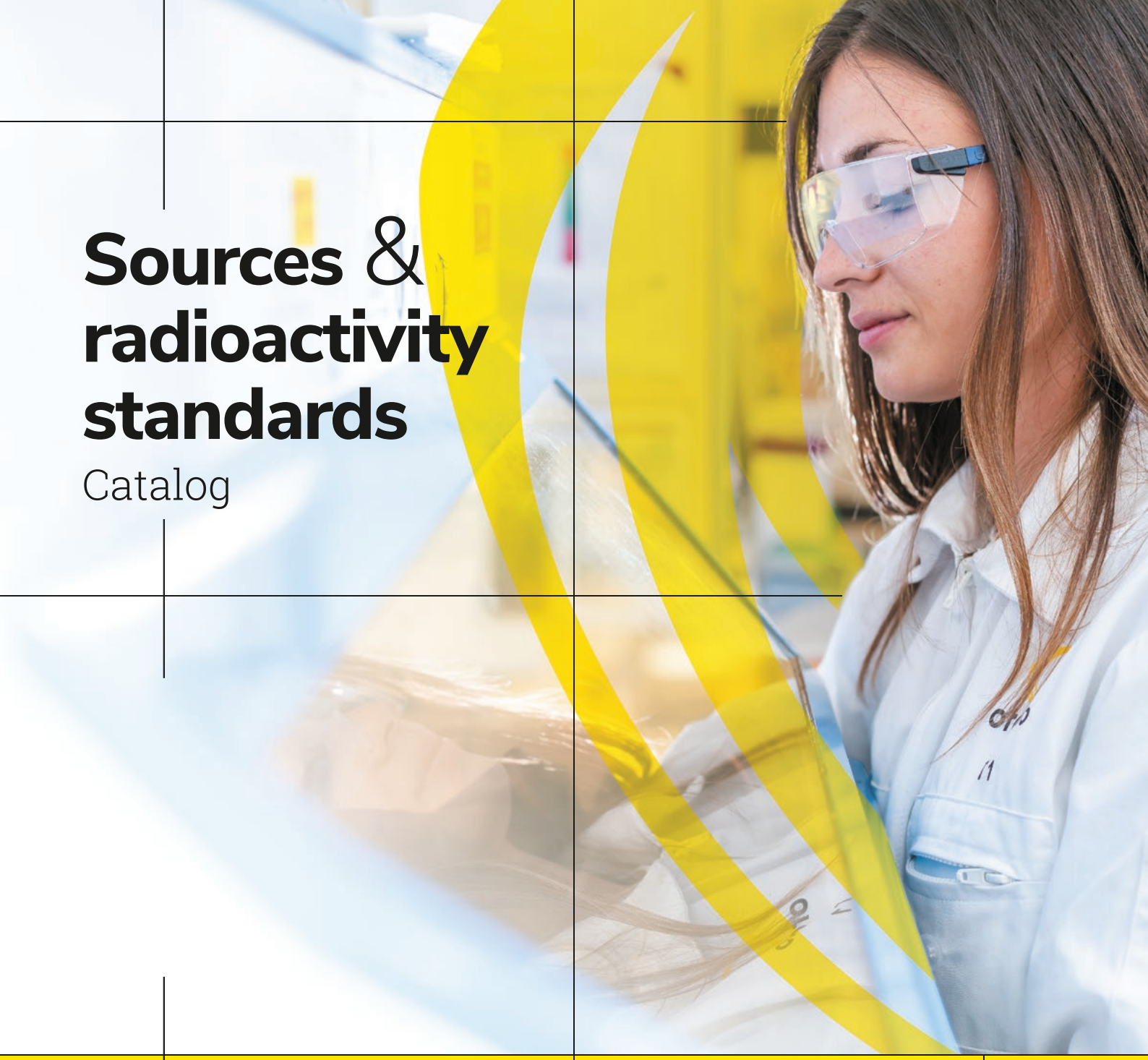
Sources & radioactivity standards

Catalog



SPE.COM.20.057.US
REV00

Laboratoire d'Etalons d'Activité

orano
Donnons toute sa valeur au nucléaire

Our values

Customer satisfaction

Continuous improvement

Respect and people development

Cohesion and team spirit

Exemplarity, integrity and responsibility

Orano at a glance

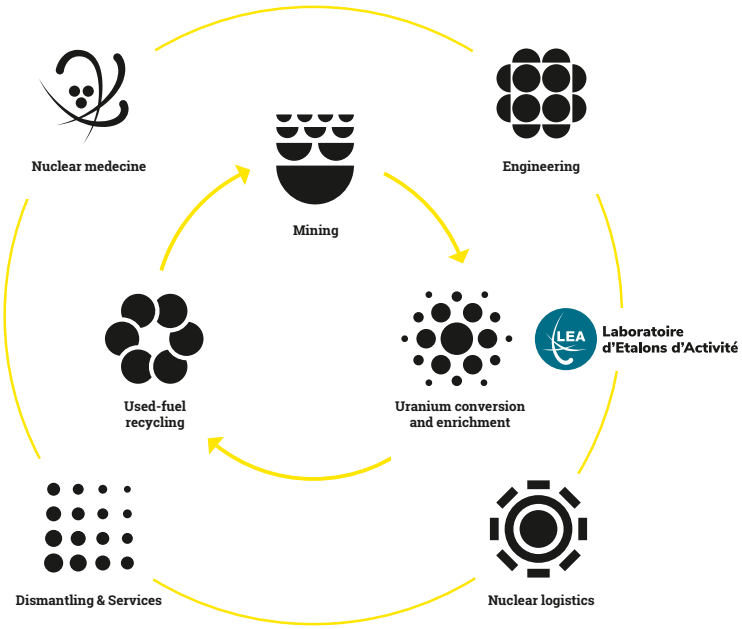
Orano transforms nuclear materials so that they can be used to support the development of society, first and foremost in the field of energy.

The group offers products and services with high added value across the whole nuclear fuel cycle, from raw materials to waste treatment. With a broad business scope from mining through to decommissioning, encompassing conversion and enrichment, recycling, logistics and engineering, the group's activity all contribute to the production of low carbon electricity.

Orano and its 16,000 employees bring to bear their expertise and their permanent search for innovation, their mastery of cutting-edge technology and their unwavering dedication to safety, to optimally serve their customers in France and abroad.

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.




orano
T4


orano
T2
orano
T1

LEA at a glance

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

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

Sources

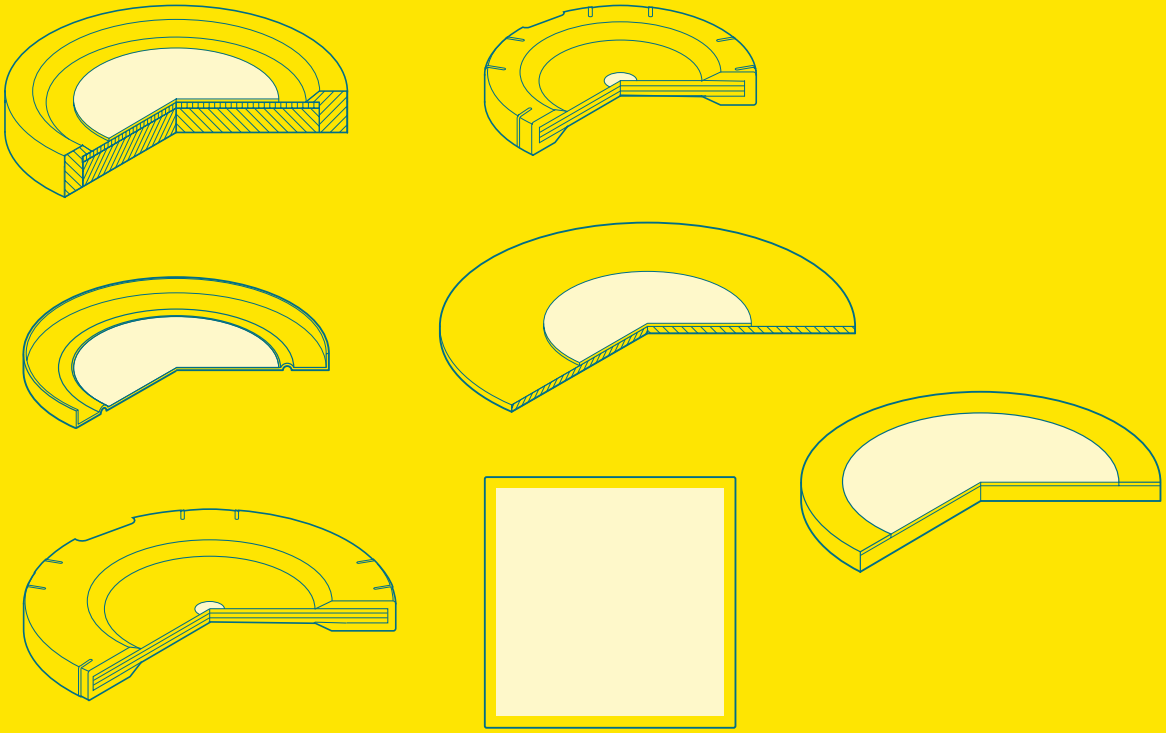
Sources

Sources

Accessories & services

Appendices

α and β solid sources



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)

1 LB SERIES © MIRION Technologies
2 WPC-1050 © ORTEC
3 HANDFOOT-FIBRE™ XLMED © MIRION Technologies
4 ARGOS © MIRION Technologies
5 BAB © BERTIN Technologies
6 Contaminamètre/ polyradiameters © BERTIN Technologies
7 Contrôle de non contamination © LEA
8 SpiR-Id © MIRION Technologies
9 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.

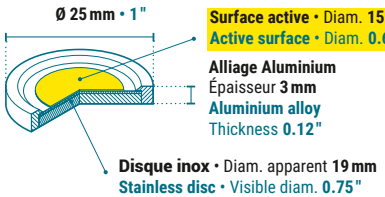
Radiological characteristics of the sources are measured with a calibrated grid cell detector.

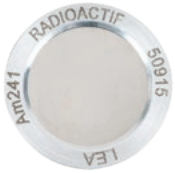
Production range

Catalog references	On request
Active diameter	
15 mm • 0.6 in	From 5 to 75 mm From 0.2 to 2.9 in
External diameter	
25 mm • 1 in	From 25 to 90 mm From 1 to 3.5 in
30 mm • 1.2 in	
38 mm • 1.5 in	
Activity	
300 Bq • 0.008 µCi	From 10 to 8000 Bq From 0.0003 to 0.2 µCi
800 Bq • 0.02 µCi	
3 000 Bq • 0.08 µCi	
Radionuclide	
^{233}U, ^{238}Pu, ^{239}Pu, ^{241}Am, ^{244}Cm	^{235}U, ^{238}U

Standard geometries

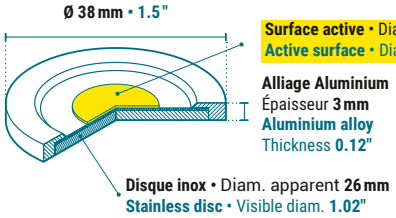
Type A





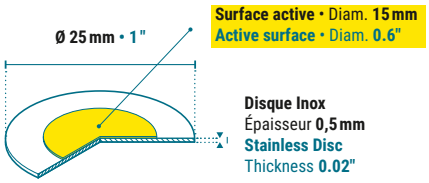
The distance between the active part and the height of the ring is 0.03 in

Type B

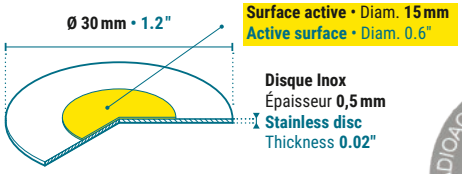


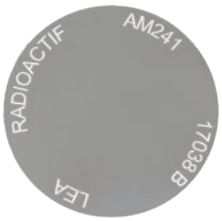
The distance between the active part and the height of the ring is 0.03 in

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%	800 Bq • 0.022 µCi	9ML04 EAS [Type] 25
^{241}Am	150	$\alpha.s^{-1}$	≤ 1.5%	300 Bq • 0.008 µCi	AM241 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	AM241 EAS [Type] 30
^{244}Cm	150	$\alpha.s^{-1}$	≤ 1.5%	300 Bq • 0.008 µCi	CM244 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	CM244 EAS [Type] 30
^{238}Pu	150	$\alpha.s^{-1}$	≤ 1.5%	300 Bq • 0.008 µCi	PU238 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	PU238 EAS [Type] 30
^{239}Pu (1)	150	$\alpha.s^{-1}$	≤ 1.5%	300 Bq • 0.008 µCi	PU239 EAS [Type] 20
	1 500	$\alpha.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	PU239 EAS [Type] 30
^{233}U (1)	150	$\alpha.s^{-1}$	≤ 1.5%	300 Bq • 0.008 µCi	U233 EAS [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 ***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.

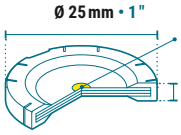
Radiological characteristics of the sources are measured with a calibrated gas flow proportional counter.

