type] 10
	40 kBq	≤ 2%	NA22 EGS [Type] 15
	400 kBq	≤ 2%	NA22 EGS [Type] 20
^{85}Sr	4 kBq	≤ 2%	SR85 EGS [Type] 10
	40 kBq	≤ 2%	SR85 EGS [Type] 15
	400 kBq	≤ 2%	SR85 EGS [Type] 20
^{88}Y	4 kBq	≤ 2%	Y88 EGS [Type] 10
	40 kBq	≤ 2%	Y88 EGS [Type] 15
	400 kBq	≤ 2%	Y88 EGS [Type] 20
12ML01**	30 kBq	[3% ; 6%]	12ML01 EGS [Type] 15

How to compose the reference ?

Replace ***[Type]*** with the letter ***A or E*** according to the required geometry.
For example:
AM241 EGS A 20.

Standard manufacturing tolerance: ± 30%
IAEA Category : 5
ISO2919 Classification : C11111

* Scope N°2-6386 available on www.cofrac.fr or upon request.

** The 12ML01 mixture – 241Am, 109Cd, 139Ce, 57Co, 60Co, 51Cr, 137Cs, 113Sn, 54Mn, 65Zn, 85Sr, 88Y – generates around 15 peaks over an energy range from 60 keV to 1836 keV. The quantity of each radionuclide is chosen so that the counting rates of the main peak of each radionuclide are the same order of magnitude. See section on tailor-made gamma sources for additional information on the 12ML01 mixture and on the other mixes available. Other geometries are available on request.

*** Recommended use time 5 years for EGSA/E20 geometry (400kBq), only for radionuclides: 241Am and 152Eu.

Kits

EGS A sources are also available in kits containing 9 sources of 0.11µCi (4kBq),1.1µCi (40kBq), 11µCi (400kBq), 19µCi (700kBq) : 241Am, 57Co, 60Co, 51Cr, 137Cs, 54Mn, 22Na, 85Sr, 88Y. Other activities are available on request.

EGS point γ sources

Technical Information

Radionuclides are deposited in the cavity of a rigid and leaktight plexiglass cylinder. The cavity is sealed with a plexiglass cap.

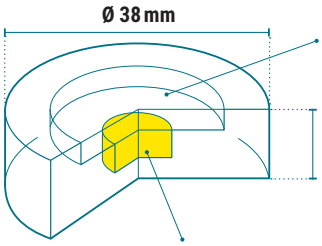
The radiological characteristics of the sources are measured with calibrated NaI scintillators, HPGe semi-conductors or ionization chambers.

Production range

Catalog references	On request
Active diameter	
3 mm	From 3 to 50 mm
10 mm	
External diameter	
38 mm	From 25 to 75 mm
Activity	
4 kBq	From 2 to 10 MBq
40 kBq	
400 kBq	
1 500 kBq	
3 500 kBq	
Radionuclide	
^{60}Co, ^{133}Ba, ^{137}Cs, ^{152}Eu, ^{241}Am	^{110m}Ag, ^{139}Ce, ^{51}Cr, ^{134}Cs, ^{59}Fe, ^{54}Mn, ^{113}Sn (Liste non exhaustive)

Standard geometries

Type B

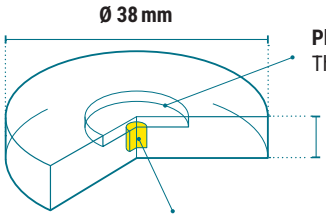


Plastic plug :
Diam. **25mm /** Thickness : **3 mm**

Plastic holder :
Thickness **10mm**

Active element :
Diam. **10 mm**
Thickness **4 mm**

Type V

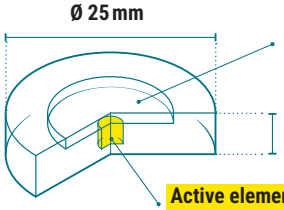


Plastic plug : Diam. **15mm /**
Thickness **1,5 mm**

Plastic holder :
Thickness **6 mm**

Active element :
Diam. **3 mm**
Thickness **3 mm**

Type HCO



Plastic plug : Diam. **15mm /**
Thickness : **1,5 mm**

Plastic holder :
Thickness **6 mm**

Active element :
Diam. **3 mm**
Thickness **3 mm**

Calibration values are systematically provided under Cofrac accreditation with an uncertainty < or equal to 3.5%.

Radionuclide	Activity	k=2 measurement uncertainty	Reference
	Under COFRAC* accreditation (HCO or on demand geometry for types B and V)		
^{241}Am	4 kBq	≤ 5%*	AM241 EGS [Type] 10
	40 kBq	≤ 5%*	AM241 EGS [Type] 15
	400 kBq	≤ 5%*	AM241 EGS [Type] 20
^{133}Ba	4 kBq	≤ 5%*	BA133 EGS [Type] 10
	40 kBq	≤ 5%*	BA133 EGS [Type] 15
	400 kBq	≤ 5%*	BA133 EGS [Type] 20
	1 500 kBq	≤ 5%*	BA133 EGS [Type] 30
	3 500 kBq	≤ 5%*	BA133 EGS [Type] 40
^{57}Co	4 kBq	≤ 5%*	CO57 EGS [Type] 10
	40 kBq	≤ 5%*	CO57 EGS [Type] 15
	400 kBq	≤ 5%*	CO57 EGS [Type] 20
	1 500 kBq	≤ 5%*	CO57 EGS [Type] 30
	3 500 kBq	≤ 5%*	CO57 EGS [Type] 40
^{60}Co	4 kBq	≤ 5%*	CO60 EGS [Type] 10
	40 kBq	≤ 5%*	CO60 EGS [Type] 15
	400 kBq	≤ 5%*	CO60 EGS [Type] 20
	1 500 kBq	≤ 5%*	CO60 EGS [Type] 30
	3 500 kBq	≤ 5%*	CO60 EGS [Type] 40
^{137}Cs	4 kBq	≤ 5%*	CS137 EGS [Type] 10
	40 kBq	≤ 5%*	CS137 EGS [Type] 15
	400 kBq	≤ 5%*	CS137 EGS [Type] 20
	1 500 kBq	≤ 5%*	CS137 EGS [Type] 30
	3 500 kBq	≤ 5%*	CS137 EGS [Type] 40
^{152}Eu	4 kBq	≤ 5%*	EU152 EGS [Type] 10
	40 kBq	≤ 5%*	EU152 EGS [Type] 15
	400 kBq	≤ 5%*	EU152 EGS [Type] 20
	1 500 kBq	≤ 5%*	EU152 EGS [Type] 30
	3 500 kBq	≤ 5%*	EU152 EGS [Type] 40

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification : C22212

* The calibration of sources can be performed on request, according to COFRAC** accredited protocols. The measurement uncertainties at k=2 are lower than or equal to 3%.

** Scope N°2-6386 available on www.cofrac.fr or upon request.

How to compose the reference ?

Replace ***[Type]*** with the letter ***B or V*** according to the required geometry. For example : ***CS137 EGS B 40.***

EGSK γ capsule sources

Technical Information

Radiology ambient measurement monitors can use a capsule-type radioactive source to ensure continuous system non-derogation. The LEA produces this type of source, adding a thread for integration into the measurement equipment (see model EGSKM3 or M4).

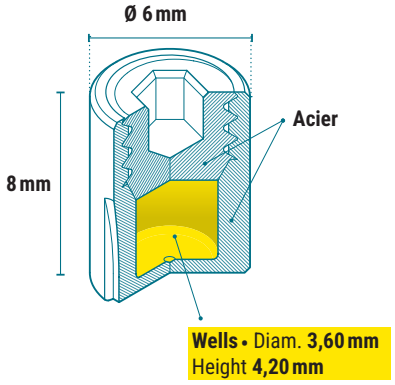
The most requested sources contain 50kBq, 200kBq or 900kBq of 241Am, 137Cs, 60Co. The activity and radionuclides can be adapted to the final need.

Production range

Catalog references	On request
Active diameter	
3 mm	From 3 to 50 mm
10 mm	
External diameter	
38 mm	From 25 to 75 mm
Activity	
4 kBq	From 2 to 10 MBq
40 kBq	
400 kBq	
1 500 kBq	
3 500 kBq	
Radionuclide	
^{57}Co, ^{133}Ba, ^{137}Cs, ^{152}Eu, ^{241}Am	-

Standard geometry

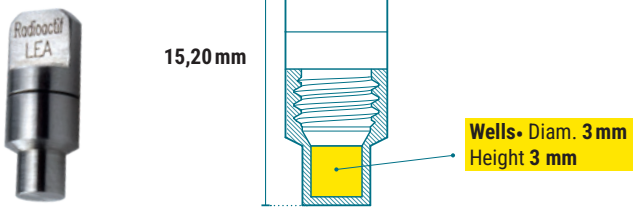
Type K



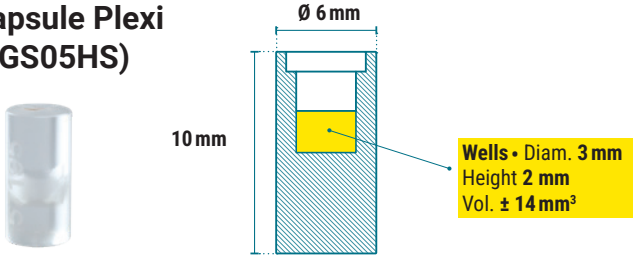
Other capsules available

EGSKM3 ou EGSKM4

EGS11HS



Capsule Plexi (EGS05HS)



Radionuclide	Activity	Reference
^{133}Ba	40 kBq	BA133 EGS K 15N
	400 kBq	BA133 EGS K 20N
	1 500 kBq	BA133 EGS K 30N
	3 500 kBq	BA133 EGS K 40N
^{57}Co	40 kBq	CO57 EGS K 15N
	400 kBq	CO57 EGS K 20N
	1 500 kBq	CO57 EGS K 30N
	3 500 kBq	CO57 EGS K 40N
	7,4 MBq	CO57 EGS K 80N
^{60}Co	40 kBq	CO60 EGS K 15N
	400 kBq	CO60 EGS K 20N
	1 500 kBq	CO60 EGS K 30N
	3 500 kBq	CO60 EGS K 40N
^{137}Cs	40 kBq	CS137 EGS K 15N
	400 kBq	CS137 EGS K 20N
	1 500 kBq	CS137 EGS K 30N
	3 500 kBq	CS137 EGS K 40 N
^{152}Eu	40 kBq	EU152 EGS K 15N
	400 kBq	EU152 EGS K 20N
	1 500 kBq	EU152 EGS K 30N
	3 500 kBq	EU152 EGS K 40N
^{241}Am	40 kBq	AM241 EGS K 15N

Manufacturing tolerance : ± 15 %
Sources can be provided with a calibration certificate.
IAEA Category : 5 – ISO 2919 Classification : C22212.

EXS point X sources

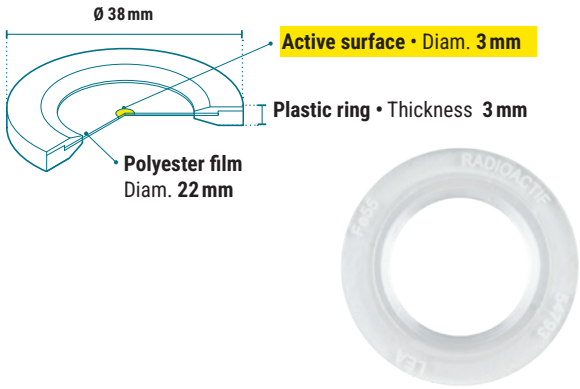
Technical Information

Radionuclides are placed between 2 hot-sealed polyester foils approximatly 75 µm thick each, then mounted in a plexiglass ring.

The radiological characteristics of the sources are measured with calibrated NaI scintillators or HPGe semi-conductors.

Standard geometry

Type B



The distance between the active part and the height of the ring is 0.8 in

Production range

Catalog references	On request
Active diameter	
3 mm	-
External diameter	
38 mm	From 25 to 75 mm
4π sr flux	
16 000 $X.s^{-1}$	-
Radionuclide	
^{55}Fe, ^{109}Cd	-

Radionuclide	4π sr X flux	k=2 measurement uncertainty	Equivalent activity	Reference
	Under COFRAC* accreditation			
^{109}Cd	16 000 $X.s^{-1}$	≤ 5%	15.7 kBq	CD109 EXS B 10
^{55}Fe	16 000 $X.s^{-1}$	≤ 5%	56.3 kBq	FE55 EXS B 10

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification : C11111

* Scope N°2-6386 available on www.cofrac.fr or upon request.

EGE γ sources in vegetable matrix

Technical Information

Our vegetable matrix is made with dry and crushed plants. Radionuclides are mixed in the volume of the matrix.

The whole is put in a standard container or in a container adapted to your needs.

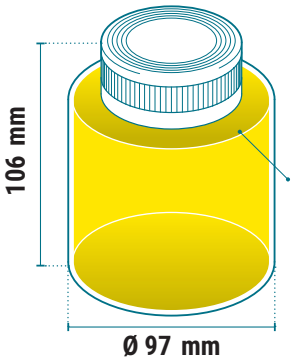
Source activity is measured with NaI scintillators or HPGe semi-conductors.

Standard geometry

SG500N Type V

Useful volume **500 cm³**

Resin mass **100 g**



Bottle **Hostalen (PP)**

Production range

Catalog references	On request
Activity	
1 kBq	From 1 to 100 kBq
Radionuclide	
Mix 12ML01	^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{51}Cr, ^{137}Cs, ^{113}Sn, ^{54}Mn, ^{22}Na, ^{85}Sr, ^{88}Y (Non-exhaustive list)

Radionuclide	Activity	k=2 measurement uncertainty	Reference
12ML01*	1 kBq	[8% ; 8,5%]	12ML01 EGE V 1KBQ

Standard manufacturing tolerance: ± 30% • IAEA Category : 5 • ISO2919 Classification : C11111

* The 12ML01 mixture – 241Am, 109Cd, 139Ce, 57Co, 60Co, 51Cr, 137Cs, 113Sn, 54Mn, 65Zn, 85Sr, 88Y – generates around 15 peaks over an energy range from 60 keV to 1836 keV. The quantity of each radionuclide is chosen so that the counting rates of the main peak of each radionuclide are the same order of magnitude. See section on tailor-made gamma sources for additional information on the 12ML01 mixture and on the other mixes available. Other geometries are available on request.

EGR γ sources in resin matrix

Technical Information

Radionuclides are incorporated into a thermosetting resin, which is then poured into container.

Our resin sources are sealed sources and are characterized by water equivalent activity, to avoid risks and constraints associated with liquid sources.

The radiological characteristics of the sources are measured with calibrated NaI scintillators or HPGe semi-conductors.

