

Calibration Standards and Instruments

Product Information



isotrak™

 Eckert & Ziegler
Nuclitec

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WIDE AREA REFERENCE SOURCES

This section contains details of sealed sources for calibrating surface contamination monitors. A wide range of

products with different dimensions and radionuclides is available. Also shown are sources designed for specific instruments and applications: calibration standards for Harwell Instrument monitors; photon emitting standards; tritium standards; standards for hand, foot, and whole body monitors.

To help you to select the right source for your application, information on source construction and measurement is included. Sources with dimensions and radionuclides other than those shown may also be available. Please use the form at the end of this section for your requests.



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1.1 General information



Applications

One of the fundamental principles of radiation protection is that the dose to workers must be as low as reasonably practicable. In many laboratories the main risk is from ingestion or inhalation of the radionuclides. It is normal practice to monitor the workplace for surface contamination regularly and, in some cases, to check for airborne radioactive particles.

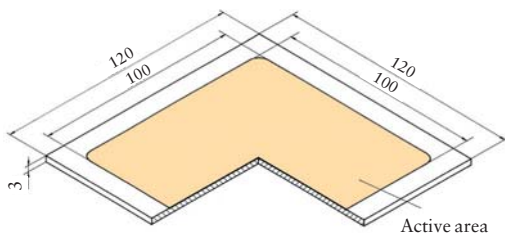
Eckert & Ziegler Nuclitec GmbH's range of wide area reference sources is designed for calibrating portable surface contamination monitors, fixed hand/foot monitors and planchet counters for filter papers.

The main applications are

- Calibrating instruments to meet statutory requirements
- Instrument type testing
- Pre-use testing of instruments to prove fitness for purpose

Sources are normally constructed from anodized aluminium foils. This type of construction results in:

- Robust, durable, sealed sources
- A thin deposit of activity to comply with international standards (ISO8769, ISO7503): the energy distribution of particles is not distorted by the source construction, which means that instrument response is easy to interpret



Construction

The sources are constructed to meet the requirements of ISO8769 (see section 9.4). The activity is incorporated in the top surface of an aluminium foil resulting in a source which has an active layer only 5µm (0.8mg/cm²) in depth. The source is also robust.

To produce anodized foil sources, micropores are etched into the surface of a 0.3mm thick aluminium foil. The micropores are less than 0.01µm in diameter, and are 4-10µm deep. The active material is then incorporated in the pores in an insoluble chemical form. The pores are chemically sealed to produce a thin layer which is mechanically robust and chemically resistant.

To construct a rigid source, the aluminium foil is mounted on a backing plate.

Measurement of emission rate and uniformity

Emission rate

The quantity of interest for wide area reference sources is the particle emission rate. This quantity is used to calibrate the instruments, and the calibration is related back to the quantity of radiological importance (the activity of the radionuclide) following the procedure in ISO7503 or national recommendations.

The particle emission rate is measured using a high efficiency windowless and/or windowed proportional counter, which is calibrated using a Class 1 source. All particles which are emitted from the surface with an energy greater than 590eV are detected. A particle emitted by a decaying nucleus can be scattered by the source material, or can lose energy in a series of inelastic collisions. The probability of high angle scattering of an alpha particle is very low, and the energy loss in inelastic collisions is low (until the alpha particle reaches the end of its range). For an alpha source, the emission rate is therefore approximately half the activity. Beta particles are deflected relatively easily, and low energy beta particles can quickly lose energy. Consequently, backscatter from the source backing plate and self-absorption of particles in the source material are more significant, and the emission rate can be greater or less than half of the activity, depending on the end-point energy of the beta particles.

Typical ratios are shown below:

Radionuclide	Beta end-point energy [MeV]	Ratio of particle emission rate to activity (source efficiency)
C-14	0.156	0.38
Pm-147	0.225	0.48
Tc-99	0.294	0.49
Co-60	0.318	0.48
Cl-36	0.710	0.63
Cs-137	0.514	0.61
Sr-90 / Y-90	0.546 / 2.280	0.63
Ru-106/Rh-106	3.541	0.64

Uniformity

The uniformity of each source is checked in accordance with ISO8769.

Uncertainties

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, providing a level of confidence of approximately 95% (see section 9.2). Sources are offered with a choice of DKD certificate (measurement uncertainty less than 5%) or Eckert & Ziegler Nuclitec GmbH certificate (measurement uncertainty less than 10%). Sources that are greater than 100cm² in area are in addition classified as class 2 or working sources in compliance with ISO8769 (see section 9.4).

For Class 2 sources, the uncertainty in the particle emission rate and activity is equal to or less than $\pm 5\%$ ($k=2$).

For natural uranium sources the uncertainty in the activity is $\pm 10\%$.

For comparison: ISO 8769 recommends that activity and surface emission rate shall be stated with an uncertainty not exceeding $\pm 6\%$ ($k=1$), which is equal to $\pm 12\%$ for $k=2$.

For Working sources, the uncertainty in the particle emission rate and activity is equal to or less than $\pm 10\%$.

Certification

Each source is supplied with a certificate of calibration which states

- Radionuclide
- Serial number
- Reference time and date
- Measured particle emission rate into 2π
- Measured activity*
- Measurement uncertainties
- Date of leak test
- ISO classification

*As the Tritium (H-3) activity cannot be calibrated, it is stated as a nominal value.

Tolerances

The maximum deviation of the delivered activity from the nominal activity is $\pm 30\%$. Other tolerances are available on request.

Traceability

The sources are calibrated in accordance with the requirements of ISO8769 and all measurements are traceable to national standards.

1. Wide area reference sources

1.1 General information

Quality assurance

The sources are manufactured in a facility which operates a quality management system which has been independently audited and approved to ISO9001:1994.

ISO classification

The sources are tested to ISO2919 which is equivalent to ANSI N542 1977 (see section 9.3). The assessed classification for the sources listed on page 11 to page 23 is C34645.

Advice on handling of sources and replacement

Sources should be recalibrated at regular intervals in accordance with national recommendations. Abrasion of the top surface of the aluminium foil will inevitably remove activity, although only from the sections of the source that have been physically damaged. Sources may be cleaned by wiping with a lint-free cloth moistened with alcohol. NB: Detergents or abrasive compounds such as metal polish should not be used.

To prevent loss of C-14 due to exchange of carbon with the atmosphere, C-14 sources should be kept in their storage box and kept out of strong sunlight and high humidity atmospheres when not in use.

Regular improvements in source design and measurement mean that it would be good working practice to renew the sources within 10 years.

Availability

Sources are normally delivered within 6 weeks of receipt of order.

Guide to selecting the source for the required application

1) Choose the nuclide to match (in terms of energy of particle emitted) the nuclide for which a calibration is needed.

Alpha emitting radionuclides

Radionuclide	Half life [years]	Main alpha particle energy [MeV]
U (nat)	4.5x10 ⁹	4.199
Th-230	75,400	4.687
Pu-239	24,000	5.156
Am-241	433	5.486
Pu-238	88	5.499

1.1 General information

Beta emitting radionuclides

Nuclide	Half life [years]	Beta end-point energy [MeV]
H-3	12.3	0.019
Ni-63	100	0.067
C-14	5700	0.156
Pm-147	2.6	0.225
Tc-99	214,000	0.294
Co-60	5.3	0.318
Cs-137	30	0.514
Cl-36	301,000	0.710
Sr-90/Y-90	28.8	0.546 / 2.280

2) Choose the active dimensions of the source

For portable contamination monitors the dimensions should be chosen so that the source is slightly larger than the detector window. This means that the source will simulate contamination spread over a large area, and all of the detector volume is irradiated.

For planchet counters, the source should be chosen to match the sample size. Please consult the instrument manual or manufacturer. (Please note that if the source size needed is not listed, Eckert & Ziegler Nuclitec GmbH can manufacture a source to meet your requirements - see page 31.)

3) Calculate the emission rate needed

For portable contamination monitors, the particle emission rate should be chosen to give an observed count rate well above the background.

1. Calculate the activity per unit area (Bq/cm²) needed to generate the required count rate. This can be calculated from the response factors (cps/Bq/cm²) given in the instrument manual, type test data, or from the instrument manufacturer.
2. Calculate the equivalent particle emission rate in particles emitted per second per square cm. By convention, this is normally taken to be half the activity, irrespective of nuclide, backscatter factors, etc.
3. Calculate the total emission rate of the source; the source area is given at the top of each table.
4. Choose the source with the emission rate that matches this value.

For planchet counters etc., consult the instrument manufacturer.

4) Choose the type of source required

Eckert & Ziegler Nuclitec GmbH recommends Class 2 sources for statutory calibration work, and Working sources for field use.

5) Select the product code from the tables on page 11 to page 23.

Example

To calibrate a Mini Instruments EP15 detector for a beta-emitting radionuclide with an energy of approximately 2MeV. From the instrument handbook we know:

- 1) Diameter of window:
4.4cm
- 2) Quoted response to Sr-90:
4.0 counts per second / Bq/cm²



This picture shows the isotrak contamination monitor.

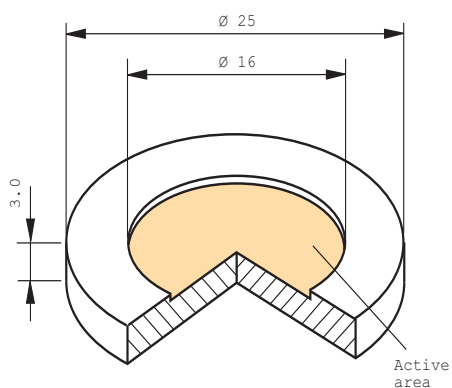
- 1) **Choose the nuclide**
In this case, Sr-90 with a beta end-point energy of 2.284MeV is a good match
- 2) **Choose the active dimensions of the source**
A source 5cm or more in diameter would be suitable.
- 3) **Calculate the emission rate needed**
For a count rate of about 500 counts per second above background.
 1. The source activity needed is:
 $500 / 4.0 = 125 \text{ Bq/cm}^2$, from the manufacturer's data
 2. The emission rate needed is therefore, by convention,
 $125 / 2.0 = 63$ betas per second per cm²
(Note: with this method of calculating an 'effective activity', we can ignore the decay scheme of Sr-90; we only need consider the emission from the source)
 3. The total emission rate from the source (radius 2.5cm) is given by:
 $63 \times 20 \text{ cm}^2 = 1260$ betas per second
 4. The most suitable source is therefore
SIR05021 or SIR05022 (see page 15)
- 4) **Select the type of source**
For the annual or statutory calibration, the source with the DKD certificate is recommended.
- 5) **Select the product code**
The best source for this application is therefore
SIR05022

The measured count rate will not be exactly 500cps, due to the manufacturing tolerance of the source ($\pm 30\%$) and variations in the detector construction.

1.2 Planchet sources



Planchet source: Drawing VZ-1366
 Active diameter: 16mm ~ 2cm²
 Overall dimensions: 25mm diameter x 3mm thick ¹⁾
 Backing plate: Aluminium



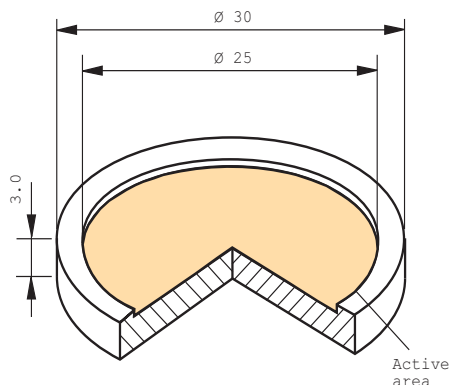
Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR01011	AMR01012
	1 kBq	~ 480	AMR01021	AMR01022
	3 kBq	~ 1450	AMR01031	AMR01032
Pu-238	185 Bq	~ 90	PPR01011	PPR01012
	1 kBq	~ 480	PPR01021	PPR01022
Pu-239	20 Bq	~ 10	PIR01011	-
Th-230	185 Bq	~ 85	TZR01011	TZR01012
Beta sources				
H-3	5 kBq	~ 50-150	TRR01051	-
Ni-63	1 kBq	~ 100	NBR01021	-
C-14	1 kBq	~ 380	CFR01021	CFR01022
Pm-147	185 Bq	~ 75	PHR01011	PHR01012
	1 kBq	~ 410	PHR01021	PHR01022
Tc-99	185 Bq	~ 90	TCR01011	TCR01012
Co-60	185 Bq	~ 90	CKR01011	CKR01012
	1 kBq	~ 480	CKR01021	CKR01022
Cs-137	185 Bq	~ 115	CDR01011	CDR01012
	1 kBq	~ 610	CDR01021	CDR01022
	3 kBq	~ 1830	CDR01031	CDR01032
Cl-36	185 Bq	~ 117	CIR01011	CIR01012
	0.5 kBq	~ 315	CIR01021	CIR01022
Sr-90/Y-90 ²⁾	185 Bq	~ 235	SIR01011	SIR01012
	1 kBq	~ 1270	SIR01021	SIR01022
	3 kBq	~ 3800	SIR01031	SIR01032

¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1. Wide area reference sources

1.2 Planchet sources



Planchet source: Drawing VZ-1367
 Active diameter: 25mm ~ 5cm²
 Overall dimensions: 30mm diameter x 3mm thick ¹⁾
 Backing plate: Aluminium

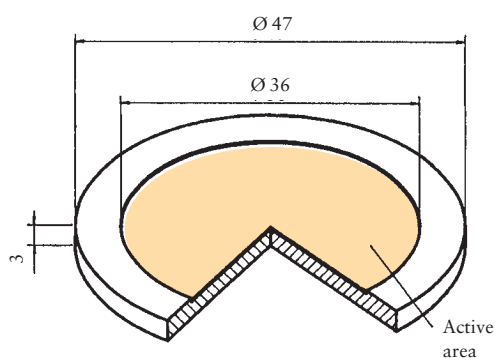
Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR02011	AMR02012
	1 kBq	~ 480	AMR02021	AMR02022
	3 kBq	~ 1450	AMR02031	AMR02032
Pu-238	185 Bq	~ 90	PPR02011	PPR02012
	3 kBq	~ 1450	PPR02031	PPR02032
Pu-239	50 Bq	~ 25	PIR02011	PIR02012
Th-230	185 Bq	~ 85	TZR02011	TZR02012
	500 Bq	~ 230	TZR02021	TZR02022
Natural U ²⁾ (U-238)	5 Bq	~ 4.6	UAR02011	-
Beta sources				
H-3	5 kBq	~ 50-150	TRR16021	-
Ni-63	1 kBq	~ 100	NBR02021	-
C-14	1 kBq	~ 380	CFR02021	CFR02022
Pm-147	1 kBq	~ 410	PHR02021	PHR02022
Tc-99	185 Bq	~ 90	TCR02011	TCR02012
	1 kBq	~ 490	TCR02021	TCR02022
Co-60	185 Bq	~ 90	CKR02011	CKR02012
	1 kBq	~ 480	CKR02021	CKR02022
Cs-137	185 Bq	~ 115	CDR02011	CDR02012
	1 kBq	~ 610	CDR02021	CDR02022
Cl-36	185 Bq	~ 117	CIR02011	CIR02012
	1 kBq	~ 315	CIR02021	CIR02022
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR02011	SIR02012
	1 kBq	~ 1270	SIR02021	SIR02022

¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1.2 Planchet sources



Planchet source: Drawing VZ-1368
 Active diameter: 36mm ~ 10cm²
 Overall dimensions: 47mm diameter x 3mm thick ¹⁾
 Backing plate: Aluminium

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR03011	AMR03012
	1 kBq	~ 480	AMR03021	AMR03022
	3 kBq	~ 1450	AMR03031	AMR03032
Pu-238	185 Bq	~ 90	PPR03011	PPR03012
Pu-239	100 Bq	~ 50	PIR03031	PIR03032
Th-230	185 Bq	~ 85	TZR03011	TZR03012
	1 kBq	~ 460	TZR03021	TZR03022
Natural U ²⁾ (U-238)	5 Bq	~ 4.6	UAR03011	-
	10 Bq	~ 9.2	UAR03021	-
Beta sources				
H-3	10 kBq	100-300	TRR03011	-
Ni-63	1 kBq	~ 100	NBR03021	-
C-14	1 kBq	~ 380	CFR03021	CFR03022
Pm-147	1 kBq	~ 410	PHR03021	PHR03022
Tc-99	1 kBq	~ 490	TCR03021	TCR03022
Co-60	185 Bq	~ 90	CKR03011	CKR03012
	1 kBq	~ 480	CKR03021	CKR03022
Cs-137	185 Bq	~ 115	CDR03011	CDR03012
	1 kBq	~ 610	CDR03021	CDR03022
	3 kBq	~ 1830	CDR03031	CDR03032
Cl-36	185 Bq	~ 117	CIR03011	CIR03012
	1 kBq	~ 630	CIR03021	CIR03022
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR03011	SIR03012
	1 kBq	~ 1270	SIR03021	SIR03022
	3 kBq	~ 3800	SIR03031	SIR03032

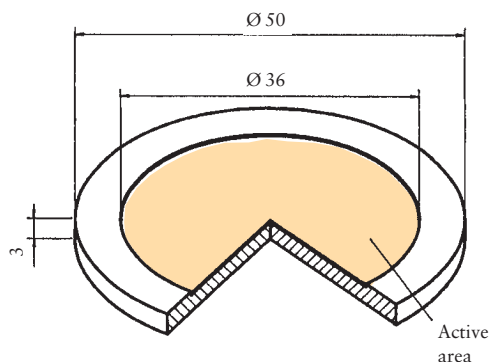
¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1. Wide area reference sources

1.2 Planchet sources



Planchet source: Drawing VZ-1369
 Active diameter: 36mm ~ 10cm²
 Overall dimensions: 50mm diameter x 3mm thick ¹⁾
 Backing plate: Aluminium

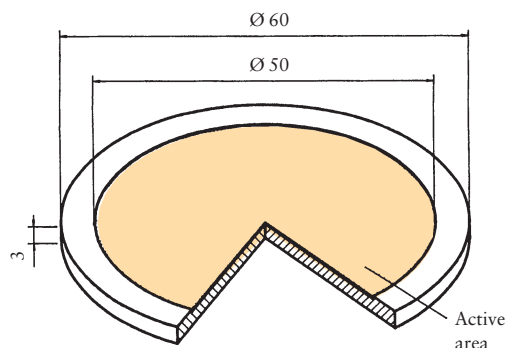
Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR04011	AMR04012
	1 kBq	~ 480	AMR04021	AMR04022
Pu-238	185 Bq	~ 90	PPR04011	PPR04012
Pu-239	100 Bq	~ 50	PIR04011	PIR04012
Th-230	185 Bq	~ 85	TZR04011	TZR04012
	1 kBq	~ 460	TZR04021	TZR04022
Natural U ²⁾ (U-238)	5 Bq	~ 4.6	UAR04011	–
	10 Bq	~ 9.2	UAR04021	–
Beta sources				
H-3	10 kBq	100-300	TRR04011	–
Ni-63	1 kBq	~ 100	NBR04021	–
C-14	1 kBq	~ 380	CFR04021	CFR04022
	3 kBq	~ 1150	CFR04031	CFR04032
Pm-147	185 Bq	~ 75	PHR04011	PHR04012
Tc-99	185 Bq	~ 90	TCR04011	TCR04012
Co-60	185 Bq	~ 90	CKR04011	CKR04012
	1 kBq	~ 480	CKR04021	CKR04022
Cs-137	1 kBq	~ 610	CDR04021	CDR04022
Cl-36	1 kBq	~ 630	CIR04021	CIR04022
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR04011	SIR04012
	1 kBq	~ 1270	SIR04021	SIR04022
	3 kBq	~ 3800	SIR04031	SIR04032

¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1.2 Planchet sources



Planchet source: Drawing VZ-1370
 Active diameter: 50mm ~ 20cm²
 Overall dimensions: 60mm diameter x 3mm thick ¹⁾
 Backing plate: Aluminium

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR05011	AMR05012
	1 kBq	~ 480	AMR05021	AMR05022
	3 kBq	~ 1450	AMR05031	AMR05032
Pu-238	185 Bq	~ 90	PPR05011	PPR05012
Pu-239	50 Bq	~ 25	PIR05011	PIR05012
Th-230	185 Bq	~ 85	TZR05011	TZR05012
	1 kBq	~ 460	TZR05021	TZR05022
Natural U ²⁾ (U-238)	5 Bq	~ 4.6	UAR05011	-
	10 Bq	~ 9.2	UAR05021	-
Beta sources				
H-3	10 kBq	100-300	TRR05011	-
Ni-63	1 kBq	~ 100	NBR05021	-
C-14	1 kBq	~ 380	CFR05021	CFR05022
Pm-147	185 Bq	~ 75	PHR05011	PHR05012
Tc-99	1 kBq	~ 490	TCR05021	TCR05022
Co-60	185 Bq	~ 90	CKR05011	CKR05012
	1 kBq	~ 480	CKR05021	CKR05022
	3 kBq	~ 1450	CKR05031	CKR05032
Cs-137	1 kBq	~ 610	CDR05021	CDR05022
Cl-36	1 kBq	~ 630	CIR05021	CIR05022
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR05011	SIR05012
	1 kBq	~ 1270	SIR05021	SIR05022
	3 kBq	~ 3800	SIR05031	SIR05032

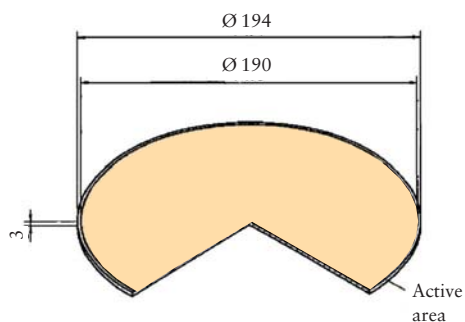
¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1. Wide area reference sources

1.2 Planchet sources



Designed for EG & G Berthold
Alpha-Beta Aerosolmonitor LB 150 D.