Production range

Catalog references	On request
Active diameter	
3 mm • 0.12 in	From 3 to 30 mm From 0.12 to 1.2 in
30 mm • 1.2 in	
External diameter	
25 mm • 1 in	From 25 to 60 mm From 1 to 2.4 in
38 mm • 1.5 in	
50 mm • 2 in	
Activity	
80 Bq • 0.002 µCi	From 50 to 30 000 Bq From 0.001 to 8.1 µCi
3 000 Bq • 0.08 µCi	
Radionuclide	
^{22}Na, ^{36}Cl, ^{60}Co, ^{90}Sr/^{90}Y, ^{137}Cs/^{137m}Ba, ^{147}Pm, ^{204}Tl, ^{89}Sr, ^{134}Cs.	^{32}P, ^{35}S, ^{45}Ca, ^{63}Ni, ^{99}Tc, ^{129}I.

Standard geometries

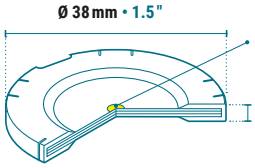
Type A



Surface active • Diam. **3 mm**
Active surface • Diam. **0.12"**

Anneau métallique
Épaisseur **3 mm**
Metal ring
Thickness **0.12"**

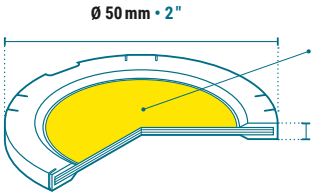
Type B



Surface active • Diam. **3 mm**
Active surface • Diam. 0.12 "

Anneau métallique
Épaisseur : **3 mm**
Metal ring
Thickness **0.12"**

Type C



Surface active • Diam. **30 mm**
Active surface • Diam. **1.2"**

Anneau métallique • Épaisseur **3 mm**
Metal ring • Thickness **0.12"**

Radionuclide	4π sr beta flux		k=2 measurement uncertainty	Equivalent activity	Reference
	Under COFRAC* accreditation				
^{36}Cl	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	CL36 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	CL36 EBS [Type] 30
^{60}Co	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	CO60 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	CO60 EBS [Type] 30
^{134}Cs	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	CS134 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	CS134 EBS [Type] 30
^{137}Cs	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	CS137 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	CS137 EBS [Type] 30
^{22}Na	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	NA22 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	NA22 EBS [Type] 30
^{147}Pm	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	PM147 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	PM147 EBS [Type] 30
^{89}Sr	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	SR89 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	SR89 EBS [Type] 30
^{90}Sr + ^{90}Y	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	SR90 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	SR90 EBS [Type] 30
^{204}Tl	80	$\beta.s^{-1}$	≤ 1.5%	80 Bq • 0.002 µCi	TL204 EBS [Type] 20
	3 000	$\beta.s^{-1}$	≤ 1.5%	3 000 Bq • 0.08 µCi	TL204 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 ^{147}Pm, ^{134}Cs, ^{137}Cs, ^{90}Sr+^{90}Y, ^{204}Tl and ^{22}Na 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.

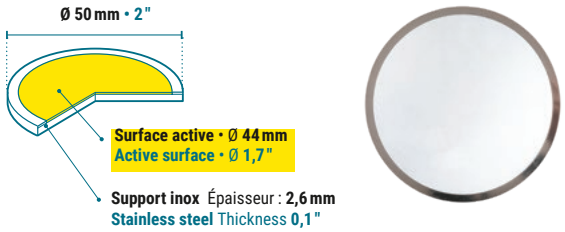
Production range

	Catalog references	On request
Active diameter		
α & β	15 mm • 0.6 in	From 15 to 160 mm From 0.6 to 6.3 in
	36 mm • 1.4 in	
	44 mm • 1.7 in	
	110 mm • 4.3 in	
External diameter		
α & β	30 mm • 1 in	From 20 to 170 mm From 0.8 to 6.7 in
	47 mm • 1.9 in	
	50 mm • 2 in	
	120 mm • 4.7 in	
Activity		
α	400 Bq • 0.01 µCi	From 100 to 2 000 Bq From 0.003 to 0.05 µCi
β	4 000 Bq • 0.11 µCi	From 500 to 8 000 Bq From 0.014 to 0.22 µCi
Radionuclide		
α	^{238}Pu, ^{239}Pu, ^{241}Am	^{233}U, ^{235}U, ^{238}U
β	^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{147}Pm	^{32}P, ^{35}S, ^{45}Ca, ^{63}Ni, ^{89}Sr, ^{99}Tc, ^{129}I

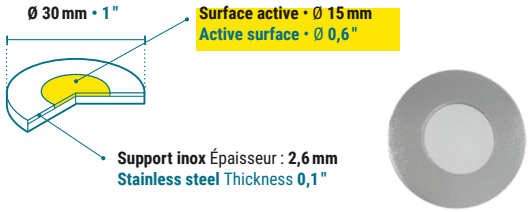
Standard geometries

Type K

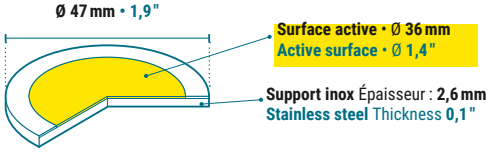
Type L



Type M



Type N



	Radionuclide	2π sr alpha flux 2π sr beta flux		k=2 measurement uncertainty	Equivalent activity	Reference
		Under COFRAC* accreditation				
α	^{241}Am	200	α.s^{-1}	≤ 6%	400 Bq • 0.01 µCi	AM241 ESA [Type] 20
	^{238}Pu	200	α.s^{-1}	≤ 6%	400 Bq • 0.01 µCi	PU238 ESA [Type] 20
	^{239}Pu (1)	200	α.s^{-1}	≤ 6%	400 Bq • 0.01 µCi	PU239 ESA [Type] 20
β	^{14}C	1 500	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	C14 ESA [Type] 20
	^{60}Co	1 900	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	CO60 ESA [Type] 20
	^{137}Cs	2 400	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	CS137 ESA [Type] 20
	^{147}Pm	1 900	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	PM147 ESA [Type] 20
	^{90}Sr + ^{90}Y	2 500	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	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 ***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.

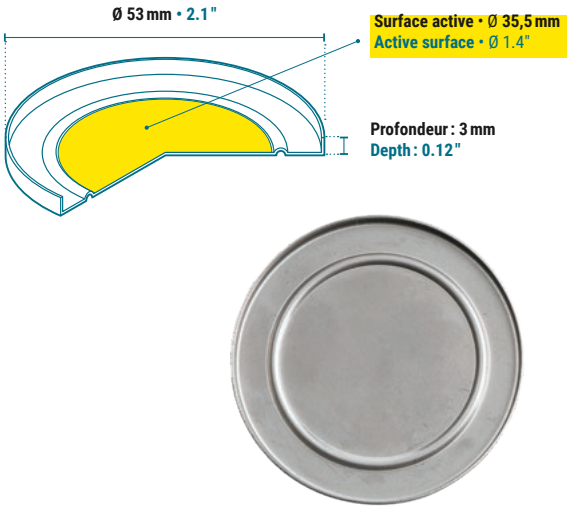
It should be noted that the size of a calibration source should be adapted to suit the size of the detector to be controlled or calibrated : **it is recommended not to use wide area sources to control detectors of a significantly different size from the detector itself.** LEA does not provide any guarantee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

Production range

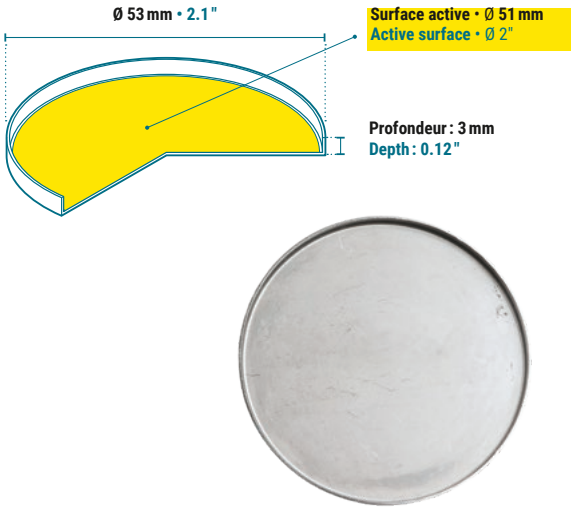
	Catalog references	On request
Active diameter		
α & β	35,5 mm • 1.4 in	From 15 to 160 mm From 0.6 to 6.3 in
	51 mm • 2 in	
External diameter		
α & β	53 mm • 2.1 in	From 20 to 170 mm From 0.8 to 6.7 in
Activity		
α	400 Bq • 0.01 µCi	From 100 to 2 000 Bq From 0.003 to 0.05 µCi
β	4 000 Bq • 0.11 µCi	From 500 to 8 000 Bq From 0.014 to 0.22 µCi
Radionuclide		
α	^{238}Pu, ^{239}Pu, ^{241}Am	^{233}U, ^{235}U, ^{238}U
β	^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{147}Pm	^{32}P, ^{35}S, ^{45}Ca, ^{63}Ni, ^{89}Sr, ^{99}Tc, ^{129}I

Standard geometries

Type I



Type J



	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%	400 Bq • 0.01 µCi	AM241 ESA [Type] 20
	^{238}Pu	200	α.s^{-1}	≤ 6%	400 Bq • 0.01 µCi	PU238 ESA [Type] 20
	^{239}Pu (1)	200	α.s^{-1}	≤ 6%	400 Bq • 0.01 µCi	PU239 ESA [Type] 20
β	^{14}C	1 500	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	C14 ESA [Type] 20
	^{60}Co	1 900	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	CO60 ESA [Type] 20
	^{137}Cs	2 400	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	CS137 ESA [Type] 20
	^{147}Pm	1 900	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	PM147 ESA [Type] 20
	^{90}Sr + ^{90}Y	2 500	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	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.

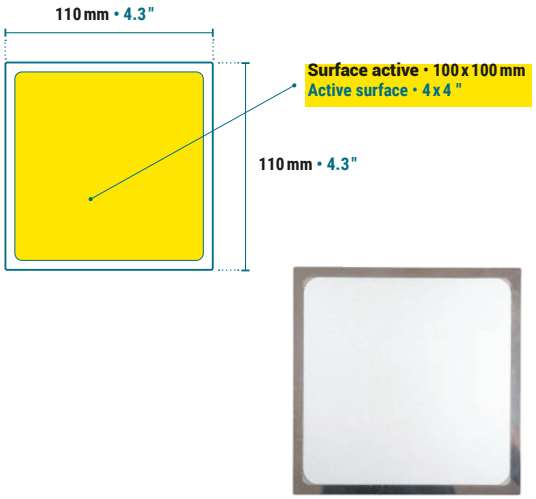
It should be noted that the size of a calibration source should be adapted to suit the size of the detector to be controlled or calibrated : **it is recommended not to use wide area sources to control detectors of a significantly different size from the detector itself.** LEA does not provide any guarantee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

Production range

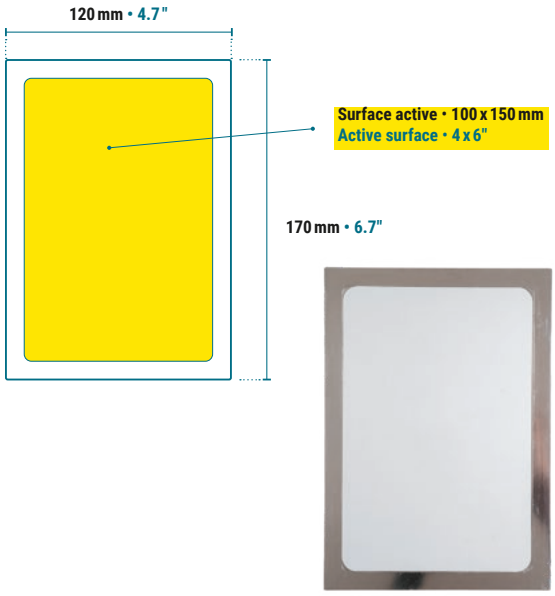
	Catalog references	On request
Active dimensions		
α & β	100 x 100 mm • 4 x 4 in	From 20 x 20 mm to 150 x 150 mm From 0.8 x 0.8 in to 6 x 6 in
	100 x 150 mm • 4 x 6 in	
External dimensions		
α & β	110 x 110 mm • 4.3 x 4.3 in	From 26 x 26 mm to 170 x 170 mm From 1 x 1 in to 6.7 x 6.7 in
	120 x 170 mm • 4.7 x 6.7 in	
Activity		
α	400 Bq • 0.01 µCi	From 100 to 2 000 Bq From 0.003 to 0.05 µCi
β	4 000 Bq • 0.11 µCi	From 500 to 8 000 Bq From 0.014 to 0.22 µCi
Radionuclide		
α	^{238}Pu, ^{239}Pu, ^{241}Am	^{233}U, ^{235}U, ^{238}U
β	^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{147}Pm	^{32}P, ^{35}S, ^{45}Ca, ^{63}Ni, ^{89}Sr, ^{99}Tc, ^{129}I