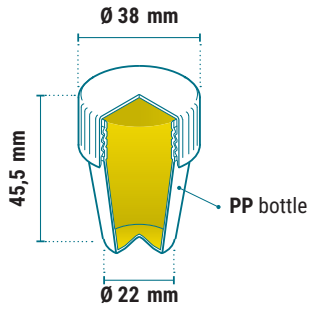
Production range

Catalog references	On request
Container	
15 ml 50 ml 250 ml 450 ml 500 ml 1 000 ml 3 000 ml	Any type of container with a volume between 10 ml and 3 000 ml
Activity	
5 kBq 18 kBq 37 kBq 55 kBq 74 kBq	From 0.1 kBq to 900 kBq
Radionuclide	
^{133}Ba, ^{137}Cs, ^{152}Eu, Mix 12ML01	^{51}Cr, ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{85}Sr, ^{88}Y, ^{109}Cd, ^{113}Sn, ^{134}Cs, ^{139}Ce, ^{241}Am

Plastic bottles

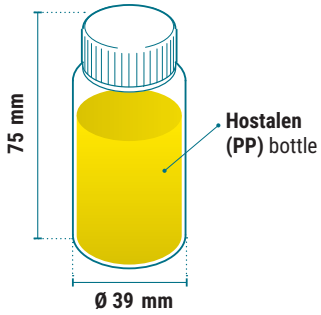
Type R *SG15*

Useful volume **15 cm³**



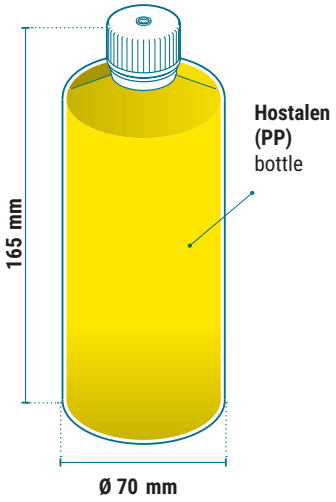
Type E *SG50*

Useful volume **50 cm³**



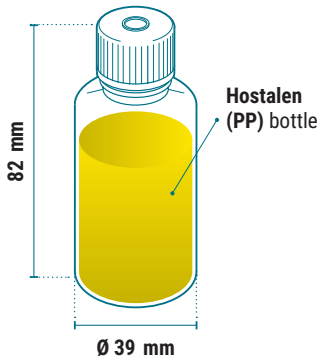
Type G

Useful volume **500 cm³**



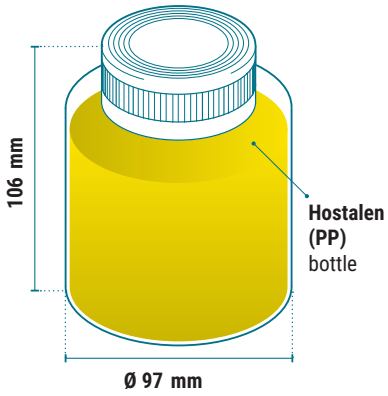
Type F

Useful volume **50 cm³**



Type H *SG500*

Useful volume **500 cm³**



Type R

Type E

Type F

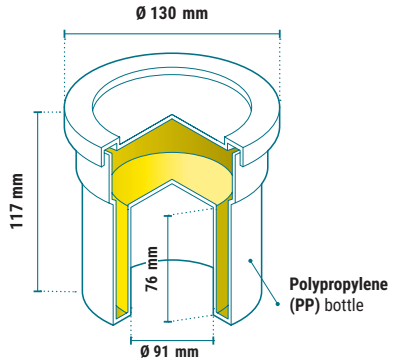
Type H

Type G

Géométries Marinelli

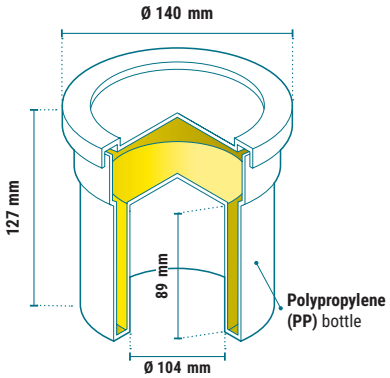
Type B *590G-E*

Useful volume **500 cm³**
Resin mass **575 g**



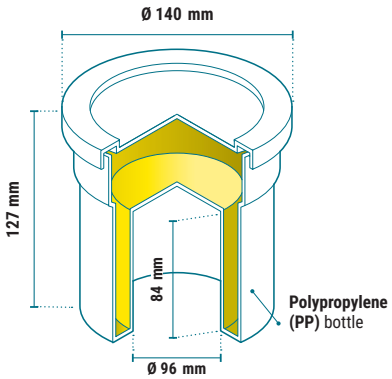
Type C *541G-E*

Useful volume **500 cm³**
Resin mass **575 g**



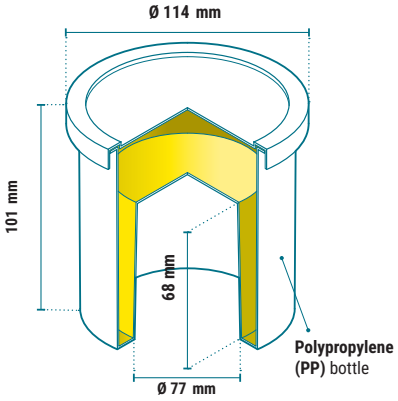
Type D *538G-E*

Useful volume **500 cm³**
Resin mass **575 g**



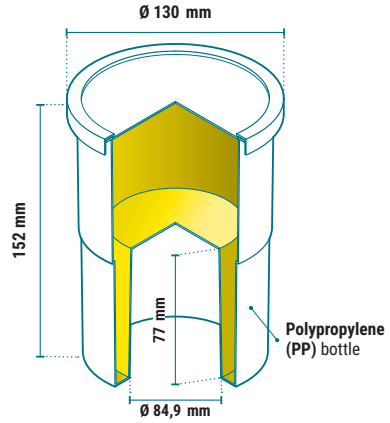
Type I

Useful volume **450 cm³**
Resin mass **518 g**



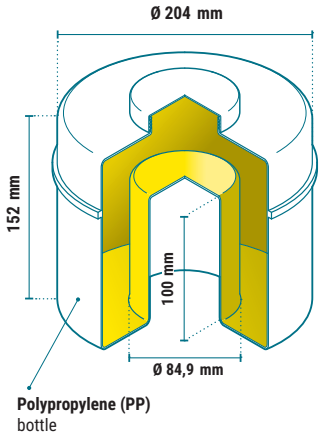
Type K

Useful volume **1000 cm³**
Resin mass **1150 g**



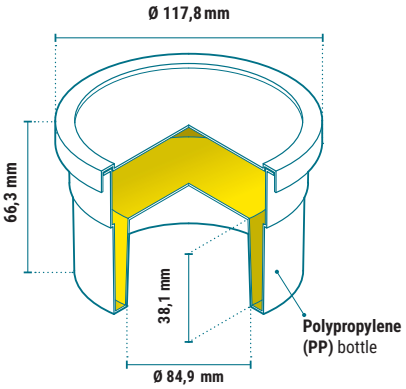
Type L *SG3000*

Useful volume **3 000 cm³**
Resin mass **3 450 g**



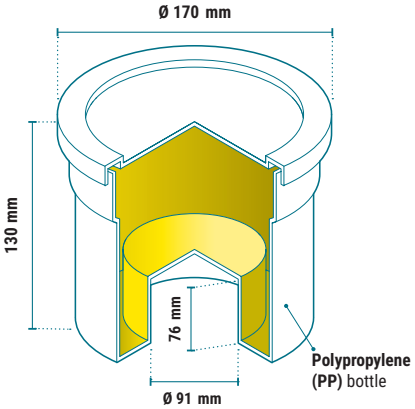
Type M

Useful volume **250 cm³**
Resin mass **287 g**



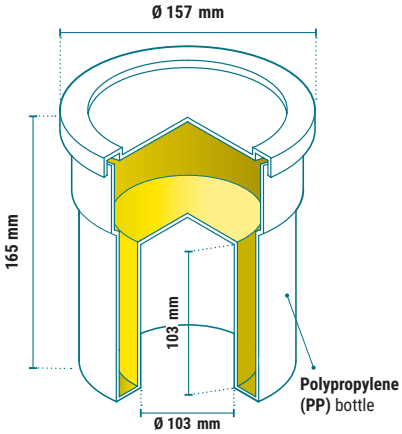
Type N *190G-E*

Useful volume **1000 cm³**
Resin mass **1150 g**



Type P *141G-E*

Useful volume **1000 cm³**
Resin mass **1150 g**




Type B


Type C


Type D


Type I


Type K


Type L


Type M


Type N


Type P

Radionuclide	Water equivalent activity	k=2 measurement uncertainty	Reference
	Under COFRAC* accreditation		
^{152}Eu	37 kBq	≤ 5%	EU152 EGR [Type] 15
^{133}Ba	37 kBq	≤ 5%	BA133 EGR [Type] 15
^{137}Cs	37 kBq	≤ 5%	CS137 EGR [Type] 15
12ML01**	5 kBq	[3,0 à 6,5 %]	12ML01 EGR [Type] 05
	18 kBq	[3,0 à 6,5 %]	12ML01 EGR [Type] 10
	37 kBq	[3,0 à 6,5 %]	12ML01 EGR [Type] 15
	55 kBq	[3,0 à 6,5 %]	12ML01 EGR [Type] 20
	74 kBq	[3,0 à 6,5 %]	12ML01 EGR [Type] 30

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification: C11111
* Scope N°2-6386 available on www.cofrac.fr or upon request.
** The 12ML01 mixture – 241Am, 109Cd, 139Ce, 57Co, 60Co, 51Cr, 137Cs, 113Sn, 54Mn, 65Zn, 85Sr, 88Y – generates around 15 peaks over an energy range from 60 keV to 1836 keV. The quantity of each radionuclide is chosen so that the counting rates of the main peak of each radionuclide are the same order of magnitude. See section on tailor-made gamma sources for additional information on the 12ML01 mixture and on the other mixes available. Other geometries are available on request.

How to compose the reference ?

Replace ***[Type]*** with the letter ***E, F, G, H, I, K, L, M or R*** according to the required geometry.
For example: ***BA133 EGR E 15.***

EDC γ sources in charcoal filter cartridges

Technical Information

Our active charcoal can be impregnated in two ways :

- Surface impregnation, a radioactive disk is placed in contact with one of the inside surfaces of the housing to simulate surface contamination (E geometry)
- Pore volume impregnation, the activated charcoal is homogeneously impregnated (D geometry)

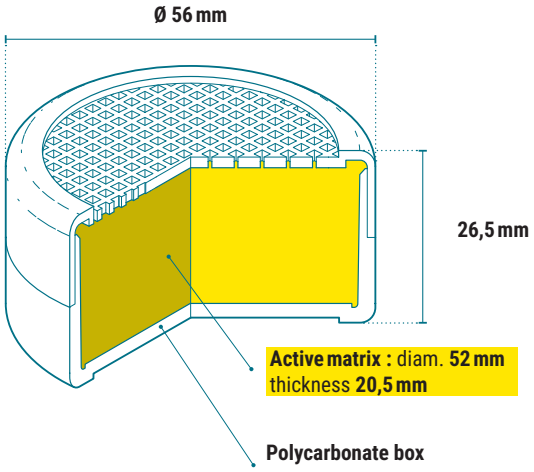
Source activity is measured with calibrated NaI scintillators or HPGe semi-conductors.

Production range

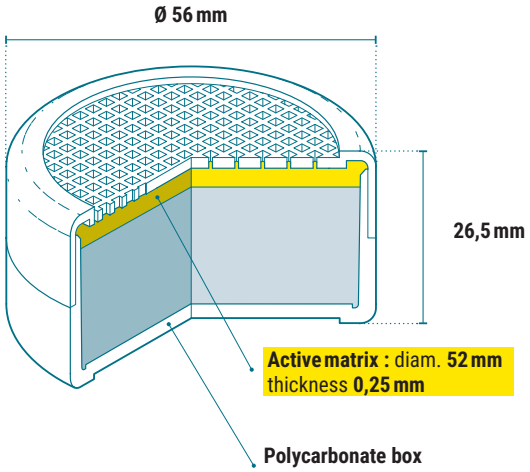
Catalog references	On request
Container	
Cartridge of useful volume 44 cm^3	Any volume of activated charcoal
Activity	
4 kBq	From 1 to 900 kBq
Radionuclide	
^{133}Ba, ^{137}Cs, ^{152}Eu, Mix 12ML01	^{51}Cr, ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{85}Sr, ^{88}Y, ^{109}Cd, ^{113}Sn, ^{139}Ce, ^{241}Am

Standard geometries

Type D



Type E



Radionuclide	Activity	k=2 measurement uncertainty	Reference
^{133}Ba	4 kBq	≤ 10%	BA133 EDC D 10
	4 kBq	≤ 10%	BA133 EDC E 10
^{137}Cs	4 kBq	≤ 10%	CS137 EDC D 10
	4 kBq	≤ 10%	CS137 EDC E 10
^{152}Eu	4 kBq	≤ 10%	EU152 EDC D 10
	4 kBq	≤ 10%	EU152 EDC E 10
12ML01*	18,5 kBq	≤ 10%	12ML01 EDC D 11
	18,5 kBq	≤ 10%	12ML01 EDC E 11

Standard manufacturing tolerance: ± 30%
IAEA Category : 5 • ISO2919 Classification : C11111
* The 12ML01 mixture – 241Am, 109Cd, 139Ce, 57Co, 60Co, 51Cr, 137Cs, 113Sn, 54Mn, 65Zn, 85Sr, 88Y – generates around 15 peaks over an energy range from 60 keV to 1836 keV. The quantity of each radionuclide is chosen so that the counting rates of the main peak of each radionuclide are the same order of magnitude. See section on tailor-made gamma sources for additional information on the 12ML01 mixture and on the other mixes available. Other geometries are available on request.

Germanium Detector

ESB γ sources in paper matrix

Technical Information

Radionuclides are deposited on a filter paper, which is then hot-sealed between two thin polyester foils.

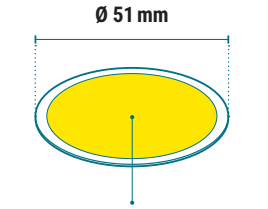
Source activity is measured with NaI scintillators or HPGe semi-conductors.