Planchet source: Drawing VZ-615
 Active diameter: 190 mm ~283cm²
 Overall dimensions: 194 mm diameter x 3mm height ¹⁾
 Backing plate: Aluminium

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2
Alpha sources				
Am-241	1 kBq	~ 480	AMR11021	AMR11022
Pu-238	1 kBq	~ 480	PPR11021	PPR11022
Th-230	1 kBq	~ 460	TZR11021	TZR11022
Natural U ²⁾ (U-238)	150 Bq	~ 140	UAR11011	UAR11012
Beta sources				
C-14	1 kBq	~ 380	CFR11021	CFR11022
Pm-147	1 kBq	~ 410	PHR11021	PHR11022
Tc-99	1 kBq	~ 490	TCR11021	TCR11022
Co-60	1 kBq	~ 480	CKR11021	CKR11022
Cs-137	1 kBq	~ 610	CDR11021	CDR11022
Cl-36	1 kBq	~ 630	CIR11021	CIR11022
Sr-90/Y-90 ³⁾	1 kBq	~ 1270	SIR01021	SIR11022

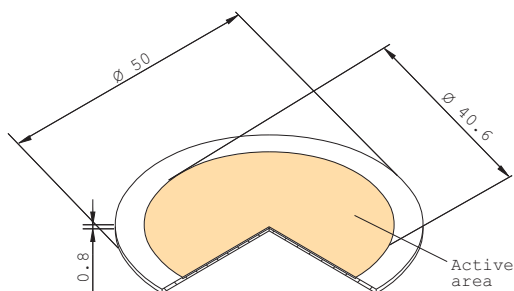
¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

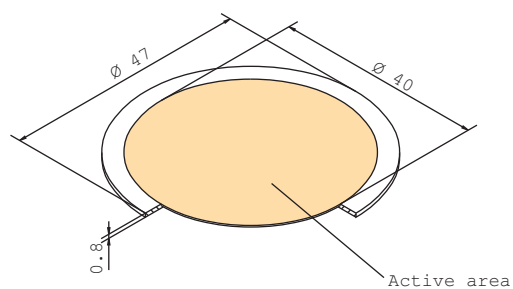
1.2 Planchet sources

Thin sources for continuous-air-monitoring applications



Planchet source: Drawing VZ-1688
 Active diameter: 40.6mm ~13cm²
 Overall dimensions: 50mm diameter x 0.8mm thick ¹⁾
 Backing plate: Aluminium

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMRB5861	AMRB5862
	1 kBq	~ 610	AMRB5863	AMRB5864
Beta sources				
Cs-137	185 Bq	~ 115	CDRB5865	CDRB5866
	1 kBq	~ 610	CDRB5867	CDRB5868
Sr-90/Y-90 ²⁾	185 Bq	~ 235	SIRB5869	SIRB5870
	1 kBq	~ 1270	SIRB5871	SIRB5872
Tc-99	185 Bq	~ 90	TCRB5873	TCRB5874
	1 kBq	~ 490	TCRB5875	TCRB5876
H-3	10 kBq	~ 100 - 300	TRRB3512	-



Planchet source: Drawing VZ-1964
 Active diameter: 40mm ~12.5cm²
 Overall dimensions: 47mm diameter x 0.8mm thick ¹⁾
 Backing plate: Aluminium

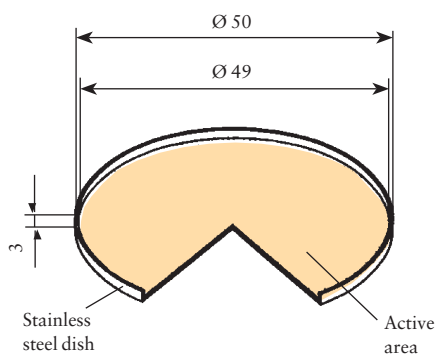
Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMRB5877	AMRB5878
	1 kBq	~ 610	AMRB5879	AMRB5880
Beta sources				
Cs-137	185 Bq	~ 115	CDRB5881	CDRB5882
	1 kBq	~ 610	CDRB5883	CDRB5884
Sr-90/Y-90 ²⁾	185 Bq	~ 235	SIRB5885	SIRB5886
	1 kBq	~ 1270	SIRB5887	SIRB5888
Tc-99	185 Bq	~ 90	TCRB5889	TCRB5890
	1 kBq	~ 490	TCRB5891	TCRB5892
H-3	10 kBq	~ 100-300	TRRB5893	-

¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1. Wide area reference sources

1.3 Dish sources



Dish source: Drawing VZ-1430
 Active diameter: 49 mm ~19cm²
 Overall dimensions: 50mm diameter x 3mm height ¹⁾
 Backing plate: Stainless steel

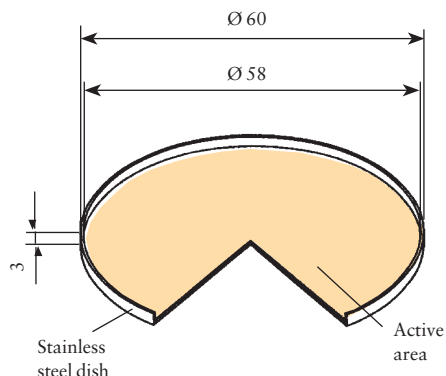
Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR0811	AMR0812
	1 kBq	~ 480	AMR0821	AMR0822
Pu-238	185 Bq	~ 90	PPR0811	PPR0812
Pu-239	185 Bq	~ 90	PIR0811	PIR0812
Th-230	185 Bq	~ 85	TZR0811	TZR0812
Natural U ²⁾ (U-238)	5 Bq	~ 4.6	UAR0811	-
Beta sources				
H-3	10 kBq	100-300	TRR16081	-
Ni-63	185 Bq	~ 85	NBR0811	-
C-14	185 Bq	~ 70	CFR0811	CFR0812
Pm-147	1 kBq	~ 410	PHR0821	PHR0822
Tc-99	185 Bq	~ 90	TCR0811	TCR0812
Co-60	185 Bq	~ 90	CKR0811	CKR0812
	1 kBq	~ 480	CKR0821	CKR0822
Cs-137	185 Bq	~ 115	CDR0811	CDR0812
	1 kBq	~ 610	CDR0821	CDR0822
Cl-36	1 kBq	~ 630	CIR0821	CIR0822
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR0811	SIR0812
	1 kBq	~ 1270	SIR0821	SIR0822

¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1.3 Dish sources



Dish source: Drawing VZ-1431
 Active diameter: 58mm ~26cm²
 Overall dimensions: 60mm diameter x 3mm height¹⁾
 Backing plate: Stainless steel

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR0911	AMR0912
	1 kBq	~ 480	AMR0921	AMR0922
Pu-238	185 Bq	~ 90	PPR0911	PPR0912
Pu-239	185 Bq	~ 90	PIR0911	PIR0912
Th-230	185 Bq	~ 85	TZR0911	TZR0912
	1 kBq	~ 460	TZR0921	TZR0922
Natural U ²⁾ (U-238)	3 kBq	~ 1380	TZR0931	TZR0932
	7.5 Bq	~ 7	UAR0911	UAR0912
Beta sources				
H-3	10 kBq	100-300	TRR16091	–
Ni-63	3 kBq	~ 300	NBR0931	–
C-14	1 kBq	~ 380	CFR0921	CFR0922
Pm-147	1 kBq	~ 410	PHR0921	PHR0922
Tc-99	1 kBq	~ 490	TCR0921	TCR0922
Co-60	185 Bq	~ 90	CKR0911	CKR0912
	1 kBq	~ 480	CKR0921	CKR0922
Cs-137	1 kBq	~ 610	CDR0921	CDR0922
Cl-36	1 kBq	~ 630	CIR0921	CIR0922
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR0911	SIR0912
	1 kBq	~ 1270	SIR0921	SIR0922

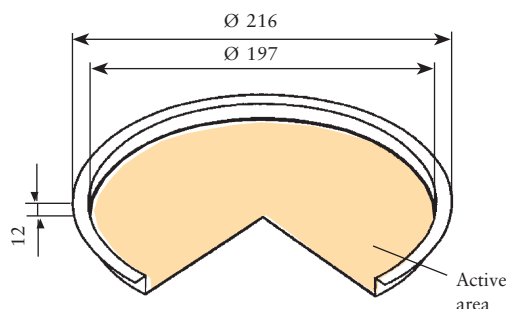
¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1. Wide area reference sources

1.3 Dish sources



Dish source: Drawing VZ-339
 Active diameter: 197mm ~305cm²
 Overall dimensions: 216mm diameter x 12mm height ¹⁾
 Backing plate: Steel

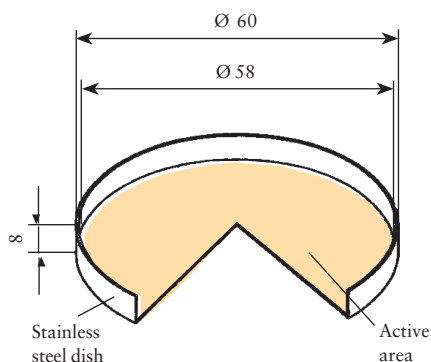
Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2
Alpha sources				
Am-241	185 Bq	~ 90	AMR1011	AMR1012
	1 kBq	~ 480	AMR1021	AMR1022
Pu-238	1 kBq	~ 480	PPR1021	PPR1022
Th-230	1 kBq	~ 460	TZR1021	TZR1022
Natural U ²⁾ (U-238)	150 Bq	~ 140	UAR1011	UAR1012
Beta sources				
C-14	1 kBq	~ 380	CFR1021	CFR1022
Pm-147	1 kBq	~ 410	PHR1021	PHR1022
Tc-99	1 kBq	~ 490	TCR1021	TCR1022
Co-60	1 kBq	~ 480	CKR1021	CKR1022
Cs-137	185 Bq	~ 115	CDR1011	CDR1012
	1 kBq	~ 610	CDR1021	CDR1022
Cl-36	1 kBq	~ 630	CIR1021	CIR1022
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR1011	SIR1012
	1 kBq	~ 1270	SIR1021	SIR1022

1) For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

2) The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

3) For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1.3 Dish sources



Dish source: Drawing VZ-1392
 Active diameter: 58mm ~26cm²
 Overall dimensions: 60mm diameter x 8mm height ¹⁾
 Backing plate: Stainless steel

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources				
Am-241	185 Bq	~ 90	AMR1411	AMR1412
10-sources-set	10 kBq/set	~ 480/source	QCR1421	QCR1422
4-sources-set	4 kBq/set	~ 480/source	QCR1441	QCR1442
Pu-238	185 Bq	~ 90	PPR1411	PPR1412
Natural U ²⁾ (U-238)	7.5 Bq	~ 7	UAR1411	UAR1412
Beta sources				
C-14	185 Bq	~ 70	CFR1411	CFR1412
Pm-147	185 Bq	~ 75	PHR1411	PHR1412
Tc-99	185 Bq	~ 90	TCR1411	TCR1412
Co-60	185 Bq	~ 90	CKR1411	CKR1412
Cs-137	185 Bq	~ 115	CDR1411	CDR1412
Cl-36	185 Bq	~ 117	CIR1411	CIR1412
Sr-90/Y-90 ³⁾	185 Bq	~ 235	SIR1411	SIR1412
10-sources-set	10 kBq/set	~ 480/source	QCR1431	QCR1432
4-sources-set	4 kBq/set	~ 480/source	QCR1451	QCR1452

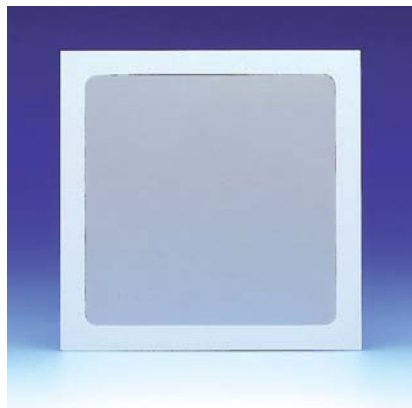
¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

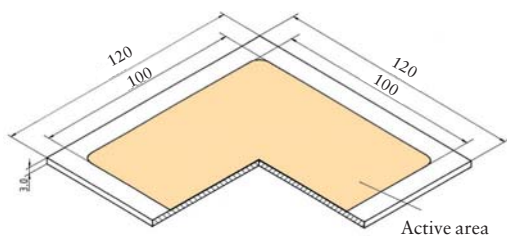
³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1. Wide area reference sources

1.4 Rectangular sources



Planar source: Drawing VZ-626
 Active dimensions: 100mm x 100mm ~100cm²
 Overall dimensions: 120mm x 120mm x 3mm thick ¹⁾
 Backing plate: Aluminium



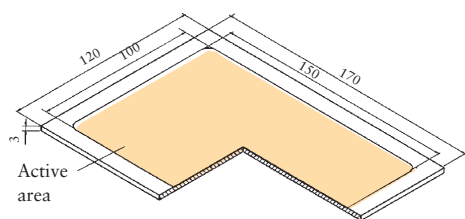
Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2
Alpha sources				
Am-241	185 Bq	~ 90	AMR06011	AMR06012
	1 kBq	~ 480	AMR06021	AMR06022
	3 kBq	~ 1450	AMR06031	AMR06032
Pu-238	1 kBq	~ 480	PPR06021	PPR06022
Pu-239	50 Bq	~ 25	PIR06011	PIR06012
	1 kBq	~ 500	PIR06021	PIR06022
Th-230	185 Bq	~ 85	TZR06011	TZR06012
	1 kBq	~ 460	TZR06021	TZR06022
Natural U ²⁾ (U-238)	25 Bq	~ 23	UAR06011	UAR06012
	50 Bq	~ 46	UAR06021	UAR06022
	100 Bq	~ 92	UAR06031	UAR06032
Beta sources				
H-3	100 kBq	800-2500	TRR16061	–
Ni-63	1 kBq	~ 100	NBR06021	–
C-14	1 kBq	~ 380	CFR06021	CFR06022
	3 kBq	~ 1150	CFR06031	CFR06032
Pm-147	1 kBq	~ 410	PHR06021	PHR06022
Tc-99	1 kBq	~ 490	TCR06021	TCR06022
	3 kBq	~ 1470	TCR06031	TCR06032
Co-60	1 kBq	~ 480	CKR06021	CKR06022
	3 kBq	~ 1450	CKR06031	CKR06032
Cs-137	1 kBq	~ 610	CDR06021	CDR06022
	3 kBq	~ 1830	CDR06031	CDR06032
Cl-36	1 kBq	~ 630	CIR06021	CIR06022
	3 kBq	~1900	CIR06031	CIR06032
Sr-90/Y-90 ³⁾	1 kBq	~ 1270	SIR06021	SIR06022
	3 kBq	~ 3800	SIR06031	SIR06032

¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1.4 Rectangular sources



Planar source: Drawing VZ-628
 Active dimensions: 100mm x 150mm ~150cm²
 Overall dimensions: 120mm x 170mm x 3mm thick ¹⁾
 Backing plate: Aluminium

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2
Alpha sources				
Am-241	1 kBq	~ 480	AMR07021	AMR07022
	3 kBq	~ 1450	AMR07031	AMR07032
Pu-238	185 Bq	~ 90	PPR07011	PPR07012
	1 kBq	~ 480	PPR07021	PPR07022
Pu-239	50 Bq	~ 25	PIR07011	PIR07012
	1 kBq	~ 500	PIR07021	PIR07022
Th-230	185 Bq	~ 85	TZR07011	TZR07012
	1 kBq	~ 460	TZR07021	TZR07022
Natural U ²⁾ (U-238)	50 Bq	~ 46	UAR07011	UAR07012
	100 Bq	~ 92	UAR07021	UAR07022
Beta sources				
H-3	100 kBq	800-2500	TRR17061	-
Ni-63	1 kBq	~ 100	NBR07021	-
C-14	1 kBq	~ 380	CFR07021	CFR07022
	3 kBq	~ 1150	CFR07031	CFR07032
Pm-147	1 kBq	~ 410	PHR07021	PHR07022
Tc-99	1 kBq	~ 490	TCR07021	TCR07022
	3 kBq	~ 1470	TCR07031	TCR07032
Co-60	1 kBq	~ 480	CKR07021	CKR07022
	3 kBq	~ 1450	CKR07031	CKR07032
Cs-137	185 Bq	~ 115	CDR07011	CDR07012
	1 kBq	~ 610	CDR07021	CDR07022
	3 kBq	~ 1830	CDR07031	CDR07032
Cl-36	185 Bq	~ 117	CIR07011	CIR07012
	1 kBq	~ 630	CIR07021	CIR07022
	3 kBq	~ 1900	CIR07031	CIR07032
Sr-90/Y-90 ³⁾	1 kBq	~ 1270	SIR07021	SIR07022
	3 kBq	~ 3800	SIR07031	SIR07032

¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

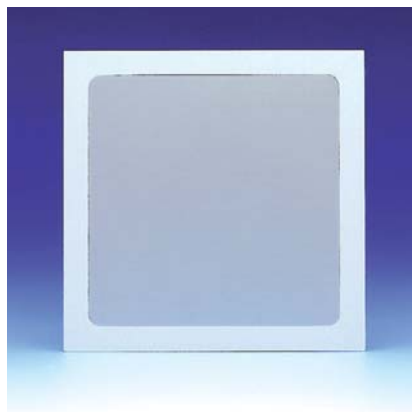
²⁾ The natural uranium source contains the uranium isotopes U-234, U-235 and U-238 (daughter nuclides below U-234 have been removed by a radiochemical separation procedure). U-238 is in equilibrium with U-234; the certificate states only the activity of the U-238 parent. The alpha surface emission rate consists of the emission rates of all uranium isotopes.

³⁾ For Sr-90/Y-90 sources, the activity quoted on the certificate is that of the Sr-90 parent only. The emission rate quoted is from both nuclides, so the activity is approximately equal to the emission.

1. Wide area reference sources

1.5 Photon sources

Photon reference sources



The sources described below are designed to meet the requirements of ISO8769 part 2. The sources are used to characterise and calibrate surface contamination monitors for photon emitting radionuclides such as Ga-67, In-111 and Tl-201.

Active dimensions: 100mm x 100mm

Overall dimensions: 150mm x 150mm x 3mm height

Further details of these standards are given in section 9.4.

The photon emission is calibrated at AWE Aldermaston.

Nuclide	Energy [keV]	Filter	Nominal activity [kBq]	Drawing	Product code
Fe-55	6	None	40	VZ-1658	IERB4536
Pu-238	17	32.5 mg/cm ² zirconium	200	VZ-1775	PPRB4472
I-129	32	81 mg/cm ² aluminium	30	VZ-1898	ISRB4474
Am-241	60	200 mg/cm ² stainless steel	40	VZ-1776	AMRB4473
Co-57	124	200 mg/cm ² stainless steel	35	VZ-1776	CTRB 3504
Cs-137	662	800 mg/cm ² stainless steel	10	VZ-2162	CDRB4475
Co-60	1200	81 mg/cm ² aluminium	5	VZ-1898	CKRB4476

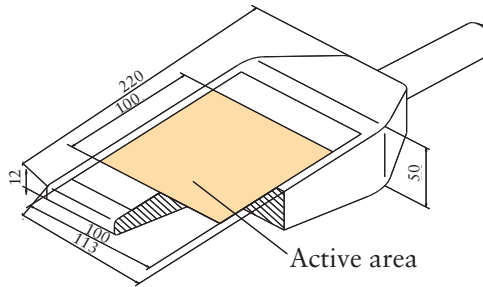
Other photon emitting standards

The sources listed in the table are a range of photon emitting radionuclides. The certificate of calibration states the activity of the source and not the emission.

Nuclide	Nominal activity [kBq]	Drawing	Active dimensions [mm]	Overall dimensions [mm]	Product code DKD certificate
Planchet type					
Fe-55	3	VZ-1366	diameter: 16	diameter: 25	IER01032
Co-57	3			height: 3	CTR01032
I-129	1	VZ-2130	diameter: 32	diameter: 50	ISRB5894
				height: 3	
Planar type					
Fe-55	3	VZ-626	100 x 100	120 x 120	IER06032
	10			height: 3	IER06102
Co-57	3				CTR06032
I-129	3	VZ-1957	100 x 100	120 x 120	ISRB5895
	10			height: 5	ISRB4180
Fe-55	3	VZ-628	100 x 150	120 x 170	IER07032
	10			height: 3	IER07102
Co-57	3				CTR07032
I-129	3	VZ-1958	100 x 150	120 x 170	ISRB5896
	10			height: 5	ISRB5897
Dish type					
Fe-55	3	VZ-1430	diameter: 49	diameter: 50	IER08032
Co-57	3			height: 3	CTR08032
Fe-55	3	VZ-1431	diameter: 58	diameter: 60	IER09032
Co-57	3			height: 3	CTR09032

1.6 Reference sources - hand and ladder type

Alpha/beta hands



Alpha/beta hand sources are used for calibrating and checking hand monitors. The activated foil is mounted on one side of the aluminium hand¹⁾.

Drawing: VZ-1614-001
 Active dimensions: 100mm x 100mm
 Overall dimensions: 113mm x 310mm x 50mm

Nuclide	Nominal activity	Particle emission rate [1/s]	Product code
Alpha source			
Am-241	1 kBq	~ 480	AMRB5929
Beta sources			
C-14	1 kBq	~ 380	CFRB5930
Cl-36	1 kBq	~ 630	CIRB5931
Co-60	1 kBq	~ 480	CKRB5932
Cs-137	1 kBq	~ 610	CDRB5933
Sr-90	1 kBq	~ 1270	SIRB5934
Tc-99	1 kBq	~ 490	TCRB5935

Ladder sources



These sources are designed for calibrating NE Technology whole body monitors²⁾.

Drawing: VZ-1634
 Active dimensions: each source 100mm x 100mm (6 sources)
 Overall dimensions: 2020mm x 267mm

Nuclide	Nominal activity per source	Total activity	Product code ³⁾
Cs-137	each 920 Bq	5.52 kBq	CDRX1878
Co-60	each 1.33 kBq	8 kBq	CKRX1916

¹⁾ For other nuclides, activities and dimensions please enquire using the faxback form on page 34. The activated foils can also be mounted on both sides of the wooden hand.

²⁾ For other types (dimensions, nuclides and activities) of ladder sources please enquire using the faxback form on page 32.

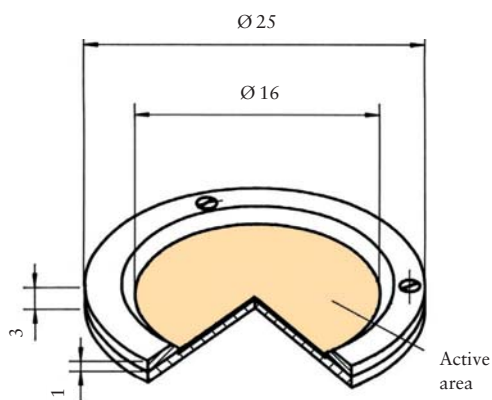
³⁾ These sources have been designed particularly for the type IPM8A/IPM8D.

1. Wide area reference sources

1.7 Beta reference sources (high activity type)



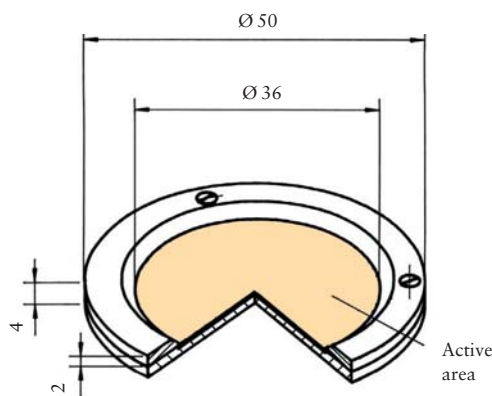
Planchet source: Drawing VZ-599
 Active diameter: 16mm ~2cm²
 Overall dimensions: 25mm diameter x 3mm thick ¹⁾
 Backing plate: Aluminium



Nuclide	Nominal activity	Product code
Tc-99	37 kBq	TCR1211
Co-60	37 kBq 370 kBq	CKR1211 CKR1221
Cs-137	37 kBq 370 kBq	CDR1211 CDR1221
Cl-36	37 kBq	CIR1211
Tl-204	37 kBq 370 kBq	TER1211 TER1221
Sr-90/Y-90	37 kBq 370 kBq	SIR1211 SIR1221

Note:
 These sources are calibrated for activity. The emission rate is not calibrated.

Planchet source: Drawing VZ-605
 Active diameter: 36mm ~10cm²
 Overall dimensions: 50mm diameter x 4mm thick ¹⁾
 Backing plate: Aluminium



Nuclide	Nominal activity	Product code
Tc-99	37 kBq	TCR1311
Co-60	37 kBq 370 kBq	CKR1311 CKR1321
Cs-137	37 kBq 370 kBq	CDR1311 CDR1321
Cl-36	37 kBq	CIR1311
Tl-204	37 kBq 370 kBq	TER1311 TER1321
Sr-90/Y-90	37 kBq 370 kBq	SIR1311 SIR1321

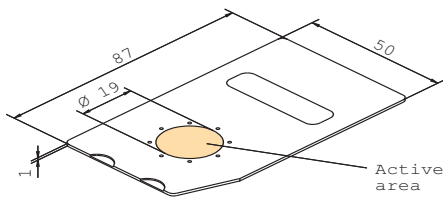
¹⁾ For other nuclides, activities and dimensions please enquire using the fax back form on page 32.

1.8 Sources for Harwell Instruments monitors

The sources listed below have been specially designed for calibrating and validating monitors manufactured by Harwell Instruments. The instruments are used for monitoring airborne contamination and surface contamination. Instructions on using the sources are given in the relevant instrument handbook.

Sources are available for use with the following instruments:

Instrument	Models
Alpha and beta in air monitors	3280, A85, 3230, B96, A96 & AB96
Stack monitors	A31, B31
Drawer units	SC100, AB12
Filter paper scanners	AB14
Portable monitors	SC100 wound probe, B84 low energy beta probe
Tritium smear monitor	T13



Alpha/Beta air monitors

Source: Drawing VZ-2020 (except for SIRB3516 - drawing VZ-2029)
 Active diameter: 19mm ~ 2.8cm²
 Overall dimensions: 87mm x 50mm x 1mm height
 Backing plate: Stainless steel

Instrument type	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources					
A96 AB96	Am-241	320 Bq		AMRB3135	AMRB3518
A85(3280)	Pu-239	2 Bq 20 Bq		PIRK7430 PIRB3125	- PIRB3517
Beta sources					
B86(3230)	Sr-90	988 Bq 2000 Bq	~ 1250 ~ 2500	SIRB3090 SIRB3091	SIRB3021 SIRB3022
B96 AB96	Cl-36	14200 Bq 198 Bq 396 Bq	~ 15000 ~ 125 ~ 250	SIRB3516 CIRB3088 CIRB3089	- CIRB3028 CIRB3029

1.8 Sources for Harwell Instruments monitors

Stack monitors

Harwell Instruments source:
Drawing VZ-2020

Active diameter:
19mm ~ 2.8cm²

Overall dimensions:
87mm x 5mm x 1mm height

Backing plate:
Stainless steel

Instrument	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class	Product code DKD certificate class 2 equivalent
Alpha sources					
A31	Am-241	320 Bq		AMRB3135	AMRB3518
Beta sources					
B31	Sr-90	988 Bq	~ 1250	SIRB3090	SIRB3021

Drawer units

Planchet source:
Drawing VZ-1370

Active diameter:
50mm ~ 20cm²

Overall dimensions:
60mm diameter x 3mm height

Backing plate:
Aluminium

Instrument	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code DKD certificate class 2 equivalent
Alpha sources				
SC100	Am-241	1 kBq	~ 480	AMR05022
Beta sources				
SC100	Cl-36	1 kBq	~ 630	CIR05022
Alpha and Beta sources				
AB12	Am-241	1 kBq	~ 480	AMR05022
	Cl-36	1 kBq	~ 630	CIR05022

Filter paper scanners

Planchet source:
Drawing VZ-1366

Active diameter:
16mm ~ 2cm²

Overall dimensions:
25mm diameter x 3mm height

Backing plate:
Aluminium

Instrument	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code DKD certificate class 2 equivalent
Alpha and Beta sources				
AB14 (25mm SAS)	Am-241	1 kBq	~ 480	AMR01022
	Cl-36	0.5 kBq	~ 315	CIR01022
AB14 (25mm PAS)	Am-241	1 kBq	~ 480	AMR01022
	Cl-36	0.5 kBq	~ 315	CIR01022

1.8 Sources for Harwell Instruments monitors

Filter paper scanners

Planchet source:
Drawing VZ-1370

Active diameter:
50mm ~ 20cm²

Overall dimensions:
60mm diameter x 3mm height

Backing plate:
Aluminium

Instrument	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code DKD certificate class 2 equivalent
Alpha and Beta sources				
AB14 (50mm SAS)	Am-241	1 kBq	~ 480	AMR05022
	Cl-36	1 kBq	~ 630	CIR05022

Hand held instruments

Planchet source:
Drawing VZ-1370

Active diameter:
50mm ~ 20cm²

Overall dimensions:
60mm diameter x 3mm height

Backing plate:
Aluminium

Instrument	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class
Alpha and Beta sources				
SC100	Am-241	1 kBq	~ 480	AMR05021
	Cl-36	1 kBq	~ 630	CIR05021

Planchet source:
Drawing VZ-1366

Active diameter:
16mm ~ 2cm²

Overall dimensions:
25mm diameter x 3mm height

Backing plate:
Aluminium

Instrument	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class
Beta source				
B84	Cl-36	0.5 kBq	~ 315	CIR01021

Tritium smear monitor

Planchet source:
Drawing VZ-497

Active diameter:
49mm ~ 19cm²

Overall dimensions:
50mm diameter x 1.5mm height

Backing plate:
Aluminium

Instrument	Nuclide	Nominal activity	Particle emission rate [1/s]	Product code EZN certificate working class
Beta source				
T13	H-3	10 kBq	100-300	TRRK6400

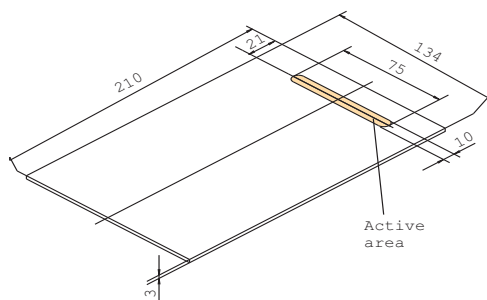
1. Wide area reference sources

1.9 Tritium reference sources



These wide area tritium sources are designed for the calibration and routine checking of tritium surface contamination monitoring equipment. Due to the extremely short range of Tritium (H-3) beta particles in air (approximately 4mm), the direct measurement of H-3 must be undertaken with great care. Therefore it is important to check the correct function of the detector using a suitable H-3 source immediately prior to measurement. These tritium sources are electrically conducting and do not suffer from the build up of electrostatic charge that can cause measurement problems. The thickness of the activated layer is approximately 3 microns. Tritium wide area reference sources are calibrated for β -emission only, not for activity.