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%	400 Bq • 0.01 µCi	AM241 ESA [Type] 20
	^{238}Pu	200	α.s^{-1}	≤ 6%	400 Bq • 0.01 µCi	PU238 ESA [Type] 20
	^{239}Pu (1)	200	α.s^{-1}	≤ 6%	400 Bq • 0.01 µCi	PU239 ESA [Type] 20
β	^{14}C	1 500	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	C14 ESA [Type] 20
	^{60}Co	1 900	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	CO60 ESA [Type] 20
	^{137}Cs	2 400	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	CS137 ESA [Type] 20
	^{147}Pm	1 900	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	PM147 ESA [Type] 20
	^{90}Sr + ^{90}Y	2 500	β.s^{-1}	≤ 6%	4 000 Bq • 0.11 µCi	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

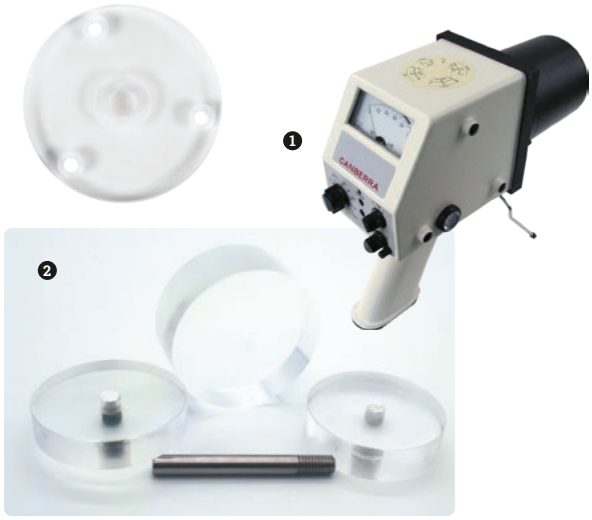
LEA can, on request, adapt the activity and the geometry of catalog sources to a specific need. **Here are six examples.**

#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 ^{90}Sr, 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.



1 Babyline 81 © MIRION Technologies
2 © LEA

#02

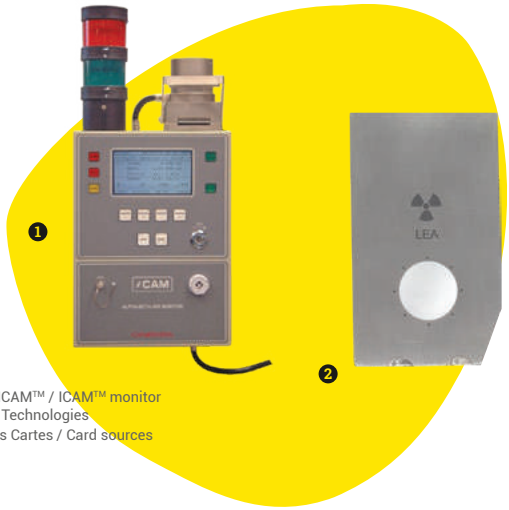
Verification of MIRION ICAM™ type fixed aerosol monitors

Atmospheric contamination monitors are used in nuclear installations when there is a risk of internal contamination.

Their periodic verification is typically done using "card sources": sources fixed to a support specially adapted to the measurement geometry of the monitor, similar to a bank card.

Non-exhaustive list of radionuclides and range of available activity:

- ^{239}Pu, ^{241}Am : from 0.003 µCi (100 Bq) to 0.03 µCi (1 kBq)
- ^{14}C, ^{60}Co, $^{90}Sr/Y$, ^{137}Cs, ^{147}Pm : from 0.01 µCi (500 Bq) to 0.1 µCi (1 kBq).

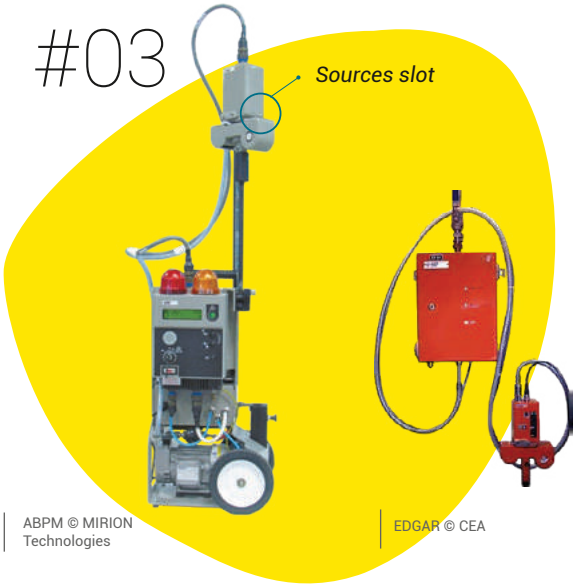


1 Balise ICAM™ / ICAM™ monitor © MIRION Technologies
2 Sources Cartes / Card sources © LEA

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 ^{137}Cs or ^{239}Pu sources of low activity (a few µCi) deposited on a support specially adapted to the measurement geometry of the monitor.



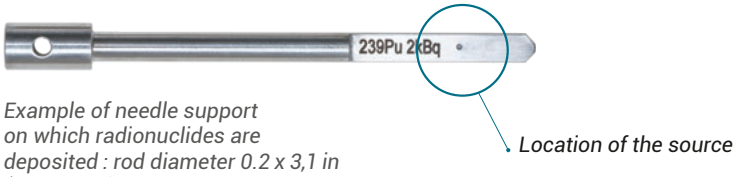
ABPM © MIRION Technologies

EDGAR © CEA

Example #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.

Example #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 the 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 racket-type source holder, embedding one or more sources suited to the radiological work environment.

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

Rackets are also available for all radionuclides and activities of ESA type sources (see page 16).

Rackets can also be delivered with a summary document specifying the operating ranges associated with the radiation protection devices used in the installation.

#06

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.

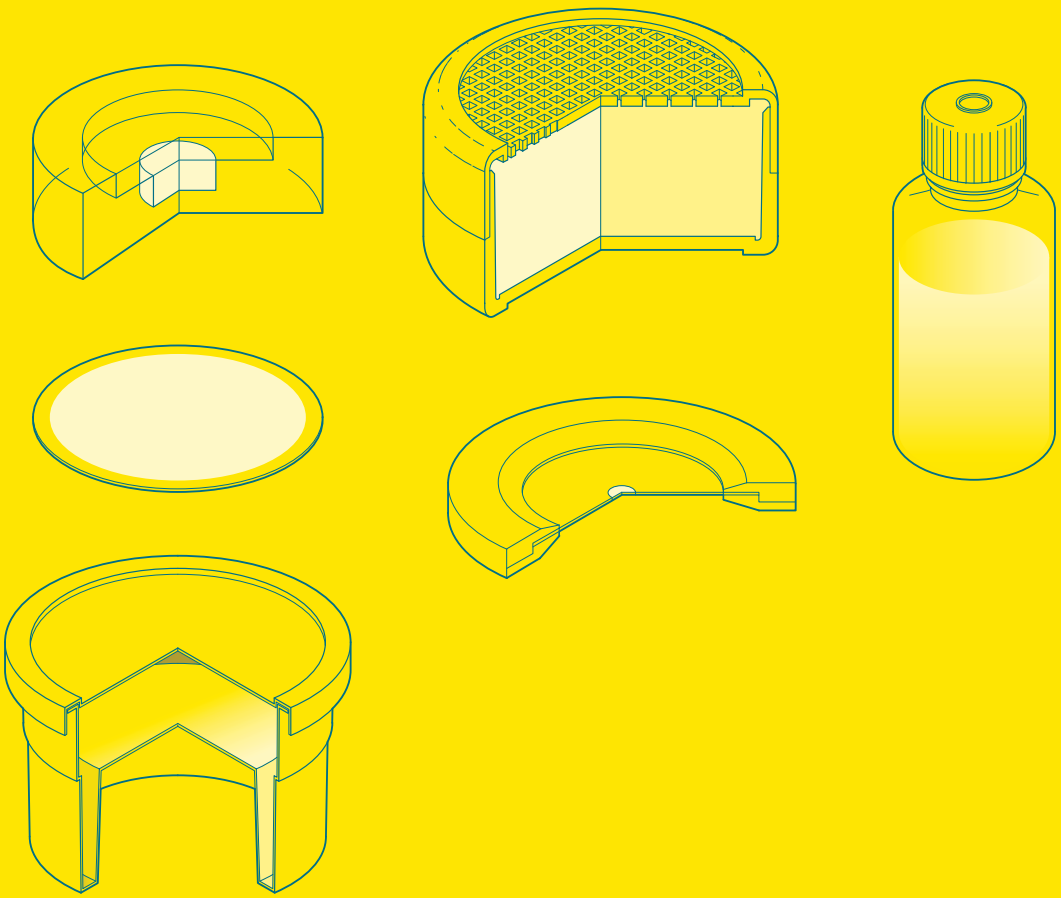
The radioactive source is chosen to generate a signal outside the region of interest.

For the NaI detectors, typically used sources are point sources of ^{241}Am or ^{137}Cs, with a nominal activity of 0.002 µCi (70 Bq) or 0.02 µCi (700 Bq), mounted inside the scintillator. The system adjusts the electronic gain to maintain the peak position (generated by the 3 alpha rays of the ^{241}Am between 5.4 and 5.5 MeV or the ^{137}Cs gamma ray of 662 keV).

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

SpiR-Id © MIRION Technologies

X and γ solid sources



Key applications

X and γ solid 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 $1/d^2$ 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

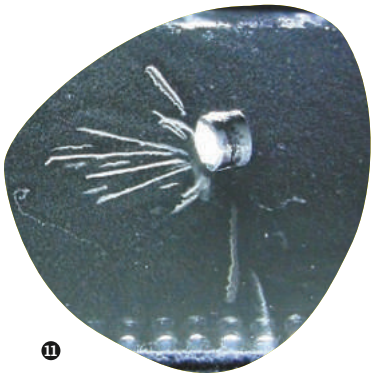
Waste characterization

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

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

Training and education

CRAB (Beta and gamma radiation counter)



Radioactive source in a cloud chamber

Detection equipment

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

Object controller

Environmental monitoring beacon

Saphygate zone exit gantry

1 & 2 Mobius et ICS/ISC-E © ORTEC
3 & 4 © Baltic Scientific Instruments (BSI)
5 © FLIR systems
6 & 7 © MIRION Technologies
8 & 9 © BERTIN Technologies
10 © CEA/JEULIN
11 © Cloudylabs

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.

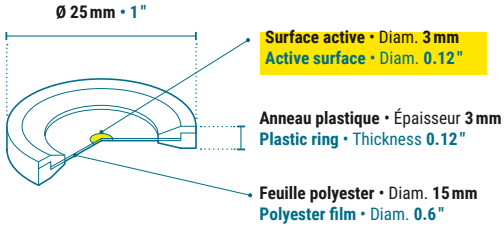
The radiological characteristics of the sources are measured with calibrated NaI scintillators or HPGe semi-conductors.

Production range

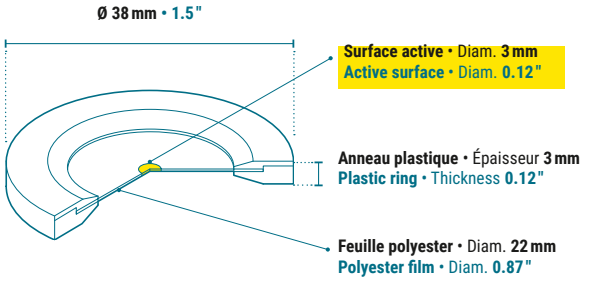
Catalog references	On request
Active diameter	
3 mm • 0.12 in	From 3 to 50 mm From 0.12 to 2 in
External diameter	
25 mm • 1 in	From 25 to 75 mm From 1 to 3 in
38 mm • 1.5 in	
Activity	
4 kBq • 0.1 µCi	From 2 to 1 000 kBq From 0.05 to 27 µCi
40 kBq • 1.1 µCi	
400 kBq • 11 µCi	
700 kBq • 19 µCi	
Radionuclide	
^{22}Na, ^{57}Co, ^{60}Co, ^{88}Y, ^{133}Ba, ^{137}Cs, ^{152}Eu, ^{241}Am, Mix 12ML01	^{110m}Ag, ^{139}Ce, ^{51}Cr, ^{134}Cs, ^{59}Fe, ^{131}I, ^{54}Mn, ^{239}Pu, ^{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	4 000 Bq • 0.11 µCi	≤ 3.5%	AM241 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 3.5%	AM241 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 3.5%	AM241 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 3.5%	AM241 EGS [Type] 25
^{133}Ba	4 000 Bq • 0.11 µCi	≤ 2%	BA133 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 2%	BA133 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 2%	BA133 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 2%	BA133 EGS [Type] 25
^{57}Co	4 000 Bq • 0.11 µCi	≤ 2%	CO57 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 1.7%	CO57 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 1.7%	CO57 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 2.5%	CO57 EGS [Type] 25
^{60}Co	4 000 Bq • 0.11 µCi	≤ 2%	CO60 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 1.5%	CO60 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 1.5%	CO60 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 1.5%	CO60 EGS [Type] 25
^{137}Cs	4 000 Bq • 0.11 µCi	≤ 2.5%	CS137 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 2%	CS137 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 2%	CS137 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 2%	CS137 EGS [Type] 25
^{152}Eu	4 000 Bq • 0.11 µCi	≤ 3%	EU152 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 3%	EU152 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 3%	EU152 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 3%	EU152 EGS [Type] 25
^{22}Na	4 000 Bq • 0.11 µCi	≤ 2%	NA22 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 2%	NA22 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 2%	NA22 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 2%	NA22 EGS [Type] 25
^{88}Y	4 000 Bq • 0.11 µCi	≤ 2%	Y88 EGS [Type] 10
	40 000 Bq • 1.1 µCi	≤ 2%	Y88 EGS [Type] 15
	400 000 Bq • 11 µCi	≤ 2%	Y88 EGS [Type] 20
	700 000 Bq • 19 µCi	≤ 2%	Y88 EGS [Type] 25
12ML01**	30 000 Bq • 0.8 µCi	[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 – ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{51}Cr, ^{137}Cs, ^{113}Sn, ^{54}Mn, ^{65}Zn, ^{85}Sr, ^{88}Y – 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.