Production range

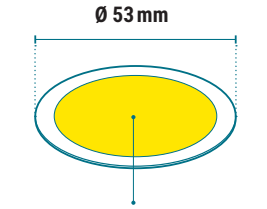
Catalog references	On request
Active diameter	
43 mm	From 15 to 160 mm
45 mm	
47 mm	
50 mm	
53 mm	
60 mm	
120 mm	
External diameter	
51 mm	From 20 to 170 mm
53 mm	
60 mm	
63 mm	
70 mm	
130 mm	
Activity	
10 kBq	From 1 to 900 kBq
20 kBq	
40 kBq	
Radionuclide	
Mix 12ML01*	^{51}Cr, ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{85}Sr, ^{88}Y, ^{109}Cd, ^{113}Sn, ^{134}Cs, ^{139}Ce, ^{241}Am

Standard geometries

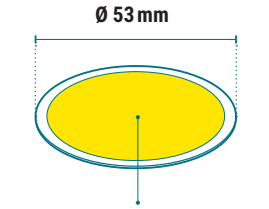
Type M45-51



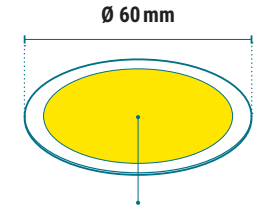
Type M43



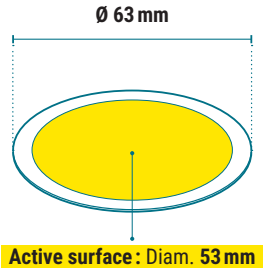
Type M47-53



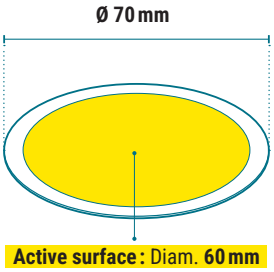
Type M50



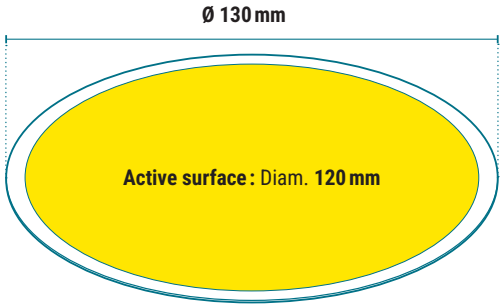
Type M53



Type M60



Type M120



Radionuclide	Activity	k=2 measurement uncertainty	Reference
12ML01*	10 kBq	≤ 10%	12ML01 ESB [Type] [10KBQ]
	20 kBq	≤ 10%	12ML01 ESB [Type] [20KBQ]
	40 kBq	≤ 10%	12ML01 ESB [Type] [40KBQ]

Standard manufacturing tolerance: ± 30% • IAEA Category : 5 • ISO2919 Classification : C11111

* The 12ML01 mixture – 241Am, 109Cd, 139Ce, 57Co, 60Co, 51Cr, 137Cs, 113Sn, 54Mn, 65Zn, 85Sr, 88Y – generates around 15 peaks over an energy range from 60 keV to 1836 keV. The quantity of each radionuclide is chosen so that the counting rates of the main peak of each radionuclide are the same order of magnitude. See section on tailor-made gamma sources for additional information on the 12ML01 mixture and on the other mixes available.

How to compose the reference ?

Replace ***[Type]*** with the codes ***M43, M50, M53, M60, M120, M45-51 or M47-53*** according to the required geometry.
For example:
12ML01 ESB M47-53 [10KBQ].

Tailor-made X and γ sources

LEA can adapt on request the activity and the geometry of catalog sources to specific needs. **Here are seven examples.**

#01

Multigamma Sources

Multi gamma sources (gamma sources composed of several gamma emitting radionuclides) are mostly used for gamma spectrometry measurement purposes in laboratories. Their purpose is to calibrate the measurement chains over an energy range whose limits depend on their end use.

The most versatile gamma mixture is the 12ML01 mix. The 12ML01 mix generates around 15 peaks over an energy range from 60 keV to 1836 keV. The quantity of each radionuclide is chosen so that the counting rates of the main peak of each radionuclide are of the same order of magnitude.

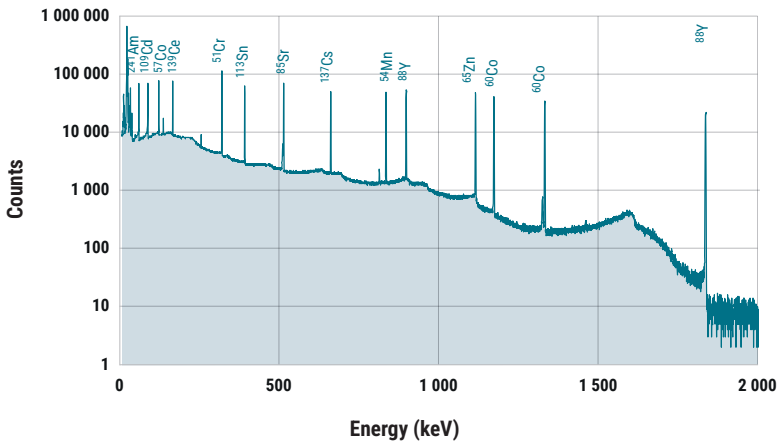
The 12ML01 mixture can be used with all the previous geometries, such as :

- Point Sources
- Resin Matrix
- Charcoal filter cartridges
- Vegetable Matrix
- Paper Matrix

Composition of the mixture

12ML01 60 keV – 1 836 keV

Radionu-clides	Main rays	% in activity (indicatif)	Emission spectrum
^{51}Cr	320 keV	22,1%	
^{54}Mn	835 keV	5,8%	
^{57}Co	122 keV 137 keV	1,1%	
^{60}Co	1 173 keV 1 333 keV	8,2%	
^{65}Zn	1 116 keV	16,5%	
^{85}Sr	514 keV	3,7%	
^{88}Y	898 keV 1 836 keV	6,9%	
^{109}Cd	88 keV	22,4%	
^{113}Sn	392 keV	4,1%	
^{137}Cs	662 keV	5,6%	
^{139}Ce	166 keV	1,4%	
^{241}Am	60 keV	2,2%	



Any other mix of 241Am, 133Ba, 60Co, 137Cs and 152Eu can be produced on request for specific activities.

Example of other mixes

		Mix code							
Radionuclides	**Main rays (keV)**	2ML01	2ML02	2ML04	3ML01	3ML02	3ML07	3ML09	5ML02
^{241}Am	60	-	-	•		•	•	-	•
^{133}Ba	81 - 303 - 356	-	•	-	•	-	-	-	•
^{60}Co	1173 - 1332	•	-	-	•	•	-	•	•
^{137}Cs	662	•	•	-	•	•	•	•	•
^{152}Eu	122 - 244 - 344 - 779 - 867 - 964 - 1408	-	-	•	-	-	•	•	•

Tailor-made X and γ sources

#02

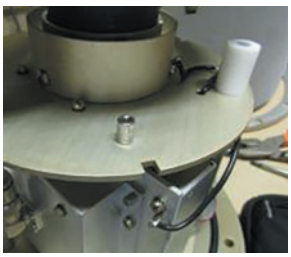
Capsules for radiological ambient measurement monitors

Radiological ambient measurement monitors can use a capsule type radioactive source in order to continuously ensure the stability of the system. LEA produces this type of source with an added thread for incorporation on the measuring equipment.

The most requested sources contain 1.4 µCi (50 kBq), 5.4 µCi (200 kBq), 10 µCi (370 kBq) or 24 µCi (900 kBq) of 241Am, 137Cs, 60Co. The activity and the radionuclides can be adapted according to the final requirements.

Capsule sources with M3 or M4 thread.

Example of mesuring equipment using capsule source



Measuring equipment with casings removed to see the control source

#03

Physical protection of sources

LEA can adapt the geometry of its sources for physical protection purposes. For example for the installation of an anti-theft device.

Example in teaching: Beta and Gamma Radiation Counter uses a radioactive source which, for safety purposes, is attached to the system by a chain. The chain is screwed directly onto the radioactive source, via an M3 thread.

Picture of a Beta and Gamma Radiation Counter. The source, disc type, can be identified by the radioactive trefoil and the chain.

Source used in the Beta and Gamma Radiation Counter

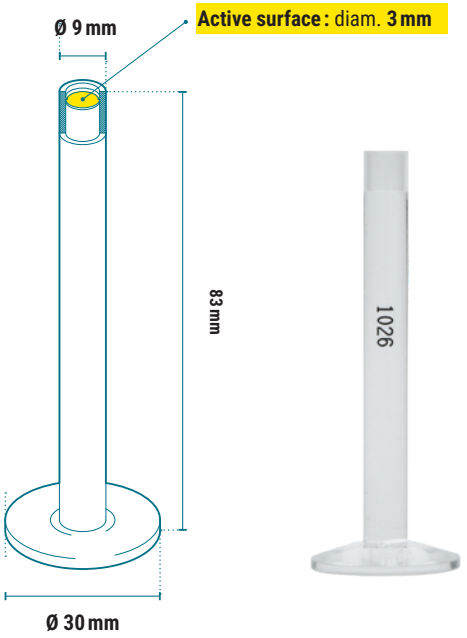
#04

Specific source holders

LEA can design and produce tailor-made source holders, such as :

- source holders adapted to the verification of well detectors used by environmental analysis laboratories or the verification of dose calibrators used in nuclear medicine
- source holders with threads to be screwed onto customer equipment.

All the gamma emitter radionuclides offered in our catalog references can be mounted on specific source holders.



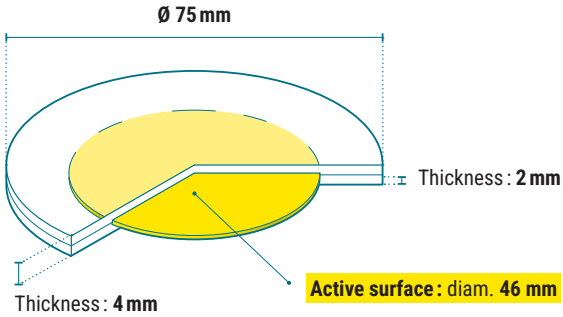
Point Source mounted on rod, specially adapted for well detectors. EGS D reference

#05

Wide area gamma sources

Our flexible manufacturing process enables us to produce wide area gamma sources with active diameters of several centimeters, for all gamma emitting radionuclides offered by LEA.

CO60 EGS C source

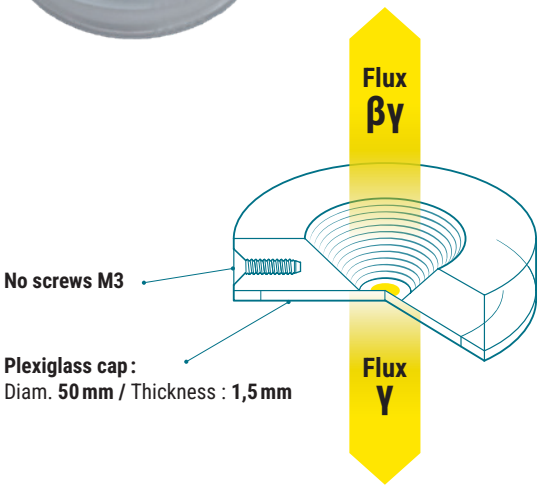


Tailor-made X and γ sources

#06

"bifaced"sources

The LEA has designed a two-sided source so that a beta/gamma flux emerges from one side and only the gamma flux emerges from the other. The conical output maximizes the beta outflow, simulating a solid detection angle. Initially planned for 137Cs, it can be modified for 60Co, or another beta/gamma emitter.



#07

Customer specific formats

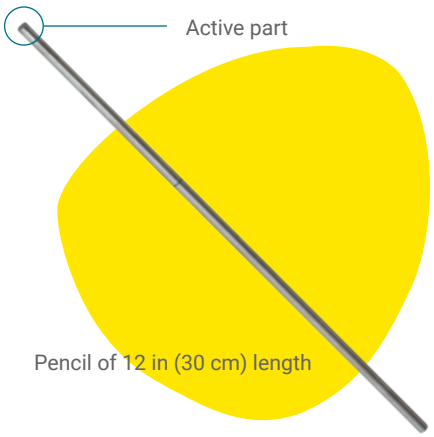
Exemple #07A

Pencil-type sources

In order to reduce the radiological exposure or to insert the source inside a well or a small cavity, pencil-type sources are an ideal solution.

Pencil-type sources offered by LEA (reference EGS03HS) have a diameter of 0.2 in (5 mm), for a total length of 4 in (10 cm) or 12 in (30 cm). The radionuclide (137Cs in that example), is deposited inside the cap which is, then, sealed with the pencil.

The size of the pencils (diameter and length), as well as radionuclides and their activity are adaptable as required.



Exemple #07B

Filiform sources

Filiform sources consist of thermosetting resins in which the radionuclides are mixed. Resins are then inserted into a sealed container, guaranteeing the seal of the whole in a stainless steel or plastic container.

Most requested radionuclides : Mixture 3ML01 (60Co, 133Ba, 137Cs), 57Co, 60Co, 137Cs, 152Eu, 241Am

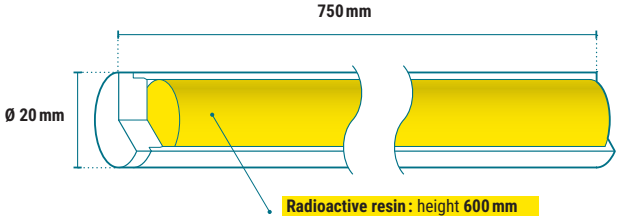
Most requested activities : 5.4 µCi (200 kBq), 21.6 µCi (800 kBq), 27 µCi (1 MBq), 81.1 µCi (3 MBq).

We can produce sources with all gamma emitters and mixtures of gamma emitters offered by LEA, for activities ranging from 1.1 µCi (40 kBq) to 1.1 mCi (40 MBq).

Filiform sources wire sources/ plastic wire sources

Example of utilization of filiform sources : calibration and control of measuring system for radioactive waste drums

Filiform sources 29.5 in (75 cm) long by 0.8 in (2 cm) in diameter containing a radioactive resin 23.6 in (60 cm) long. Ideal for the measurement of radioactive waste drums such as 200 liter I 55 gallon oil drums (≈31.5 in [80 cm] high by 23.6 in [60 cm] in diameter).



Example of 200 litre / 55 gallon radioactive waste drum © LEA

Example of an insertion guide © LEA

Filiform source for radioactive waste drums

Tailor-made X and γ sources

#08

Calibration and control of whole-body counting systems

Exemple #08A

Source for phantom IGOR™

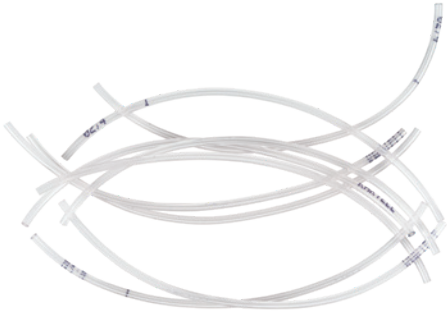
IGOR™ whole-body phantoms ranging from 88.2 lbs to 242.6 lbs contain up to 130 polyethylene blocks of different sizes, simulating different body builds from 26.5 lbs to 242.5 lbs. About 260 sources are needed to reproduce a homogeneous whole-body source term, simulating blood contamination.

Most requested radionuclides : 57Co, 60Co, 137Cs, 152Eu, 133Ba, 241Am, alone or mixed (references 2ML01 or 3ML01).

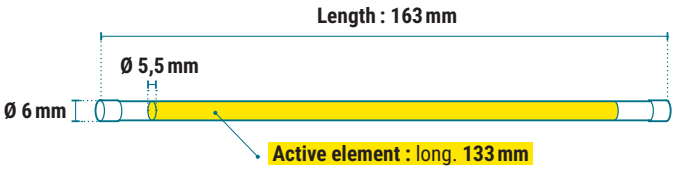
Most requested activities : 0.003 µCi (100 Bq), 0.005 µCi (200 Bq), 0.01 µCi (500 Bq), 0.03 µCi (1 kBq), 0.04 µCi (1.5 kBq).