Planar source for Eberline/ FAG tritium contamination monitor FHT 111M

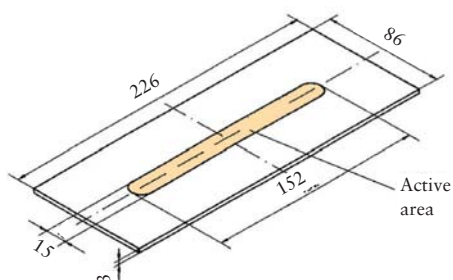


Drawing: VZ-1610¹⁾
Active dimensions: 10mm x 75mm
Overall dimensions: 134mm x 210mm
Backing plate: Aluminium

Radionuclide	Nominal activity	β -emission rate [1/s]	Product code
H-3	10 kBq	100 - 300	TRRB1951



Planar source for Berthold tritium contamination monitor LB 6255



Drawing: VZ-1516¹⁾
Active dimensions: 15mm x 152mm
Overall dimensions: 86mm x 226mm
Backing plate: Aluminium

Radionuclide	Nominal activity	β -emission rate [1/s]	Product code
H-3	10 kBq	100 - 300	TRR16161

¹⁾ For other activities and dimensions please see also pages 11 to 23.

If the wide area reference source required is not shown in this catalogue, Eckert & Ziegler Nuclitec GmbH will try to assist you.

Please photocopy the form on the next page, fill in the details as far as possible, and fax the form to your local Eckert & Ziegler Nuclitec GmbH office.

Alternatively, contact us by e-mail on:

infoisotrak@ezag.com

or visit our Internet page at:

<http://www.nuclitec.de>

We will reply via your local Eckert & Ziegler Nuclitec GmbH office.

Enquiry Form

To: Your local Eckert & Ziegler Nuclitec GmbH office for forwarding the isotrak Technical Service

From: Name: _____
Institute/company _____
Address: _____

Country: _____
Tel: _____
Fax: _____
E-mail: _____

Date: _____

Nuclide: _____

Calibrated for: activity/emission/both (delete as applicable)

Emission required: _____ particles per second
or

Activity required: _____ Bq or _____ nCi (note: The activity tolerance is normally $\pm 30\%$.)

Tolerance required: _____

Certificate of calibration: DKD/Eckert & Ziegler Nuclitec GmbH (delete as applicable)

Active dimensions: _____

Dimensions of backing plate: _____ Material: _____

(note: it is often possible to fix sources to holders supplied by yourselves)

Please include sketch or technical drawing if possible.

Number of sources required: _____

Please write here a brief description of the application of the source, type of instrument to be calibrated and indicate if the source will be subject to extreme conditions (for example, high temperature/vibration/humidity/corrosive atmosphere). This may help us to offer alternative sources if we cannot manufacture to your exact specification.

INSTRUMENT CHECK SOURCES

This section shows single or mixed radionuclide sources which have been developed to check the correct functioning of

radiation measurement equipment such as surface contamination monitors, survey dosimeters and personal dosimeters. Stainless steel encapsulated sources are also available for instrument checking and oil well logging devices. For calibration standards, see sections 1 and 3. If a modified source of this type is required, please send us your specification using the form at the end of this section.



Alpha-, beta-, gamma-check sources	35
Low energy check sources	38
Neutron source	39
Oil well logging source	40
Stainless steel encapsulated sources	41
Form to request custom source	45



Certification

Each source is supplied with a certificate which states the nominal activity and leakage test results.

Quality assurance

The sources are manufactured in a facility that operates a quality management system that has been independently audited and approved to ISO9001:1994.

Applications

All radiation detection instruments should be checked daily to ensure that they are working correctly. These daily checks are sometimes obligatory under national regulations.

The sources in this section offer a cost-effective and convenient method to perform functionality checks on the following types of instrument:

- Portable contamination monitors: pages 35 to 38
- Survey dosimeters: pages 35 to 38

Note: These sources are uncalibrated and can only be used for checking that the instrument is operating correctly and is stable.

ISO classification

The International Organization for Standardization has published a classification of sealed sources based on safety requirements of typical usage. The source types have been assessed to ISO2919 which is equivalent to ANSI N542-1977.

Useful working life

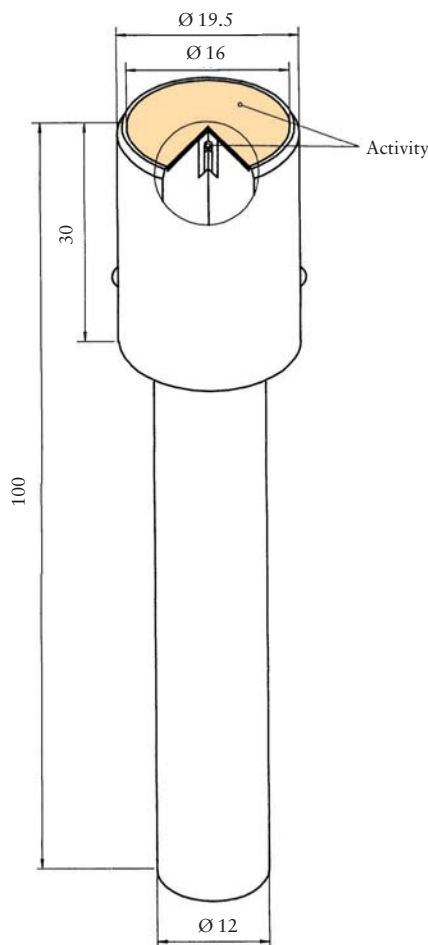
Regular improvements in source design mean that it would be good working practice to renew the sources every 10 years. Sources may be cleaned by wiping the surfaces with a lint free cloth with alcohol (detergents or abrasive compounds such as metal polish should not be used).

Availability

Sources are normally delivered within 6 weeks of receipt of order.

2.2 Check sources for contamination monitors and survey dosimeters

Mixed nuclide check sources



Application

These sources emit alpha-, beta- and gamma-radiation for checking the operation of surface contamination monitors and survey dosimeters. The advantages are

Cost effective	-one source type can be used for all monitors on site
Convenient	-saves specifying 3 or more sources
Compact	-saves carrying sets of sources

Construction

The source is constructed from 3 active components (drawing: VZ-1444). Am-241 is incorporated in the surface of an anodized aluminium foil, and mounted at the top of the source. A Sr-90 foil is constructed in the same way and mounted below the Am-241 foil. An ion-exchange resin bead impregnated with Cs-137 is glued into an inner capsule and mounted under the foils.

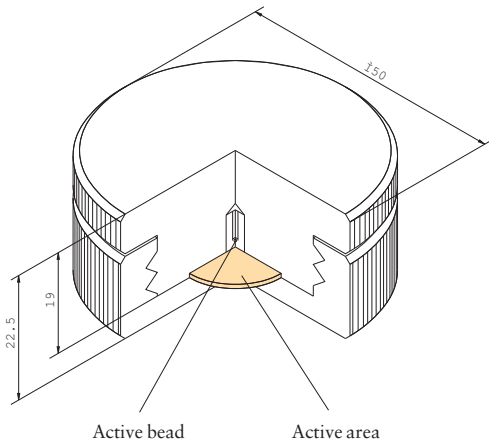
The casing is constructed from black anodized aluminium and the source is supplied in a lightweight storage case. A plastic cap is supplied to protect the surface of the source when not in use.

Ordering information

Radionuclides	Nominal activity [kBq]	Particle emission rate	Product code
Am-241	0.8	400 alphas/s	QCRB1282
Sr-90	0.5	150 betas/s	
Cs-137	15	Gamma radiation	

2. Instrument check sources

2.2 Check sources for contamination monitors and survey dosimeters



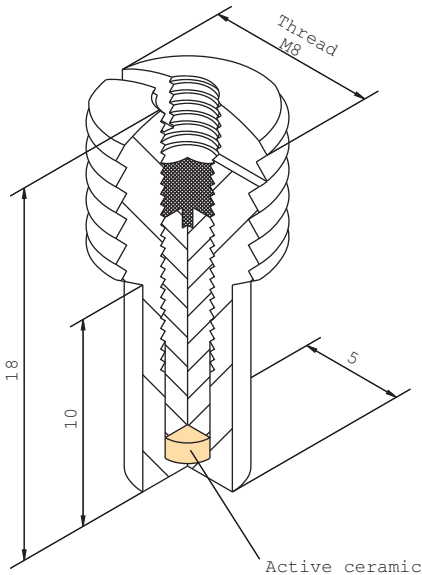
Construction

The source is constructed from 3 active components (drawing: VZ-2263). Am-241 is incorporated in the surface of an anodized aluminium foil, and mounted at the top of the source. A Sr-90 foil is constructed in the same way and mounted below the Am-241 foil. An ion-exchange resin bead impregnated with Cs-137 is glued into an inner capsule and mounted under the foils.

The casing is constructed from aluminium. An aluminium cover screws in place over the source to protect the surface of the source when not in use.

Ordering information

Radionuclides	Nominal activity [kBq]	Particle emission rate	Product code
Am-241	0.14	70 alphas/s	QCRB5203
Sr-90	2	2200 betas/s	
Cs-137	15	Gamma radiation	



Construction

The Cs-137 activity is incorporated into a ceramic pellet which is mounted in a brass capsule. The head of the capsule has an M8 thread, and a slot for a screwdriver so that the source can be mounted easily into a jig.

The sources meet the requirements of standard DIN44427 'Test source with container - Materials, dimensions and marking'.

ISO classification

C.33323 Drawing: VZ-269

Ordering information

Radionuclide	Nominal activity [kBq]	Product code
Cs-137	37	CDR11
Cs-137	370	CDR12
Cs-137	3700	CDR13

2.2 Check sources for contamination monitors and survey dosimeters

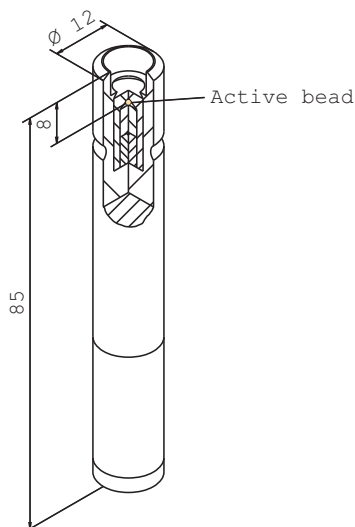
Cs-137 check sources for survey dosimeters**Application**

These sources can be used for functionality checking of dose and dose-rate survey meters.

Construction

The Cs-137 activity is incorporated into an ion exchange resin bead which is enclosed in a stainless steel capsule sealed into an aluminium holder. The source is supplied with an aluminium shielded container.

For other nuclides more detailed information is available on pages 129 and 130.

**ISO classification**

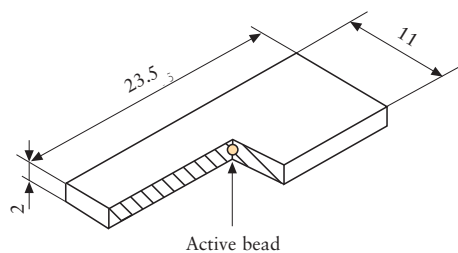
C.23312 Drawing: VZ-296 and storage container VZ-297

Ordering information

Radionuclide	Nominal activity [kBq]	Product code
Cs-137	370	CDR82902

2. Instrument check sources

2.3 Low energy check sources for surface contamination monitors



ISO classification

C.34343
Drawing: VZ-1240

Application

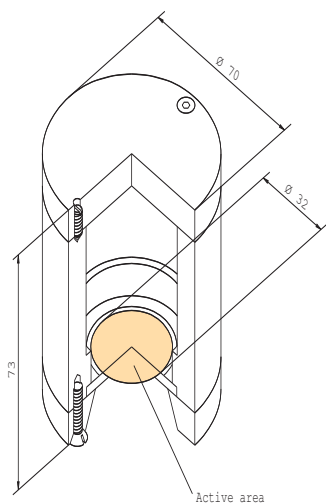
These sources can be used to check the performance of surface contamination monitors designed for detecting low energy photon-emitting radionuclides such as I-129, Cr-51 etc.. The photons emitted by Fe-55 are close in energy to the low energy threshold of these monitors, so a check using an Fe-55 source is a sensitive method to identify any faults with the equipment (eg., drifts in the high voltage applied to the detector).

Construction

The source consists of an ion exchange resin bead mounted in a solid plastic holder.

Ordering information

Radionuclide	Nominal activity [MBq]	Product code
Fe-55	1.85	IER15510



Fe-55 test source and jig for Mini Instruments 44B probe

This source and jig are intended for daily performance checks on Mini Instruments 44B monitors. The jig positions the detector at an accurately reproducible distance from the source so that long term drifts in instrument response can be recorded.

Construction

The Fe-55 active deposit is heat-sealed between two plastic foils which are mounted on an aluminium backing plate. The source is then placed into a robust Teflon jig, with a protective rotating cover.

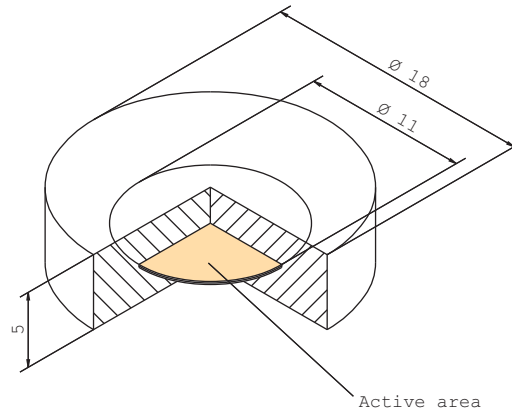
Ordering information

Radionuclide	Description	Nominal activity [kBq]	Product code
Fe-55	Source and jig to drawings VZ-2044 and VZ-2012	70	IERB3621
Fe-55	Replacement source to drawing VZ-2044	70	IERB3748

2.4 Neutron source

Application

These Am-241/Be sources are designed for the functionality checking of neutron dosimeters. The source produces a neutron flux, which simulates a neutron background which allows the dosimeter's measurement function to be checked.

**ISO classification**

C.34313
Drawing: VZ-342

Construction

The Am-241 activity is fixed between 2 beryllium discs 11 mm in diameter and 1mm thick and sealed into a plastic capsule 18mm in diameter and 5mm thick.

Ordering information

Radionuclide	Nominal activity [MBq]	Product code
Am-241/Be	3.33	AMNB3423

2. Instrument check sources

2.5 Sources for particular applications

Application

These calibrated sources have been designed for routine checking and calibration of radiation detection instrumentation eg.

- Gamma dosimeters
- Survey meters
- Radiation alarms
- Oil well logging devices



High pressure tested sources

Construction

The Cs-137 is fixed in a glass matrix and sealed by welding the glass between two stainless steel discs. This inner capsule is welded into an outer stainless steel capsule. The overall dimensions are 12.7mm diameter x 3.2mm. The active diameter is 5.8mm.

These sources meet the requirements for oil well logging sources and each source is pressure tested to 25,000psi.

ISO classification

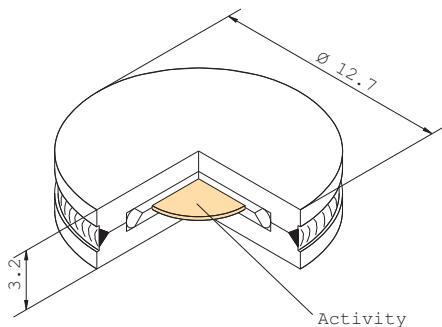
C.66646

Drawing: VZ-2134

The IDNS model number is CDC.PLS.

Certification

Each source is supplied with a Eckert & Ziegler Nuclitec certificate of measurement.

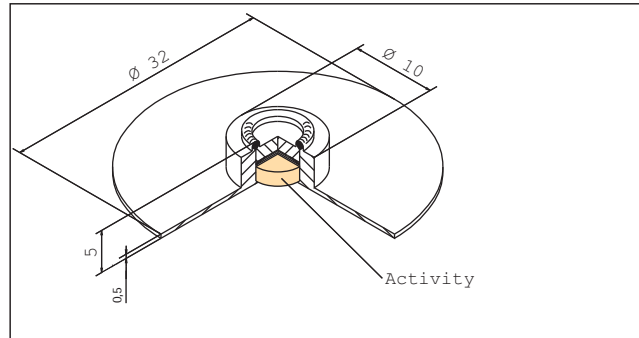


Ordering information

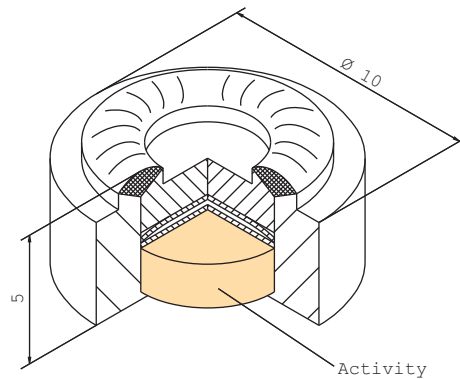
Radionuclide	Nominal activity		Product code
	[kBq]	[nCi]	
Cs-137	18.5	500	CDRB4399
Cs-137	30.0	810	CDRB5517
Cs-137	59.2	1600	CDRB4400

2.5 Sources for particular applications

Calibrated gamma point sources



VZ-542



VZ-543

Construction

The activity is in the form of a ceramic disc, fixed with a bronze spring and welded into an stainless steel capsule (drawing VZ-543). In case of drawing VZ-542 this capsule is mounted on a stainless steel disc.

The overall dimensions of the capsule are 10mm diameter x 5mm. The dimensions of the stainless steel plate are 32mm diameter x 0.5mm.

ISO classification

C.66543
Drawing: VZ-542

Certification

Each source is supplied with a Eckert & Ziegler Nuclitec certificate of measurement.

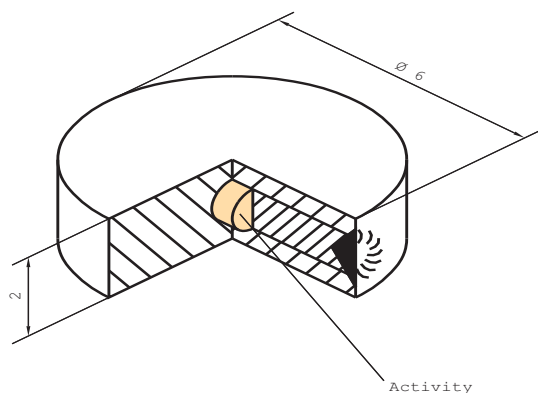
Ordering information

Radionuclide	Drawing	Nominal activity [kBq]	Product code
Am-241	VZ-542	1850	AMRK6140
Cs-137	VZ-542	1850	CDRK5800
Cs-137	VZ-542	33.3	CDRQ6986
Co-60	VZ-542	555	CKRK6141
Cs-137	VZ-543	37	CDRK4853

2. Instrument check sources

2.5 Sources for particular applications

Calibrated gamma point sources



ISO classification

C.65344
Drawing: VZ-2936-001

Construction

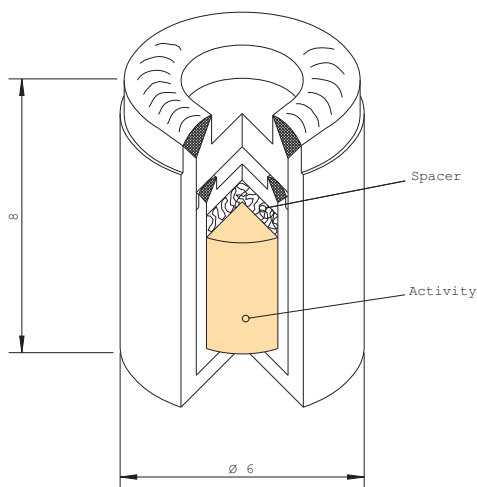
Cs-137 in the form of a ceramic pellet is welded into a stainless steel capsule. The overall dimensions are 6mm diameter x 2mm thick.

Certification

Each source is supplied with a Eckert & Ziegler Nuclitec certificate of measurement.

Ordering information

Radionuclide	Nominal activity [kBq]	Product code
Cs-137	37	CDRB3078



Calibrated welded Cs-137 gamma point sources

Construction

Cs-137 in the form of a ceramic disc is welded into an inner stainless steel capsule. The inner capsule is mounted into an outer stainless steel capsule. The overall dimensions are 6mm diameter x 8mm.

ISO classification

C.64444 Drawing: VZ-130
The IDNS model number is CDC.P1.

Certification

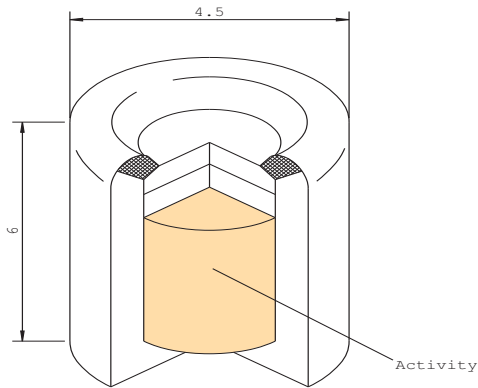
Each source is supplied with a Eckert & Ziegler Nuclitec certificate of measurement.

Ordering information

Radionuclide	Nominal activity [kBq]	Product code
Cs-137	37	CDRB5947
Cs-137	370	CDRB5948
Cs-137	3700	CDRB5949

2.5 Sources for particular applications

Calibrated robust Cs-137 gamma point sources



ISO classification

C.66445
Drawing: VZ-1145

Construction

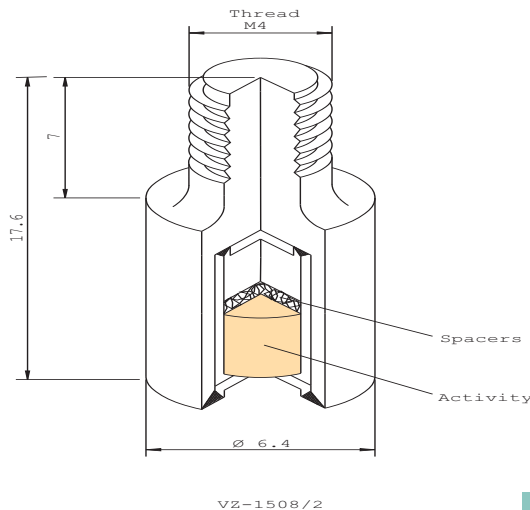
Cs-137 in the form of a ceramic pellet is welded into a stainless steel capsule. The overall dimensions are 4.5mm diameter x 6mm long.

Certification

Each source is supplied with a Eckert & Ziegler Nuclitec certificate of measurement.

Ordering information

Radionuclide	Nominal activity [kBq]	Product code
Cs-137	37	CDRB5952
Cs-137	370	CDRB5953
Cs-137	3700	CDRB5954



Calibrated robust Cs-137 point sources with thread

Construction

Cs-137 in the form of a ceramic disc is welded into an inner stainless steel capsule. The inner capsule is mounted into an outer stainless steel capsule which has an M4 thread on the top of the source. The overall dimensions are 6.4mm diameter x 17.6mm.

ISO classification

C.66646

Drawing: VZ-2733

Ordering information

Radionuclide	Nominal activity [kBq]	Product code
Cs-137	37	CDRB5950
Cs-137	370	CDRB3542
Cs-137	3700	CDRB5951

Certification

Each source is supplied with a Eckert & Ziegler Nuclitec certificate of measurement.