Kits

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

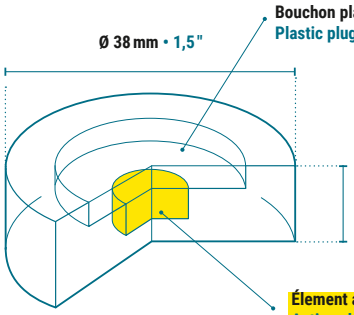
The radiological characteristics of the sources are measured with calibrated NaI scintillators, HPGe semi-conductors or ionization chambers.

Production range

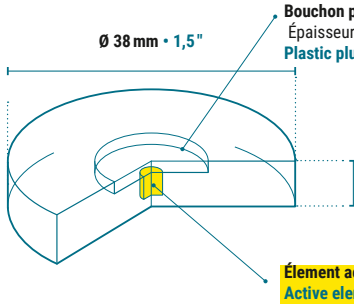
Catalog references	On request
Active diameter	
3 mm • 0.12 in	From 3 to 50 mm From 0.12 to 2 in
10 mm • 0.4 in	
External diameter	
38 mm • 1.5 in	From 25 to 75 mm From 1 to 3 in
Activity	
4 kBq • 0.1 µCi	From 2 to 40 000 kBq From 0.05 to 1081 µCi
40 kBq • 1.1 µCi	
400 kBq • 11 µCi	
1 500 kBq • 41 µCi	
3 500 kBq • 95 µCi	
Radionuclide	
^{60}Co, ^{133}Ba, ^{137}Cs, ^{152}Eu, ^{241}Am	^{110m}Ag, ^{139}Ce, ^{51}Cr, ^{134}Cs, ^{59}Fe, ^{131}I, ^{54}Mn, ^{239}Pu, ^{113}Sn (Non-exhaustive list)

Standard geometries

Type B



Type V



Radionuclide	Activity	k=2 measurement uncertainty	Reference
^{241}Am	4 kBq • 0.11 µCi	≤ 5%*	AM241 EGS [Type] 10
	40 kBq • 1.1 µCi	≤ 5%*	AM241 EGS [Type] 15
	400 kBq • 11 µCi	≤ 5%*	AM241 EGS [Type] 20
	1 500 kBq • 41 µCi	≤ 5%*	AM241 EGS [Type] 30
	3 500 kBq • 95 µCi	≤ 5%*	AM241 EGS [Type] 40
^{133}Ba	4 kBq • 0.11 µCi	≤ 5%*	BA133 EGS [Type] 10
	40 kBq • 1.1 µCi	≤ 5%*	BA133 EGS [Type] 15
	400 kBq • 11 µCi	≤ 5%*	BA133 EGS [Type] 20
	1 500 kBq • 41 µCi	≤ 5%*	BA133 EGS [Type] 30
	3 500 kBq • 95 µCi	≤ 5%*	BA133 EGS [Type] 40
^{60}Co	4 kBq • 0.11 µCi	≤ 5%*	CO60 EGS [Type] 10
	40 kBq • 1.1 µCi	≤ 5%*	CO60 EGS [Type] 15
	400 kBq • 11 µCi	≤ 5%*	CO60 EGS [Type] 20
	1 500 kBq • 41 µCi	≤ 5%*	CO60 EGS [Type] 30
	3 500 kBq • 95 µCi	≤ 5%*	CO60 EGS [Type] 40
^{137}Cs	4 kBq • 0.11 µCi	≤ 5%*	CS137 EGS [Type] 10
	40 kBq • 1.1 µCi	≤ 5%*	CS137 EGS [Type] 15
	400 kBq • 11 µCi	≤ 5%*	CS137 EGS [Type] 20
	1 500 kBq • 41 µCi	≤ 5%*	CS137 EGS [Type] 30
	3 500 kBq • 95 µCi	≤ 5%*	CS137 EGS [Type] 40
^{152}Eu	4 kBq • 0.11 µCi	≤ 5%*	EU152 EGS [Type] 10
	40 kBq • 1.1 µCi	≤ 5%*	EU152 EGS [Type] 15
	400 kBq • 11 µCi	≤ 5%*	EU152 EGS [Type] 20
	1 500 kBq • 41 µCi	≤ 5%*	EU152 EGS [Type] 30
	3 500 kBq • 95 µCi	≤ 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.***

EXS point X sources

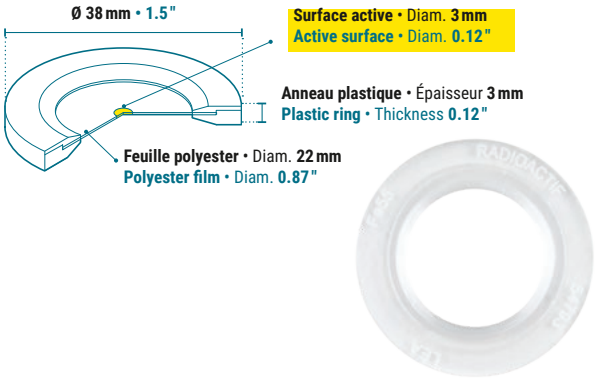
Technical Information

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 • 0.12 in	From 3 to 50 mm From 0.12 to 2 in
External diameter	
38 mm • 1.5 in	From 25 to 75 mm From 1 to 3 in
4π sr flux	
16 000 X.s^{-1}	From 1 000 X.s-1 to 400 000 X.s-1
Radionuclide	
^{55}Fe, ^{109}Cd	^{65}Zn, ^{85}Sr

Radionuclide	4π sr X flux		k=2 measurement uncertainty	Equivalent activity	Reference
	Under COFRAC* accreditation				
^{109}Cd	16 000	X.s^{-1}	≤ 5%	15 700 Bq • 0.42 µCi	CD109 EXS B 10
^{55}Fe	16 000	X.s^{-1}	≤ 5%	56 300 Bq • 1.5 µCi	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.

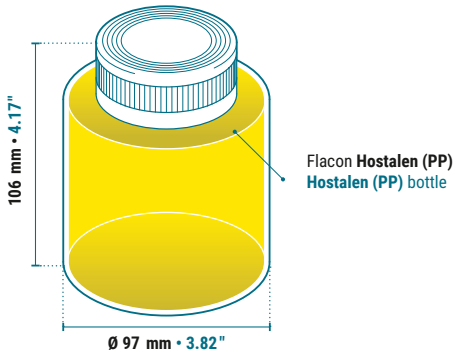
Production range

Catalog references	On request
Activity	
1 kBq • 0.03 µCi	From 1 to 1 000 kBq From 0.03 to 27 µCi
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)

Standard geometry

SG500N Type V

Volume utile **500 cm³** | Useful volume **30 in³**
Masse de résine **575 g** | Resin mass **20.3 oz**



Radionuclide	Activity	k=2 measurement uncertainty	Reference
12ML01*	1 kBq • 0,03 µCi	[8% ; 8,5%]	12ML01 EGE V 1KBQ

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

* The 12ML01 mixture – ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{51}Cr, ^{137}Cs, ^{113}Sn, ^{54}Mn, ^{65}Zn, ^{85}Sr, ^{88}Y – 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.

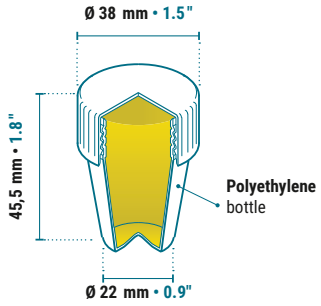
Production range

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 • 0.14 µCi 18 kBq • 0.5 µCi 37 kBq • 1 µCi 55 kBq • 1.5 µCi 74 kBq • 2 µCi	From 100 Bq to 1 MBq From 0.003 to 27 µCi
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, ^{137}Cs, ^{139}Ce, ^{241}Am (Non-exhaustive list)

Standard geometries

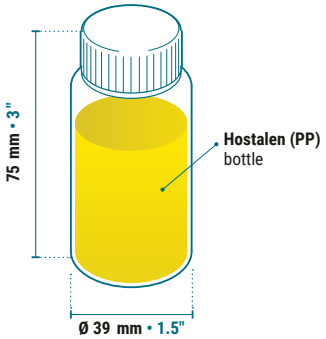
Type R *SG15*

Volume utile **15 cm³** | Useful volume **0.92 in³**



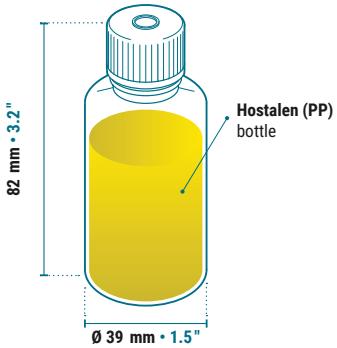
Type E *SG50*

Volume utile **50 cm³** | Useful volume **3.1 in³**



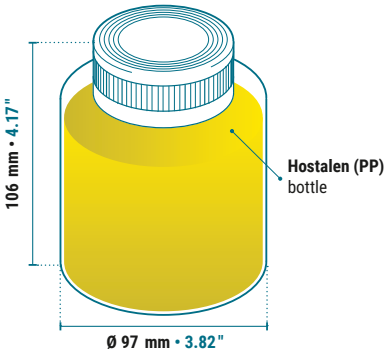
Type F

Volume utile **50 cm³** | Useful volume **3.1 in³**



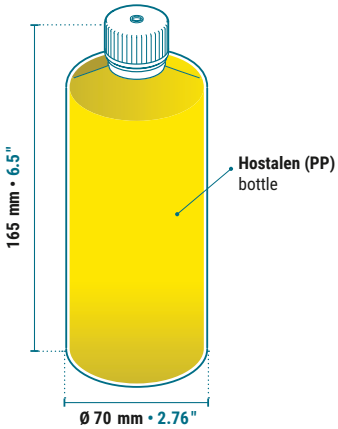
Type H *SG500*

Volume utile **500 cm³** | Useful volume **30 in³**



Type G

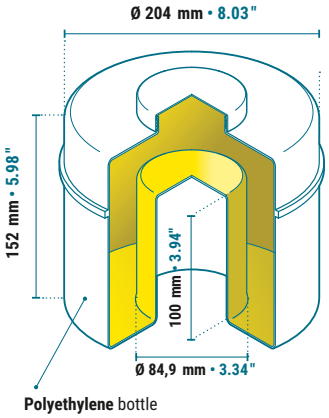
Volume utile **500 cm³** | Useful volume **30 in³**



Type L *SG3000*

Volume utile **3 000 cm³** | Useful volume **183 in³**

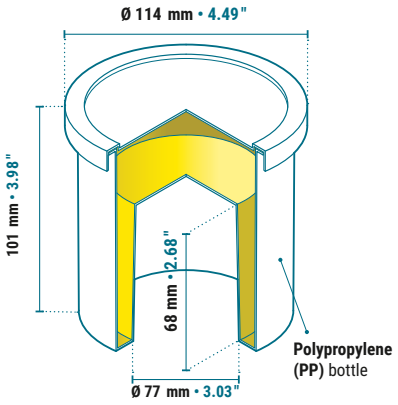
Masse de résine **3 450 g** | Resin mass **121,7 oz**



Type I *Marinelli*

Volume utile **450 cm³** | Useful volume **27 in³**

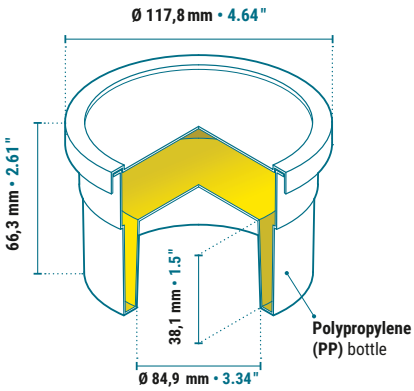
Masse de résine **518 g** | Resin mass **18.3 oz**