LEA can produce sources with all gamma emitters and mixtures of gamma emitters for other activity levels.

Fantôme IGOR™ © RADEK



Filiform source for IGOR™ phantom. EGRO reference



Carrying case IGOR™

Under COFRAC accréditation : Scope N°2-6386 avaible on www.cofrac.fr or upon request

Le LEA est titulaire de la licence IRSN.

Exemple #08B

Sources for phantom RMC II, ACCUSCAN™ and FASTSCAN™

RMC II phantoms are designed for ACCUSCAN™ and FASTSCAN™ whole body counters.

RMC II phantoms simulate the binding of radionuclides in the thyroid, lungs, gastrointestinal system or the whole body, using 1 to 4 radioactive sources inserted in the appropriate slot.

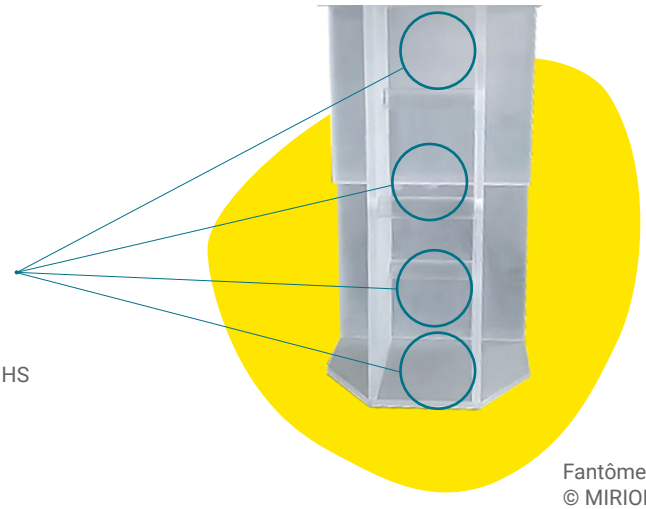
Most requested radionuclides : 57Co, 60Co, 137Cs, 152Eu, alone or mixed (references 2ML01 or 3ML01).

Most requested activities : 0.003 µCi (100 Bq), 0.005 µCi (200 Bq), 0.01 µCi (500 Bq), 0.03 µCi (1 kBq), 0.04 µCi (1.5 kBq).

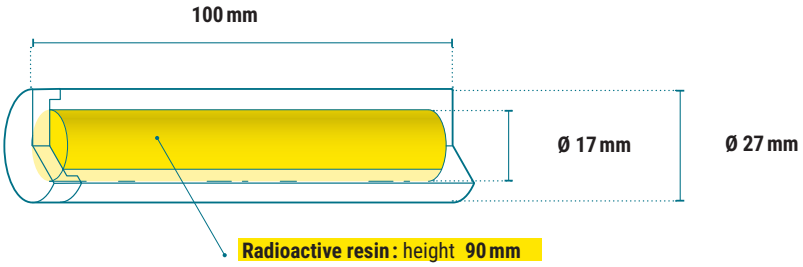
LEA can produce sources with all gamma emitters and mixtures of gamma emitters for other activity levels.

ACCUSCAN™ & FASTSCAN™
© MIRION TECHNOLOGIES

Cylindrical sources for Phantom RMC II. EGR01HS reference



Fantôme RMC II™
© MIRION Technologies



Liquid sources

Key applications

Liquid sources are mostly used in laboratories **detection metrology purposes:** calibration of detectors, periodic quality inspections such as control charts, periodic verification of detection performance.

The associated measurement systems are the devices used to control the discharge of liquid effluents into the environment: gamma spectrometry or liquid scintillation counting.

1 TRI-CARB™ Liquid scintillation Counter

2 Ultra Low Background HPGe detector for environnemental monitoring

Handling precautions

Liquid sources are considered as unsealed sources.

Handling Precautions: PPE (goggles, gloves, overalls, lead protection as appropriate) must be worn. The use of accessories (tweezers, file, ampoule holder and ampoule breaker) is recommended to limit radiological exposure and to reduce the risk of contamination.

During a dilution, the diluent used must have the same chemical composition and the same non-radioactive material concentration as the provided source (LEA provides on request the chemical carriers used for the manufacture of its sources).

Metrological guarantee

Bulb geometry: The LEA recommends and guarantees calibration values for a period of 2 radioactive periods or within a maximum of 2 years.

V-Vial-Penicillin geometry: The LEA recommends and guarantees calibration values for a period of 3 months.

ELS liquid sources

Technical Information

The specific activity of our liquid sources is characterized by means of NaI scintillators, HPGe semi-conductors or liquid scintillation analyzers. They are calibrated under COFRAC* protocols. The measurement uncertainty varies between 1% and 8% depending on the radionuclide and the geometry.

Activities

The specific activity levels available as catalog reference are:

- 0. 001 µCi/g (0.04 kBq/g)
- 0.01 µCi/g (0.4 kBq/g)
- 1.1 µCi/g (40 kBq/g)
- 21.6 µCi/g (800 kBq/g)
- 261.2 µCi/g (8 000 kBq/g)

Standard geometries

- Ampoules
- V-Vial bottles
- Penicillin bottles
- Standardized bottles

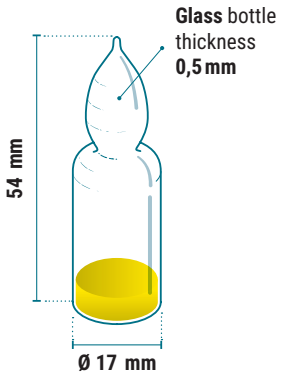
Our liquid sources can be conditioned in other geometries offered in our catalog or provided by the customer.

* Scope N°2-6386 available on www.cofrac.fr or upon request.

Standard geometries

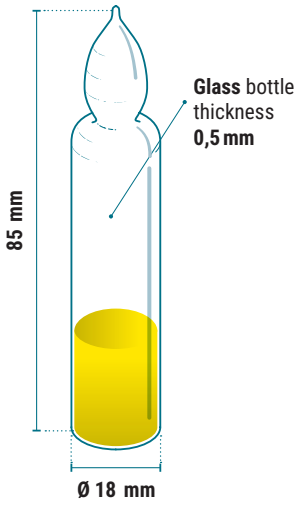
Type A *Ampoule*

Useful volume **1 cm³**



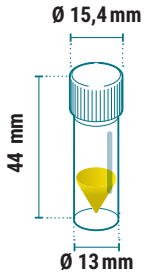
Type B *Ampoule*

Useful volume **5 cm³**



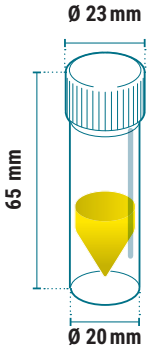
Type U *V-Vial*

Useful volume **1 cm³**



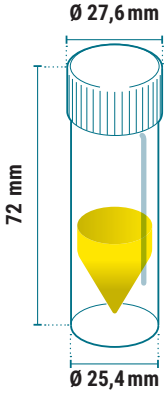
Type V *V-Vial*

Useful volume **5 cm³**



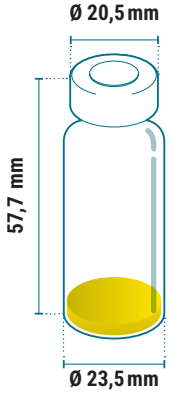
Type W *V-Vial*

Useful volume **10 cm3**



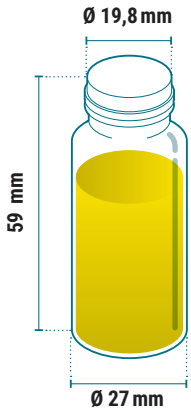
Type D *Pénicilline*

Useful volume **1 cm³**



Type J *Pénicilline*

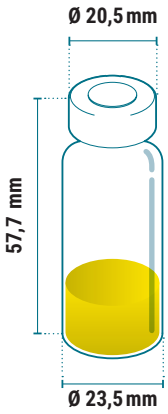
Useful volume **20 cm3**



* Maximum activity = 0.04 kBq/g

Type L *Pénicilline*

Useful volume **5 cm³**



Duration of use see annexes

ELS liquid sources

Geometries [Type]
- Ampoules . . **A ou B**
- V-Vial . . . . . **U, V ou W**
- Penicillin . . . **D, J* ou L**

Activies [Act]
- 0.04 kBq/g
- 0.4 kBq/g
- 40 kBq/g
- 800 kBq/g
- 8 000 kBq/g
- Other activity on request

How to compose the reference ?

Replace ***[Type]*** and ***[Act]*** with the letter and the value according to the required geometry and activity.

For example, a 5ml ampoule (B type) containing 1.1 µCi/g (40 kBq/g) of 137Cs is referenced as ***CS137 ELS B 40kBq/g.***

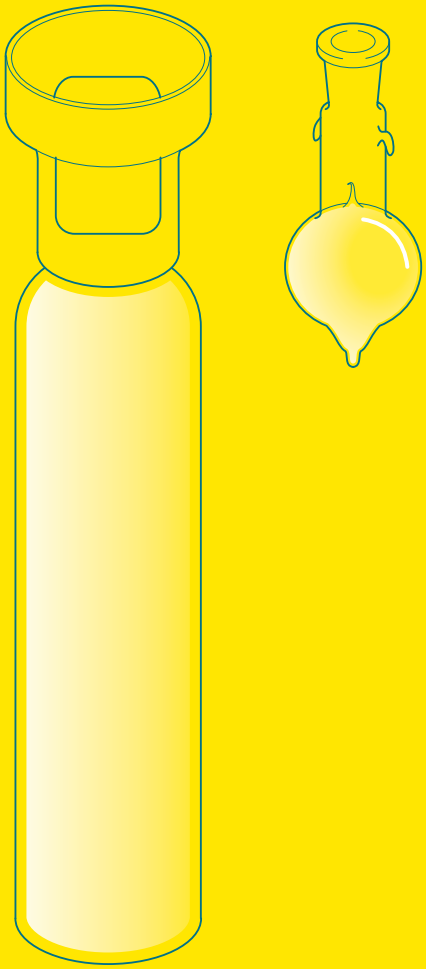
	Radionuclide	Chemical form	Carrier	Reference	Note
α αγ	^{237}Np	HCL 6N ou HNO_3 3N	Oxalic acid [33µg/g]	NP237 ELS [Type] [Act]	Available geometries : A, B, U, V, W Maximum = 40 kBq/g
	^{238}Pu	HNO_3 3N	-	PU238 ELS [Type] [Act]	Available geometries : A, B, U, V, W Maximum = 40 kBq/g
	^{239}Pu	HNO_3 3N	-	PU239 ELS [Type] [Act]	Available geometries : A, B, U, V, W Maximum = 40 kBq/g
	^{241}Am	HNO_3 1N	$EuCl_3$ [10µg/g]	AM241 ELS [Type] [Act]	Available geometries : A, B, U, V, W Maximum= 40 kBq/g
	^{244}Cm	HNO_3 1N	-	CM244 ELS [Type] [Act]	Available geometries : A, B, U, V, W Maximum= 40 kBq/g
β	^{3}H	H_2O	-	H3 ELS [Type] [Act]	Only available in A and B type Maximum= 800 kBq/g
	^{14}C	H_2O	D-glucose [50µg/g] + formaldehyde [1mg/g]	C14 ELS [Type] [Act]	Maximum= 800 kBq/g
	^{32}P	HCL 0,1N	Na_2HPO_4 [10µg/g]	P32 ELS [Type] [Act]	Maximum= 800 kBq/g
	^{35}S	HCL 0,1N	Na_2SO_4 [10µg/g]	S35 ELS [Type] [Act]	Maximum= 800 kBq/g
	^{36}Cl	H_2O	NaCl [10µg/g]	CL36 ELS [Type] [Act]	Maximum= 800 kBq/g
	^{45}Ca	HCL 0,1N	$CaCl_2$ [10µg/g]	CA45 ELS [Type] [Act]	Maximum= 800 kBq/g
	^{63}Ni	HCL 0,1N	$NiCl_2$ [10µg/g]	NI63 ELS [Type] [Act]	Maximum= 800 kBq/g
	^{89}Sr	HCL 0,1N	$SrCl_2$ [20µg/g]	SR89 ELS [Type] [Act]	Maximum= 800 kBq/g
	$^{90}Sr + ^{90}Y$	HCL 0,1N	$SrCl_2$ [20µg/g] + YCl_3 [10µg/g]	SR90 ELS [Type] [Act]	-
	^{99}Tc	H_2O	-	TC99 ELS [Type] [Act]	Maximum= 800 kBq/g
	^{147}Pm	HCL 0,1N	$LaCl_3$ [10µg/g]	PM147 ELS [Type] [Act]	Maximum= 800 kBq/g

	Radionuclide	Chemical form	Carrier	Reference	Note
βγ γ	^{22}Na	HCL 0,1N	$NaCl$ [10µg/g]	NA22 ELS [Type] [Act]	-
	^{51}Cr	HCL 0,1N	$CrCl_3$ [60µg/g]	CR51 ELS [Type] [Act]	-
	^{54}Mn	HCL 0,1N	$MnCl_2$ [26µg/g]	MN54 ELS [Type] [Act]	-
	^{55}Fe	HCL 0,1N	$FeCl_3$ [10µg/g]	FE55 ELS [Type] [Act]	-
	^{57}Co	HCL 0,1N	$CoCl_2$ [10µg/g]	CO57 ELS [Type] [Act]	-
	^{59}Fe	HCL 1N	$FeCl_3$ [10µg/g]	FE59 ELS [Type] [Act]	-
	^{60}Co	HCL 0,1N	$CoCl_2$ [10µg/g]	CO60 ELS [Type] [Act]	-
	^{65}Zn	HCL 0,1N	$ZnCl_2$ [55µg/g]	ZN65 ELS [Type] [Act]	-
	^{85}Sr	HCL 0,1N	$SrCl_2$ [20µg/g]	SR85 ELS [Type] [Act]	-
	^{88}Y	HCL 0,1N	YCl_3 [10µg/g]	Y88 ELS [Type] [Act]	-
	^{109}Cd	HCL 1N	$CdCl_2$ [10µg/g]	CD109 ELS [Type] [Act]	-
	^{110m}Ag	NH_4OH 0.1N ou 1N	AgCN [10µg/g]	AG110 ELS [Type] [Act]	-
	^{113}Sn	HCL 6N	$SnCl_4$ [10µg/g]	SN113 ELS [Type] [Act]	-
	^{125}I	H_2O	$Na_2S_2O_3$ [50µg/g] + NaI [50µg/g]	I125 ELS [Type] [Act]	Only available in A and B type
	^{129}I	H_2O	$Na_2S_2O_3$ [50µg/g] + NaI [50µg/g]	I129 ELS [Type] [Act]	Only available in A and B type
	^{131}I	H_2O	$Na_2S_2O_3$ [50µg/g] + NaI [50µg/g]	I131 ELS [Type] [Act]	Only available in A and B typeMaximum= 800 kBq/g
	^{133}Ba	HCL 1N	$BaCl_2$ [33µg/g]	BA133 ELS [Type] [Act]	-
	^{134}Cs	HCL 0,1N	CsCl [10µg/g]	CS134 ELS [Type] [Act]	-
	^{137}Cs	HCL 0,1N	CsCl [10µg/g]	CS137 ELS [Type] [Act]	-
	^{139}Ce	HCL 0,1N	$CeCl_3$ [10µg/g]	CE139 ELS [Type] [Act]	-
	^{152}Eu	HCL 1N	$EuCl_3$ [10µg/g]	EU152 ELS [Type] [Act]	-
Mix γ	12ML01*	HCL 1N	Mix of unit trainers	12ML01 ELS [Type] [Act]	Available : •80 Bq/g •800 Bq/g •40 kBq/g •800 kBq/g

Standard manufacturing tolerance : ± 30% • IAEA Category : 5

* The 12ML01 mixture – 241Am, 109Cd, 139Ce, 57Co, 60Co, 51Cr, 137Cs, 113Sn, 54Mn, 65Zn, 85Sr, 88Y – generates around 15 peaks over an energy range from 60 keV to 1836 keV. The quantity of each radionuclide is chosen so that the counting rates of the main peak of each radionuclide are the same order of magnitude. See section on tailor-made gamma sources for additional information on the 12ML01 mixture and on the other mixes available.