2.6 Custom preparation service

If the check source required is not shown in this catalogue, Eckert & Ziegler Nuclitec GmbH will try to assist you.

Please photocopy the form on the opposite page, fill in the details as far as possible, and fax the form to your local Eckert & Ziegler Nuclitec GmbH office.

Alternatively, contact us by e-mail on:

infoisotrak@ezag.com

or visit our internet page at:

<http://www.nuclitec.de>

We will reply via your local Eckert & Ziegler Nuclitec GmbH office.

Request for custom check source

Enquiry Form

To: Your local Eckert & Ziegler Nuclitec GmbH office for forwarding the isotrak Technical Service

From: Name: _____
 Institute/company _____
 Address: _____

 Country: _____
 Tel: _____
 Fax: _____
 E-mail: _____

Date: _____

Please send me a quotation for the following check source:

Radionuclide: _____

Nominal emission required: _____ particles/second

or

Nominal activity required: _____ Bq or _____ nCi

Active dimensions: _____

Dimensions of backing _____

plate holder: _____ (note: it is sometimes possible to fix sources to holders supplied by yourselves)

Please write here a brief description of the application of the source, type of instrument to be checked and indicate if the source will be subject to extreme conditions (for example, high temperature/vibration/humidity/corrosive atmosphere). This may help us to offer alternative sources if we cannot manufacture to your exact specification.

POINT AND TUBE SOURCES (GAMMA AND ELECTRON EMITTERS)

A wide range of gamma-ray and electron emitting reference sources of different geometries is described in this section. The

single radionuclide point sources or source sets containing up to 9 different radionuclides are used for calibrating gamma-ray spectrometers and gamma counters. Mixed radionuclide, X-ray and conversion electron sources are also available to cover a wide energy range for different detectors. If a modified source of this type is required, please send us your specification using the form at the end of this section.



Point sources (rectangular type)	50
Point sources (disc type)	52
Mixed nuclide sources (thin foil type)	54
X-ray sources	57
Conversion electron sources	59
Tube type sources	60
Form to require custom source	63

3. Point and tube sources (gamma and electron emitters)

3.1 General information

Applications

These gamma reference sources are designed for calibrating and checking gamma-ray spectrometers, gamma counters and electron spectrometers. Typical applications in research, environmental measurements and nuclear medicine include:

- 1) Calibrating high resolution gamma-ray spectrometers
 - Single radionuclides p 51, 53
 - Sets of sources p 51, 53
 - Mixed radionuclide point sources with low self-absorption p 54, 55
- 2) Calibrating NaI spectrometers
 - Single radionuclides p 51, 53
 - Mixed radionuclide point source p 76
- 3) Calibrating NaI counters
 - Tube type sources p 60

The advantages of the sources described are:

- Sealed sources - robust design for cost effective, long, useful life
- Easy to mount in jigs for reproducible measurement conditions
- Choice of capsule dimensions and source activities
- Minimal self-absorption and small active volume - accurate calibrations
- Traceable to national standards laboratories including NIST, NPL, PTB, LPRI

Tolerances

The maximum deviation of the delivered activity from the nominal values stated is $\pm 30\%$, unless stated otherwise.

Uncertainties

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, providing a level of confidence of approximately 95% (see section 9.2).



Traceability

The sources are traceable to standards held by national laboratories such as the Physikalisch-Technische Bundesanstalt (Germany), the National Physical Laboratory (UK), the National Institute of Standards and Technology (USA), the Laboratoire Primaire des Rayonnements Ionisants (France), and many other laboratories world-wide. Further details are given in section 9.1.

Certification

Each source is supplied with a certificate of calibration which states:

- Activity of radionuclide
- Uncertainty
- Reference time and date
- Activity of any gamma-ray emitting impurities detected, expressed as a percentage of the activity of the main radionuclide at the reference time
- Serial number
- ISO classification
- Results and date of leakage test

Quality assurance

The sources are calibrated at Eckert & Ziegler Nuclitec's DKD accredited measurement laboratory at Eckert & Ziegler Nuclitec in Germany. The facility operates a quality management systems which have been independently audited and approved to ISO9001:1994.

ISO classification

The International Organization for Standardization has published a classification of sealed sources based on safety requirements of typical usage. The source types have been tested to ISO2919 which is equivalent to ANSI N542-1977 (see section 9.3). The ISO classification is given for each source type in the following pages.

Useful working life

The useful working life of the sources is usually limited by the half life of the radionuclide. In addition, regular improvements in source design and measurement mean that it is good working practice to renew the sources every 10 years.

Availability

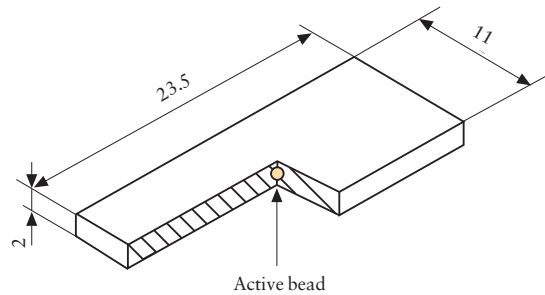
Sources are normally delivered within 6 weeks from receipt of order.

3. Point and tube sources (gamma and electron emitters)

3.2 Rectangular type sources

Construction

The radioactive isotope is absorbed in an ion-exchange bead approximately 1mm in diameter. The bead is fixed inside a solid plastic capsule. The active bead is visible, and located at the geometric centre of the source. The engraving is colour-coded.



Tolerance

The maximum deviation of the delivered activity from the nominal values is -10% to +30% for all radionuclides with the exception of Hg-203 which is -10% to +50%.

Absorption corrections

The effect of absorption and scattering in the source depends on the measurement geometry and the measurement equipment. The table below shows the transmission factor for the main gamma rays emitted. Transmission factors at other energies may be calculated by interpolation. The transmission factor is the fraction of gamma rays produced in the source that will emerge from its surface calculated for narrow beam emission normal to the plane of the source.

ISO classification

C.34343
Drawing: VZ-1240

Energy [keV]	Radionuclide	Transmission factor
60	Am-241	0.970
88	Cd-109	0.981
122	Co-57	0.982
279	Hg-203	0.986
344	Eu-152	0.987
662	Cs-137	0.990
834	Mn-54	0.991
1173	Co-60	0.993
1836	Y-88	0.994

3.2 Rectangular type sources

Ordering information - Single radionuclides

Radionuclide	Nominal activity [kBq]	Overall uncertainty [%]	Product code (DKD certificate)
Am-241	37	3	AMR1122
	370	3	AMR1152
Ba-133	37	3	BDR1122
	370	3	BDR1152
Cd-109	37	4	CUR1122
	370	4	CUR1152
Cs-137	37	3	CDR1122
	370	3	CDR1152
Co-57	37	3	CTR1122
	370	3	CTR1152
Co-60	37	3	CKR1122
	370	3	CKR1152
Eu-152	37	3	EFR1122
	370	3	EFR1152
Hg-203	74	4	MBR1222
	740	4	MBR1252
Mn-54	37	3	MFR1122
	370	3	MFR1152
Na-22	37	3	SKR1122
	370	3	SKR1152
Y-88	37	3	YER1122
	370	3	YER1152



Radionuclide sets

Each set of sources is supplied in a presentation box which also contains a pair of forceps, two positron absorbers, and an adaptor plate. For easy reference, a copy of the calibration information is shown in the lid of the box.

Ordering information - Radionuclide sets

Radionuclide	Nominal activity [kBq]	Product code (DKD certificate)
Set 1, containing:		QCR3110 (total activity = 370kBq)
Am-241	37	
Ba-133	37	
Cs-137	37	
Co-57	37	
Co-60	37	
Hg-203	74	
Mn-54	37	
Na-22	37	
Y-88	37	
Set 2, containing		QCR310 (total activity = 3.7MBq)
Am-241	370	
Ba-133	370	
Cs-137	370	
Co-57	370	
Co-60	370	
Hg-203	740	
Mn-54	370	
Na-22	370	
Y-88	370	

3. Point and tube sources (gamma and electron emitters)

3.3 Disc type sources



Construction

With the exception of Ra-226, Am-241 and Pb-210 sources, the radioactive isotope is absorbed in an ion-exchange bead approximately 1mm in diameter. The bead is fixed inside a solid plastic capsule 25mm in diameter and 3mm thick. The active bead is visible, and located at the geometric centre of the source.

For Am-241 and Pb-210, the active component is in the form of a ceramic bead.

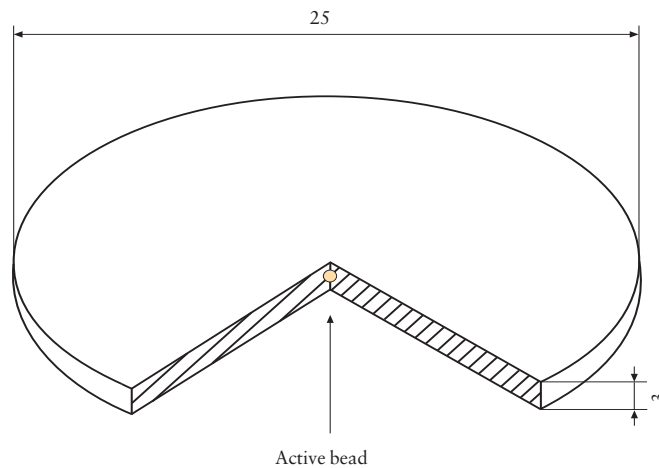
For Ra-226, the ion exchange bead is sealed inside a glass capillary tube before being fixed inside a 6 mm thick plastic disc. This construction (drawing VZ-590) reduces the possibility of release of radon gas from the decay of Ra-226.

Tolerances

The maximum deviation of the delivered activity from the nominal values is -10% to +30% for all radionuclides with the exception of Hg-203 (which is -10% to +50%) and Ra-226 (which is $\pm 30\%$).

ISO classification

C.34313
Drawing: VZ-477
Drawing: VZ-478
(Pb-210, Am-241)



(Note: Ra-226 sources are 6mm thick.)

Absorption corrections

The effect of absorption and scattering in the source depends on the measurement geometry and the measurement equipment. The table shows the transmission factor for the main gamma rays emitted. Transmission factors at other energies may be calculated by interpolation. The transmission factor is the fraction of gamma-rays produced in the source that will emerge from its surface calculated for narrow beam emission normal to the plane of the source.

Energy [keV]	Radionuclide	Transmission factor
47	Pb-210	0.964
60	Am-241	0.958
88	Cd-109	0.970
122	Co-57	0.973
279	Hg-203	0.979
344	Eu-152	0.979
662	Cs-137	0.985
834	Mn-54	0.987
1173	Co-60	0.988
1836	Y-88	0.991

3.3 Disc type sources

Ordering information - Single radionuclides

Radionuclide	Nominal activity [kBq]	Overall uncertainty [%]	Product code (DKD certificate)
Am-241	37	3	AMR8122
	370	3	AMR8152
Ba-133	37	3	BDR8122
	370	3	BDR8152
	3700	3	BDR8252
Cd-109	370	4	CUR8152
Cs-137	37	3	CDR8122
	370	3	CDR8152
	3700	3	CDR8252
Co-57	37	3	CTR8122
	370	3	CTR8152
	3700	3	CTR8252
Co-60	37	3	CKR8122
	370	3	CKR8152
	3700	3	CKR8252
Eu-152	37	3	EFR8122
	370	3	EFR8152
Hg-203	74	4	MBR8222
	740	4	MBR8252
Mn-54	37	3	MFR8122
	370	3	MFR8152
Na-22	37	3	SKR8122
	370	3	SKR8152
	3700	3	SKR8252
Pb-210	200	4	RBR8122
Ra-226	100	3	RARB9480
Y-88	37	3	YER8122
	370	3	YER8152



Radionuclide set

The set contains 8 sources of long-lived radionuclides for calibrating gamma-ray spectrometers from 46keV to 1836keV.

The set of sources is supplied in a presentation box and includes a positron absorber. For easy reference, a copy of the calibration information is shown in the lid of the box.

Ordering information - Radionuclide set

Radionuclide	Nominal activity [kBq]	Product code (DKD-Certificate)
Set comprising:		QCRB9481 (total activity = 452kBq)
Am-241	37	
Ba-133	37	
Cs-137	37	
Co-60	37	
Eu-152	37	
Na-22	37	
Pb-210	200	
Ra-226	30	

3. Point and tube sources (gamma and electron emitters)

3.4 Mixed radionuclide calibration source for 88 - 1836keV range

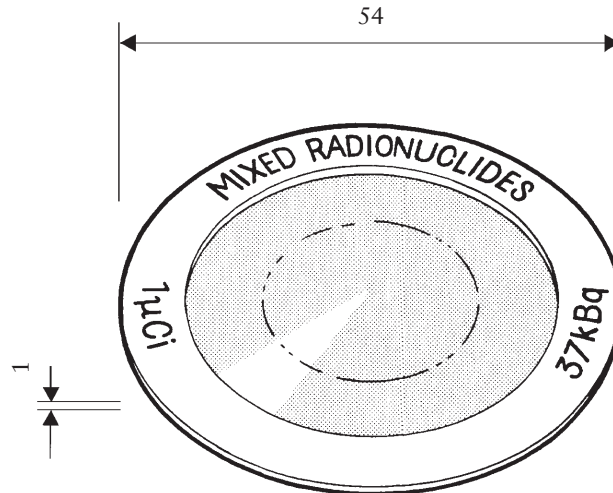
Application

The QCD1 source can be used for calibrating high resolution gamma-ray spectrometers where a solid source with minimal self-absorption is required.

The energy range covered is 88-1836keV

Certification

The source is supplied with a UKAS certificate of calibration.



Construction

The source is prepared by dispensing an accurately weighed aliquot of mixed radionuclide solution onto a polyester tape 0.06mm thick. The aliquot is dried in an atmosphere of hydrogen sulphide to prevent volatilization of mercury, and then covered with a second layer of tape. The active deposit is approximately 5 mm in diameter. The tape is attached to a 1mm thick aluminium annulus of inner diameter 38mm and outer diameter 54mm.

The source is constructed of thin polyester tape to minimise self-absorption of the gamma-rays. The source should be handled carefully by its aluminium ring using rubber-tipped forceps.

Ordering information

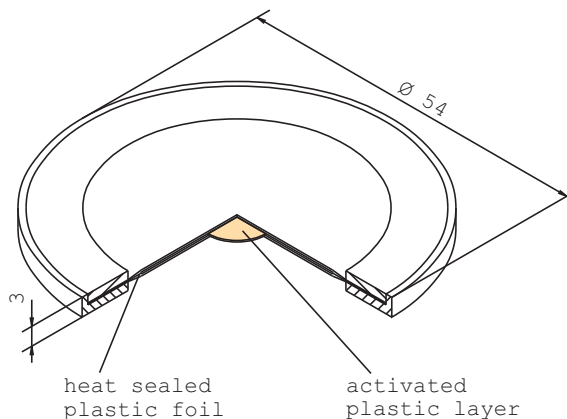
Radionuclide	Activity [kBq] [μCi]	Gamma-ray energy [keV]	Overall uncertainty [%]	Product code
The source contains:				QCD1 (total activity 40 kBq)
Cd-109	17 0.5	88	4	
Co-57	1 0.02	122	2.5	
Ce-139	1 0.02	166	2.5	
Hg-203	2 0.05	279	2.5	
Sn-113	3 0.08	392	5	
Sr-85	4 0.1	514	2.5	
Cs-137	3 0.08	662	2.5	
Co-60	3 0.08	1173	1	
		1333	1	
Y-88	6 0.2	898	4	
		1836	4	

3.5 Mixed radionuclide calibration source for 60-1836keV and 46-136keV ranges

Application

Similar in construction to QCD1, these sources cover the energy ranges 60-1836keV or 46-136keV, where a solid source with minimal self-absorption characteristics is required.

Please ask for other nuclide mixtures.



Construction

The radioactive material is incorporated in a plastic layer, 10mm in diameter and 0.2mm thick. The plastic layer is covered on each side by a paper label, 0.15mm thick, and the assembly is heat sealed between 0.125mm thick plastic foils. The foils are mounted in a ring, 54mm in diameter, 3mm thick (drawing VZ-1159).

Ordering information

Radionuclides	Activity [kBq]	Gamma-ray energy [keV]	Overall uncertainty [%]	Product code (DKD certificate)
Radionuclide mixture NG3 containing:				QCRB1186 (total activity 40kBq)
Am-241	3	60	3	
Cd-109	15.6	88	4	
Co-57	0.6	122	2.5	
Ce-139	0.7	166	2.5	
Hg-203	2.1	279	2.5	
Sn-113	2.8	392	5	
Sr-85	3.8	514	2.5	
Cs-137	2.6	662	2.5	
Co-60	3.0	1173	1	
		1333	1	
Y-88	5.9	898	4	
		1836	4	
Radionuclide mixture NG4 containing:				QCRB4136 (total activity 46kBq)
Pb-210	20	47	5	
Am-241	4	60	3	
Cd-109	20	88	4	
Co-57	2	122	2.5	

3. Point and tube sources (gamma and electron emitters)

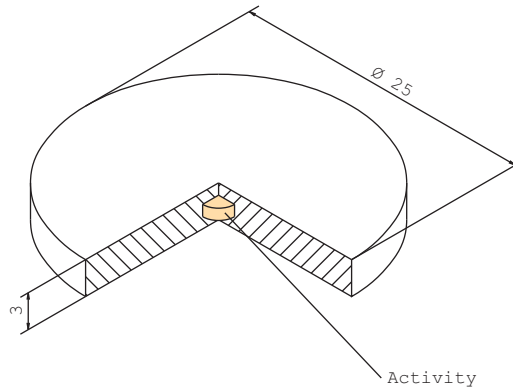
3.6 Source for NaI spectrometers

Application

This source type is used for the energy calibration of NaI spectrometers, or as a check source for Ge-spectrometers.

Construction

The activity of each radionuclide is adsorbed in one ion exchange bead 1mm in diameter. The beads are mounted in a plastic disc 25mm in diameter and 3mm thick (drawing VZ-1285).



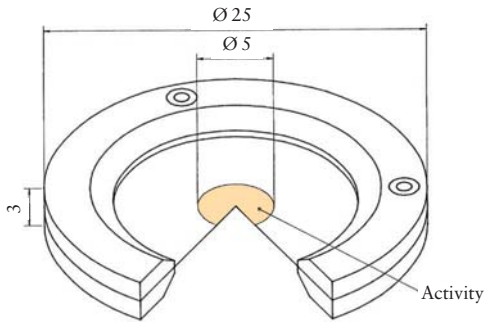
Ordering information

Radionuclide	Nominal activity [kBq]	Product code
Am-241	37	QCRB 5936
Co-57	37	(total activity
Co-60	37	148kBq)
Cs-137	37	

3.7 X-ray and low energy photon sources

Application

These sources have been designed to minimise self-absorption of low energy photons, so they are suitable for calibrating X-ray spectrometers such as Si(Li) detectors. For energy calibration only, a more robust source design is used.



Sources for energy and efficiency calibration

Construction

A thin deposit of active material 5mm in diameter is heat sealed between plastic foils. The foils are mounted in an aluminium frame 25mm in diameter, 3mm thick (drawing VZ-1562). The 20 - 37 kBq sources are sealed between foils 0.1mm and 0.015mm thick, with the thinner foil on the engraved side. The 370 kBq sources are sealed between plastic foils 150 µCi thick (drawing VZ-2402).

Ordering information - VZ-1562

Radionuclide	Nominal activity [kBq] (calibrated for activity and emission)	Product code
Am-241 ¹⁾	37	AMRB5937
Ba-133	37	BDRB5938
Cd-109	37	CURB5939
Co-57	37	CTRB4056
Fe-55	37	IERB5941
Nb-93m	20	NHRB9483
Pb-210	37	RBRB9482
Zn-65	37	ZARB5943

¹⁾ Source should be wipe-tested regularly.

Ordering information - VZ-2402

Radionuclide	Nominal activity [kBq] (calibrated for activity)	Product code
Am-241 ¹⁾	37	AMRB9484
Ba-133	370	BDRB7369
Cd-109	370	CURB6235
Co-57	370	CTRB8045
Fe-55	370	IERB6236

¹⁾ Source should be wipe-tested regularly.

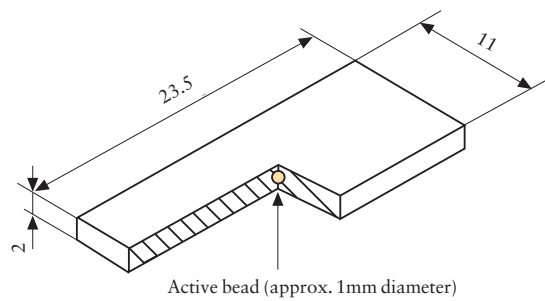
3. Point and tube sources (gamma and electron emitters)

3.7 X-ray and low energy photon sources

Robust source for energy calibration

Construction

The radioactive isotope is absorbed in an ion-exchange bead approximately 1mm in diameter. The bead is fixed inside a solid plastic capsule. The active bead is visible, and located at the geometric centre of the source. This source is uncalibrated and is intended for energy calibration only.



ISO classification

C.34343
Drawing: VZ-1240

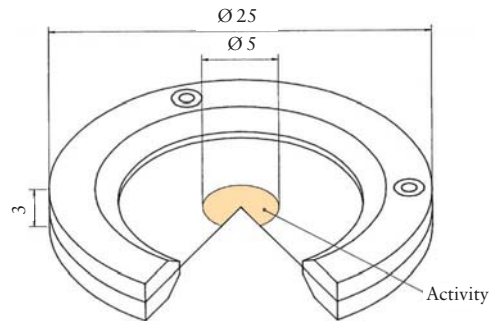
Ordering information

Radionuclide	Nominal activity [MBq] (uncalibrated)	Product code
Fe-55	1.85	IER15510

Application

These sources are intended for calibrating the energy response of magnetic or solid state electron detectors. The calibrated Bi-207 source can also be used to estimate the detection efficiency.

Radionuclides have been chosen that have intense, easily resolvable, electrons from internal conversion.



Construction

A thin deposit of active material is glued between Mylar foils (drawing VZ-486), 0.9mg/cm² thick, or between titanium foils (drawing VZ-392) each 2.4mg/cm² thick. The foils are supported in an aluminium frame 25mm in diameter, 3mm thick. The diameter of the active deposit is approximately 5mm.

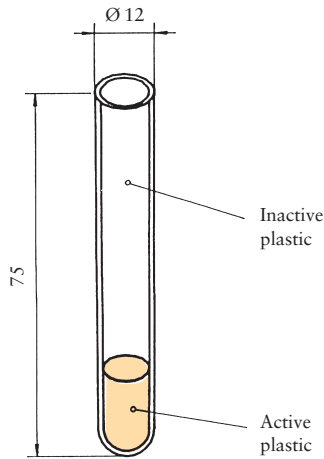
Ordering information

Radio-nuclide	Nominal activity [kBq]	Window material	Calibrated	Product code
Bi-207	37	Titanium	Uncalibrated	BIRB1082
Bi-207	37	Mylar	Uncalibrated	BIRB1083
Bi-207	37	Mylar	Calibrated ¹⁾	BIRB4391
Cs-137	37	Mylar	Uncalibrated	CDRB4630
Cs-137	370	Mylar	Uncalibrated	CDRB4944
Cs-137	370	Titanium	Uncalibrated	CDRB5552
Cd-109	370	Mylar	Uncalibrated	CURB2955

¹⁾ Calibrated for activity

3. Point and tube sources (gamma and electron emitters)

3.9 Tube type sources



Application

Tube type sources are used in the quality control of well-type NaI detectors used in biomedical research and nuclear medicine.

For the quality control of multi-well detectors, matched sets of tube sources and multi-finger sources are available. The advantages of using a multi-finger source are:

- Saves time - 1 source for 12 measurements simultaneously
- No half life correction needed (I-129 sources)
- Sealed sources - safer to handle than liquid standards

Construction

The radioactive material is homogeneously incorporated in 1ml or 2ml of resin at the base of a plastic tube, 12mm in diameter and 75mm long. The rest of the tube is filled with inactive resin.

ISO classification

C.23233
Drawing: VZ-1236



Ordering information - single sources

Radionuclide	Nominal activity [kBq]	Overall uncertainty [%]	Product code (DKD certificate)
Am-241	3.7	3	AMRB4541
Ba-133	3.7	3	BDRB4543
Cs-137	3.7	3	CDRB4545
Co-57	3.7	3	CTRB4547
Co-60	3.7	3	CKRB4549
Eu-152	3.7	3	EFRB4551
Na-22	3.7	3	SKRB4555
I-129	3.7	3	ISRB4557
I-125	3.7	3	IMRB5829 ¹⁾

¹⁾ Please allow 12 weeks for delivery of this source from receipt of order.

3.9 Tube type sources

Ordering information - Source set (uncalibrated)

Radionuclide	Nominal activity [kBq]	Product code
Ba-133	3.7	
Cs-137	3.7	
Co-57	3.7	
Co-60	3.7	
I-129	3.7	
total activity	18.5	QCR5410

3. Point and tube sources (gamma and electron emitters)

3.10 Custom preparation service

If the point or tube source required is not shown in this catalogue, Eckert & Ziegler Nuclitec GmbH will try to assist you.

Please photocopy the form on the opposite page, fill in the details as far as possible, and fax the form to your local Eckert & Ziegler Nuclitec GmbH office.

Alternatively, contact us by e-mail on:

infoisotrak@ezag.com

or visit our internet page at:

<http://www.nuclitec.de>

We will reply via your local Eckert & Ziegler Nuclitec GmbH office.