Type M *Marinelli*

Volume utile **250 cm³** | Useful volume **15 in³**

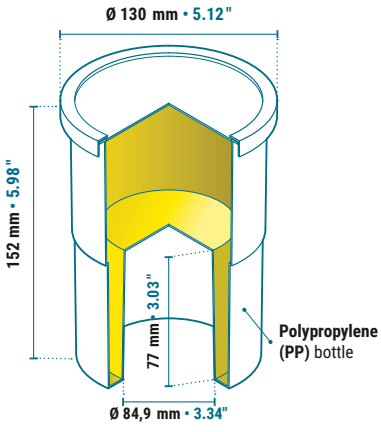
Masse de résine **287 g** | Resin mass **10.1 oz**



Type K *Marinelli*

Volume utile **1000 cm³** | Useful volume **61 in³**

Masse de résine **1150 g** | Resin mass **40,6 oz**



Radionuclide	Water equivalent activity	k=2 measurement uncertainty	Reference
	Under COFRAC* accreditation		
^{152}Eu	37 000 Bq • 1 µCi	≤ 5%	EU152 EGR [Type] 15
^{133}Ba	37 000 Bq • 1 µCi	≤ 5%	BA133 EGR [Type] 15
^{137}Cs	37 000 Bq • 1 µCi	≤ 5%	CS137 EGR [Type] 15
12ML01**	5 000 Bq • 0.14 µCi	[3% ; 6%]	12ML01 EGR [Type] 05
	18 000 Bq • 0.5 µCi	[3% ; 6%]	12ML01 EGR [Type] 10
	37 000 Bq • 1 µCi	[3% ; 6%]	12ML01 EGR [Type] 15
	55 000 Bq • 1.5 µCi	[3% ; 6%]	12ML01 EGR [Type] 20
	74 000 Bq • 2 µCi	[3% ; 6%]	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 – ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{51}Cr, ^{137}Cs, ^{113}Sn, ^{54}Mn, ^{65}Zn, ^{85}Sr, ^{88}Y – 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)

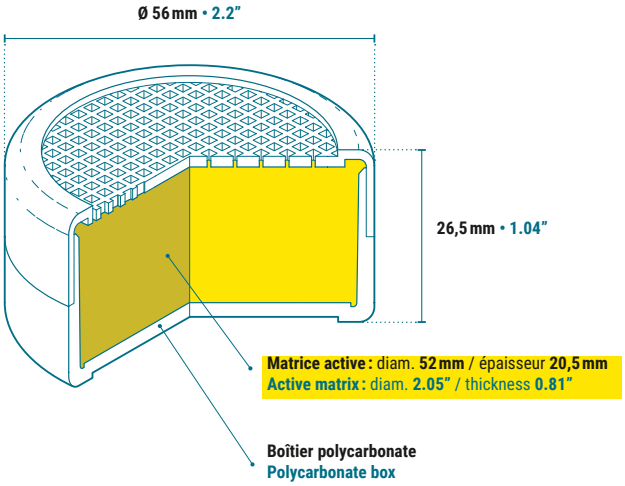
Source activity is measured with calibrated NaI scintillators or HPGe semi-conductors.

Production range

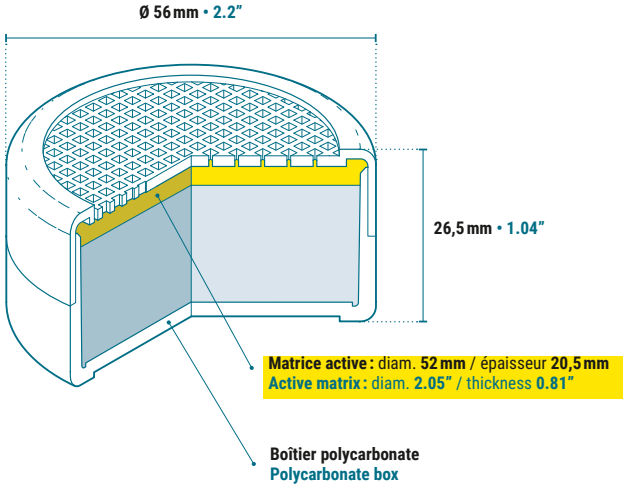
Catalog references	On request
Container	
Cartridge of useful volume 2.68 in^3	Any volume of activated charcoal
Activity	
4 kBq • 0.1 µCi	From 1 to 1 000 kBq From 0.03 to 27 µCi
Radionuclide	
^{133}Ba, ^{137}Cs, ^{152}Eu, Mix 12ML01	^{51}Cr, ^{54}Mn, ^{57}Co, ^{60}Co, ^{65}Zn, ^{85}Sr, ^{88}Y, ^{109}Cd, ^{113}Sn, ^{134}Cs, ^{139}Ce, ^{241}Am (Non-exhaustive list)

Standard geometries

Type D



Type E



Radionuclide	Activity	k=2 measurement uncertainty	Reference
^{133}Ba	4 kBq • 0.11 µCi	≤ 5%	BA133 EDC D 10
	4 kBq • 0.11 µCi	≤ 5%	BA133 EDC E 10
^{137}Cs	4 kBq • 0.11 µCi	≤ 7%	CS137 EDC D 10
	4 kBq • 0.11 µCi	≤ 8%	CS137 EDC E 10
^{152}Eu	4 kBq • 0.11 µCi	≤ 5%	EU152 EDC D 10
	4 kBq • 0.11 µCi	≤ 5%	EU152 EDC E 10
12ML01*	18,5 kBq • 0.5 µCi	[6% ; 8%]	12ML01 EDC D 11
	18,5 kBq • 0.5 µCi	[6% ; 8%]	12ML01 EDC E 11

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

* The 12ML01 mixture – ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{51}Cr, ^{137}Cs, ^{113}Sn, ^{54}Mn, ^{65}Zn, ^{85}Sr, ^{88}Y – 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 © Mirion Technologies

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.

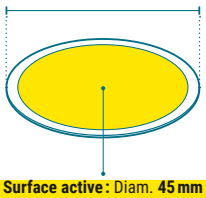
Production range

Catalog references	On request
Active diameter	
43 mm • 1.7 in	From 15 to 160 mm From 0.6 to 6.3 in
45 mm • 1.8 in	
47 mm • 1.9 in	
50 mm • 2 in	
53 mm • 2.1 in	
60 mm • 2.4 in	
120 mm • 4.7 in	
External diameter	
51 mm • 2.01 in	From 20 to 170 mm From 0.8 to 6.7 in
53 mm • 2.1 in	
60 mm • 2.4 in	
63 mm • 2.5 in	
70 mm • 2.8 in	
130 mm • 5.1 in	
Activity	
10 000 Bq • 0.3 µCi	From 1 kBq to 1 MBq From 0.03 to 27 µCi
20 000 Bq • 0.5 µCi	
40 000 Bq • 1.1µCi	
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 (Non-exhaustive list)

Standard geometries

Type M45-51

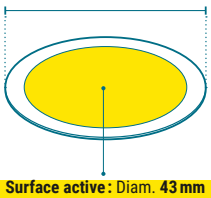
Ø 51 mm • 2”



Surface active : Diam. **45 mm**
Active surface : Diam. **1.8”**

Type M43

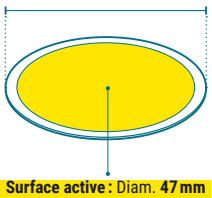
Ø 53 mm • 2.1”



Surface active : Diam. **43 mm**
Active surface : Diam. **1.7”**

Type M47-53

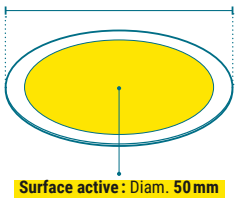
Ø 53 mm • 2.1”



Surface active : Diam. **47 mm**
Active surface : Diam. **1.9”**

Type M50

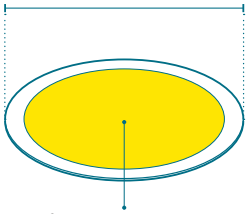
Ø 60 mm • 2.4”



Surface active : Diam. **50 mm**
Active surface : Diam. **2”**

Type M53

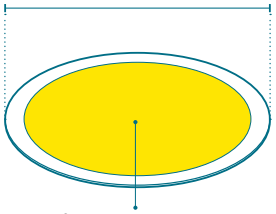
Ø 63 mm • 2.5”



Surface active : Diam. **53 mm**
Active surface : Diam. **2.1”**

Type M60

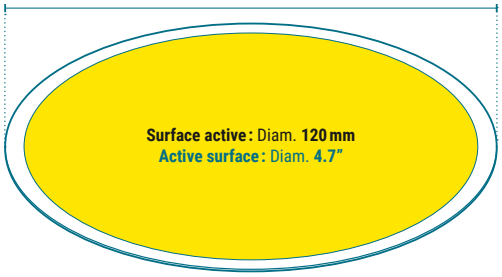
Ø 70 mm • 2.8”



Surface active : Diam. **60 mm**
Active surface : Diam. **2.4”**

Type M120

Ø 130 mm • 5.1”



Radionuclide	Activity	k=2 measurement uncertainty	Reference
12ML01*	10 000 Bq • 0.3 µCi	≤ 10%	12ML01 ESB [Type] [10KBQ]
	20 000 Bq • 0.5 µCi	≤ 10%	12ML01 ESB [Type] [20KBQ]
	40 000 Bq • 1.1 µCi	≤ 10%	12ML01 ESB [Type] [40KBQ]

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

* The 12ML01 mixture – ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{51}Cr, ^{137}Cs, ^{113}Sn, ^{54}Mn, ^{65}Zn, ^{85}Sr, ^{88}Y – 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 solid 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:

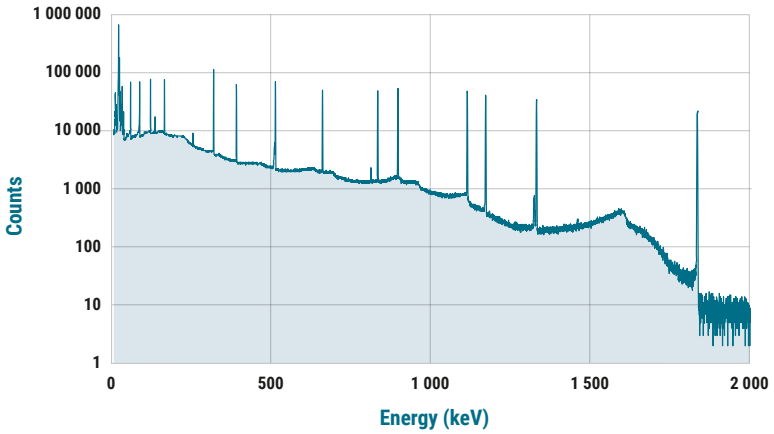
- Point Sources
- Resin Matrix
- Charcoal filter cartridges
- Vegetable Matrix
- Paper Matrix

Composition of the mixture

12ML01 60 keV – 1 836 keV

Radionuclides	Main rays	% in activity (indicatif)
^{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%

Emission spectrum



Any other mix of ^{241}Am, ^{133}Ba, ^{60}Co, ^{137}Cs and ^{152}Eu 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 solid 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.

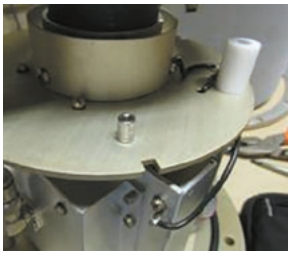
The most requested sources contain 1.4 µCi (50 kBq), 5.4 µCi (200 kBq), 10 µCi (370 kBq) or 24 µCi (900 kBq) of ^{241}Am, ^{137}Cs, ^{60}Co. The activity and the radionuclides can be adapted according to the final requirements.

© LEA

Pictures of capsule sources with M3 thread.
References EGS4HS or EGS07HS

© CEA

Example of mesuring equipment using capsule source



© CEA

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.

© CEA / JEULIN

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

© LEA

Source used in the Beta and Gamma Radiation Counter

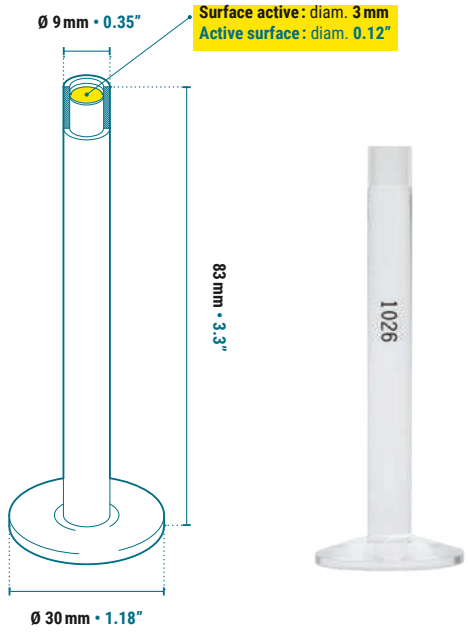
#04

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.