Gas sources



EZS gas sources

LEA produces 85Kr gas and other radionuclides on request (133Xe…) packaged in glass ampoules or in metal cylinders.

Gas sources are used in detection metrology, as part of the environmental monitoring of releases from nuclear facilities.

Associated measurement systems are mainly ionization chambers, Geiger Muller detectors or atmospheric monitors installed on process lines.

Technical Information

Our 85Kr sources (ampoules or cylinders) are considered as unsealed sources.

Manufacturing tolerance are ± 30%. The uncertainty associated with the measurement of volume activity is ± 5% at k=2.

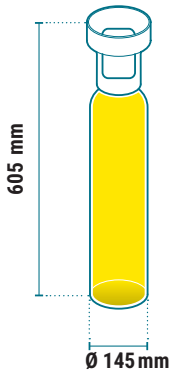
The default pressure in metal bottles is 100 bar. The pressure in the ampoules is lower than 0.5 bar.

Installation of an empty 85Kr cylinder

Filling a 85Kr ampoule

Type E *Cylinder*

Useful volume **5 000 cm³**

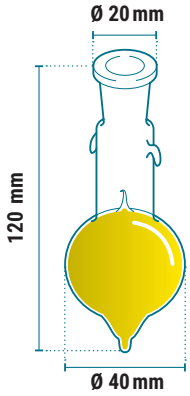


Radionuclide	Volume activity	k=2 measurement uncertainty	Equivalent activity	Reference
	Under COFRAC* accreditation			
^{85}Kr	0.2 kBq/cm³	5%	100 MBq	KR85 EZS E 20

* Scope N°2-6386 available on www.cofrac.fr or upon request.

Type A *Ampoule*

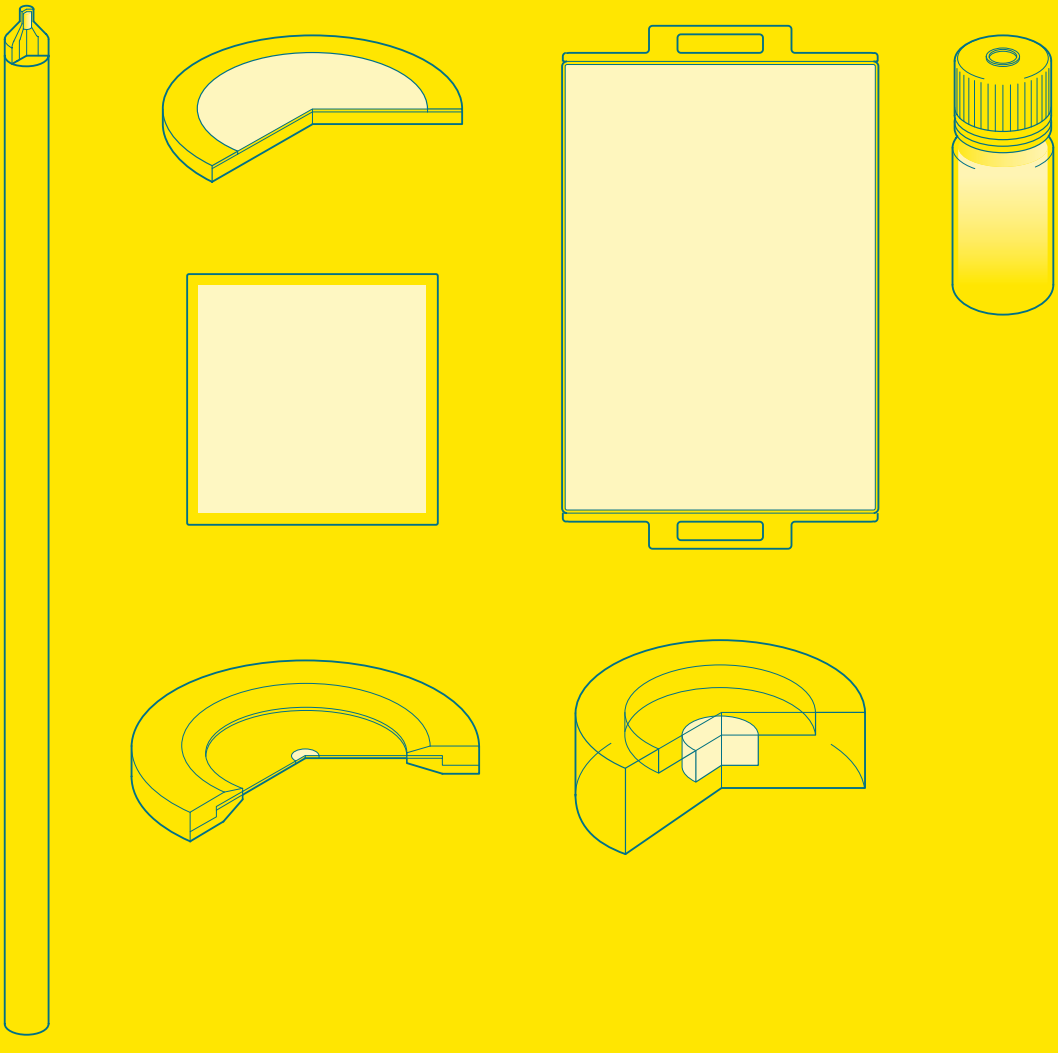
Useful volume **3 cm³**



Radionuclide	Total activity	k=2 measurement uncertainty	Reference
^{85}Kr	240 kBq	5%	KR85 EZS A 40
	120 MBq	5%	KR85 EZS A 60

LEA also offers SG500 or SG3000 gas containers, equipped with sampling probes and mounted staubli fittings (see page 81).

Medical sources



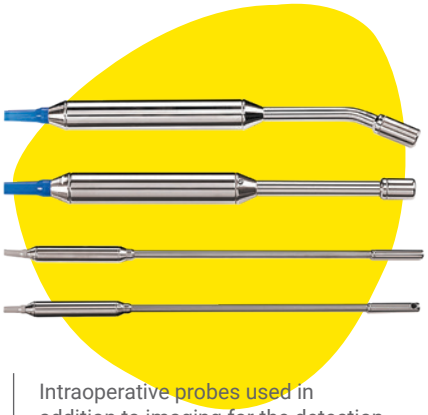
Key applications

The sealed sources used in nuclear medicine serve mainly to perform operating checks (stability, efficiency, homogeneity) or calibration of several types of key radiodiagnostic equipment:

- **SPECT** cameras (using gamma sources)
- **PET** cameras (using beta sources) **see p.76 for PET sources**
- **Dose calibrators** used to quantify the radiopharmaceutical medication injected
- **Well detectors** used for measuring sample tubes
- **Means of radiation protection** used by the personnel of nuclear medicine services

Gamma Caméra portable
© DAMAVAN IMAGING

❶ SPECT Symbia Intevo
❷ TEP Biograph Vision™
© SIEMENS HEALTHINEERS



Intraoperative probes used in addition to imaging for the detection of the sentinel node in breast cancer and melanoma

Dose calibrator used in nuclear medicine to know with precision the activity administered to patients

Floods

LEA produces and distributes Flood sources, Co-57 rectangular sources designed for rectangular FOV (field of view) gamma cameras to check the nominal settings and the uniformity of response of the system.

These sealed sources are at least classified C 22212 in accordance with ISO2019. Flood sources are made of a shell (to ensure a secure seal) containing a resin in which the radionuclide is uniformly distributed.

Flood sources have a percentage of differential non-uniformity ≤3% over the entire active surface of the source.

As an option, they are equipped with handles, thus limiting dosimetry at the hands and facilitating manipulations. Lead-protected mobile carry cases are also available to facilitate movement and storage of Flood sources.

Lead-protected mobile carry cases are also available to facilitate movement and storage of Flood sources.

* décision du 25/11/2008 fixant les modalités du contrôle de qualité des installations de médecine nucléaire à visée diagnostique, JORF n°0289 du 12/12/2008 texte n°46.

Radionuclide	Activity	Reference
^{57}Co	370 MBq	CO57 EHS [Type] 40 / CO57#BM01L-10
	550 MBq	CO57 EHS [Type] 45 / CO57#BM01L-15
	740 MBq	CO57 EHS [Type] 50 / CO57#BM01L-20

How to compose the reference ?

Replace ***[Type]*** with the letter ***I*** if you desire handles or ***H*** if not.
For example: ***CO57 EHS H 30.***

Geometry

Galette CO57 © LEA

LEA Flood model **available with or without handle** (specify when ordering).

The total dimensions of the model without handle are 24.97 x 17.4 in (63.4 x 44.4 cm) respectively for length and width.

Lead-protected mobile carry case for storage.

LEA can also offer other Flood geometries:

• square, with a total dimensions of 11.5 x 11.5" (29 x 29 cm) and an active surface area of 10 x 10" (25 x 25 cm) for activities of 0.5 mCi (18.5 MBq), 3mCi (111 MBq), 10mCi (370MBq), 15 mCi (555MBq), 20mCi (740MBq).

Equipment type : CZT gamma camera

Square series BM05
© Radqual

Pen point marker

Pen markers are used for anatomical marking in imaging.

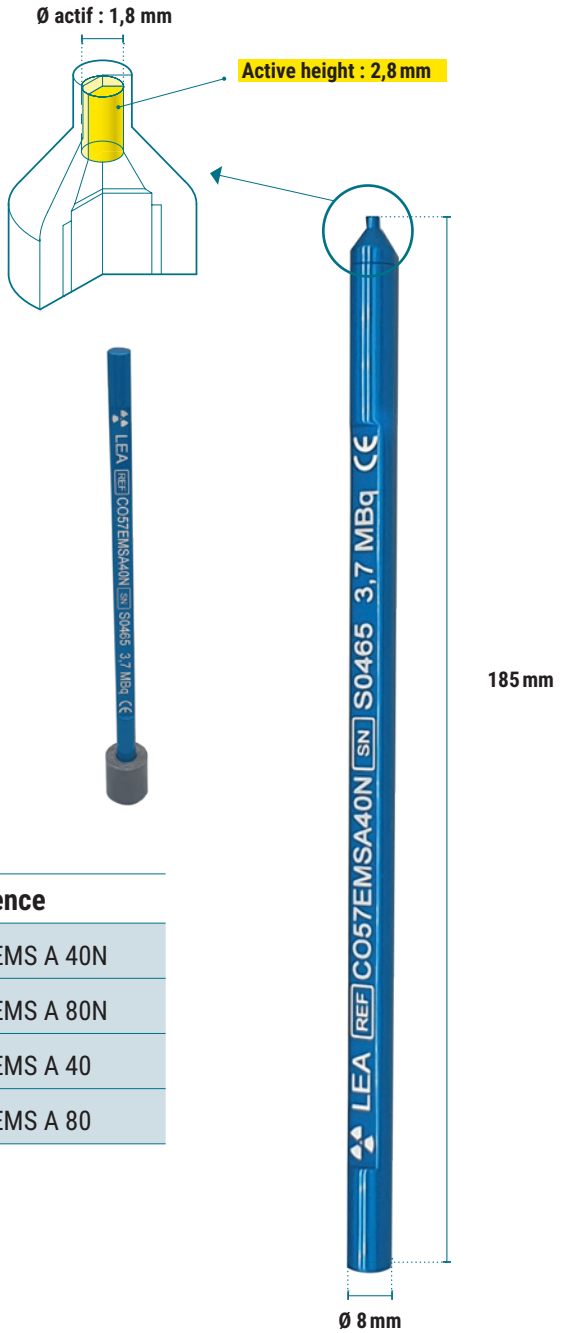
57Co is deposited punctually in a hollow tip, itself screwed and sealed at the end of an aluminum rod.

They are delivered with their leaded support for personnel and storage protection.

> Note that pen-point markers a**re not point-sources**, so they are not to be used to calibrate or control detection probes.

Standard geometry

Type A



Radionuclide	Activity	Reference
^{57}Co	3,7 MBq	CO57 EMS A 40N
	7,4 MBq	CO57 EMS A 80N
	3,7 MBq*	CO57 EMS A 40
	7,4 MBq*	CO57 EMS A 80

Manufacturing tolerance: -15% + 30%
IAEA Category: 5 • ISO2919 Classification: C22212 • CE Marking

* Sources can be provided with a metrological certificate.
The measurement uncertainties at k = 2 are lower than 10%.

Class I medical device, in accordance with the European regulation no. 2017/745

Dose calibrator sources

The checks for accuracy, repeatability and correctness of the activometers require by regulation* the use of two sources of constancy, having a calibration certificate for the following minimum activities at the time of the checks :

- 57Co activity greater than or equal to 40MBq,
- 137Cs activity greater than or equal to 5MBq,
- 133Ba activity greater than or equal to 5MBq.

The dose calibrators are sealed sources, made in a plastic bottle allowing easy and safe handling. The radionuclide is distributed homogeneously within a thermosetting resin.

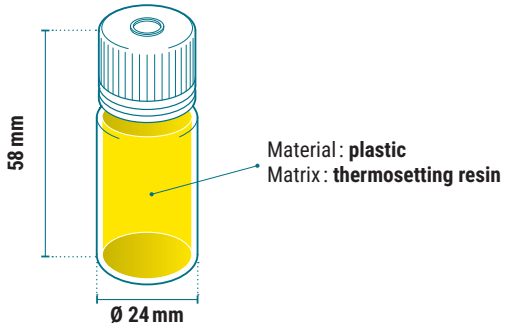
The radionuclides supplied by LEA emit gamma rays close to those of the radionuclides most used in nuclear medicine (18F, 99mTc, 123I, 131I, 111In, 201Tl).

* décision du 25/11/2008 fixant les modalités du contrôle de qualité des installations de médecine nucléaire à visée diagnostique, JORF n°0289 du 12/12/2008 texte n°46.