Enquiry Form

To: Your local Eckert & Ziegler Nuclitec GmbH office for forwarding the isotrak Technical Service

From: Name: _____
Institute/company _____
Address: _____

Country: _____
Tel: _____
Fax: _____
E-mail: _____

Date: _____

Radionuclide(s) required : _____

Activity: _____

Active dimensions: _____

Overall dimensions: _____

Application: _____

Special environmental conditions: _____

Please attach a sketch of the source you require if possible.

ALPHA SPECTROMETRY SOURCES

alpha emitting radiation sources. A radionuclide selection chart and plots of the alpha spectra are shown to help you to choose the right nuclide for your application.

This section contains detailed information about unsealed

alpha emitting radiation sources. A radionuclide selection chart and plots of the alpha spectra are shown to help you to choose the right nuclide for your application.



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Nuclitec

4. Alpha spectrometry sources

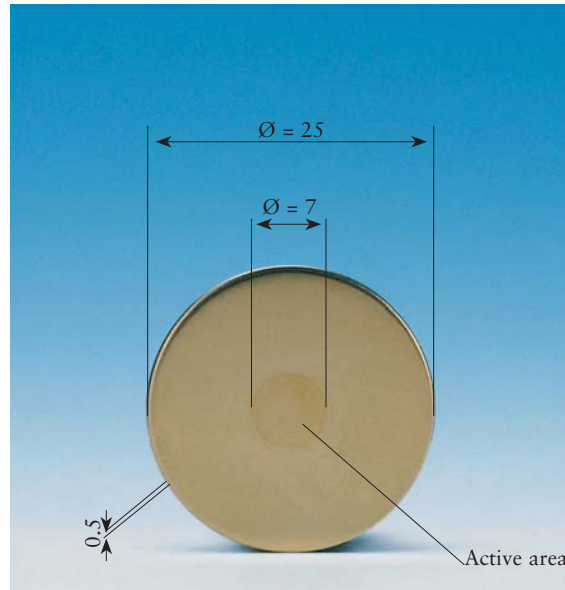
4.1 General information

Applications

Alpha spectrometry sources are intended for calibrating and checking solid state alpha spectrometers, for applications in environmental monitoring and research.

The advantages of these sources are:

- Narrow line widths (normally less than 20keV) - easy, accurate, calibration of spectrometer
- Wipe test results comparable to sealed sources - low risk of contaminating equipment



Construction

The radionuclides are deposited onto a stainless steel disc, 25mm in diameter, 0.5mm thick (drawing: VZ-1679). The reagents used are ultra-pure, resulting in an essentially massless deposit. This process minimises line broadening and produces sources exhibiting line widths of less than 20keV full width half maximum (sources containing Np-237 have line widths typically 50keV, due to the low specific activity of Np-237). Wipe test results comparable with sealed sources are achieved for this manufacturing process. However, any material placed over the active deposit will degrade the spectrum, so it is not possible to construct a source that can be classified as a sealed source as defined in ISO2919.

Certification

Calibrated single nuclide sources are supplied with a DKD certificate stating alpha particle emission rate and activity.
Triple nuclide sources are designed for energy calibration applications.

Uncertainties

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, providing a level of confidence of approximately 95% (see section 9.2).

The expanded uncertainty of the emission rate for a calibrated single nuclide source is $\leq 3\%$.

4.1 General Information

Traceability

The sources are traceable to standards held by national laboratories such as the Physikalisch-Technische Bundesanstalt (Germany), the National Physical Laboratory (UK), the National Institute of Standards and Technology (USA) the Laboratoire Primaire des Rayonnements Ionisants (France), and many other national laboratories world-wide. Further details are given in section 9.1.

Quality assurance

The sources are calibrated at Eckert & Ziegler Nuclitec GmbH's DKD accredited measurement laboratory in Germany. The manufacturing facility operates a quality management system which has been independently audited and approved to ISO9001:1994.

To help select the source needed, the energies and intensities of the most intense alpha particles emitted by the different nuclides are shown in the table.

Recommendations on source handling

To maintain the accuracy of measurements, these sources must be handled with care. Sources should be handled with tweezers to avoid leaving grease on the surface of the source, which would degrade the spectrum. The sources must not be cleaned with abrasive compounds such as metal polish, as this would remove the active deposit. The sources should be kept in their storage boxes when not in use.

Tolerances

The maximum deviation of the measured activity at the reference time from the nominal value is +/-30%.

Availability

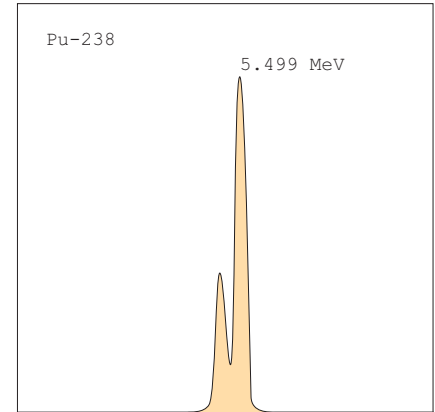
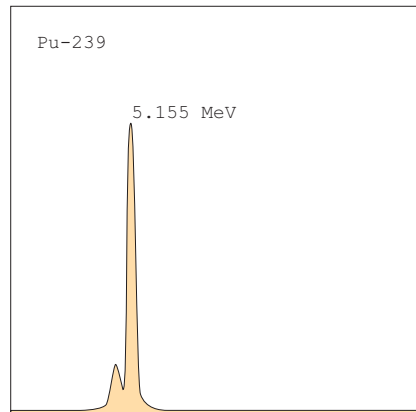
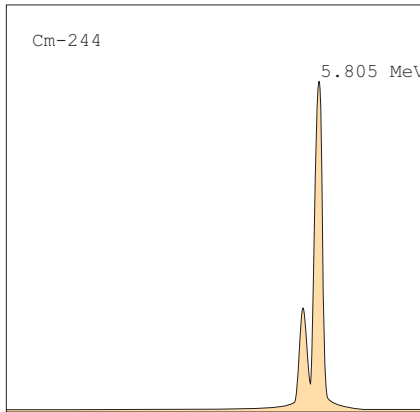
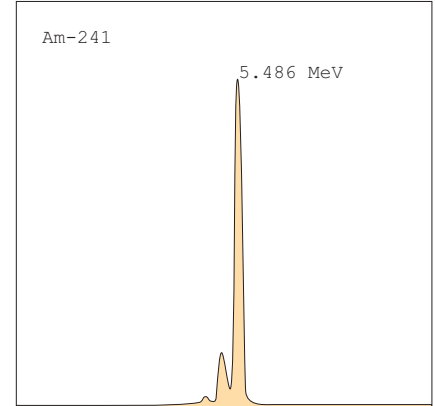
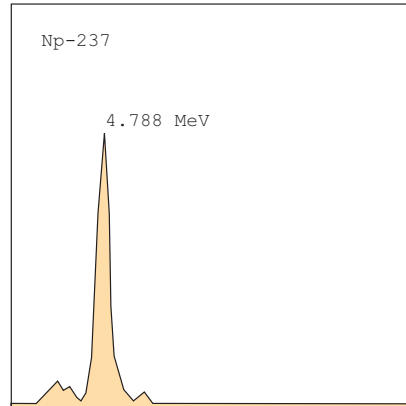
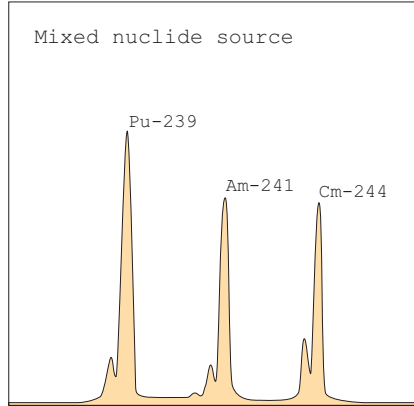
The sources are normally delivered within 4-6 weeks from receipt of order.

Selection chart

Radionuclide	Alpha particle energy [MeV]	Intensity [%]
Np-237	4.640	6.2
	4.766	8.0
	4.772	25.0
	4.788	47.0
Pu-239	5.105	11.5
	5.143	15.1
	5.155	73.4
Am-241	5.388	1.4
	5.443	12.8
	5.486	85.2
Pu-238	5.456	28.3
	5.499	71.6
Cm-244	5.763	23.3
	5.805	76.7

4. Alpha spectrometry sources

4.2 Reference sources



Ordering information

Radionuclide	Nominal activity	Energy of most intense alpha particle [MeV]	Product code uncalibrated ¹⁾	Product code calibrated ²⁾
Am-241	50 Bq	5.486	AMR11	AMR21
Am-241	500 Bq	5.486	AMR12	AMR22
Am-241	5000 Bq	5.486	AMR13	AMR23
Am-241	40000 Bq	5.486	AMR14	not available
Pu-238	1000 Bq	5.499	PPRB2505	PPRB2497
Pu-239	1000 Bq	5.155	PIRB2506	PIRB2498
Cm-244	1000 Bq	5.805	CLRB2507	CLRB2499
mixed nuclide				
Pu-239	1000 Bq	5.155	QCRB2508	QCRB2500 ³⁾
Am-241	1000 Bq	5.486		
Cm-244	1000 Bq	5.805		
mixed nuclide				
Np-237	150 Bq	4.788	QCRB4020	QCRB4021 ³⁾
Am-241	100 Bq	5.486		
Cm-244	100 Bq	5.805		

¹⁾ For energy calibration only - no certificate of calibration is included

²⁾ For energy and efficiency calibration - certificate of calibration included

³⁾ The certificate of calibration states the total α emission rate and the nominal activities of individual radionuclides

4.3 Custom preparation service

If the alpha spectrometry source required is not shown in this catalogue, Eckert & Ziegler Nuclitec GmbH will try to assist you.

Please photocopy the form on the next page, fill in the details as far as possible, and fax the form to your local Eckert & Ziegler Nuclitec GmbH office.

Alternatively, contact us by e-mail on:

infoisotrak@ezag.com

or visit our internet page at:

<http://www.nuclitec.de>

We will reply via your local Eckert & Ziegler Nuclitec GmbH office.

Enquiry Form

To: Your local Eckert & Ziegler Nuclitec GmbH office for forwarding the isotrak Technical Service

From: Name: _____
Institute/company _____
Address: _____

Country: _____
Tel: _____
Fax: _____
E-mail: _____

Date: _____

Nuclide(s) required : _____

Activity: _____

Dimensions of backing plate: _____

Any special requirement: _____

Date required by: _____

Our technical experts may be able to recommend an alternative source. If you wish, please tell us your application: _____

GEOMETRY REFERENCE SOURCES

This section describes calibrated single and mixed radionuclide sources in different geometries for the energy and efficiency calibration of gamma-ray spectrometers.

A range of sources simulating different samples, for example, charcoal filters and gas standards, is also shown. The sources listed in this section are supplied with a certificate of the German Calibration Service. If a reference source is needed to match your particular sample, please specify your requirements using the form at the end of this section.



Standard geometries (container supplied by Eckert & Ziegler Nuclitec GmbH)	
- 1 litre Marinelli beakers (own Geometry)	75
- 1 litre plastic bottles (own Geometry)	77
- Marinelli beakers (type GA-MA)	78
- Simulated filters	79

Standard geometries (using customer supplied containers)	
- Bottles/Beakers SG-Type (for France)	81
- Simulated gas standards (type GA-MA)	83
GAMATOOL - Attenuation correction software	85
Form to require custom source	87

5.1 General information



Construction

Mixed or single radionuclide solutions are incorporated homogeneously into a plastic resin which is then poured into the container and allowed to set. The active resin is normally covered by a layer of inactive resin. A lid is fixed to the container to make a sealed, solid, source.

Gas equivalent sources are prepared by combining the active solution with plastic foam.



Applications

High resolution gamma-ray spectrometry is widely used for identifying and assaying gamma-ray emitting radionuclides in environmental samples. To meet the requirements of quality management systems, the spectrometers should be calibrated using reference sources that are traceable to national standards. The reference sources must also match as closely as possible the geometry, density and composition of the sample to be assayed.

This range of ready-for-use geometry reference sources has been developed to meet these requirements. The advantages of this type of source are:

- No source preparation needed - saves time and resources
- No dilution of solutions needed - calibration is directly traceable to national standards
- No dispensing of strong acids for dilution is needed - source is safer to handle
- Sealed source - no risk of contaminating sensitive equipment
- Stable source - will not deteriorate over time
- Source checked for homogeneity - consistent, accurate, results year after year
- Matches closely the samples to be measured - can be prepared in your own container (see page 87) with a wide range of densities from gas equivalent (0.02g/cm^3) to cement (3g/cm^3)
- Layout of certificate of calibration matches the requirements of commercial gamma-ray spectrometry software - calibration easy and quick to carry out
- Correction software available - accurate corrections for variations in sample composition and density (see section 5.11).
- Wide range of commonly used beakers or bottles available - short delivery times
- Custom geometry - to meet your special requirements (please allow longer delivery times)

Measurement

For mixed radionuclide reference sources, each radionuclide is assayed individually using a method which is traceable to national standards. The mixed solution is then prepared, and checked by high resolution gamma-ray spectrometry. The solid reference source is then manufactured using the mixed radionuclide solution, and the final source is checked again for accuracy and homogeneity by high resolution gamma-ray spectrometry.

5.1 General information

Certification

Each source listed in this section is supplied with a DKD certificate of calibration which states:

- Reference time and date
- Activity of main radionuclides and/or gamma-ray emission rates of main gamma-energies
- Activity of any gamma-ray emitting impurities detected
- Serial number
- Results and date of leakage test

Quality assurance

The sources are calibrated at Eckert & Ziegler Nuclitec's DKD accredited measurement laboratory in Germany. The manufacturing facility operates a quality management system which has been independently audited and approved to ISO9001:1994.

Radionuclidic purity

Gamma-ray emitting impurities are determined by high resolution gamma-ray spectrometry of each individual radionuclide in the mixture. The final mixture is checked for cross-contamination. In addition to the main gamma rays shown on the certificate, several low intensity gamma-ray peaks may be observed in the spectrum. The most significant are listed in the table below.

Spectrum notes

Energy [keV]	Origin
1325	Escape peak from 1836keV peak of Y-88
814	Double escape peak from 1836keV peak of Y-88
511	Annihilation radiation from positron decay of Y-88 (may not be resolved from the 514keV peak from Sr-85)
225	From decay of Sn-113
136	From decay of Co-57
80-90	X-rays from decay of Hg-203
2506	Sum peak from Co-60 decay (1173+1333keV)
2734	From decay of Y-88

Uncertainties

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, providing a level of confidence of approximately 95% (see section 9.2).

Traceability

The sources are traceable to standards held by national laboratories such as the Physikalisch-Technische Bundesanstalt (Germany), the National Physical Laboratory (UK), the National Institute of Standards and Technology (USA), the Laboratoire Primaire des Rayonnements Ionisants (France), and many other national laboratories world-wide. Further details are given in section 9.1.

Recommendations on source storage and replacement

Regular improvements in source design and measurement mean that it would be good working practice to renew the sources within 10 years. For many sources, the useful working life is limited by the half life of the radionuclides. The sources should be kept out of direct sunlight and away from other sources of direct heat, to avoid the possibility of cracking the container due to thermal expansion of the resin.

Availability

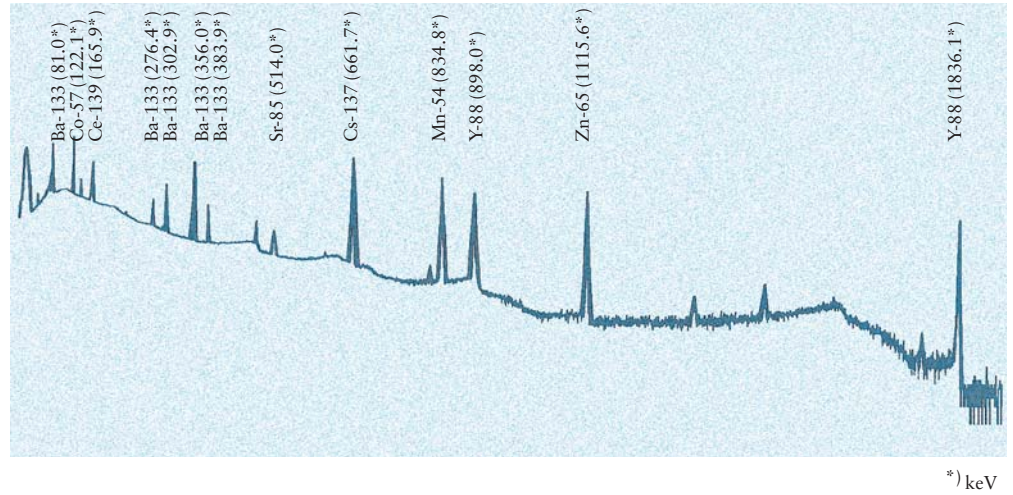
Sources are normally delivered within 6 weeks from receipt of order.

5. Geometry reference sources

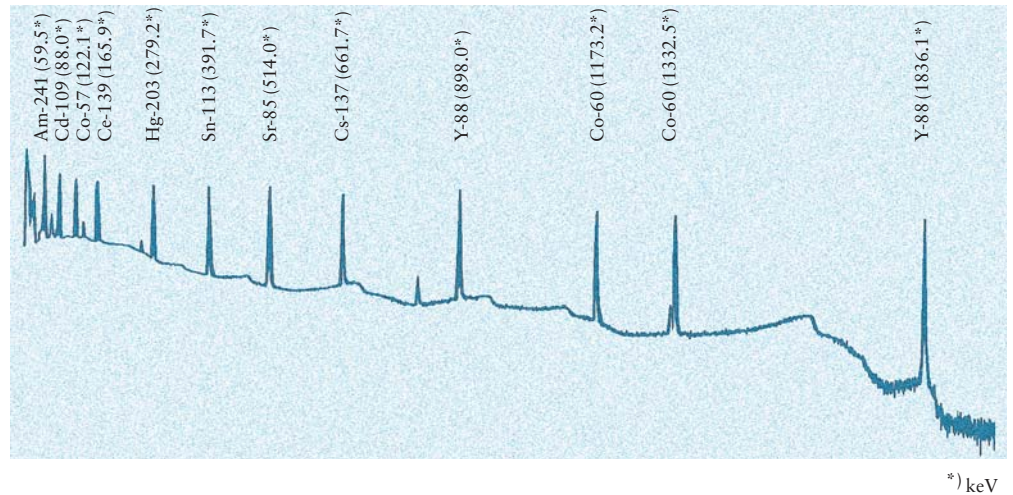
5.1 General information

The mixtures of radionuclides are recommended by NIST (USA) and PTB (Germany) for calibrating high resolution gamma-ray spectrometers. Typical spectra are shown below.

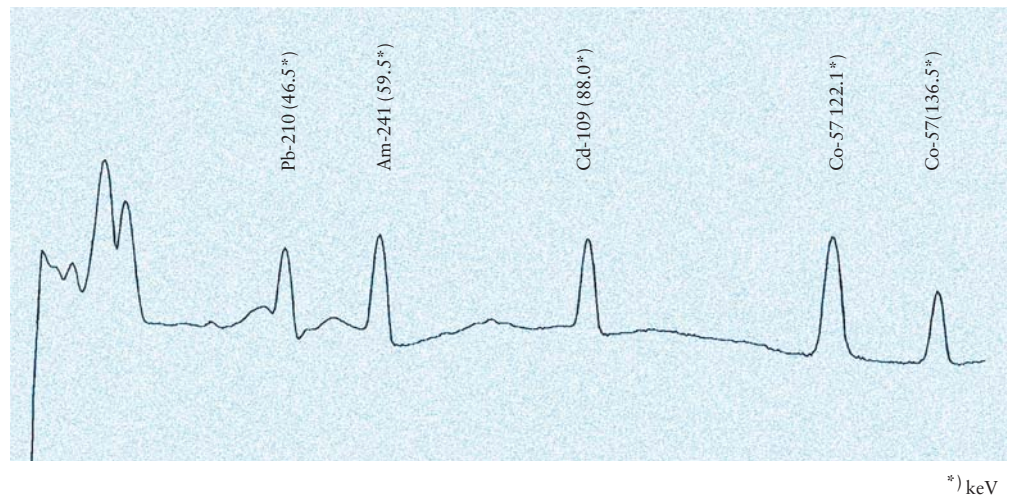
A typical gamma spectrum for the NG1 radionuclide mixture



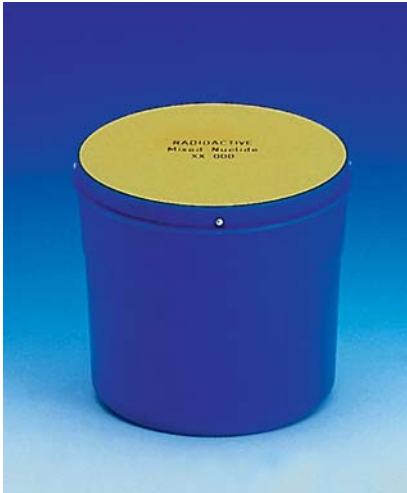
A typical gamma spectrum for the NG3 radionuclide mixture



A typical gamma spectrum for the NG4 radionuclide mixture

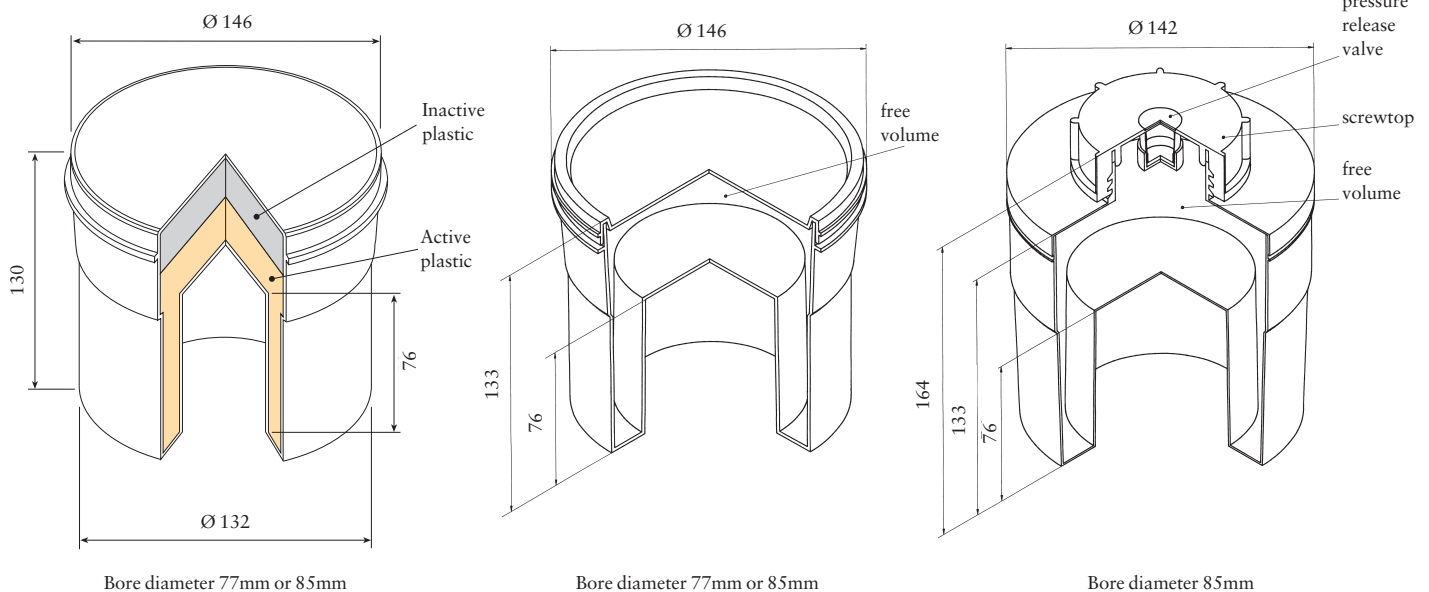


5.2 1 litre Marinelli beakers for Ge spectrometers



Application

Marinelli beakers are used when the radioactivity to be measured is low and the limits of detection require special geometries of the sample container in order to maximise the counting efficiency of the measurement system. The use of solid reference sources minimises contamination risk and avoids calibration errors due to incorrect handling of solutions.



ISO classification

C.22323
Drawing: VZ-1262
and VZ-1520

Construction

These Marinelli beakers are constructed from polypropylene and are resistant to acids and most organic solvents. The radioactive material is homogeneously incorporated in a special water-equivalent plastic matrix. The matrix density is normally 1g/cm^3 , but for Ra-226 and Th-232/Th-228 sources, the density is 1.15g/cm^3 .

The empty beakers are available with a choice of a tight fitting lid (for aqueous solutions) or a more robust screw-top version (for low viscosity liquids).