© LEA

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

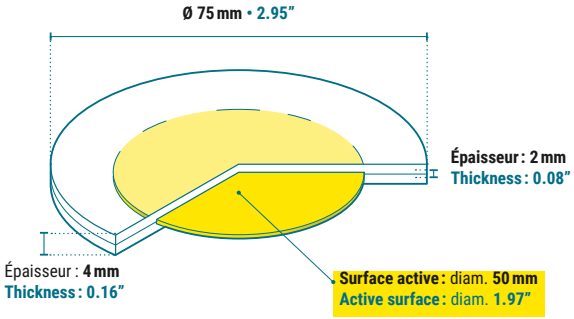
#05

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.

© LEA

CO60 EGS C source



Tailor-made X and γ solid sources

#06 Customer specific formats

Example #06A

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 (^{137}Cs in that example), is deposited inside the cap which is, then, sealed with the pencil.

© LEA
Pencil of 12 in (30 cm) length

Example #06B

Filiform sources

Filiform sources consist of thermosetting resins in which the radionuclides are mixed. Resins are then inserted into a sealed container.

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

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

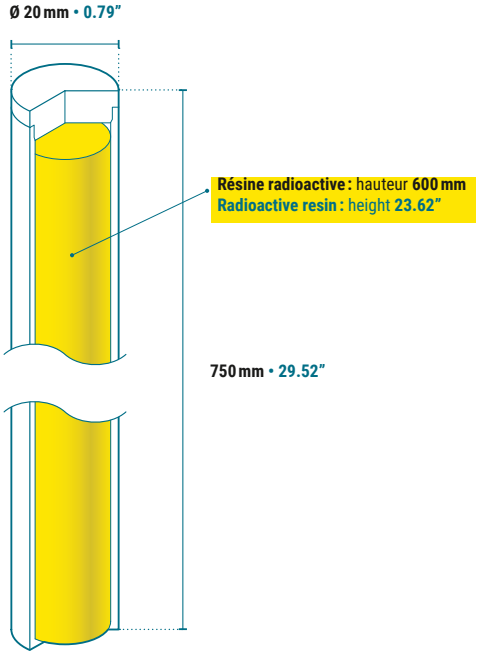
We can produce sources with all gamma emitters and mixtures of gamma emitters offered by LEA, for activities ranging from 1.1 µCi (40 kBq) to 1.1 mCi (40 MBq).

© LEA
Filiform sources for waste drums

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)

© ANDRA
Example of a 200 liters | 55 gallon radioactive drum



Examples of insertion guides for filiform sources

Tailor-made X and γ solid sources

#07 Calibration and control of whole-body counting systems

Example #07A

Source for phantom IGOR™

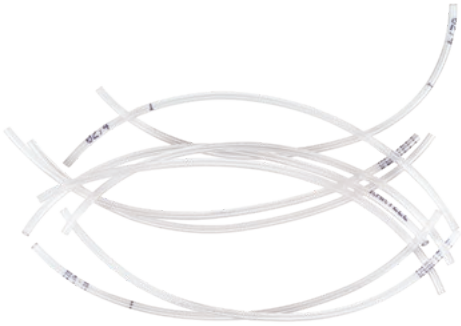
IGOR™ whole-body phantoms contain up to 130 polyethylene blocks of different sizes, for simulating different body builds from 26.5 lbs to 242.5 lbs. About 300 sources are needed to reproduce a homogeneous whole-body source term, simulating blood contamination.

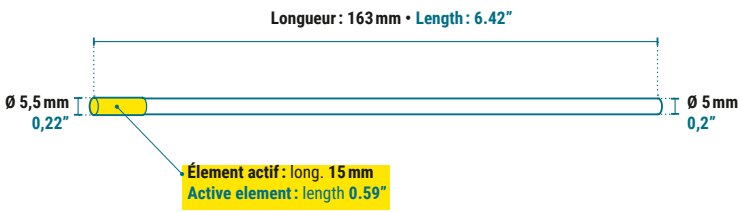
Most requested radionuclides : ^{57}Co, ^{60}Co, ^{137}Cs, ^{152}Eu, alone or mixed (references 2ML01 or 3ML01)

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





© LEA

Filiform source for IGOR™ phantom. EGRO reference

Example #07B

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.

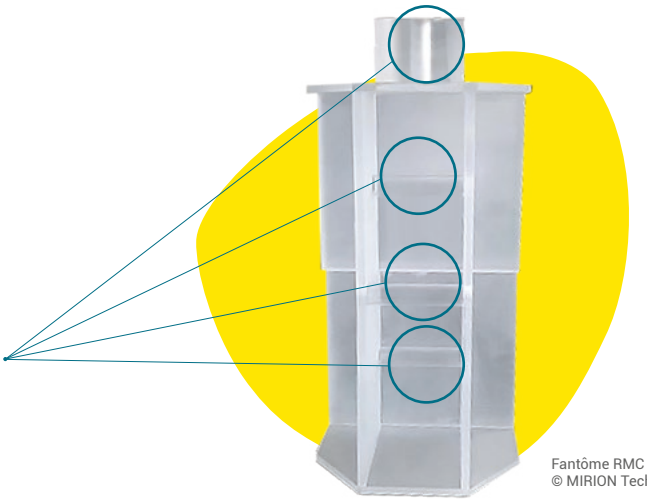
Most requested radionuclides: ^{57}Co, ^{60}Co, ^{137}Cs, ^{152}Eu, alone or mixed (references 2ML01 or 3ML01)

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).

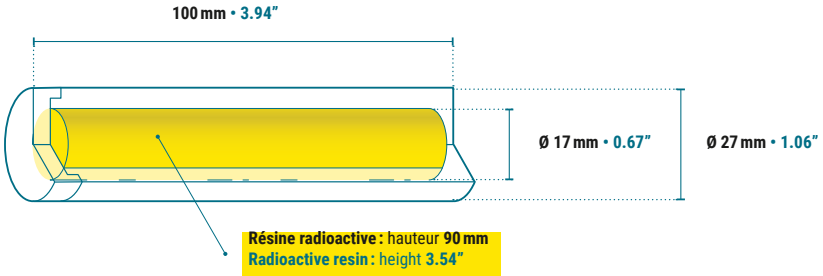
LEA can produce sources with all gamma emitters and mixtures of gamma emitters for other activity levels.

ACCUSCAN™ & FASTSCAN™
© MIRION TECHNOLOGIES

© LEA
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.

❶ TRI-CARB™ Liquid scintillation Counter
© PERKIN-ELMER

❷ Ultra Low Background HPGe detector for environnemental monitoring
© Baltic Scientific Instruments (BSI)

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).

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

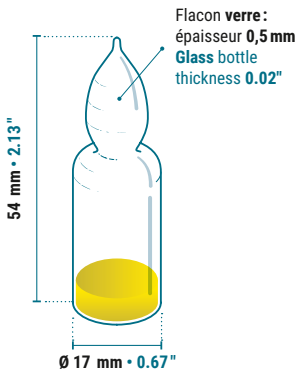
Our liquid sources can be conditioned in other geometries offered in our catalog or provided by the customer.

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

Standard geometries

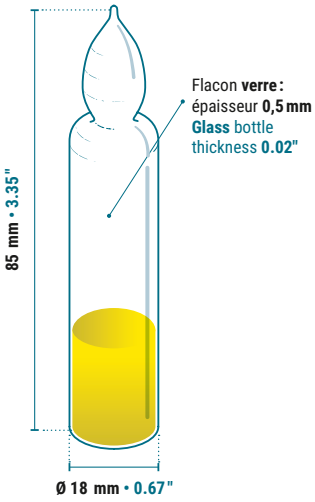
Type A *Ampoule*

Volume utile **1 cm³** | Useful volume **0.06 in³**



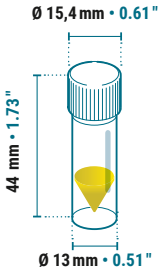
Type B *Ampoule*

Volume utile **5 cm³** | Useful volume **0.31 in³**



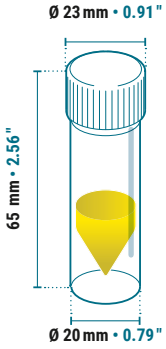
Type U *V-Vial*

Volume utile **1 cm³** | Useful volume **0.06 in³**



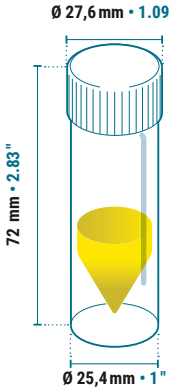
Type V *V-Vial*

Volume utile **5 cm³** | Useful volume **0.31 in³**



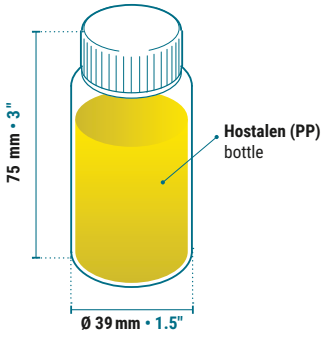
Type W *V-Vial*

Volume utile **10 cm3** | Useful volume **0.61in3**



Type E *SG50*

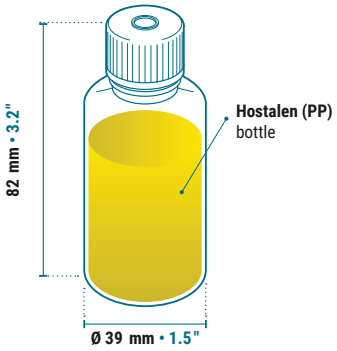
Volume utile **50 cm³** | Useful volume **3.1 in³**



Non-openable bottle

Type F

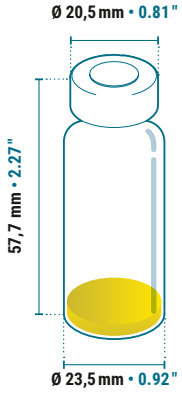
Volume utile **50 cm³** | Useful volume **3.1 in³**



Non-openable bottle

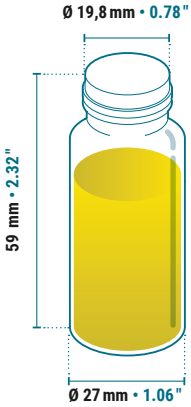
Type D *Penicillin*

Volume utile **1 cm³** | Useful volume **0.06 in³**



Type J *Penicillin*

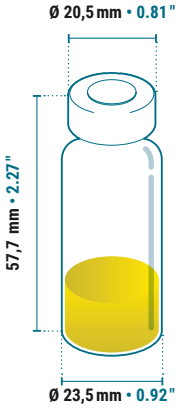
Volume utile **20 cm3** | Useful volume **1.22 in3**



*Maximum activity = 0.001 µCi/g

Type L *Penicillin*

Volume utile **5 cm³** | Useful volume **0.31 in³**



ELS liquid sources

Geometries . . . [Type]
- Ampoules. . . . . **A or B**
- V-Vial . . . . . **U, V or W**
- Penicillin . . . . . **D, J* or L**
- SG . . . . . **E or F**

Activities [Act]
- 0. 001µCi/g
- 0.01µCi/g
- 1.1µCi/g
- 21.6µCi/g
- 261.2µCi/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 ^{137}Cs is referenced as **CS137 ELS *B 40kBq/g.***

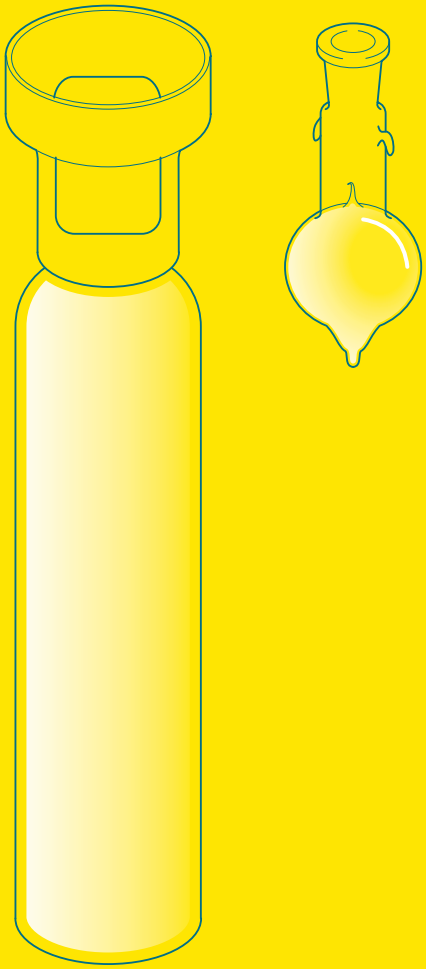
	Radionuclide	Chemical form	Carrier	Reference	Note
α αγ	^{237}Np	HCL 6N ou HNO_3 3N	Oxalic acid [33µg/g]	NP237 ELS [Type] [Act]	Available geometries: A, B, U, V, W Maximum = 800 kBq/g
	^{238}Pu	HNO_3 3N	-	PU238 ELS [Type] [Act]	Available geometries: A, B, U, V, W Maximum = 800 kBq/g
	^{239}Pu	HNO_3 3N	-	PU239 ELS [Type] [Act]	Available geometries: A, B, U, V, W Maximum = 800 kBq/g
	^{241}Am	HNO_3 1N	$EuCl_3$ [10µg/g]	AM241 ELS [Type] [Act]	Available geometries: A, B, U, V, W Maximum = 800 kBq/g Maximum = 8 000 kBq/g for A and B type
	^{244}Cm	HNO_3 1N	-	CM244 ELS [Type] [Act]	Available geometries: A, B, U, V, W Maximum = 800 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]	-
	^{129}I	H_2O	$Na_2S_2O_3$ [50µg/g] + NaI [50µg/g]	I129 ELS [Type] [Act]	-
	^{131}I	H_2O	$Na_2S_2O_3$ [50µg/g] + NaI [50µg/g]	I131 ELS [Type] [Act]	Maximum = 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	Mélange d'entraîneurs unitaires	12ML01 ELS [Type] [Act]	Available: •0,002 µCi/g •0,02µCi/g •1,1 µCi/g •21,6 µCi/g

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

* The 12ML01 mixture – ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{51}Cr, ^{137}Cs, ^{113}Sn, ^{54}Mn, ^{65}Zn, ^{85}Sr, ^{88}Y – 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 ^{85}Kr gas and other radionuclides on request (^{133}Xe…) 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 ^{85}Kr 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.