Standard geometry

Type F

Useful volume **10 cm³**



Radionuclide	Activity	k=2 measurement uncertainty	Reference
^{133}Ba	10 MBq	≤ 3%*	BA133 EGA F 50
	20 MBq	≤ 3%*	BA133 EGA F 55
^{57}Co	100 MBq	≤ 3%*	CO57 EGA F 80
	200 MBq	≤ 3%*	CO57 EGA F 90
	370 MBq	≤ 3%*	CO57 EGA F 100
^{137}Cs	10 MBq	≤ 3%*	CS137 EGA F 50
	20 MBq	≤ 3%*	CS137 EGA F 55
	40 MBq	≤ 3%*	CS137 EGA F 65

Manufacturing tolerance: -15% / +30%
IAEA Category : 5 • ISO2919 Classification : C22212* The calibration of sources can be performed on request, according to COFRAC** accredited protocols. The measurement uncertainties at k=2 are lower than or equal to 3%.

** Scope N°2-6386 available on www.cofrac.fr or upon request.

Other nuclides can be provided on request (60Co...)

Spot markers (point sources)

Spot markers are used to adjust the orientation of gamma cameras as well as for checking intraoperative probes.
The best-selling EGS sources in the medical environment are A type (EGS A) and V type (EGS V), with 22Na, 57Co, 133Ba ou 137Cs.
See EGS type point gamma sources, pages 30 to 33.

[1] Tel que défini en France par la décision du 25 novembre 2008 fixant les modalités du contrôle de qualité des installations de médecine nucléaire à visée diagnostique.

EGS V

EGS A

Sources for radiation protection devices

Sources suitable for the radiation protection equipment used in nuclear medicine departments can be found on :
- page 16 for discs sources,
- page 20 for rectangular and square sources.

Discs sources

Rectangular and square sources

Sources for medical application

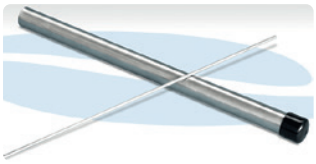
LEA can provide calibration and control sources for key PET equipment (Siemens, General Electric and Philips).

Siemens : Biograh PET/CT Classic, Biograph MCT or Horizon, Biograph 6/40 True V, Inveon 120, Biograph mmR, Biograph Vision,
GE : Discovery CT, Discovery 600/610, Discovery 690, Discovery 710, Discovery IQ,
Spectrum Dynamics : D Spect - Veriton
Philips : Gemini TF, Vereos, Ingenuity
Spectrum Dynamics : D Spect - Veriton.

LEA also markets calibration sources for 68Ge dose calibrators, which can be supplied in V-Vial type and syringe format, of 500 or 1 000 µCi (18.5 or 37 MBq) activity.

Sources étalons pour activimètres en ^{68}Ge fournies en Flacon V-Vial
© Radqual

VQC Phantom 68Ge
© Sanders



Spectrum Dynamics Line Sources Co57
© Radqual

Other sources

In addition to the catalog sources, LEA can offer specific products and services suited to your projects :

- **Tailor-made calibration sources** (activities, uncertainties, tolerances, geometries, matrices, supports...) from LEA production, or supplied by LEA partner manufacturers
- **Imported high** activity sources and associated services (transportation, storage, used source recovery...)
- Catalog and tailor-made **accessories**
- **Used sources** recovery and other services

You will find here after some examples of the products and services offered by LEA.

Please contact us for further information !

Tailor-made standard sources

Beyond the catalog references presented in the previous pages, LEA can also produce tailored-made sources suited to your needs.

Process

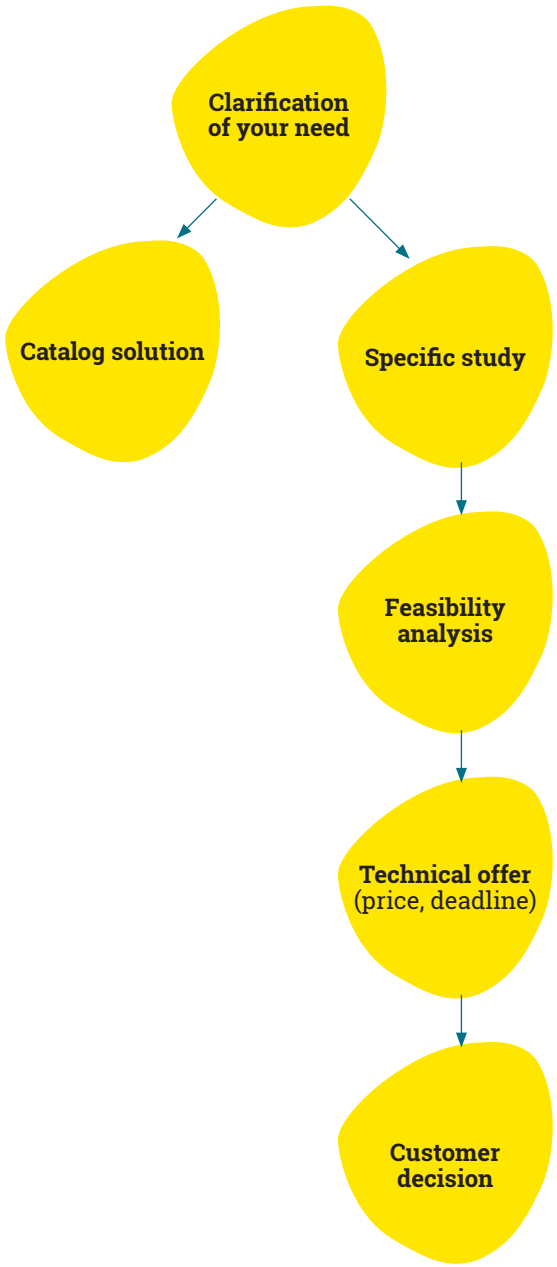
Based on your needs and specifications, an internal study is initiated to validate:

- the production feasibility (manufacturing and measuring if necessary) of the source in accordance with the scope of LEA's license,
- the possibility to issue a calibration certificate under COFRAC* accreditation,
- the level of uncertainty of the measurement,
- the type of packaging and associated transport,

or we will suggest a catalog source close to your desired specification.

This feasibility study also helps defining the price and schedule associated with the requested supply. If the source is close to one of our catalog references, the completion time can be very short (a few weeks).

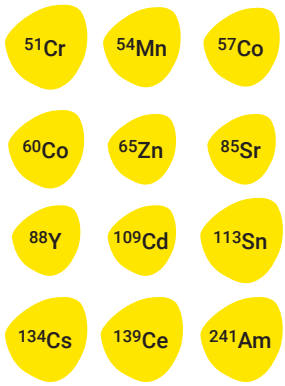
For more complex cases, requiring R&D and/or an LEA license upgrade, the time associated with the study and the necessary funding are then communicated to you for prior validation.



Tailor-made standard sources examples

Specific mix of radionuclides

LEA proposes alpha and gamma multi-nuclides sources. LEA can also offer tailor-made multi-nuclides standards (from 3 to 12 nuclides). The percentage of each nuclide in the mixture can be specified by the customer. Default is the same activity for each radionuclide.



Specific activities or emission rates

The possible activities by nuclides and by geometry are specified in the previous chapters.
In terms of uncertainty, the COFRAC* scope defines the minimum level that LEA can provide under accreditation. If a COFRAC* certificate is not required, we may be able to offer reduced uncertainties; consult us for this.

Reduced or specific manufacturing tolerance

Insofar that its manufacturing capabilities allow, LEA can offer tailor-made products with a reduced or asymmetrical manufacturing tolerance: for example, - 0% / 30% thus guaranteeing a minimum activity to ensure sufficient counting on your device, or conversely, -30% / -0% guaranteeing maximum activity to avoid saturating your measurement chains or remain in compliance with your material possession license.

* Scope N°2-6386 available on www.cofrac.fr or upon request.

Tailor-made standard sources

Tailor-made standard sources examples

Specific active diameter

Depending on the size of your detectors, a different active surface may be required for the standard source. Possible active diameters by source type and geometry are specified in previous chapters.

Specific matrices

Sand, soil, cement, gas equivalents... we can study the production of tailor-made standards in matrices close to that which you require to control or characterize.

Specific dilution medium

The solutions manufactured by LEA are provided according to a given chemical composition (particularly dilution and molarity). A specific medium can be offered as a tailor-made product at your request.

Capsules

See gamma source chapter for more details and examples of achievement

LEA proposes sealed sources in the form of capsules for activities < 27 µCi (1 MBq).

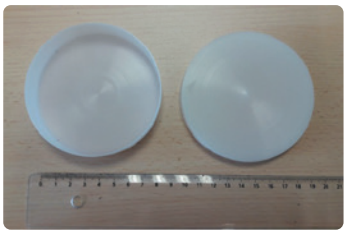
For sealed sources > 27 µCi (1 MBq), ISO 2919 "radiation protection — sealed radioactive sources — general requirements and classification" requires a minimum classification of C22212 for calibration sources (or a more restrictive specific classification, depending on the intended use). Source constraints, associated with the desired classification level, can lead to specific developments, and in all cases require testing to obtain this classification.

Customer-specific supports

Customer-specific bottles

To produce sources with your specific bottles, 5 samples will be required for preliminary testing.

12 ML source resin in a 500 ml and 1 liter bottle supplied by a customer



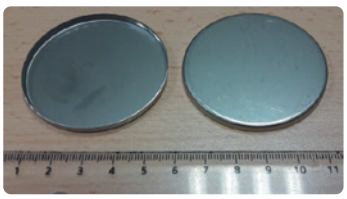
12 ML source resin in a 30 ml supplied by a customer

Bernard Dumas glass or cellulose paper filters

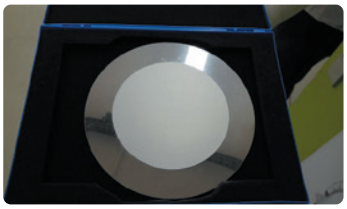
used in environmental monitors in nuclear facilities.

Stainless steel tray

(wide area sources)



External diameter 2.17 in, active diameter 2,1 in



External diameter 5.7 in, active diameter 3.9 in

Various

Customer-specific stainless steel supports

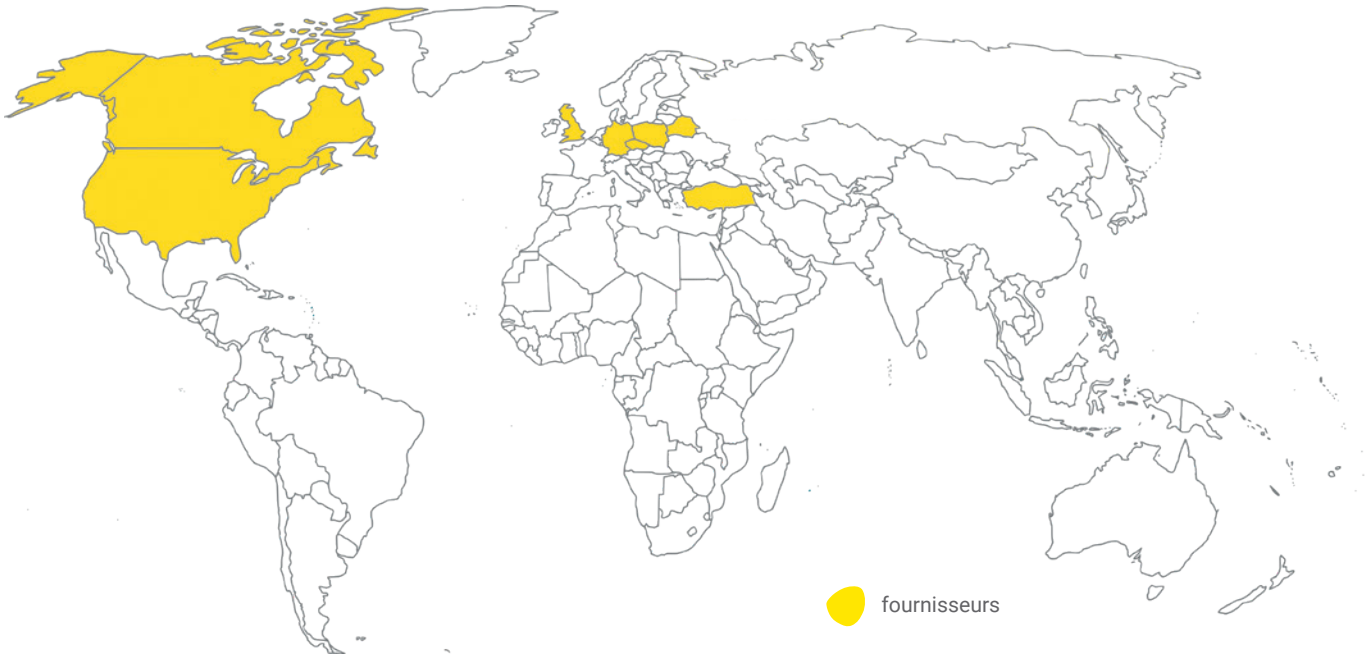
Active size source 1.5 x 1.7 in, external dimension 1.7 x 1.9 in mounted on a specific stainless steel support

Third-party supplier sources

For your requests that cannot be met by our own production, we can import and distribute products (sources and accessories) made by our partners. LEA takes care of all the formalities such as import, delivery, used sources collection.

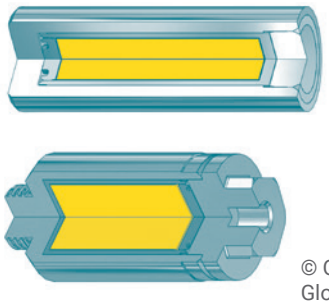
Calibration sources
(outside LEA's manufacturing range)

- Alpha calibration sources
- Beta calibration sources
- X standard
- Gamma calibration sources
- Standard for surface contamination control
- Multi gamma/spectrometry standard
- Gas standard



High activity sources for industry and R&D applications

Sources for Oil Well Logging (OWL) or mining: 60Co, 137Cs, AmBe et 252Cf sources.



© QSA Global

Sources for Process control for nuclear fuel cycle facilities: 60Co, 137Cs, AmBe et 252Cf sources.

Sources for Construction and agriculture: neutron and gamma sources to measure moisture or soil density. The sources are used to determine the water content of bulk materials (agricultural silo, gravel, wood chips…) or soil density by measurement with a neutron emitting source (AmBe type) or by association with a 137Cs source and an AmBe source.

Sources for Industrial gauges:

- paper weight measurements (beta sources of 85Kr and 147Pm),
- thickness and density measurements (beta sources of 90Sr, 85Kr and 147Pm),
- level control (sources of d'241Am and 137Cs).

Sources for X-ray fluorescence for the detection of lead in paints. The sources proposed by LEA are made of 109Cd et 57Co from 4.9 mCi (180 MBq) to 23 mCi (850 MBq).

These capsules are made of stainless steel.

Accessories & services

Sources

Accessories & services

Appendices

Accessories

To facilitate your sources manipulation, here is a non-exhaustive list of accessories developed or distributed by LEA. Contact us for any requests.