5. Geometry reference sources

5.2 1 litre Marinelli beakers for Ge spectrometers

Ordering information - VZ-1262 - bore diameter 77mm ¹⁾

container
supplied by
Eckert & Ziegler
Nuclitec

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	0.97	QCRB1240
88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.97	QCRB1242
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.97	QCRB1155
46-136keV	Mixture NG4: Pb-210, Am-241, Cd-109, Co-57	46	0.97	QCRB2186
662keV	Cs-137	5	0.97	CDRB1154
Multiline	Th-232 in equilibrium with Th-228	1	1.15	TYRB1239
Multiline	Ra-226	3	1.15	RARB1136
Empty container	not applicable			NQ7013

Ordering information - VZ-1520 - bore diameter 85mm ¹⁾

container
supplied by
Eckert & Ziegler
Nuclitec

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	0.97	QCRB1241
88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.97	QCRB1243
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.97	QCRB1244
46-136keV	Mixture NG4: Pb-210, Am-241, Cd-109, Co-57	46	0.97	QCRB2197
662keV	Cs-137	5	0.97	CDRB1249
Multiline	Th-232 in equilibrium with Th-228	1	1.15	TYRB1250
Multiline	Ra-226	3	1.15	RARB1414
Empty container (tight fitting lid)	not applicable			NQB1245
Empty container (screw-top)	not applicable			NQB2205

¹⁾ Custom geometries: Where other plastic matrix densities or customer-specified geometries are required, Eckert & Ziegler Nuclitec GmbH can offer sealed, solid sources to customers' specification as special orders. Custom-designed reference sources can be supplied when customers supply their own sample containers for filling with Eckert & Ziegler Nuclitec GmbH's plastic resin. Sample containers must be suitable for this purpose. Please enquire using the fax back form on page 87.

5.3 1 litre plastic bottles

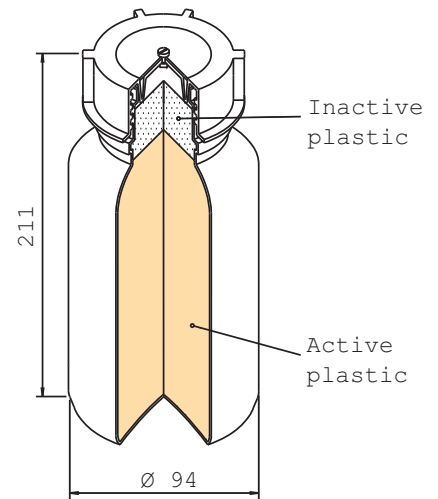
Application

1 litre bottles are used when safe, sealed, easy-to-handle containers are required. This measurement geometry is not as efficient as that of a Marinelli beaker, but is satisfactory when the radioactivity contained in the sample is sufficient to meet the detection limits of the measurement system.

Construction

The bottles according to drawing VZ-526 are constructed from polypropylene (Kautex™), and are resistant to acids and most organic solvents. The radioactive material is homogeneously incorporated in a special water-equivalent plastic matrix. The matrix density is normally 1g/cm^3 .

Due to the difference in chemical composition between water (samples) and plastic (reference sources), absorption corrections for low energies may need to be applied. Details are available on request or supplied with the source when necessary.



container
supplied by
Eckert & Ziegler
Nuclitec

Ordering information ¹⁾

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	0.97	QCRB1073
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.97	QCRB1204
662keV	Cs-137	10	0.97	CDRB2208
Empty bottle	not applicable			NQB1414

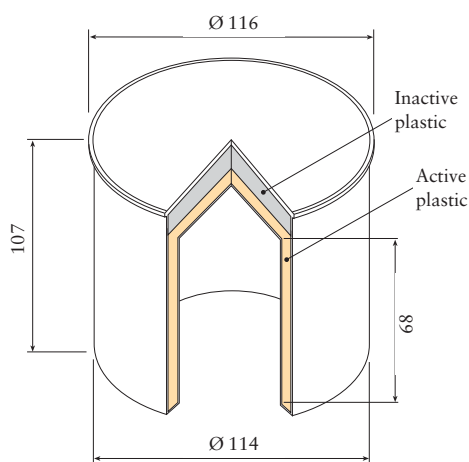
¹⁾ Custom geometries: Where other plastic matrix densities or customer-specified geometries are required, Eckert & Ziegler Nuclitec GmbH can offer sealed, solid sources to customers' specification as special orders. Custom-designed reference sources can be supplied when customers supply their own sample containers for filling with

Eckert & Ziegler Nuclitec GmbH's plastic resin. Sample containers must be suitable for this purpose. A wide range of other standard bottles is also available. Please enquire using the fax back form on page 87.

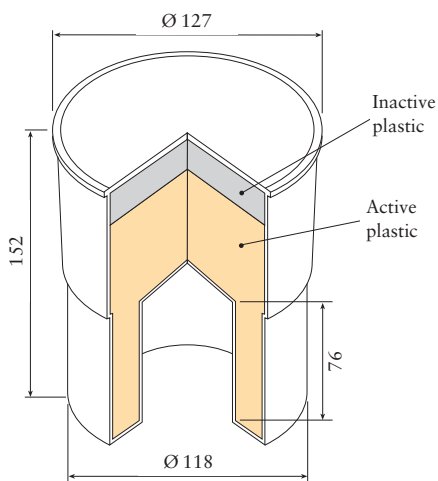
5.4 Marinelli beakers - type GA-MA

Construction

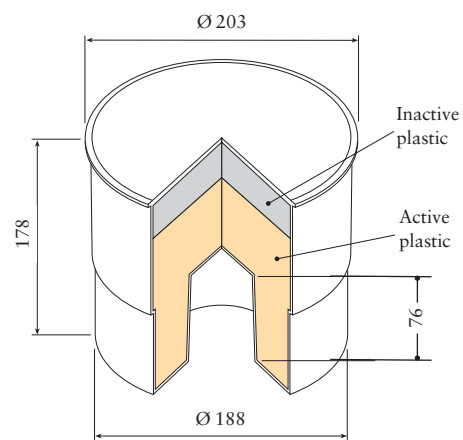
The beakers are constructed from polyethylene, and are resistant to acids and most organic solvents. The radioactive material is homogeneously incorporated in a special water-equivalent plastic matrix. The bore diameter is 77mm.



450ml beaker type 530G
Drawing: VZ-1267



1 litre beaker type 130G
Drawing: VZ-700



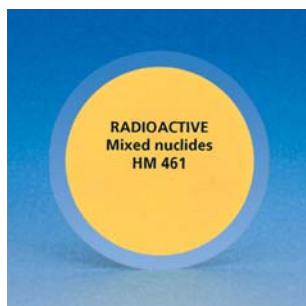
3.6 litre beaker type 430G
Drawing: VZ-699

Ordering information

container
supplied by
Eckert & Ziegler
Nuclitec

Beaker type	Energy range	Radionuclide(s)	Nominal total activity	Density [g/cm ³]	Product code
530G	88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37kBq	0.97	QCR13
130G	88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37kBq	0.97	QCR14
430G	88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37kBq	0.97	QCR15

5.5 Simulated filters



Application

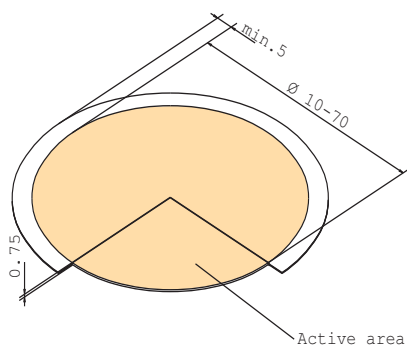
These standards are designed for the calibration of instruments, used for the measurement of adsorbed activity in charcoal and aerosol filters.

Construction

An activated plastic layer 0.2mm thick, is located between two paper labels 0.15mm thick and heat sealed between plastic foils 0.125mm thick (drawing: VZ-1158). Please enquire for larger diameters.

Ordering information ¹⁾

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Active diam. [mm]	Overall diam. [mm]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	40	50	QCRB1027
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	50	60	QCRB2491
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	70	80	QCRB2654

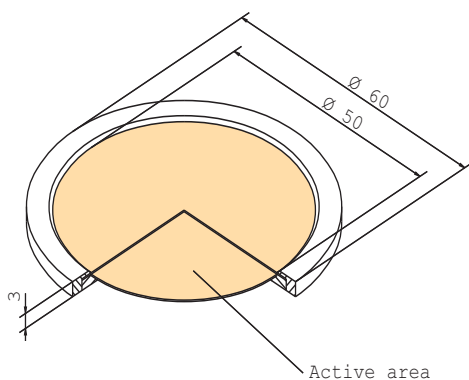


Construction

An activated plastic layer 0.3mm thick, 50mm in diameter is mounted onto a backing plate and covered with a 0.3mm thick aluminium foil. The backing plate is glued into a ring holder 60mm in diameter, 3mm thick (drawing: VZ-538).

Ordering information ¹⁾

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	QCRB1074
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	QCRB1072



¹⁾ Simulated filter sources are also available with other active or overall dimensions and other radionuclide mixtures (see pages 99 - 101). Please enquire using the fax back form on page 87.

5.6 Simulated charcoal filter cartridges

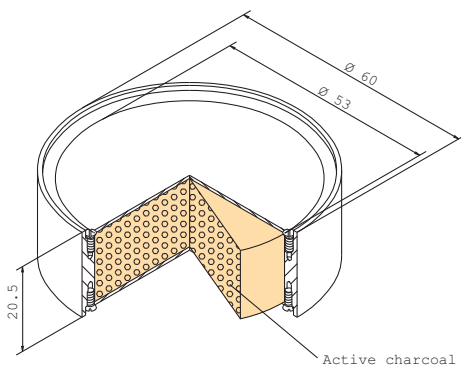
Construction

Homogeneous activated charcoal is fixed in a plastic cartridge 60mm in diameter and 20.5mm thick sealed with 2 plastic foils which are glued on the top and bottom of the cartridge (drawing: VZ-2139). The foils are secured with screws.

Application

These standards are for calibrating instruments used to measure charcoal cartridges from ventilation monitoring systems.

Ordering information - homogeneous activated type



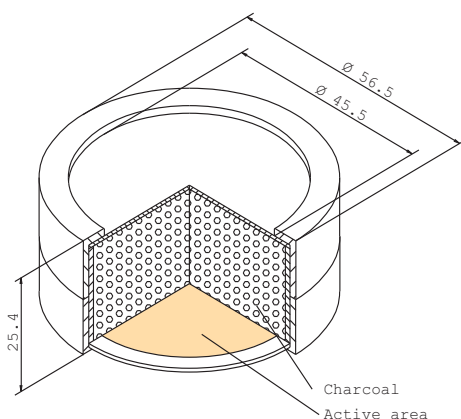
homogeneously activated type

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	0.5-0.6	QCRB5966
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.5-0.6	QCRB5967

Construction

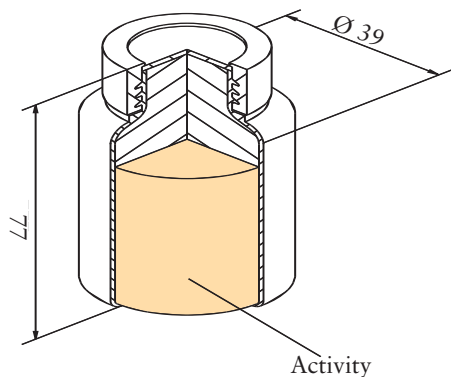
An activated plastic layer is heat sealed between plastic foils 0.25mm thick and mounted onto the top of the source. The empty volume of the cartridge, 56.5mm in diameter and 25.4mm thick, is filled with inactive charcoal (drawing: VZ-1311).

Ordering information - face loaded type



faceloaded type

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	0.5-0.6	QCRB5968
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.5-0.6	QCRB1127



50ml bottle - type SG50T

Construction

These bottles and beakers are constructed from polyethylene, and are resistant to acids and most organic solvents. The radioactive material is homogeneously incorporated in a special water-equivalent plastic matrix.

These sources are mainly used in France.
Please supply the empty containers.

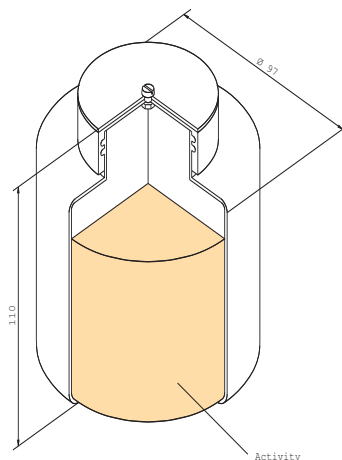
Ordering information - Type SG50T - Drawing: VZ-1892

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.97	QCRB5955
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.97	QCRB2647
46-136keV	Mixture NG4: Pb-210, Am-241, Cd-109, Co-57	46	0.97	QCRB5956

5. Geometry reference sources

5.7 Bottles / Beakers - SG-type

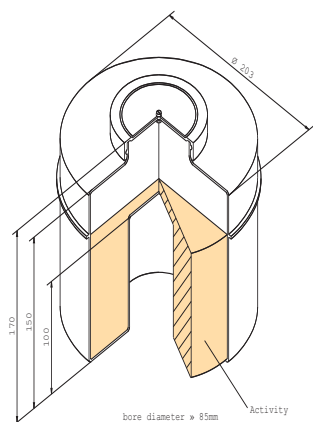
Ordering information - Type SG500 - Drawing: VZ-1841



500ml bottle - type SG500

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.97	QCRB5960
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.97	QCRB2639
46-136keV	Mixture NG4: Pb-210, Am-241, Cd-109, Co-57	46	0.97	QCRB2605

Ordering information - Type SG3000 - Drawing: VZ-2084



3000ml bottle - type SG3000

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.97	QCRB5963
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.97	QCRB5964
46-136keV	Mixture NG4: Pb-210, Am-241, Cd-109, Co-57	46	0.97	QCRB5965

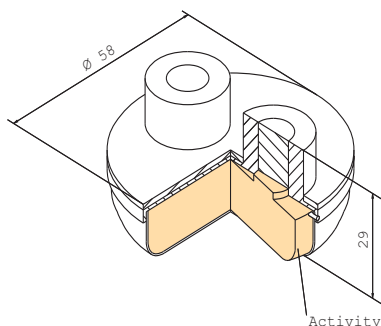
5.8 Simulated gas standards - GA-MA type

Application

These simulated gas standards are intended for the calibration of high resolution gamma-ray spectrometers used for the measurement of noble gases. The mixed radionuclide standards cover an energy range of 60-1836keV, which covers the energy of photons emitted by Kr-85, Xe-127 and Xe-133 (81 - 574keV).

The main advantages are:

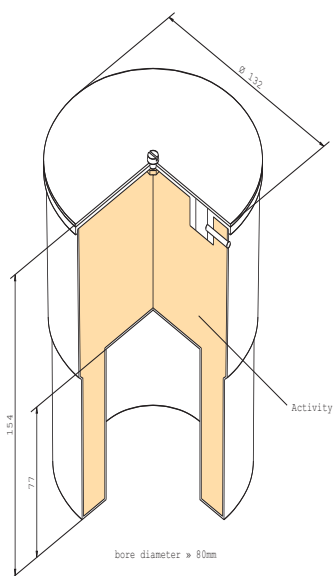
- Transfer errors eliminated (no diffusion of noble gases, no absorption of gas in rubber septums or grease)
- Based on a low-density foam matrix - no correction for self absorption needed



25ml beaker type RG-25
Drawing: VZ-646

Construction

The beakers are constructed from polyethylene, and are resistant to acids and most organic solvents. The radioactive material is homogeneously incorporated into a special low density (gas simulating) foam matrix. Please supply the empty containers.



1 litre beaker type G-130G
Drawing: VZ-645

Ordering information

Beaker type	Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm ³]	Product code
RG-25	88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.02	QCR21
G-130G	88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.02	QCR22
RG-25	60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.02	QCR24
G-130G	60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.02	QCR25

5. Geometry reference sources

5.9 Custom geometries

Please note:

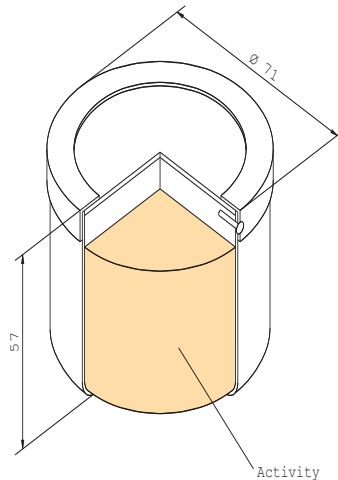
1. Geometry reference sources are normally available with the following densities:
 - 0.02g/cm³: gas equivalent (1 atmosphere)
 - 0.1g/cm³: gas equivalent (10 atmospheres)
 - 0.2g/cm³: gas equivalent (20 atmospheres)
 - 0.5-0.6g/cm³: equivalent to granulated charcoal
 - 0.97g/cm³: water equivalentor any density from 0.7 to 3.0g/cm³
Epoxy resin sources are also available (density 1.17g/cm³)
Other densities may be possible on request.
2. The minimum volume recommended is 1ml.
3. The maximum volume recommended is 20 litres.
4. We recommend that the activity of each radionuclide should be greater than 5kBq. Lower activities are available at additional cost.
5. Some of the resins cannot be used with some containers. If you would like us to use your own type of container, please send us 3 examples for assessment with your enquiry.

If the geometry reference source required is not shown in this catalogue, Eckert & Ziegler Nuclitec GmbH will try to assist you. Either a suitable container to match the dimensions you need can be recommended, or your own container can be filled with the active material.

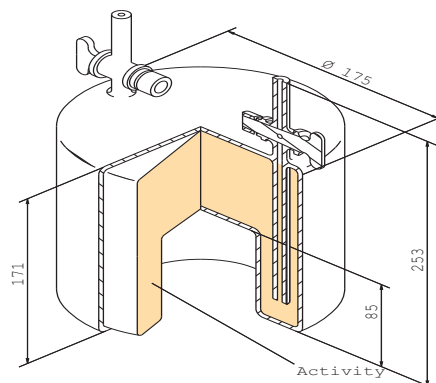
5.10 Examples for custom geometries

This section shows some examples of the wide range of other non-standard geometries which can be manufactured using customer supplied components. Please enquire using the fax back form on page 87.

100ml container



Simulated gas Marinelli reference source



bore diameter 95mm



5.11 Density/composition correction software - 'Gamatool'

Application

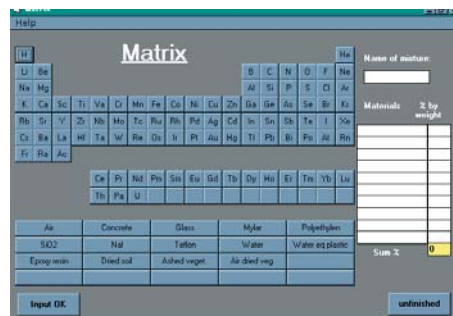
Gamatool™ is a PC windows software package for calculating correction factors for the self-absorption of gamma-rays in samples which have cylindrical symmetry (Marinelli beakers or bottles). The activities of the radionuclides present in the sample can be accurately determined, using the calculated correction factors and an efficiency calibration curve obtained using a reference source or standardized solution.

The gamma-rays emitted by the radionuclides distributed throughout the sample can be absorbed in the sample material before reaching the detector. This self-absorption may be different for the sample and the calibration source, so estimates of the radionuclide activities based solely on the calibration curve can be in error. Gamatool offers a user-friendly method to correct for these effects to give an accurate estimate of the activities.

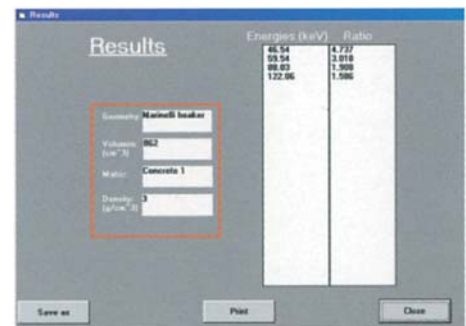
The advantages of Gamatool are:

- Based on a method developed at PTB (Germany) (for further details see 'Measurement of the activity of radioactive samples in Marinelli beakers' by Klaus Debertin and Ren Jianping in Nuclear Instruments and Methods, Volume A278 (1989) p 541-549)
- Attenuation factors for sample matrix densities included
- No detailed knowledge of the detector construction is required
- Results are obtained rapidly (calculation times vary between a few seconds and a few minutes, depending on the processor speed)
- User-friendly operation

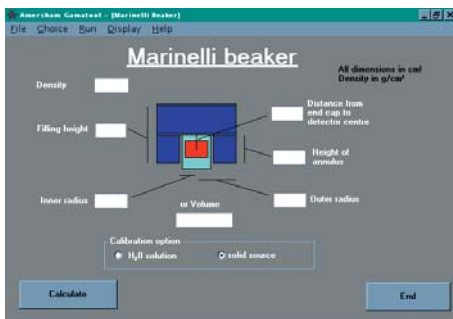
Further details on this computer program are available on request. Please contact your local Eckert & Ziegler Nuclitec office.



Choice - Matrix



Results - Correction factors



Choice - Geometry

Description

Gamatool self-absorption correction software

Product code

NIGB3059

5.12 Custom preparation service

Please photocopy the form on the opposite page, fill in the details as far as possible, and fax the form to your local Eckert & Ziegler Nuclitec office.

Alternatively, contact us by e-mail on:

infoisotrak@ezag.com

or visit our Internet page at:

<http://www.nuclitec.de>

We will reply via your local Eckert & Ziegler Nuclitec office.

Request for custom geometry reference source

Enquiry Form

To: Your local Eckert & Ziegler Nuclitec GmbH office for forwarding the isotrak Technical Service

From: Name: _____
 Institute/company _____
 Address: _____

 Country: _____
 Tel: _____
 Fax: _____
 E-mail: _____

Date: _____

Recommended radionuclide mixtures (composition see pages 95 - 97):

NG1 NG2 NG3 NG4 NG5 NG6

Total activity: _____

Other radionuclides/activities: _____

For beakers/bottles/containers:

Active volume: _____ ml

Density: _____ g/cm³

For simulated filters:

Active diameter: _____ mm

Overall diameter: _____ mm

Date required by: _____

Number of sources required: _____

Container material: _____

Please sketch the container.

The plastic resins used cannot be used with some containers. If the container is not suitable, would you like us to offer an alternative that matches closely the dimensions of your container?

Yes/No

Thank you. Please send 3 empty containers to your local office for testing, marking your name and address clearly on the container.

6.5 NPL standards for environmental measurements

Uncertainties

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor $k=2$, providing a level of confidence of approximately 95% (see section 9.2).

Traceability

The solutions are directly traceable to UK absolute primary radioactivity standards. NPL regularly participates in validation and calibration exercises with other national standards laboratories organised under the auspices of the International Bureau for Weights and Measures (BIPM). Via this route and the Mutual Recognition Arrangement, traceability to NPL is accepted as attributing traceability to other national standards laboratories in many other countries, eg. NIST (USA), LNHB (France) and PTB (Germany).

Regulations/licensing

An export licence may be needed for these solutions. Please contact your local Eckert & Ziegler Nuclitec GmbH office, who will help you with the formalities.

Availability (lead time)

The solutions are despatched within two weeks of receipt of order, or within two weeks of receipt of export license if required.

Quality assurance

NPL Management Ltd has been approved by Lloyds Register Quality Assurance Ltd for certification to ISO9001:2000.

The provision of NPL's environmental standards has been accredited by UKAS to ISO17025:1999.



Courtesy of National Physical Laboratory¹⁾

¹⁾ © Crown Copyright 1996. Reproduced by permission of the Controller of HMSO.

6. Radioactive solutions and gases

6.5 NPL standards for environmental measurements

Ordering information - Solutions

Radio-nuclide	Chemical form & carrier concentration	Radioactive concentration		Total activity		Nominal mass [g]	Product code
		[Bq/g]	(nCi/g)	[Bq]	(nCi)		
Am-241	4M HCl	10	(0.27)	100	(2.7)	10	AMP21301
Am-243	1M HNO ₃	1 0.15	(0.027) (0.004)	10 0.45	(0.27) (0.01)	10 3	ATP21800 ATP21810
C-14	5mg/g Na ₂ CO ₃ + 1mg/g HCHO in water	100	(2.7)	1000	(27)	10	CFP21902
C-14		2000	(54)	20000	(540)	10	CFP21903
Cm-244	1M HNO ₃	20000	(540)	20000	(540)	1	CLP22514
		1000	(27)	1000	(27)	1	CLP22513
		20000	(540)	200000	(5400)	10	CLP22504
		50	(1.3)	500	(13)	10	CLP22501
		2.5	(0.07)	25	(0.7)	10	CLP22500
Cs-134	0.1mg/g Cs in 0.1M HCl	10	(0.27)	100	(2.7)	10	CCP20501
Cs-137	0.1mg/g Cs in 0.1M HCl	10	(0.27)	100	(2.7)	10	CDP20301
Eu-152	0.1mg/g Eu in 0.1M HCl	100	(2.7)	1000	(27)	10	EFP20903
H-3	H ₂ O	10	(0.27)	100	(2.7)	10	TRP23001
I-129	0.06mg/g NaI + 1.5mg/g Na ₂ SO ₃ in 0.001M NaOH	100	(2.7)	1000	(27)	10	ISP21402
Np-237	0.08mg/g H ₂ C ₂ O ₄ in 5M HCl	10000	(270)	10000	(270)	1	NGP22114
		10000	(270)	100000	(2700)	10	NGP22104
		1	(0.027)	10	(0.27)	10	NGP22100
Pb-210	0.05 mg/g each of Pb & Bi in 1.2M HNO ₃	1	(0.027)	10	(0.27)	10	RBP22200
Pu-239	1M HNO ₃	20000	(540)	200000	(5400)	10	PIP22404
		50	(1.3)	500	(13)	10	PIP22401
		2.5	(0.07)	25	(0.7)	10	PIP22400
Pu-242	2M HNO ₃	1	(0.027)	10	(0.27)	10	PRP21500
		0.3	(0.008)	0.9	(0.02)	3	PRP21510
Sr-90	0.02mg/g Sr, 0.02mg/g Y in 0.1M HCl	40	(1.1)	400	(11)	10	SIP20102
		100	(2.7)	1000	(27)	10	SIP20103

6.5 NPL standards for environmental measurements

Radio-nuclide	Chemical form & carrier concentration	Radioactive concentration		Total activity		Nominal mass [g]	Product code
		[Bq/g]	(nCi/g)	[Bq]	(nCi)		
Tc-99	0.1M NH ₄ OH	0.6	(0.02)	6	(0.16)	10	TCP21110
		100	(2.7)	1000	(27)	10	TCP21102
Th-229	2M HNO ₃	10	(0.27)	100	(2.7)	10	TPP22601
		1	(0.027)	10	(0.27)	10	TPP22600
		0.3	(0.008)	0.9	(0.02)	3	TPP22610
		0.3	(0.008)	3	(0.08)	10	TPP22620
U-232	2M HNO ₃	1	(0.027)	10	(0.27)	10	UDP22000
U-232		100	(2.7)	1000	(27)	10	UDP22002
U-232		0.3	(0.008)	0.9	(0.02)	3	UDP22010
U-238	2M HNO ₃	100	(2.7)	1000	(27)	10	UAP22802
		10	(0.27)	100	(2.7)	10	UAP22801
Mixed: Am-241 Cd-109 Co-57 Ce-139 Cr-51 Sn-113 Sr-85 Cs-137 Co-60 Y-88 Zn-65 Mn-54	In 4M HCl: 0.025mg/g of Cd, Co, Ce, Cr, Sn, Sr, Cs, Y, Mn, Zn	1000	(27)	10000	(270)	10	QCP20803
		10000	(270)	100000	(2700)	10	QCP20804

If the radioactive solution required is not shown in this catalogue, Eckert & Ziegler Nuclitec GmbH will try to assist you.