© LEA

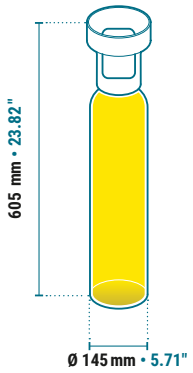
Installation of an empty ^{85}Kr cylinder

© LEA

Filling a ^{85}Kr ampoule

Type E *Cylinder*

Volume utile **5 000 cm³** | Useful volume **305.12 in³**

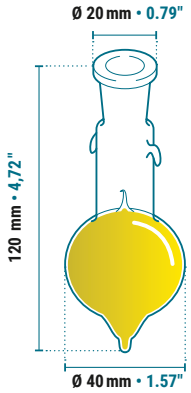


Radionuclide	Volume activity	k=2 measurement uncertainty	Equivalent activity	Reference
	Under COFRAC* accreditation			
^{85}Kr	0.2 kBq/cm^3 • 0.005 µCi/cm3	5%	100 000 kBq • 2 703 µCi	KR85 EZS E 20

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

Type A *Ampoule*

Volume utile **3 cm³** | Useful volume **0,18 in³**



Radionuclide	Total activity	k=2 measurement uncertainty	Reference
^{85}Kr	240 kBq • 6.5 µCi	5%	KR85 EZS A 40
	120 000 kBq • 3 243 µCi	5%	KR85 EZS A 60

LEA also offers SG500 or SG3000 gas containers, equipped with sampling probes and mounted staubli fittings (see page 74).

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

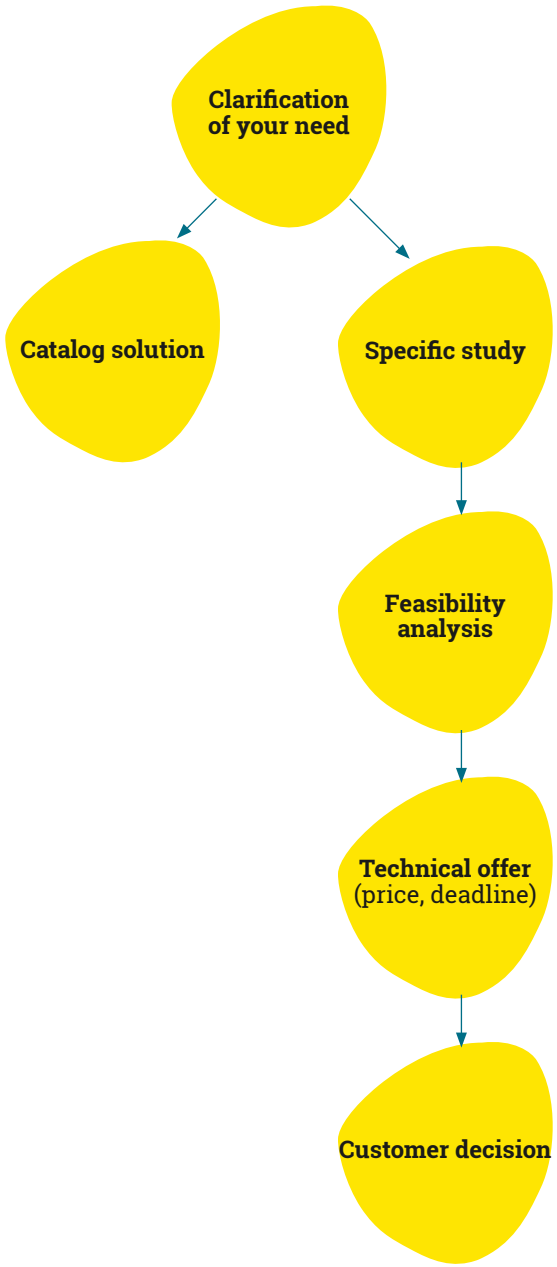
Based on your needs and specifications, an internal study is initiated to validate:

- the production feasibility (manufacturing and measuring if necessary) of the source in accordance with the scope of the 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.

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

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.

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.

Supports adapted to equipment

ICAM

^{241}Am sources for alpha and beta aerosol monitors (ICAM model)

Ball

Source plexiglass ball mounted on stem support

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.

Customer-specific supports

Customer-specific bottles

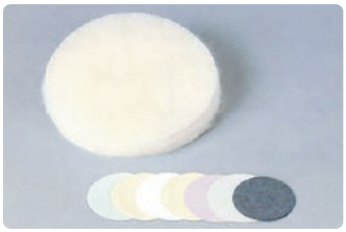
To produce sources with your specific bottles, 5 samples will be required for preliminary testing.

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

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

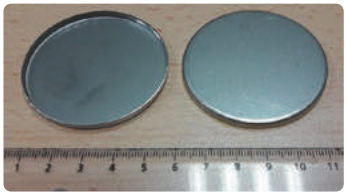
Bernard Dumas glass or cellulose paper filters

used in environmental monitors in nuclear facilities.

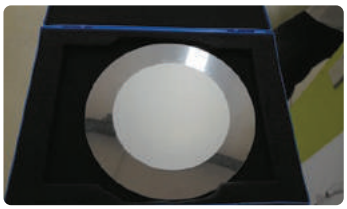


Stainless steel tray

(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

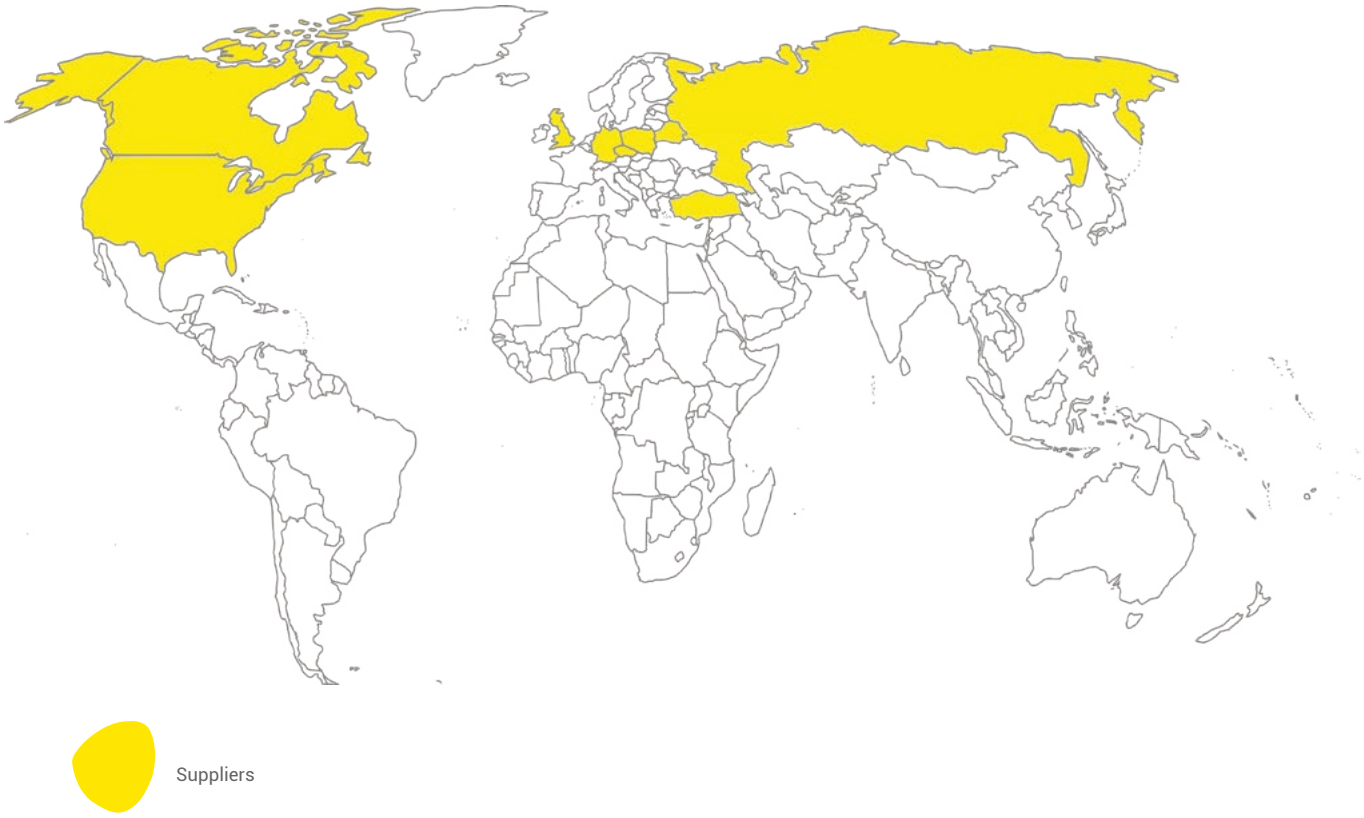
Active size source 1.5 x 1.7 in, external dimension 1.7 x 1.9 in mounted on a specific stainless steel support

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

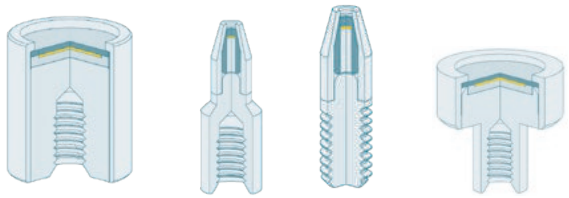


Suppliers

High activity sources for industry and R&D applications

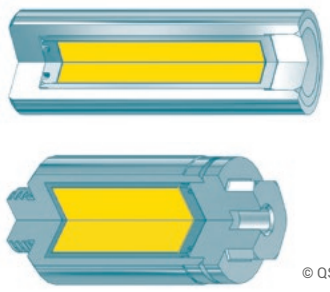
Sources for Mossbauer Spectrometry, used in physics, chemistry and biology to determine the structure of materials and mechanisms of interaction. The proposed sources could be either ^{57}Co or ^{119}Sn. The standard matrices are in rhodium (for ^{57}Co) or CaSnO3 (for ^{119}Sn), the beryllium window ensuring the absence of radioactive contamination.

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



© Ritverc

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



© QSA Global

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 ^{137}Cs source and an AmBe source.

Sources for Industrial gauges:
• Paper weight measurements
(beta sources of ^{85}Kr and ^{147}Pm),
• thickness and density measurements
(beta sources of ^{90}Sr, ^{85}Kr and ^{147}Pm),
• level control (sources of d'^{241}Am and ^{137}Cs).

Sources for X-ray fluorescence for the detection of lead in paints. The sources proposed by LEA are made of ^{109}Cd, ^{57}Co 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 © Lecron

TC1 © Lecron

TNB 169

Source Box

Boxes
for beta or gamma sources

Carry cases
Shielded case for flood sources

Protections

Lead pots

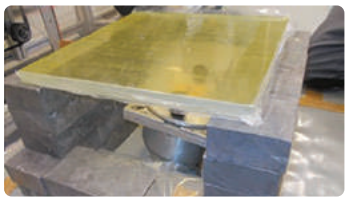
Source storage safe

© Manutan

Source holder and Handling

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 (^{133}Ba source)

Source holder to facilitate verifications on radiation protection probes.

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

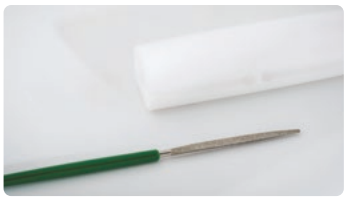
Source holder to incorporate capsules sources on the measuring.

Source holder to incorporate capsules sources on the measuring.