Packaging

Transport packaging
A type

MC1 © Nuc emballage

TC1 © Nuc emballage

Source box

1913 LVNF © LEA

Transport packaging
For Beta and Gamma sources

Carry cases
Shielded case for flood sources

Protections

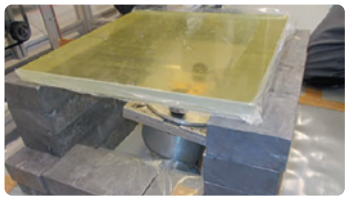
Lead pots

Source storage safe

© Manutan

Specific biological shielding

LEA designs and implements (neutron and gamma) shieldings together with its partners for operations involving highly active sources. These shieldings can be used for storage or transport, or as tools to facilitate source manipulations (assembly/ disassembly, transfer, ...).



© Total

Lead glass and brick shielding as part of a project to dismantle sources (133Ba source).

Porte-source et Préhension

Source holder to facilitate verifications on radiation protection probes.

Source holder for electro-deposited alpha sources (EAS type) used for EDGAR monitors.

Source holder to incorporate capsules sources on the measuring.

Source holder suitable for well detector

Référence EGSD

Source holder adapted to training actions

Tweezers for handling sources to avoid depositing a film of grease on alpha sources (which would degrade the emerging signal)

Ampoule breaker for easily opening glass ampoules

Accessoires

Spectrometry

Centring tools for adjusting the source detector distance.

Modular 3 in 1 centering tool, suitable for a 3.1 in (78 mm) diameter end cap HPGe detector, for positioning 3 different source geometries: 2.05 in (52mm) diameter filter, 4.7 in (120 mm) diameter filter or SG50 standardized bottle.

Marinelli beakers or standardized bottles

Product	Cm^3	Reference
Plastic bottle type Beaker Marinelli	250	9ACETL11
Plastic bottle type Beaker Marinelli	500	9ACETL9
Plastic bottle type Beaker Marinelli	1 000	9ACETL1
Plastic bottle type SG50N	50	9ACETL5
Plastic bottle marron	50	9ACETL7
Plastic bottle type SG500N	500	9ACETL6
Plastic bottle marron	500	9ACETL8
Bottle type SG3000	3 000	9ACETL2
Bottle type SG15	15	9ACETL3

Gas containers

SG500

SG3000

LEA also offers SG500 or SG3000 gas containers, equipped with sampling probes and mounted staubli fittings. These SG500 and SG3000 containers come with a volume calibration certificate and a 7 bar pressure resistance certificate. These gas containers allow specific gas samples to be taken for specific spectro-gammametric analysis, mainly in nuclear power plants.

Projets clefs-en-main pour des sources de haute activité

LEA has a wide range of authorizations and capabilities covering the import, distribution and recovery of high activity sources including their transportation and replacement:

• **Large network of suppliers and partners** to cover a wide range of services, in particular in conjunction with Orano resources (engineering, transport, and radiation protection) and with primary metrology laboratories for source characterization,

• **Knowledge of relevant regulations,** in particular in France,

• **Secured installations** within the Tricastin industrial platform (South of France), offering high logistical flexibility, in particular controlled areas for carrying out source servicing or assembly / disassembly operations,

• Partners for carrying out source **reconditioning or recycling,**

• **A secured storage room** to facilitate logistics for new and spent sources.

LEA already has recognized experience in this area in particular for neutron sources (252Cf and AmBe) and gamma sources (60Co) for various applications: manufacturing of EPR nuclear reactor primary rods, gamma scanning of nuclear fuel rods, replacement of sources for industrial gammagraphy in nuclear process plants or for irradiators.

Production line for EPR nuclear reactor rods

Remote handling of sources of gamma radiation used to study materials' behavior under irradiation.

Services

In addition to the supply of new sources (catalog and tailor-made) and the management of turnkey projects, LEA offers the following range of services.

Reprise des sources

The LEA undertakes to take back all sealed sources of its manufacture and considers on a case-by-case basis the recovery of those provided by other manufacturers.

The LEA does not generally recovers unsealed sources, however it is possible to study a disposal solution if existing. The LEA in the frame of used sources recovery :

- Assists you in the preparation of files and advises you on parcel packaging (supply of packaging kits on request) in compliance with Transport regulations,

-Plans pick up and drop off transportation on request,

-Issue certificates of recovery after receipt and control of packages,

-Stores sources safely and securely,

-Manages the disposal of used sources through appropriate channels.

Temporary storage of sources

The LEA has a secured surface area of 43055ft2 and the necessary licenses for storing spent sources awaiting return to their supplier.

Administrative forms are available on our website: www.lea-sources.com.

Conditions for used sources recovery are defined in our GTC - "Useful documents" section

characterization of sources

LEA can carry out measurements on customer-supplied sources in-house or in conjunction with partners. This can include assistance with the packaging and transport of sources and the associated administrative tasks if required. LEA will provide a measurement report or a calibration certificate. This characterization can be combined with the recovery of sources for sources for which LEA controls the disposal process.

Precision weighing

LEA can perform precision weighings in controlled areas thanks to calibrated precision scales (µg).

Training

LEA can organize training courses on the use of sources in radiation protection and metrology. Sources and equipment are provided by LEA. Participants are supervised by LEA's staff (manufacturers, measurement technicians, competent person in radiation protection)

Appendices

Sources

Accessories & services

Appendices

How to place an order ?

Here is our process if you want to purchase LEA sources. Please consult our Sales team if you have any questions.

#01 Contact our Sales team to receive your quotation (for catalog and on-demand sources, services or accessories). Our sources are usually shipped CPT to the airport of your choice (Incoterms 2010 or 2020), except otherwise agreed. Our prices are in Euros, tax-free.

#02 We will send you a quotation as quickly as possible taking account of your specific requirements (catalog or tailor-made standard sources and accessories, logistical or administrative specificities...) as well as our commercial terms & conditions and the required documents (available on our website www.lea-sources.com):

- Material possession license certificate,
- End-user certificate for sources subject to Export Control.

#03 Submit your order and required documents.

#04 You will receive an acknowledgment of order indicating the date of shipment

Relevant regulations

Based in France, LEA operates under the authorization of the French Nuclear Safety Authority ASN (license No. F530042) according to **France's Public Health regulation**. LEA is licensed to manufacture, distribute, import and export nuclides, sources, products or devices for industrial, medical and research applications.

Our sealed sources > 1MBq meet the requirements **of ISO 2919**, which validates their quality as sealed sources following specific tests.

LEA also abides by the **transportation regulations,** both European (ADR) and international (IAEA ICAO, IATA).

Some sources are subject to export controls on dual-use goods in accordance with CE Regulation 428/2009 from council of 5 May 2009 and its upcoming revisions. These sources are subject of a specific certification request (End User Certificate). They are clearly identified in red in the catalog.

Threshold for the radionuclides concerned by the dual purpose measure :

Whatever the activity :

Uranium 233	Uranium 235	Plutonium 239

If the activity is greater than 0,7mCi (0,26 GBq):
Neptunium 237

If the activity is greater than à 10mCi (0,37 GBq):
Radium 226

If the activity is greater than 100mCi (3,7 GBq) :

Actinium 225	Actinium 227	Californium 253
Curium 240	Curium 241	Curium 242
Curium 243	Curium 244	Einsteinium 253
Einsteinium 254	Gadolinium 148	Plutonium 236
Plutonium 238	Polonium 208	Polonium 209
Polonium 210	Radium 223	Thorium 227
Thorium 228	Uranium 230	Uranium 232

We kindly remind our foreign customers tostrictly comply with the regulatory requirements of the country in which they own and use the sources provided by LEA.

Quality and traceability

LEA's quality system meets requirement of French and international standards

LEA is :

• **ISO 9001 certified** (certificate 2019/83489.1);

• **COFRAC* accredited** (for calibration in the field of ionising radiation; NF EN ISO/IEC 17025: 2017, scope N°2-6386 available on www.cofrac.fr or upon request).

LEA is accredited by COFRAC, France's accreditation body signatory to ILAC MRA** in the field of calibration of ionizing radiations, in accordance with ISO 17025:2017. LEA's traceability to the International System of Units (SI) is performed through calibrations with LNHB (Laboratoire National Henri Becquerel), France's National Metrology Institute (equivalent to NIST in the US). LNHB is also accredited by COFRAC in the field of calibration of ionizing radiations. Both NIST and LNHB are signatories to CIPM-MRA***, meaning NIST and LNHB mutually recognize the validity of their calibrations and certificates. Therefore, through both COFRAC accreditation and calibrations traceable to LNHB, LEA certificates provide the same traceability to SI as NIST-traceable certificates.*

• Our radiation protection management system is certified according to the order of November 27.2013 relating to companies operating in establishments carrying out nuclear activities by the **Qualianor** organization (certificate No.296-R).

Therefore, every year several internal and external audits are carried out by independent organizations and contribute to ensure optimal quality.

afaq ISO 9001 Qualité AFNOR CERTIFICATION

ilac-MRA

cofrac ETALONNAGE

QUALIANOR Certification RP Entreprise RADIOPROTECTION

* Scope N°2-6386 available on www.cofrac.fr or upon request.

Calibration certificate

Each source calibrated under COFRAC* accreditation scope will be supplied with a COFRAC* calibration certificate, which mentions the calibration result and related uncertainty, the measurement method. The possible impurity content can be mentioned upon request.

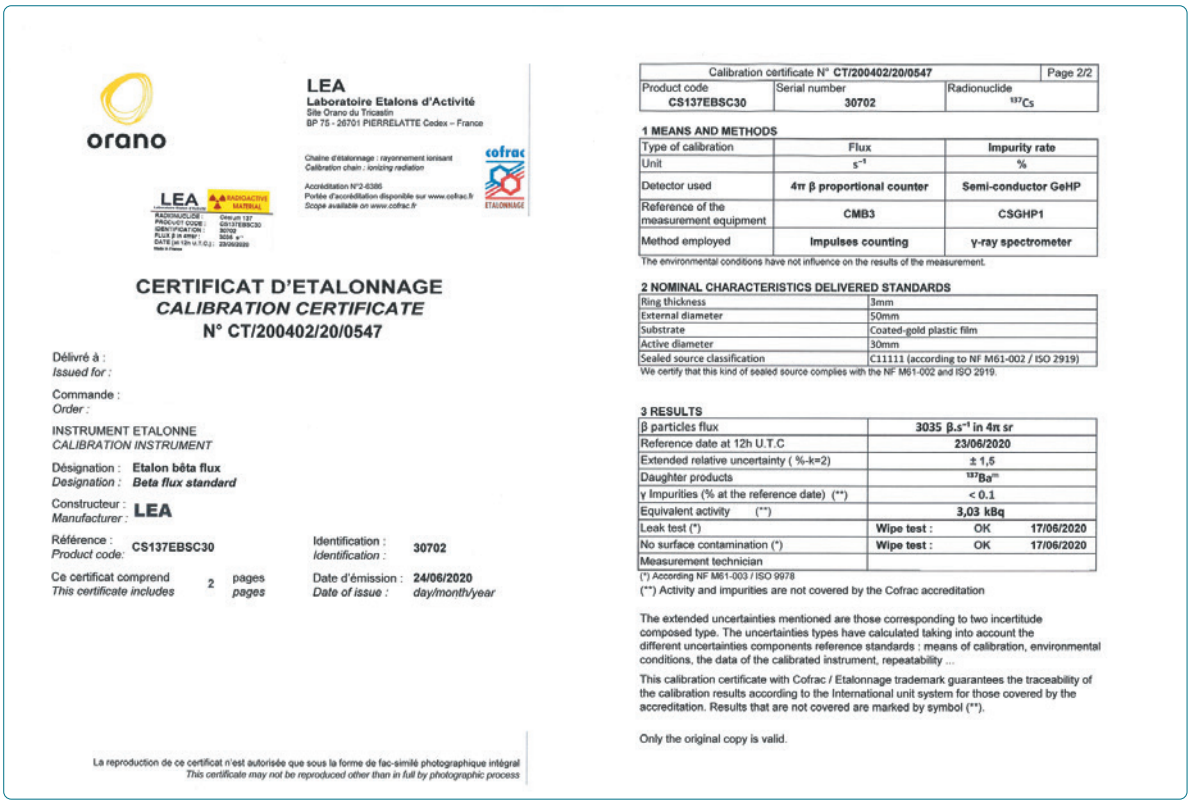
LEA can also supply sources without a COFRAC* calibration certificate:

• standard sources, which calibration is performed out of LEA's COFRAC* accreditation scope,

• check sources with a nominal activity level.

The certificate must be kept for the whole duration of the source's detention (the calibration certificate will be requested during the spent source recovery process).

Upon request and according to your applications, LEA can also provide a sealed source calibration certificate.



orano

LEA
Laboratoire Etalons d'Activité
Site Orano du Tricastin
BP 75 - 26701 PIERRELATTE Cedex – France

Chaîne d'étalonnage : rayonnement ionisant
Calibration chain : ionizing radiation

Accréditation N°2-6386
Portée d'accréditation disponible sur www.cofrac.fr
Scope available on www.cofrac.fr

cofrac ETALONNAGE

LEA RADIOACTIVE MATERIAL

RADIONUCLIDE : Cesium 137
PRODUCT CODE : CS137EBSC30
IDENTIFICATION : 30702
FLUX β en 4πsr : 3035 s⁻¹
DATE (at 12h U.T.C.) : 23/06/2020

CERTIFICAT D'ETALONNAGE
CALIBRATION CERTIFICATE
N° CT/200402/20/0547

Délivré à :
Issued for :

Commande :
Order :

INSTRUMENT ETALONNE
CALIBRATION INSTRUMENT

Désignation : **Etalon bêta flux**
*Designation : **Beta flux standard***

Constructeur : **LEA**
Manufacturer :

Référence : **CS137EBSC30**
Product code:

Identification : **30702**
Identification :

Ce certificat comprend **2** pages
This certificate includes **2** *pages*

Date d'émission : **24/06/2020**
Date of issue : day/month/year

La reproduction de ce certificat n'est autorisée que sous la forme de fac-similé photographique intégral
This certificate may not be reproduced other than in full by photographic process

Calibration certificate N° **CT/200402/20/0547** — Page 2/2

Product code	Serial number	Radionuclide
CS137EBSC30	**30702**	**^{137}Cs**

1 MEANS AND METHODS

Type of calibration	Flux	Impurity rate
Unit	s^{-1}	%
Detector used	**4π β proportional counter**	**Semi-conductor GeHP**
Reference of the measurement equipment	**CMB3**	**CSGHP1**
Method employed	**Impulses counting**	**γ-ray spectrometer**

The environmental conditions have not influence on the results of the measurement.

2 NOMINAL CHARACTERISTICS DELIVERED STANDARDS

Ring thickness	3mm
External diameter	50mm
Substrate	Coated-gold plastic film
Active diameter	30mm
Sealed source classification	C11111 (according to NF M61-002 / ISO 2919)

We certify that this kind of sealed source complies with the NF M61-002 and ISO 2919.