Please photocopy the form on the next page, fill in the details as far as possible, and fax the form to your local Eckert & Ziegler Nuclitec GmbH office.

Alternatively, contact us by e-mail on:

infoisotrak@ezag.com

or visit our Internet page at:

<http://www.nuclitec.de>

We will reply via your local Eckert & Ziegler Nuclitec GmbH office.

Request for custom radioactive solution

Enquiry Form

To: Your local Eckert & Ziegler Nuclitec GmbH office for forwarding the isotrak Technical Service

From: Name: _____
 Institute/company _____
 Address: _____

 Country: _____
 Tel: _____
 Fax: _____
 E-mail: _____

Date: _____

Nuclide(s) required: _____
 Chemical form (eg. in 0.1M HCl) _____

Total activity: _____ Bq or _____ Ci

Total volume: _____ ml

Date required by: _____

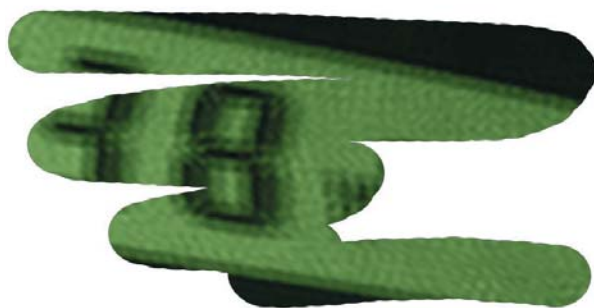
Any special requirement: _____

Our technical experts may be able to recommend an alternative radionuclide. If you wish, please tell us your application: _____

INSTRUMENTS

This section shows a range of state-of-the-art surface contamination monitors,

survey dosimeters and personal alarm dosimeters from approved manufacturers.



Personal alarm dosimeter	120
Survey meters	122
Beta secondary standard	123

7.2 DoseGUARD - Personal alarm dosimeter

Application / Description



DoseGUARD™ personal alarm dosimeters are precision instruments for ensuring that radiation doses are kept as low as reasonably achievable. The dose rate or cumulative dose is shown on an LCD display. An audible alarm sounds if a preset dose or dose rate is exceeded. The instrument can also be set to give an audible warning of the instantaneous dose rate. Energy compensation circuits ensure high accuracy. Key parameters are stored in EEPROM and are retained even if the battery is removed.

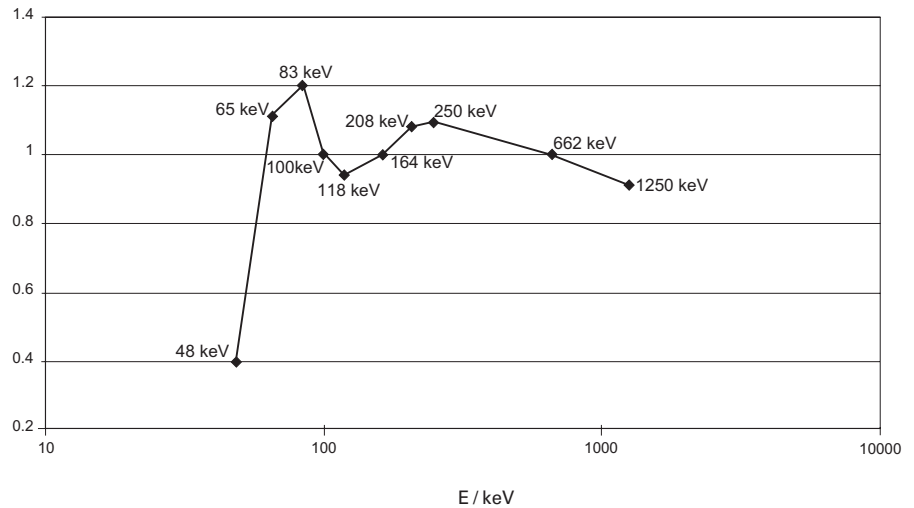
The dosimeter casing is robust and splash-proof, and is constructed from smooth high impact plastic for easy decontamination. The instrument has been designed to protect the readings against accidental erasure due to mechanical shock or an RF field. It is battery operated, and requires one standard AAA size alkaline cell.

Technical data



Radiation type:	Gamma and X-ray
Energy range:	60keV - 3MeV (better than $\pm 25\%$)
Dose measurement range:	1 μ Sv - 9.99Sv
Dose rate measurement range:	5 μ Sv/h - 3Sv/h
Calibration accuracy:	better than $\pm 5\%$ (Cs-137; 662keV at 2mSv/h)
Type of detector:	Silicon diode
Dimensions:	78mm x 67mm x 22mm
Weight:	80g with battery
Battery:	Alkaline 1.5V (type AAA)

DoseGUARD Hp (10) Energy Response,
Energy normalised with Cs-137



New features

- Enhanced RF immunity
- Ruggedized clip fixing
- Easier to decontaminate
- Louder Volume

7.2 DoseGUARD - Personal alarm dosimeter



Features

- Digital display of dose rate or cumulative dose
- Six user-selectable alarm levels for dose and dose rate
- Self-diagnostic operational checking
- Lightweight design with strong pocket clip
- Power reserve of 12 hours after low battery warning

Options

DoseGUARD dosimeters can be configured for particular applications using a reader head connected to a PC (not included) via the serial port. With the reader head it is possible to:

- Prevent a user changing settings using the pushbutton
- Obtain a hard copy printout of the recorded dose
- Customize the alarm settings and chirp rate

Ordering information



	Product code
Dosimeter DoseGUARD	NIGB2000 ex-stock
Dosimeter DoseGUARD S	NIGB3000* (Germany) ex-stock
Reader head ADR-1 and software ADR-1/50	NIGB4955 ex-stock
Checking device with 3.7MBq Cs-137 Source	CDRB7000* (Germany)

*Für Kunden in Deutschland:

Das Dosimeter ist unter der Bezeichnung DoseGUARD S zur innerstaatlichen Eichung zugelassen und ist auch bereits geeicht unter der Bestellnummer NIGB3001 erhältlich. Die zugehörige radioaktive Kontrollvorrichtung wird bereits geeicht geliefert. Weitere Details sind auf Anfrage verfügbar.

7.3 Survey meters



Application / Description

The portable dose survey meters 6150AD5 and 6150AD6 are radiation measurement instruments for the detection of gamma and X-ray radiation. The 6150AD6 dosimeter is recommended for low dose rate measurements, and the 6150AD5 for dose rates up to 1Sv/h. An audible and optical alarm indicates if a preset alarm level is exceeded. The survey meters have a robust, waterproof aluminium die-cast housing, which is easy to decontaminate.

The Teletector 6112M and the Teletector 6150ADT (consists of 6150AD5/6 and 6150AD-t) are microprocessor controlled dose rate meters with telescope to measure gamma radiation and to detect beta radiation. Two GM counting tubes serve as detectors. The stainless steel telescope can be continuously extended up to more than four metres.

A wide range of counting tubes and other accessories is available for these instruments. Please enquire for further information.

Technical data

Instrument type:	6150AD5	6150AD6	6112M	6150AD-t
Energy range:	45keV - 3MeV	60keV - 1.3MeV	65keV - 1.3MeV	65keV - 3MeV
Dose measurement range:	0.01 μ Sv - 9.99Sv	0.01 μ Sv - 99.9mSv	10nSv - 10Sv	0.01 μ Sv - 9.99Sv
Dose-rate measurement range:	0.1 μ Sv/h - 999mSv/h	0.01 μ Sv/h - 9.99mSv/h	0.01 μ Sv/h - 10Sv/h	0.01 μ Sv/h - 9.99Sv/h

Ordering information



New: Teletector 6112M

Accessories:

- Earphone
- Connecting cable for a PC
- Software for data processing
- Probe cover
- Aluminium case

	Product code
Instrument type 6150AD5	NIGB6000
Instrument type 6150AD6	NIGB6001
Belt bag for 6150AD5 / AD6	NIGB6248
Alpha-beta counting tube 6150AD-17 with window	NIGB4974
Gamma counting tube 6150AD-15 (high dose tube)	NIGB5944
Gamma counting tube 6150AD-18 (low dose tube)	NIGB5945
Teletector probe 6150AD-t (requires 6150AD5/6)	NIGB6240
Teletector 6112M	NIGB9000

7.5 Dosimetry systems

7.5.1 Beta secondary standard



radiation		
		2000.06.18 13:46:33
Quantities	Dosemeter Number	Actual Dose
<input type="radio"/> Hp(0,07)	<input type="text" value="B123456Y"/>	0,00 mSv
<input type="radio"/> H'(0,07)	Nominal Dose	± 2,1 % (k=2)
<input type="radio"/> Dg(0) [Beta]	<input type="text" value="3,000"/>	Irradiation Time
Source	Nominal Angle in deg	<input type="text" value="0,0 s of 311 s"/>
<input type="radio"/> Sr-90	<input type="text" value="0"/>	Source: Sr-90 / 1
<input type="radio"/> Kr-85	Remark	Filter: Sr-90 / 1
<input type="radio"/> Pm-147	<input type="text" value="Beta Sekundärnormal 2"/>	Distance: 30 cm
Distance	<input type="button" value="Closed"/>	Angle: 0 deg
<input type="radio"/> 11 cm	<input type="button" value="Start"/>	Temperature: 20,0 °C
<input type="radio"/> 20 cm	<input type="button" value="Stop"/>	Atm.Press.: 101,300 kPa
<input type="radio"/> 30 cm	<input type="button" value="Exit"/>	Humidity: 60 %
<input type="radio"/> 50 cm		
Phantom		
<input type="radio"/> Finger		
<input type="radio"/> Slab		
<input type="radio"/> ohne		
PTB Fachlaboratorium 6.31		

Application / Description

The PTB Beta Secondary Standard (BSS) was first developed nearly 20 years ago for calibrating personal dosimeters and survey instruments for beta radiation. Calibrations are traceable to the PTB's primary standard, and the BSS meets the requirements of ISO6980.

The new BSS (BSS2) is a complete irradiation facility including beta sources, mechanics, electronics, sensors for air pressure, temperature and humidity, and a personal computer to control all irradiation parameters and to deliver the desired dose to the instrument under test.

The main features of the new facility are:

- Dosimeters can be positioned easily at the calibrated point in the radiation field
- Irradiation table rotates in 5 degree steps for measuring polar response
- High activity Pm-147, Kr-85 and Sr-90 sources - dose rate from 7 μ Gy/s to 38 μ Gy/s with beam flattening filters in place
- Sr-90 source also calibrated without filter for source-detector distances of 11, 30 and 50cm
- Each source contained in an individual shield with built-in shutter - reduced operator dose, no special handling equipment needed
- Low activity Tl-204 source replaced by high activity Kr-85 source

For quality assurance purposes and to deliver the required dose to the dosimeter, the computer automatically records the following parameters:

1. Radionuclide and source identification number
2. Type of beam flattening filter
3. Distance between source and dosimeter
4. Angle of incidence of radiation
5. Temperature and air pressure

7.5 Dosimetry systems

Ordering information



Shielded adapter for sources



Type A approved packaging and storage container

	Product code
Beta Secondary Standard comprising:	
Basic irradiation facility	NIGB6243
Control unit	NIGB6244
PC or Notebook with software	NIGB6413
Case with accessories	NIGB7581
Radiation source set (PTB-calibrated)	QCRB6245

Radiation sources parameters

Parameter	Pm-147	Kr-85	Sr-90/Y-90
Half life $T_{1/2}$	958d	3915d	28.8y
Maximum energy E_{\max}	0.225MeV	0.687MeV	2.3MeV
Mean energy E_{mean}	0.06MeV	0.24MeV	0.8MeV
Nominal activity	3.7GBq	3.7GBq	460MBq
Source window in mg/cm^2	2.22Ti	22.5Ti	79h.-g. steel
Calibration distance	20cm	30cm	30cm
Nominal dose rate (in calibration distance)	7 $\mu\text{Gy}/\text{s}$	38 $\mu\text{Gy}/\text{s}$	15 $\mu\text{Gy}/\text{s}$
Drawing/Capsule	VZ-1407	X.1088	VZ-2104
US-model no.	PHC.C1	KAC.D3	SIC.L8
ISO classification	C.33222	C.43232	C.64444

Ordering information - Replacement sources

Radionuclide	Product code
Pm-147	PHRB4809
Kr-85	KARB4810
Sr-90	SIRB4568

PTB calibrated sources mounted into shielded adapter with beam flattening filter.

PRODUCTS FOR EDUCATION AND TRAINING

This section gives
detailed information

about products to support training in radiation protection, applications of radioactivity and handling radioactive materials.

The demonstration set AktivLab™ can be used to show the basic properties of radioactivity. Alpha, beta and gamma sources have been also specifically designed for demonstration purposes during training sessions.



AktivLab - Basic training on radioactivity	126
Cs-137/Ba-137m isotope generator	128
Demonstration sources	129

8.1 AktivLab - Demonstration set for experiments on radioactivity

Applications

AktivLab™ contains everything needed to carry out experiments to demonstrate the fundamental properties of radioactivity. The kit includes detailed descriptions of experiments which are suitable for physics courses and for training professional health physicists. The radioactive source used is a radionuclide generator, similar in principle to generators used in nuclear medicine.



Experiments that are performed with AktivLab include:

- Measuring the half life of Ba-137m
- The absorption of gamma rays in lead
- The inverse square law
- Estimating the activity of a radioactive source
- The statistics of radioactive decay
- Measuring the plateau of a detector

Technical description



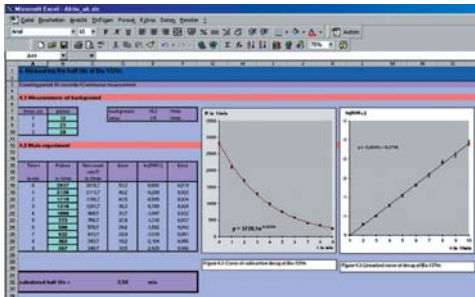
AktivLab comprises

- 1 Isotrak ratemeter
- 2 1 Geiger-Müller tube
- 3 1 Optical bench with holders
- 4 1 Cs-137/Ba-137m isotope generator (see page 136)
- 5 1 Flask with eluting solution for generator
- 6 Vials for the generator eluate
- 7 1 Jig for the vials
- 8 1 Set of lead and aluminium absorbers
- 9 1 Flask of potassium chloride (K-40)
- 10 1 Holder for demonstration sources (see also pages 137, 138)

Storage case with booklet of experiments and handling instructions

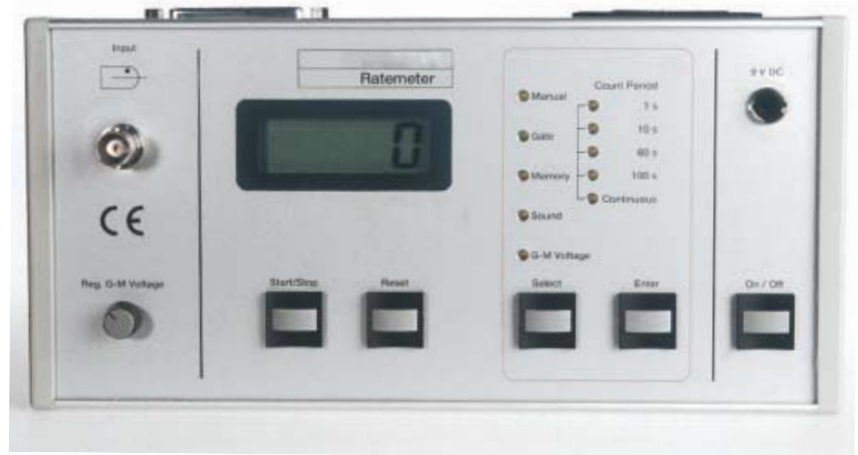
8.1 AktivLab - Demonstration set for experiments on radioactivity

Isotrak ratemeter



The ratemeter can be operated under computer control via the RS 232 interface.

Power supply	9V battery or mains adaptor
Selectable count times	1s, 10s, 60s, 100s and continuous
Counter tube voltage range	250 - 600V
Display	4 digit LCD
Memory	up to 50 counting results
Dimensions	220 x 108 x 60mm
Output	RS 232 interface



Geiger-Müller tube

Radiations detected	alpha, beta and gamma
Window thickness	1.5 - 2.0mg/cm ²
Effective window diameter	9mm

Ordering information

AktivLab (ratemeter with RS232 interface)

CDRB5645

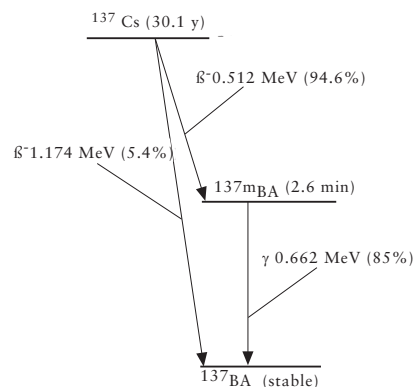
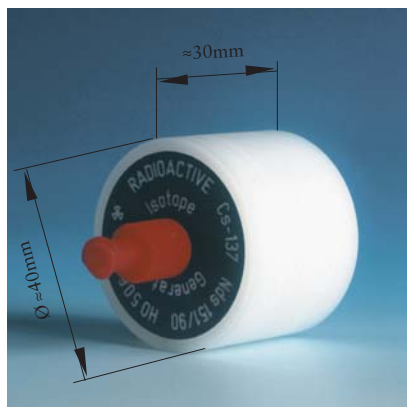
ex-stock

8. Products for education and training

8.2 Cs-137/Ba-137m isotope generator

Applications

The Eckert & Ziegler Nuclitec Cs-137/Ba-137m Isotope generator has been specifically designed for use in experiments in schools, universities and trainings centres to demonstrate the properties of radioactivity including half life.



Technical description

The Isotope generator (Drawing VZ-1390 License number ¹⁾Nds 151/90) can be eluted up to 1,000 times to produce small /aliquots of a short lived radioactive solution. A flask containing 250ml of the necessary eluting solution is supplied with each generator, and the eluting solution is also available separately.

The generator contains 33kBq or 370kBq of Cs-137 as the long-lived parent nuclide (half life 30.1 years).

The decay scheme of Cs-137 is shown above.

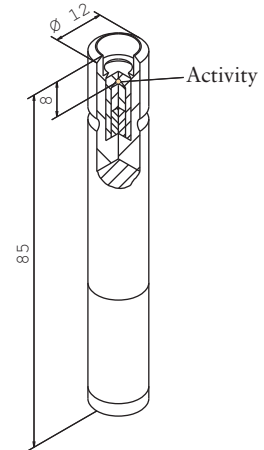
Ordering information

Radionuclide/Product	Nominal activity	Product code
Cs-137	33 kBq	CDRB5215
Cs-137	370 kBq	CDRB1385
Eluting solution 250ml (0.9% NaCl)	inactive	NQB1948

¹⁾The design of this source has been tested by the Physikalisch-Technische Bundesanstalt (PTB) and has been approved by the German authorities.

Applications

A set of easy-to-handle sources of different radionuclides is available for further experiments on radioactivity. The design of the sources and their activities have been selected to permit effective experiments while minimising the potential hazard.¹⁾



Construction

The radioactive substance is housed in a recess in an aluminium holder 85mm long and 12mm in diameter. The activity is either sealed in a stainless steel capsule (Cs-137, Co-60), incorporated in a metal foil (Sr-90, Am-241) or fixed on a disc (Na-22). The mixed source consists of a stainless steel capsule containing Cs-137, in front of which foils incorporating Sr-90 and Am-241 are placed.

For reference the construction of the sources is shown in drawing VZ-2297.

Ordering information - Source sets

Radionuclide	Nominal activity	Product code
Set 1		QCRB8149
Am-241	74 kBq	
Co-60	74 kBq	
Na-22	74 kBq	
Sr-90	74 kBq	
Set 2		QCRB7471
Am-241	74 kBq	
Co-60	74 kBq	
Na-22	74 kBq	
Sr-90	74 kBq	
Cs-137	74 kBq	
Set 3		QCRB8150
Am-241	74 kBq	
Co-60	74 kBq	
Na-22	74 kBq	
Sr-90	74 kBq	
Mixed nuclide source Am-241, Sr-90, Cs-137	342 kBq	

¹⁾ The design of these sources has been tested by the Physikalisch-Technische Bundesanstalt (PTB) and has been approved by the German authorities (Licence Nds 002/99).

8.3 Demonstration sources



Ordering information - Single sources

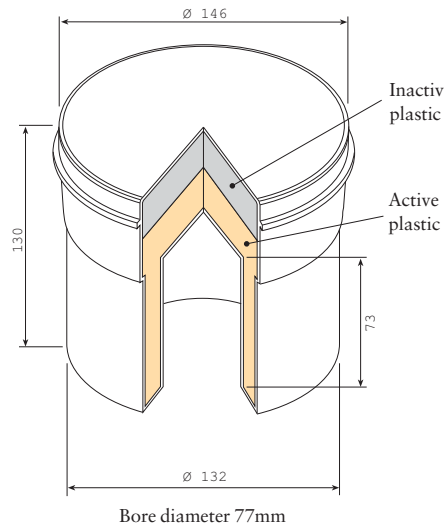
all
ex-stock

Radionuclide	Nominal activity	License ¹⁾	Product code
Am-241	74 kBq	Nds 002/99	AMRB8151
Cs-137	74 kBq	Nds 002/99	CDRB8151
	370 kBq	Nds 155/78	CDR82902
Co-60	3.7 kBq		CKRB8153
	74 kBq	Nds 002/99	CKRB8151
Na-22	74 kBq	Nds 002/99	SKRB8151
Sr-90	74 kBq	Nds 002/99	SIRB8151
Mixed nuclide source		Nds 002/99	QCRB7472
Am-241	4.4 kBq		
Sr-90	4.4 kBq		
Cs-137	333 kBq		

¹⁾The design of these sources has been tested by the Physikalisch-Technische Bundesanstalt (PTB) and has been approved by the German authorities.

Applications

Samples measured by environmental monitoring laboratories usually contain very low levels of radioactivity. Marinelli beakers are used for large volume samples, for example, water samples, so that the sample is placed as close as possible to the detector for maximum sensitivity. This source can be used to calibrate a gamma-ray spectrometer. Empty beakers are also available.



Technical description

The Marinelli beaker is constructed from polypropylene and is resistant to acids and most organic solvents. The radioactive material is homogeneously incorporated in a special water-equivalent plastic matrix. The matrix density is 1g/cm^3 . The bore diameter is 77mm.

ISO classification

C.22323

Drawing: VZ-1262

Ordering information

Radionuclide/Product	Nominal activity	License ¹⁾	Product code
Cs-137	5 kBq	Nds 152/96	CDRB5072
Empty beakers ²⁾	inactive		NQ7013

¹⁾ The design of these sources has been tested by the Physikalisch-Technische Bundesanstalt (PTB) and has been approved by the German authorities.

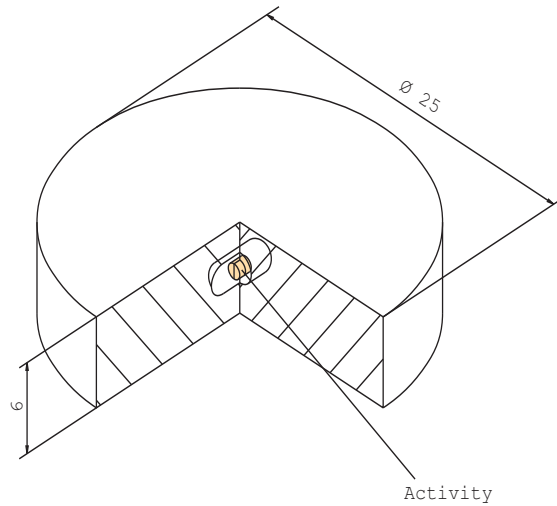
²⁾ The minimum order quantity is 30 empty beakers.