EGSD reference

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



Ampoule holder
Base for placing the ampoules when cutting

Accessories

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
Flacon plastique type Beaker Marinelli	250	9ACETL11
Flacon plastique type Beaker Marinelli	500	9ACETL9
Flacon plastique type Beaker Marinelli	1 000	9ACETL1
Flacon plastique type SG50N	50	9ACETL5
Flacon plastique marron	50	9ACETL7
Flacon plastique type SG500N	500	9ACETL6
Flacon plastique marron	500	9ACETL8
Flacon type SG3000	3 000	9ACETL2
Flacon 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.

Turnkey projects for high activity sources

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 (^{252}Cf and AmBe) and gamma sources (^{60}Co) 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.

© LEA
Production line for EPR nuclear reactor rods

© IRSN Saclay
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.

Spent source recovery

LEA collects the sealed sources it has supplied once they are expired or disused and will examine the feasibility of collecting sealed sources supplied by other manufacturers on a case-by-case basis. Although unsealed sources are usually not recovered, LEA can also examine the feasibility of their recovery.

This service is aimed at customers both in France and abroad.

As part of the spent sources recovery service, LEA:

- helps you preparing paperwork and transport to LEA in compliance with Transportation regulations (providing packaging kit on request),
- manages collection and transport on request,
- issues recovery certificates after reception and control of the packages,
- stores sources safely and securely,
- manages the disposal of spent sources via the appropriate routes.

The necessary forms are available from our website: www.lea-sources.com.

Temporary storage of sources

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

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)

Precision weighing

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

Calibration and 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.

Appendices

Sources

Accessories & services

Appendices

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 control 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 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 to strictly 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.

** ILAC MRA: International Laboratory Accreditation Cooperation Mutual Recognition Arrangement

*** CIPM-MRA: International Committee for Weights and Measures - Mutual Recognition Arrangement

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

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 :

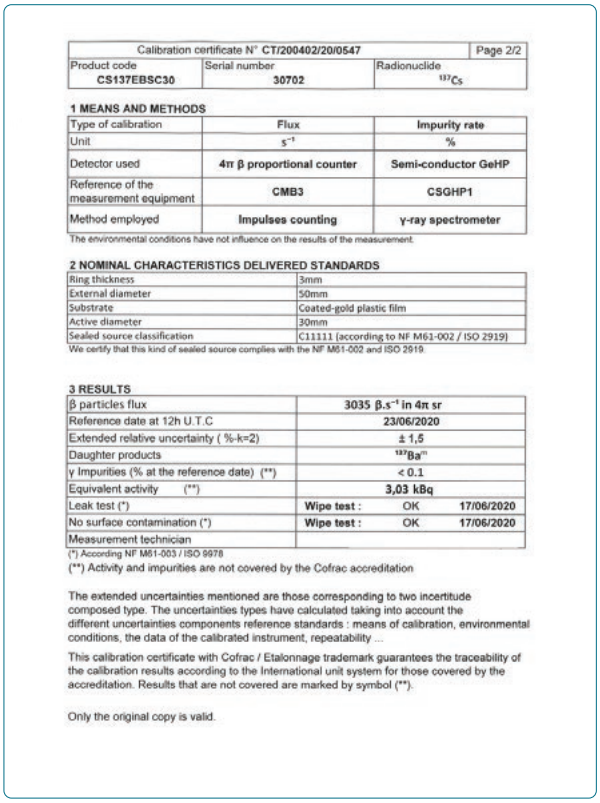
Référence : **CS137EBSC30**
Product code:

Identification : **30702**
Identification :

Ce certificat comprend 2 pages
This certificate includes 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 a physical integrity standpoint, the recommended working life of sealed sources according to ISO2919 is 10 years in normal usage conditions (usage guidelines 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 10^{10} 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.82).

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.

RN	PERIOD			MAIN EMISSIONS *								SPECIFIC ACTIVITY		IAEA EXEMPTION THRESHOLDS**		FRANCE EXEMPTION THRESHOLDS***	
				α		β			X		γ			Solid source	Liquid source	Solid source	Liquid source
	Years	Days	Seconds	E (MeV)	Ratio	E Max (keV)	E moy (keV)	Ratio	E (keV)	Ratio	E (keV)	Ratio	Bq/g	Ci/g	Activity (kBq)	Concentration (kBq/g)	Activité • Activity (kBq)	Concentration (Bq/g)
Ag110m		2,50E+02	2,16E+07	-	-	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	1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g
Am241	432,6	1,58E+05	1,37E+10	5.388 5.443 5.486	1.7% 13.2% 84.5%	-	-	-	13.8 17.1 21.2	13.0% 18.9% 4.8%	59,5	35,8%	1,27E+11	3,43	10 kBq	0,001 kBq/g	10 kBq	0,0001 kBq/g
Ba133	10,5	3,83E+03	3,33E+08	-	-	-	-	-	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	1 000 kBq	0,1 kBq/g	1 000 kBq	-
C14	5 700	2,08E+06	1,80E+11	-	-	156,5	49,2	100%	-	-	-	-	1,66E+11	4,48	10 000 kBq	10 kBq/g	10 000 kBq	0,001 kBq/g
Ca45		1,63E+02	1,41E+07	-	-	256,4	77,2	100%	-	-	-	-	6,58E+14	17 795	10 000 kBq	10 kBq/g	10 000 kBq	0,1 kBq/g
Cd109		4,62E+02	3,99E+07	-	-	-	-	-	22.0 22.2 25.0 25.5	29.0% 54.7% 15.1% 2.6%	88	3,6%	9,59E+13	2 593	1 000 kBq	10 kBq/g	1 000 kBq	0,001 kBq/g
Ce139		1,38E+02	1,19E+07	-	-	-	-	-	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	1 000 kBq	0,1 kBq/g	1 000 kBq	0,001 kBq/g
Cl36	301 000	1,10E+08	9,50E+12	-	-	708,6	251,2	98,1%	-	-	-	-	1,22E+09	0,033	1 000 kBq	10 kBq/g	1 000 kBq	0,001 kBq/g
Cm244	18,1	6,61E+03	5,71E+08	5.763 5.805	23.3% 76.7%	-	-	-	17,1	8,7%	-	-	2,99E+12	80,9	10 kBq	0,01 kBq/g	10 kBq	0,001 kBq/g
Co57		2,72E+02	2,35E+07	-	-	-	-	-	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	1 000 kBq	0,01 kBq/g	1 000 kBq	0,001 kBq/g
Co60	5,27	1,92E+03	1,66E+08	-	-	317,3	95,6	99,8%	-	-	1173.2 1332.5	100% 100%	4,18E+13	1 130	100 kBq	0,01 kBq/g	100 kBq	0,0001 kBq/g
Cr51		2,77E+01	2,39E+06	-	-	-	-	-	4.9 5.4	20.1% 2.7%	320	9,8%	3,42E+15	92 383	10 000 kBq	1 kBq/g	10 000 kBq	0,1 kBq/g
Cs134	2,06	7,52E+02	6,51E+07	-	-	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	10 kBq	0,01 kBq/g	10 kBq	0,0001 kBq/g
Cs137	30,1	1,10E+04	9,48E+08	-	-	514.0 1175.6	174.3 416.3	94.4% 5.6%	31.8 32.2	1.9% 3.6%	661,7	85%	3,21E+12	86,8	10 kBq	0,01 kBq/g	10 kBq	0,0001 kBq/g
Eu152	13,5	4,93E+03	4,27E+08	-	-	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%	6,43E+12	174	1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g
Fe55	2,75	1,00E+03	8,67E+07	-	-	-	-	-	5.9 6.5	25.0% 3.4%	-	-	8,75E+13	2 365	1 000 kBq	10 kBq/g	1 000 kBq	1 kBq/g
Fe59		4,45E+01	3,84E+06	-	-	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	1 000 kBq	0,01 kBq/g	1 000 kBq	0,001 kBq/g
H3	12,3	4,49E+03	3,89E+08	-	-	18,6	5,7	100%	-	-	-	-	3,58E+14	9 676	1 000 000 kBq	1 000 kBq/g	1 000 000 kBq	0,1 kBq/g
I125		5,94E+01	5,13E+06	-	-	-	-	-	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	1 000 kBq	1 kBq/g	1 000 kBq	0,1 kBq/g
I129	16 100 000	5,88E+09	5,08E+14	-	-	-	-	-	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	100 kBq	0,1 kBq/g	100 kBq	0,00001 kBq/g
I131		8,02E+00	6,93E+05	-	-	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	1 000 kBq	0,1 kBq/g	1 000 kBq	0,01 kBq/g
Mn54		3,13E+02	2,71E+07	-	-	-	-	-	5.4 6.0	22.7% 3.1%	834,8	100%	2,86E+14	7 719	1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g
Na22	2,60	9,49E+02	8,21E+07	-	-	546,4	215,5	89.8%	-	-	511 1274.5	178% 100%	2,31E+14	6 241	1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g
Ni63	98,7	3,60E+04	3,11E+09	-	-	67,0	17,4	100%	-	-	-	-	2,13E+12	57,5	100 000 kBq	100 kBq/g	100 000 kBq	0,1 kBq/g
Np237	2 140 000	7,81E+08	6,75E+13	4.766 4.771 4.788	9.5% 25.0% 47.0%	-	-	-	15,7	54,5%	29.4 86.5	15.3% 12.3%	2,61E+07	0,00070	1 kBq	0,001 kBq/g	1 kBq	0,001 kBq/g
P32		1,43E+01	1,23E+06	-	-	1710,7	695,5	100%	-	-	-	-	1,06E+16	285 566	100 kBq	1 kBq/g	100 kBq	1 kBq/g
Pm147	2,62	9,56E+02	8,28E+07	-	-	224,7	62,0	100%	-	-	-	-	3,43E+13	927	10 000 kBq	10 kBq/g	10 000 kBq	1 kBq/g
Pu238	87,7	3,20E+04	2,77E+09	5.456 5.499	28.8% 71.0%	-	-	-	16,2	10,6%	-	-	6,33E+11	17,1	10 kBq	0,001 kBq/g	10 kBq	0,0001 kBq/g
Pu239	24 100	8,80E+06	7,61E+11	5.106 5.144 5.157	11.9% 17.1% 70.8%	-	-	-	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	10 kBq	0,001 kBq/g	10 kBq	0,0001 kBq/g
S35		8,73E+01	7,54E+06	-	-	167,1	48,6	100%	-	-	-	-	1,58E+15	42 710	100 000 kBq	100 kBq/g	100 000 kBq	0,1 kBq/g
Sn113		1,15E+02	9,94E+06	-	-	-	-	-	24.0 24.2 27.3 27.9	27.7% 51.9% 14.6% 2.8%	255.1 391.7	2.1% 65.0%	3,71E+14	10 037	10 000 kBq	1 kBq/g	10 000 kBq	0,001 kBq/g
Sr85		6,49E+01	5,60E+06	-	-	-	-	-	13.3 13.4 15.0	17.2% 33.0% 8.0%	514	98,5%	8,76E+14	23 680	1 000 kBq	0,1 kBq/g	1 000 kBq	0,001 kBq/g
Sr89		5,06E+01	4,37E+06	-	-	1495,1	584,6	100%	-	-	-	-	1,07E+15	29 002	1 000 kBq	1 kBq/g	1 000 kBq	1 kBq/g
Sr90	28,8	1,05E+04	9,09E+08	-	-	545,9	195,7	100%	-	-	-	-	5,10E+12	138	10 kBq	0,01 kBq/g	10 kBq	0,001 kBq/g
Tl204	3,79	1,38E+03	1,20E+08	-	-	763,7	243,9	97,1%	-	-	-	-	1,71E+13	462,475	10 kBq	10 kBq/g	10 kBq	0,001 kBq/g
Tc99	214 000	7,81E+07	6,75E+12	-	-	293,7	85,4	100%	-	-	-	-	6,24E+08	0,017	10 000 kBq	10 kBq/g	10 000 kBq	0,001 kBq/g
U233	1 590	5,80E+05	5,02E+10	4.729 4.783 4824	1.6% 13.2% 84.4%	-	-	-	15,7	5,3%	-	-	3,57E+10	0,965	10 kBq	0,001 kBq/g	10 kBq	0,001 kBq/g
Y88		1,07E+02	9,21E+06	-	-	-	-	-	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	1 000 kBq	0,01 kBq/g	1 000 kBq	-
Zn65		2,44E+02	2,11E+07	-	-	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	1 000 kBq	0,01 kBq/g	1 000 kBq	0,0001 kBq/g

* LARA, LNHB, 2007 — **IAEA SAFETY STANDARDS SERIES N°. GSR Part 3, 2017 — ***Code de la Santé Publique, Annexe 13-8, Décret n°2018-434 du 4 juin 2018

Sources & radioactivity standards

Catalog

SPE.COM.20.057
REV00

design karactère - www.karactere.com | crédits: Cyril Crespeau - iStock - LEA | 2020

Laboratoire d'Etalons d'Activité

Site Nucléaire du Tricastin - BP 75
26701 Pierrelatte Cedex - France
www.lea-sources.com

orano
Donnons toute sa valeur au nucléaire

125 Avenue de Paris
92320 Chatillon Cedex - France
www.orano.group