3 RESULTS

β particles flux	**3035 β.s^{-1} in 4π sr**		
Reference date at 12h U.T.C	**23/06/2020**		
Extended relative uncertainty (%-k=2)	**± 1,5**		
Daughter products	**^{137}Ba^{m}**		
γ Impurities (% at the reference date) (**)	**< 0.1**		
Equivalent activity (**)	**3,03 kBq**		
Leak test (*)	**Wipe test :**	OK	17/06/2020
No surface contamination (*)	**Wipe test :**	OK	17/06/2020
Measurement technician			

(*) According NF M61-003 / ISO 9978
(**) Activity and impurities are not covered by the Cofrac accreditation

The extended uncertainties mentioned are those corresponding to two incertitude composed type. The uncertainties types have calculated taking into account the different uncertainties components reference standards : means of calibration, environmental conditions, the data of the calibrated instrument, repeatability ...

This calibration certificate with Cofrac / Etalonnage trademark guarantees the traceability of the calibration results according to the International unit system for those covered by the accreditation. Results that are not covered are marked by symbol (**).

Only the original copy is valid.

COFRAC* calibration certificate example

* Scope N°2-6386 available on www.cofrac.fr or upon request.

Manufacturing tolerances

Product type	Deviation from the nominal activity
Nominal solutions	± 30 %
Standard sealed sources or standard solutions	± 30 %
Medical products: flood sources, pen point markers, dose calibrator sources	- 15 % + 30 %

Recommended working life

The quality of calibration standards can deteriorate due to physical & chemical phenomena (eg. degradation of liquid's homogeneity, loss of active deposits' adherence over time) and usage conditions (frictions, dust...).

From the point of view of the physical integrity of sealed sources (unless more restrictive in terms of references for certain sealed sources as indicated on the previous pages), the recommended life of sealed sources according to ISO 2918 is 10 years under normal conditions of use (instructions are provided with our sources).

From a metrological standpoint, our metrological values are valid in our calibration's conditions. We recommend using these values no longer than 2 radioactive periods, with a maximum of 2 years from the reference calibration date, due to cumulative uncertainties from radioactive periods as well as interactions between matter and ionizing radiations.

Technical information

Uncertainties

Uncertainty is the estimate of a possible variation between the level of activity measured by LEA and the actual activity.

The uncertainty indicated in the calibration certificate corresponds to the expanded uncertainty expressed with a k=2 enlargement factor. The value of the enlargement factor is related to the desired confidence level:

- 68% for k = 1
- 95% for k = 2
- 99% for k = 3

These percentages correspond to the application of the gaussian mathematical function.

Units

The unit of radioactivity adopted by the International System of Units (SI) is becquerel (Bq). This unit corresponds to the transformation of a nucleus with emission of ionizing radiation. This is called disintegration.

Bq = the number of decays of one nucleus per second.

The other unit, still in use, is the curie (Ci) which corresponds to the number of nuclei that disintegrate in one gram of radium 226 per second (old system).

1 Ci = 3.7 x 1010 Bq

Conversion table Becquerel/Curie

1 Bq	≈ 27 pCi	1 Ci	≈ 37 GBq
1 kBq	≈ 27 nCi	1 mCi	≈ 37 MBq
1 MBq	≈ 27 µCi	1 µCi	≈ 37 kBq
1 GBq	≈ 27 mCi	1 nCi	≈ 37 Bq
1 TBq	≈ 27 Ci	1 pCi	≈ 37 mBq

T = téra (10^{12})	m = milli (10^{-3})
G = giga (10^{9})	µ = micro (10^{-6})
M = méga (10^{6})	n = nano (10^{-9})
k = kilo (10^{3})	p = pico (10^{-12})

Calibration standard

A calibration standard is a source which activity is defined well enough in order to be used for equipment calibration. Measurement of calibration standards must meet traceability equipements to SI (see p.90).

Radioactive purity

The standards described in this catalog are produced from raw materials containing a minimum of radioactive impurities. Care is taken to minimize impurities throughout the production process. Impurities in the finished products are identified and analyzed using α or γ spectrometry.

Impurity contents are stated in the calibration certificate at the reference date.

Notes


SBM
240

Nuclear data

IAEA EXEMPTION THRESHOLDS**		FRANCE EXEMPTION THRESHOLDS***			
Solid source	**Solid source**	**Solid source**	**Solid source**		
Activité • Activity (kBq)	Concentration (kBq/g)	Activité • Activity (kBq)	Concentration (Bq/g)	E (MeV)	Ratio
1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g	-	-
10 kBq	0,001 kBq/g	10 kBq	0,0001 kBq/g	5.388 5.443 5.486	1.7% 13.2% 84.5%
1 000 kBq	0,1 kBq/g	1 000 kBq	-	-	-
10 000 kBq	10 kBq/g	10 000 kBq	0,001 kBq/g	-	-
10 000 kBq	10 kBq/g	10 000 kBq	0,1 kBq/g	-	-
1 000 kBq	10 kBq/g	1 000 kBq	0,001 kBq/g	-	-
1 000 kBq	0,1 kBq/g	1 000 kBq	0,001 kBq/g	-	-
1 000 kBq	10 kBq/g	1 000 kBq	0,001 kBq/g	-	-
10 kBq	0,01 kBq/g	10 kBq	0,001 kBq/g	5.763 5.805	23.3% 76.7%
1 000 kBq	0,01 kBq/g	1 000 kBq	0,001 kBq/g	-	-
100 kBq	0,01 kBq/g	100 kBq	0,0001 kBq/g	-	-
10 000 kBq	1 kBq/g	10 000 kBq	0,1 kBq/g	-	-
10 kBq	0,01 kBq/g	10 kBq	0,0001 kBq/g	-	-
10 kBq	0,01 kBq/g	10 kBq	0,0001 kBq/g	-	-
1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g	-	-
1 000 kBq	10 kBq/g	1 000 kBq	1 kBq/g	-	-
1 000 kBq	0,01 kBq/g	1 000 kBq	0,001 kBq/g	-	-
1 000 000 kBq	1 000 kBq/g	1 000 000 kBq	0,1 kBq/g	-	-
1 000 kBq	1 kBq/g	1 000 kBq	0,1 kBq/g	-	-
100 kBq	0,1 kBq/g	100 kBq	0,00001 kBq/g	-	-
1 000 kBq	0,1 kBq/g	1 000 kBq	0,01 kBq/g	-	-
1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g	-	-
1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g	-	-
100 000 kBq	100 kBq/g	100 000 kBq	0,1 kBq/g	-	-
1 kBq	0,001 kBq/g	1 kBq	0,001 kBq/g	4.766 4.771 4.788	9.5% 25.0% 47.0%
100 kBq	1 kBq/g	100 kBq	1 kBq/g	-	-
10 000 kBq	10 kBq/g	10 000 kBq	1 kBq/g	-	-
10 kBq	0,001 kBq/g	10 kBq	0,0001 kBq/g	5.456 5.499	28.8% 71.0%
10 kBq	0,001 kBq/g	10 kBq	0,0001 kBq/g	5.106 5.144 5.157	11.9% 17.1% 70.8%
100 000 kBq	100 kBq/g	100 000 kBq	0,1 kBq/g	-	-
10 000 kBq	1 kBq/g	10 000 kBq	0,001 kBq/g	-	-
1 000 kBq	0,1 kBq/g	1 000 kBq	0,001 kBq/g	-	-
1 000 kBq	1 kBq/g	1 000 kBq	1 kBq/g	-	-
10 kBq	0,01 kBq/g	10 kBq	0,001 kBq/g	-	-
10 kBq	10 kBq/g	10 kBq	0,001 kBq/g	-	-
10 000 kBq	10 kBq/g	10 000 kBq	0,001 kBq/g	-	-
10 kBq	0,001 kBq/g	10 kBq	0,001 kBq/g	4.729 4.783 4824	1.6% 13.2% 84.4%
1 000 kBq	0,01 kBq/g	1 000 kBq	-	-	-
1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g	-	-

MAIN EMISSIONS *							SPECIFIC ACTIVITY		PERIOD			RN
β			X		γ							
E Max (keV)	E moy (keV)	Ratio	E (keV)	Ratio	E (keV)	Ratio	Bq/g	Ci/g	Années	Jours	Secondes	
83.1 529.9	21.6 165.3	67.5% 30.8%	-	-	657.8 763.9 884.7 937.5 1384.3 1505.0	94.4% 22.3% 74.0% 34.5% 24.7% 13.2%	1,76E+14	4 751		249.78E+0	21.58E+6	**Ag110m**
-	-	-	13.8 17.1 21.2	13.0% 18.9% 4.8%	59,5	35,8%	1,27E+11	3,43	432,6	1,58E+05	1,37E+10	**Am241**
-	-	-	30.6 31.0 35.1 35.9	34.0% 62.8% 18.2% 4.6%	81.0 302.8 356.0 383.8	32.9% 18.3% 62.1% 8.9%	9,43E+12	255	10,5	3.85E+3	9.44E+12	**Ba133**
156,5	49,2	100%	-	-	-	-	1,66E+11	4,48	5 700	2,08E+06	1,80E+11	**C14**
256,4	77,2	100%	-	-	-	-	6,58E+14	17 795		1,63E+02	1,41E+07	**Ca45**
-	-	-	22.0 22.2 25.0 25.5	29.0% 54.7% 15.1% 2.6%	88	3,6%	9,59E+13	2 593		4,62E+02	3,99E+07	**Cd109**
-	-	-	33.0 33.4 37.9 38.8	22.8% 41.9% 12.5% 3.1%	165,9	79,9%	2,52E+14	6 822		1,38E+02	1,19E+07	**Ce139**
708,6	251,2	98,1%	-	-	-	-	1,22E+09	0,033	302 000	1,10E+08	9.53E+12	**Cl36**
-	-	-	17,1	8,7%	-	-	2,99E+12	80,9	18,1	6,61E+03	5,71E+08	**Cm244**
-	-	-	6.4 7.1	50.0% 7.1%	14.4 122.1 136.5	9.1% 85.5% 10.8%	3,12E+14	8 425		2,72E+02	23.48E+6	**Co57**
317,3	95,6	99,8%	-	-	1173.2 1332.5	100% 100%	4,18E+13	1 130	5,27	1.93E+3	1,66E+08	**Co60**
-	-	-	4.9 5.4	20.1% 2.7%	320	9,8%	3,42E+15	92 383		2,77E+01	2,39E+06	**Cr51**
88.8 415.4 658.1	23.5 123.5 210.0	27.2% 2.5% 70.2%	-	-	563.2 569.2 604.7 795.8 802.0	8.4% 15.4% 97.6% 85.5% 8.7%	4,78E+13	1 292	2,06	7.54E+02	6,51E+07	**Cs134**
514.0 1175.6	174.3 416.3	94.4% 5.6%	31.8 32.2	1.9% 3.6%	661,7	85%	3.22E+0	86,8	30,1	1,10E+04	9,48E+08	**Cs137**
175.4 384.8 695.6 1474.5	47.4 112.3 221.7 535.4	1.8% 2.4% 13.8% 8.2%	6.4 39.5 40.1 45.5 46.7	13.0% 20.8% 37.7% 11.8% 3.0%	121.8 244.7 344.3 778.9 867.4 964.1	28.4% 7.6% 26.6% 13.0% 4.2% 14.5%	6.44E+12	174	13,5	4.94E+3	4,27E+08	**Eu150**
-	-	-	5.9 6.5	25.0% 3.4%	-	-	8,75E+13	2 365	2.76	1,00E+03	124.54E+3	**Fe55**
273.6 465.9	81.0 149.5	45.2% 53.3%	-	-	1099.2 1291.6	56.6% 43.2%	1,84E+15	49 723		4,45E+01	3,84E+06	**Fe59**
18,6	5,7	100%	-	-	-	-	3,58E+14	9 676	12,3	4.5E+3	3,89E+08	**H3**
-	-	-	27.2 27.5 31.1 31.8	39.7% 74.0% 21.2% 4.6%	35,5	6,7%	6,50E+14	17 578		5,94E+01	5,13E+06	**I125**
-	-	-	27.2 27.5 31.1 31.8	39.7% 74.0% 21.2% 4.6%	35,5	6,7%	6,37E+06	0,00017	16 100 000	5,88E+09	5,08E+14	**I129**
247.9 333.8 606.3	69.4 96.6 191.6	2.1% 7.4% 89.4%	29.5 29.8	1.5% 2.8%	284.3 364.5 637	6.1% 81.2% 7.3%	4,59E+15	124 189		8,02E+00	6,93E+05	**I131**
-	-	-	5.4 6.0	22.7% 3.1%	834,8	100%	2,86E+14	7 719		3,13E+02	26.97E+6	**Mn54**
546,4	215,5	89.8%	-	-	511 1274.5	178% 100%	2,31E+14	6 241	2,60	9.50E+02	8,21E+07	**Na22**
67,0	17,4	100%	-	-	-	-	2,13E+12	57,5	98,7	3,60E+04	3,11E+09	**Ni63**
-	-	-	15,7	54,5%	29.4 86.5	15.3% 12.3%	2,61E+07	0,00070	2 140 000	7.83E+08	6,75E+13	**Np237**
1710,7	695,5	100%	-	-	-	-	1,06E+16	285 566		1,43E+01	1,23E+06	**P32**
224,7	62,0	100%	-	-	-	-	3,43E+13	927	2,62	9.58E+02	8,28E+07	**Pm147**
-	-	-	16,2	10,6%	-	-	6,33E+11	17,1	87,7	3,20E+04	2,77E+09	**Pu238**
-	-	-	16,2	4,7%	129.3 375.0 413.7 451.5	0.00631% 0.00154% 0.00146% 0.000187%	2,30E+09	0,062	24 100	8,80E+06	7,61E+11	**Pu239**
167,1	48,6	100%	-	-	-	-	1,58E+15	42 710		8,73E+01	7,54E+06	**S35**
-	-	-	24.0 24.2 27.3 27.9	27.7% 51.9% 14.6% 2.8%	255.1 391.7	2.1% 65.0%	4.60E+15	10 037		1,15E+02	9,94E+06	**Sn113**
-	-	-	13.3 13.4 15.0	17.2% 33.0% 8.0%	514	98,5%	8,76E+14	23 680		6,49E+01	5,60E+06	**Sr85**
1495,1	584,6	100%	-	-	-	-	1,07E+15	29 002		5,06E+01	4,37E+06	**Sr89**
545,9	195,7	100%	-	-	-	-	5,10E+12	138	28,8	1,05E+04	9,09E+08	**Sr90**
763,7	243,9	97,1%	-	-	-	-	1,71E+13	462,475	3,79	1,38E+03	1,20E+08	**Tl204**
293,7	85,4	100%	-	-	-	-	6.31E+08	0,017	214 000	7,81E+07	6,75E+12	**Tc99**
-	-	-	15,7	5,3%	-	-	3,57E+10	0,965	1 590	5,80E+05	5,02E+10	**U233**
-	-	-	14.1 14.2 15.9 16.1	17.3% 33.2% 8.2% 1.1%	898.0 1836.1	93.9% 99.3%	5,15E+14	13 911		1,07E+02	9,21E+06	**Y88**
329,9	143,1	1,4%	8.0 8.9	34.7% 4.8%	511.0 1115.5	2.8% 50.2%	3,04E+14	8 230		2,44E+02	2,11E+07	**Zn65**

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