8.5 Point radium source

Applications

Ra-226 emits a wide range of gamma-rays from 53keV to 2.2MeV, and has a long half life (1600 years).

This is a useful, general purpose, demonstration source for gamma-ray spectrometers and gamma counters.



Construction

The Ra-226 activity is incorporated in a ceramic pellet which is encapsulated in glass. The glass capsule is mounted into an plastic disc. The Ra-226 is in radioactive equilibrium with its radioactive decay products.

ISO classification

C.34313

Drawing: VZ-590

Ordering information

Radionuclide	Nominal activity	Product code
Ra-226	10 kBq	RARB2543

TECHNICAL APPENDICES

contamination monitoring. An overview of quality control requirements for sealed radioactive sources is given. A table of nuclear decay scheme data is given at the end of this section.

This section contains detailed information about the traceability of measurement results, the calculation of uncertainties and surface



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9.1 Traceability

Traceability is the property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons.

Reference sources and standardized solutions supplied by Eckert & Ziegler Nuclitec GmbH are traceable to standards held by National Laboratories such as: the Physikalisch-Technische Bundesanstalt (PTB), Germany; the National Physical Laboratory (NPL), UK; the Laboratoire Primaire de Rayonnements Ionisants (LPRI), France; and the National Institute of Standards and Technology (NIST), USA.

The National Laboratories participate in validation and intercomparison exercises organised under the auspices of the International Bureau for Weights and Measures (BIPM) in France. Traceability to one National Laboratory can often be accepted as attributing traceability to other laboratories.

The administrative system to confirm traceability depends on the country to which traceability is sought. In particular, there are differences between the systems for Europe and the USA.

Traceability in Europe - Accreditation

Eckert & Ziegler Nuclitec GmbH operates an accredited measurement laboratory in Germany.

Accreditation is a system of assessment of laboratories by independent experts to the European standard EN ISO/IEC 17025. The assessments are carried out by experts representing the national accreditation body. The accreditation body in the UK is the United Kingdom Accreditation Service (UKAS), and in Germany the body is the Deutscher Kalibrierdienst (DKD).

The assessors check that the laboratories are meeting essential conditions, such as:

- technical competence
- impartiality
- valid calibration methods
- traceability to national standards
- effective quality system

If the laboratory passes the assessment and the surveillance visits, the laboratory is permitted to issue certificates of calibration marked with the symbol issued by the accreditation body (UKAS uses the UKAS logo under license from the UK government, DKD uses the DKD logo under license from the PTB).

The advantages of UKAS or DKD certificates are:

- Assurance that work has been carried out to the required standard
- Assurance that agreed methods have been followed
- Assurance that measurements are traceable to national standards

In turn, accreditation bodies such as UKAS and DKD are evaluated by a team of assessors from the European Co-operation for Accreditation of Laboratories (EA). The EA has set up mutual recognition agreements, so a UKAS or DKD certificate has one further advantage:

- Accepted in many countries world-wide

For example, a UKAS or DKD certificate of calibration has the same status in France as a COFRAC certificate (the accreditation body in France).

Traceability in the USA - NIST

The requirements for traceability to the National Institute of Standards and Technology are set out in the American National Standards Institute standard ANSI N42.22-1995 'American National Standard - Traceability of Radioactive Sources to the National Institute of Standards and Technology (NIST) and Associated Instrument Quality Control'.

The standard requires that source manufacturers meet certain criteria. The criteria fall under four main headings:

- Quality assurance management system
- Facilities and equipment
- Participation in NIST measurement assurance program
- Certificates of calibration

9.1 Traceability

Eckert & Ziegler Nuclitec GmbH's reference sources and standardized solutions satisfy the criteria for traceability as:

- Eckert & Ziegler Nuclitec GmbH's measurement laboratory and production facilities meet the requirements of international standards (ISO 9001), but for the sake of completeness have also been audited against the specific requirements of ANSI N42.22 and found to be in full compliance.
- Facilities and equipment are audited by independent experts from UKAS and DKD
- Eckert & Ziegler Nuclitec GmbH is a charter member of the Steering Group of the Nuclear Energy Institute (NEI)/NIST Measurement Assurance Program. Eckert & Ziegler Nuclitec GmbH's measurement laboratory carries out intercomparison exercises with NIST, and ensure that the results meet the acceptance criteria required by ANSI N42.22.
- The certificates of calibration provide the information required by ANSI N42.22.

9.2 Calculation of uncertainties

Every measurement is subject to an error, where the error is defined to be the measured result minus the (unknown) true value. The uncertainty is the range about zero in which the error is thought to lie, with a certain level of confidence.

For all of the standards described in this catalogue, the uncertainties in the measurements have been calculated following the 'Guide to the Expression of Uncertainty in Measurement', published by the International Organisation for Standardization, Geneva, in 1993. The guide was written by the BIPM, IEC, ISO and OIML, under the auspices of the Comité International des Poids et Mesures. The method described in the guide is recommended by national standards laboratories and accreditation bodies (see for example, NIST Technical Note 1297 (1994), UKAS document NIS3003 (1995)).

In brief, the uncertainties are calculated in the following way:

- The overall uncertainty is composed of many different components (eg, counting statistics, instrumental drifts, uncertainties in standards).
- Each component of the uncertainty is classified as either a Type A or a Type B uncertainty:
 - Type A: uncertainty estimated by a statistical method
 - Type B: uncertainty estimated by another method (eg, theoretical calculation)
- Each component is then characterised by a standard deviation (u_i), taking into account the probability distribution of the error (eg, Gaussian, rectangular, U-shaped etc.).
- The estimated standard deviations are then summed in quadrature to give the overall standard deviation: $u_c = (\sum u_i^2)^{1/2}$
- This figure is multiplied by a coverage factor (k) to obtain the expanded uncertainty (U): $U = k u_c$. For the standards in this catalogue, the coverage factor chosen is 2.0, which is approximately equivalent to a level of confidence of 95%.

Formerly, uncertainties were calculated following ICRU Report 12 ('Certification of Standardized Radioactive Sources') published by the International Commission on Radiation Units and Measurement in 1968. The main differences with the new approach are:

- The terms random and systematic uncertainties are no longer used. The reason is that a random uncertainty at one stage in a measurement can become a systematic uncertainty at the next (for example, the uncertainty in a calibration standard).
- Under the new scheme, components of the uncertainty are combined in quadrature rather than linearly as in ICRU Report 12. The disadvantages of combining uncertainties linearly are that the uncertainty can be unrealistically large, and the probability that a result is near the edge of the overall uncertainty quoted is extremely low.

The new method of calculating uncertainties therefore allows a more meaningful comparison of measurements.

ISO classification

The International Organization for Standardization (ISO) has proposed a system of classification of sealed radioactive sources based on the safety requirements for typical uses (see ISO2919:1999). This system provides a manufacturer of sealed radioactive sources with a set of tests to evaluate the safety of his products. It also assists a user of such sealed sources to select types which suit the application in mind.

The tests to which specimen sources are subjected are listed in the following table. Each test can be applied in several degrees of severity. Test results are expressed as a five figure code to indicate the severity of the tests.

These figures are preceded by the letter C or E to show whether the source activity is less than or greater than certain limits. These limits depend upon the toxicity, solubility and reactivity of the active component of the source.

C indicates that the activity level of the source does not exceed the prescribed limit and E that the limit is exceeded.

Classification of sealed radioactive source performance standards according to ISO 2919

Test	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
Temperature	No test	-40°C (20min) +80°C (1h)	-40°C (20min) +180°C (1h)	-40°C (20min) +400°C (1h) and thermal shock 400°C to 20°C	-40°C (20min) +600°C (1h) and thermal shock 600°C to 20°C	-40°C (20min) +800°C (1h) and thermal shock 800°C to 20°C
External pressure	No test	25kPa absolute to atmospheric	25kPa absolute to 2MPa absolute	25kPa absolute to 7MPa absolute	25kPa absolute to 70MPa absolute	25kPa absolute to 170MPa absolute
Impact	No test	50g from 1m	200g from 1m	2kg from 1m	5kg from 1m	20kg from 1m
Vibration	No test	3 x 10min 25kHz to 500Hz at 5g acceleration max. amplitude	3 x 10min 25Hz to 50Hz at 5g acceleration max. amplitude and 50Hz to 90Hz at 0.635mm amplitude peak to peak and 90Hz to 500Hz at 10g acceleration max. amplitude	3 x 30min 25Hz to 80Hz at 1.5mm amplitude peak to peak and 80Hz to 2000Hz at 20g acceleration max. amplitude		
Puncture	No test	1g from 1m	10g from 1m	50g from 1m	300g from 1m	1kg from 1m

IAEA special form

‘Special Form’ is a test specification for sealed sources given in the IAEA transport regulations (IAEA Safety Standards Series No. ST-1, 1996). It is used in determining the maximum acceptable activities for various types of transport containers.

Leakage and contamination tests

Stringent tests for leakage are an essential feature of radioactive sources production. They are based on ISO9978. Some standard methods used for testing radiation sources are listed below.

Wipe test I (A)	Immersion test II (L)	Bubble test III (D)	Emanation test IV
The source is wiped with a swab or tissue, moistened with ethanol or water; the activity removed is measured.	The source is immersed in a suitable liquid at 50°C for 4 hours and the activity removed is measured.	The source is immersed in water or a suitable liquid and the pressure in the vessel reduced to 25-15 kPa. No bubbles must be observed. (This test conforms to ISO9978 except that for sources, the 100mm ³ free volume requirement is not met).	The source is placed in a gas tight enclosure with a suitable absorber and is left there for at least 3h. The source is considered leak tight when not more than 200Bq Radon related to a collection time of 12h can be measured afterwards.
Limit 200Bq	Limit 200Bq		

9.4 Surface contamination monitoring

In this appendix, the difference between class 2 and working sources will be explained in the context of measuring surface contamination.

Measuring surfaces in the workplace for radioactive contamination is an important part of ensuring that the radiation doses workers receive are kept as low as reasonable practicable.

Two written standards have been published by ISO (International Organization for Standardization) to advise on the measurement of radioactive contamination on surfaces:

ISO8769:1988 part 1 ‘Reference sources for the calibration of surface contamination monitors - Beta emitters (maximum beta energy greater than 0.15MeV) and alpha emitters’.

This document describes how calibration standards should be constructed and measured for beta and alpha emitting radionuclides.

ISO8769:1996 part 2 ‘Reference sources for the calibration of surface contamination monitors - Electrons of energy less than 0.15MeV and photons of energy less than 1.5MeV’.

The second part extends the standard to include photon emitting radionuclides (eg, Ga-67, Tc-99m, In-111).

ISO7503:1988 part 1 ‘Evaluation of surface contamination - Part 1: Beta emitters (maximum beta energy greater than 0.15MeV) and alpha emitters’.

This document then describes how the calibrated instrument is used to assay beta- and alpha-emitting contamination on surfaces.

ISO7503:1988 part 2 ‘Evaluation of surface contamination - Tritium surface contamination’.

ISO7503:1996 part 3 ‘Evaluation of surface contamination - Isomeric transition and electron capture emitters, low energy beta emitters (maximum beta energy less than 0.15MeV)’.

These documents extend part 1 to cover tritium and photon emitting radionuclides.

Alpha-and beta-surface emitting radionuclides - ISO8769

This document defines a hierarchy of calibration standards. There are 3 levels:

Class 1 standards

- The sources must be as close as possible to an ideal, infinitely thin, source.
- The surface emission rate must be measured at a National Standards Laboratory with an uncertainty which shall not exceed 3%.

Class 2 standards

- The sources must be as close as possible to an ideal, infinitely thin, source.
- The particle emission rate must be measured against a class 1 standard with an uncertainty which shall not exceed 6%.

Working sources

- A robust source construction can be used; the source does not have to be as close as possible to an ideal, infinitely thin, source.
- The surface emission rate must be measured against either a class 1 source or a class 2 source. The stated uncertainty is normally $\pm 10\%$ or less.

In general, class 1 sources are used by source manufacturers to calibrate transfer instruments used to produce class 2 and working sources. The class 2 sources are used by instrument calibration facilities or users to calibrate contamination monitors for the statutory annual test (depending on the country's regulations). Working sources are used more frequently (monthly, or daily) to check calibrations in the field.

Eckert & Ziegler Nuclitec GmbH has implemented ISO8769 in the following way, taking account of the different applications of the sources:

- Class 1, class 2 and working sources are all constructed using the same manufacturing method, which results in a robust but thin active layer
- Class 1 sources are calibrated at a National Laboratory (available on request).
- Class 2 sources are issued with an DKD certificate of calibration, due to the requirement for proof of traceability to national standards for statutory tests.
- Working sources are issued with an Eckert & Ziegler Nuclitec GmbH certificate of calibration to provide cost-effective sources for regular use.

Strictly, the terms class 1, class 2 and working sources only apply to sources greater than 100cm² in area. The classification has been retained for smaller sources to help identify the best source for different applications.

Photon emitting wide area reference sources - ISO8769 part 2

The certificate of calibration for each source states the mean photon energy and the photon emission rate (for the sources listed on page 28, these quantities are directly traceable to UK primary standards). To use the source set, the monitor response is determined at each photon energy. A calibration curve is then plotted and the response of the instrument to any photon-emitting radionuclide can then be estimated.

The advantages of using this set of sources are:

- Comply with international standard for calibrating monitors for photon emitting radionuclides
- Calibration factors can be derived for any photon emitting radionuclide
- Consistent, defined, method for comparing suitability of different types of monitor

Many radionuclides (for example, Tc-99m used in nuclear medicine) decay by emitting photons only. The set of sources described in ISO8769 part 2 can be used to calibrate surface contamination monitors for such radionuclides.

Each of the seven sources (see page 28) in the set has been constructed to emit monoenergetic photons covering a range of energies from 6keV to 1200keV. The active area of each source is 10x10cm² on a 3mm thick backing plate 15x15cm² in area. Where applicable, the source is covered with an inactive foil to absorb particles that could interfere with the measurements.

The nuclear decay scheme data shown on the following pages are intended as a guide for selecting the radionuclides for your application¹⁾ and show the major radiations only. The decay scheme data are taken from the JEF-2.2 Radioactive Decay Data library. The JEF (Joint Evaluated File) project started in 1981 with the aim of setting up a comprehensive database for fission reactor applications, for OECD member countries. The latest version (JEF-2.2) contains the decay schemes of 2344 radionuclides and includes the energies and intensities of 69835 gamma rays.

Key to symbols

α	alpha decay
β^-	beta decay ²⁾
β^+	positron decay
ec	electron capture
it	isomeric transition
ic	internal conversion
y	years
d	days
h	hours
m	minutes
s	seconds

For further details on the JEF-2.2 library contact:

OECD countries:
NEA Databank
Le Seine St-Germain
12, Boulevard des Îles
92130 Issy-les-Moulineaux
France
e-mail: NEA@FRNEAAB51

USA and Canada:
National Nuclear Data Center
Brookhaven National Laboratory
Upton
NY 11973-5000
USA

Non-OECD countries:
IAEA Nuclear Data Section
PO Box 100
A-1400 Vienna
Austria

¹⁾ The decay scheme data relevant to a particular source are given on the certificate of calibration or measurement report. These data may not be exactly the same as the data listed here, as regulations may require that specific data are used.

²⁾ The energy given in the table is the end-point energy.

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
H-3	12.33y	β^-			0.019	100.0		
Be-7	53.3d	ec				100.0	0.478	10.3
C-14	5730y	β^-			0.157	100.0		
Na-22	2.60y	β^+			0.546	90.5	0.511	from β^+
		ec			1.820	0.06	1.275	99.94
							9.5	
Na-24	14.98h	β^-			0.277	0.1	1.369	100.0
					1.390	99.9	2.754	99.9
P-32	14.3d	β^-			1.710	100.0		
S-35	87.5d	β^-			0.168	100.0		
Cl-36	3.02x10 ⁵ y	β^-			0.710	98.1		
		ec				1.9		
K-42	12.4h	β^-			1.684	0.35	0.313	0.35
					1.997	18.4	1.525	18.9
					3.521	81.1		
Ca-45	163d	β^-			0.256	100.0		
Sc-46	83.8d	β^-			0.357	100.0	0.889	100.0
					1.478	0.004	1.121	100.0
Ca-47	4.54d	β^-			0.691	82.0	0.489	6.7
					1.221	0.1	0.530	0.1
					1.988	18.0	0.767	0.2
							0.808	6.9
							1.297	74.9
via Sc-47	3.40d	β^-			0.441	70.0	0.159	70.0
					0.600	30.0		
Cr-51	27.7d	ec				100.0	0.320	9.8
							0.005	22% X-rays
Mn-54	312.5d	ec				100.0	0.835	99.98
Fe-55	2.7y	ec				100.0	0.006	28% X-rays

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon		
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	
Co-56	78.8d	β^+			0.423	1.1	0.511	from β^+	
					1.461	18.6	0.847	99.9	
		ec					0.977	1.4	
							1.038	14.1	
							1.175	2.3	
							1.238	67.0	
							1.360	4.3	
							1.771	15.5	
							2.015	3.0	
							2.035	7.8	
							2.599	16.7	
							3.010	1.0	
							3.202	3.0	
				3.254	7.4				
				3.273	1.7				
				3.451	0.9				
Co-57	271.4d	ec				100.0	0.014	9.6	
							0.122	85.5	
							0.136	10.7	
							0.692	0.2	
Co-58	70.8d	β^+			0.473	15.0	0.511	from β^+	
						85.0	0.811	99.5	
		ec					0.864	0.7	
							1.675	0.5	
Fe-59	45.1d	β^-			0.085	0.1	0.143	1.0	
					0.132	1.3	0.192	3.1	
					0.275	45.3	0.335	0.3	
					0.467	53.1	0.382	0.02	
					1.566	0.2	1.099	56.5	
							1.292	43.2	
					1.482	0.1			
Co-60	5.27y	β^-			0.318	99.9	1.173	99.9	
					1.491	0.1	1.333	99.98	
Ni-63	100.0y	β^-			0.066	100.0			
Zn-65	244.3d	β^+			0.329	1.5	1.116	50.7	
						98.5			
Ga-67	3.26d	ec				100.0	0.091	3.0	
							0.093	37.0	
							0.185	20.4	
							0.209	2.3	
							0.300	16.6	
							0.394	4.6	
							0.494	0.1	
							0.794	0.1	
							0.888	0.1	

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon			
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]		
Se-75	119.8d	ec				100.0	0.066	1.1		
							0.097	3.5		
							0.121	17.3		
							0.136	59.0		
							0.199	1.5		
							0.265	59.1		
							0.280	25.2		
							0.304	1.3		
				0.401	11.6					
via As-75m	17ms	it					0.304	0.9		
Br-82	1.47d	β^-			0.258	1.4	0.221	2.3		
					0.439	98.6	0.554	70.6		
							0.606	1.2		
							0.619	43.1		
							0.698	27.9		
							0.776	83.4		
							0.828	24.2		
							1.008	1.3		
							1.044	27.4		
							1.317	26.9		
				1.475	16.6					
				1.650	0.8					
Kr-85	10.72y	β^-			0.173	0.4	0.514	0.4		
					0.687	99.6				
Sr-85	64.84d	ec				100.0	0.514	98.3		
							0.014	60% X-rays		
Rb-86	18.7d	β^-			0.698	8.8	1.077	8.8		
					1.775	91.2				
Y-88	106.6d	β^+			0.761	0.2	0.511	from β^+		
						99.8	0.898	94.0		
		ec					1.836	99.4		
							2.734	0.6		
Sr-89	50.5d	β^-			0.583	0.01				
					1.492	99.99				
via Y-89m	16.06s	it					0.909	0.01		
in equilibrium										
Sr-90	29.12y	β^-			0.546	100.0				
			via Y-90	2.67d	β^-			0.523	0.016	1.761
			0.02ic					2.284	99.98	
Y-90	2.67d	β^-			0.523	0.016	1.761			
			0.02ic			2.284	99.98			
Y-91	58.5d	β^-			0.338	0.3	1.205	0.3		
					1.543	99.7				

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
Nb-93m	16.4y	it				100.0	0.017	11% X-rays
Nb-95	35.2d	β^-			0.160	100.0	0.766	100.0
Zr-95	63.98d	β^-			0.365 0.398 0.887	55.0 44.6 0.7	0.724 0.757	44.4 54.9
via Nb-95m in equilibrium	3.61d						0.235	0.3
via Nb-95	35.2d	β^-			0.160	100.0	0.766	100.0
Mo-99	2.75d	β^-			0.436 0.848 1.214	16.6 1.2 82.0	0.041 0.140 0.181 0.366 0.740 0.778	1.1 4.9 6.1 1.2 12.2 4.3
via Tc-99m in equilibrium	6.02h	it				100.0	0.140	89.0
Tc-99	2.13×10^5 y	β^-			0.294	100.0		
Tc-99m	6.02h	it					0.140	89.00
Ru-103	39.4d	β^-			0.112 0.225 0.723	6.5 90.0 3.5	0.053 0.295 0.444 0.497 0.557 0.610	0.37 0.25 0.32 88.9 0.83 5.6
via Rh-103m	56.1m	it					0.040 0.021	0.1 8% X-rays
Ru-106	1.01y	β^-			0.039	100.0		
via Rh-106	29.8s	β^-			1.979 2.407 3.029 3.541	1.7 9.8 8.4 78.6	0.512 0.622 0.874 1.050 1.128 1.562	20.7 9.8 0.4 1.5 0.4 0.2
Cd-109	1.27y	ec				100.0	0.023	68% X-rays
via Ag-109m in equilibrium	39.6s	it					0.088 0.023	3.7 35% X-rays

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
Ag-110m	249.9d	β^-			0.084	67.5	0.447	3.7
					0.531	30.6	0.620	2.8
							0.658	94.7
							0.678	10.7
							0.687	6.5
							0.707	16.7
							0.744	4.7
							0.764	22.4
							0.818	7.3
							0.885	72.9
							0.937	34.3
				1.384	24.4			
				1.476	4.0			
				1.505	13.1			
				1.562	1.2			
via Ag-110	24.6s	β^-			2.235	4.4	0.658	4.5
					2.893	95.2		
In-111	2.83d	ec				100.0	0.171	90.2
							0.245	94.0
Sn-113	115.1d	ec				100.0	0.255	1.8
via In113m	1.66h	it				100.0	0.392	64.9
I-123	13.2h	ec				100.0	0.159	83.3
							0.529	1.4
Sb-124	60.2d	β^-			0.212	8.8	0.603	97.9
					0.612	52.0	0.646	7.2
					0.867	3.6	0.709	1.4
					0.948	2.0	0.714	2.4
					1.580	5.4	0.723	11.3
					1.657	2.5	0.791	0.7
					2.303	22.6	0.968	1.8
							1.045	1.8
							1.326	1.4
							1.355	0.9
							1.368	2.4
				1.437	1.0			
				1.691	48.8			
				2.091	5.6			
I-125	60.1d	ec				100.0	0.035	6.7
							0.028	140%X-rays

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
Sb-125	2.73y	β^-			0.095	13.6	0.036	4.3
					0.125	5.8	0.176	6.8
					0.131	18.1	0.321	0.4
					0.242	1.6	0.380	1.5
					0.303	40.2	0.428	29.4
					0.323	0.1	0.463	10.5
					0.446	7.1	0.601	17.8
					0.622	13.5	0.607	5.0
							0.636	11.3
							0.671	1.8
via Te-125m	58.0d	it			100.0	0.035	6.7	
not necessarily in equilibrium						0.109	0.3	
I-129	1.57x10 ⁷ y	β^-			0.150	100.0	0.040	7.5
						0.030	65% X-rays	
I-131	8.04d	β^-			0.248	2.1	0.080	2.6
					0.304	0.6	0.284	6.1
					0.334	7.4	0.364	81.2
					0.606	89.4	0.637	7.3
					0.807	0.4	0.723	1.8
via Xe-131m	11.9d	it			100.0	0.164	2.0	
Ba-133	10.52y	ec				100.0	0.053	2.2
							0.080	2.6
							0.081	34.1
							0.161	0.6
							0.223	0.4
							0.276	7.2
							0.303	18.3
							0.356	62.1
				0.384	8.9			
Xe-133	5.25d	β^-			0.266	0.7	0.080	0.2
					0.346	99.3	0.081	37.1
							0.161	0.1
Cs-134	2.06y	β^-			0.089	27.1	0.475	1.5
					0.415	2.5	0.563	8.4
					0.658	70.3	0.569	15.0
							0.605	97.5
							0.796	85.1
							0.802	8.8
				1.038	1.0			
				1.168	1.9			
				1.365	3.2			

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
Cs-137	30.00y	β^-			0.512	94.6		
					1.173	5.4		
via Ba-137m in equilibrium	2.55m	it					0.662 0.033	85.1 7% X-rays
Ce-139	137.6d	ec				100.0	0.166 0.034	79.9 80% X-rays
Ba-140	12.74d	β^-			0.454	24.7	0.014	1.2
					0.567	9.9	0.030	13.7
					0.872	3.8	0.163	6.2
					0.991	39.0	0.305	4.3
					1.005	23.0	0.424	3.1
							0.438	1.9
				0.537	24.4			
La-140	1.68d	β^-			1.213	0.6	0.329	20.7
					1.239	11.1	0.432	3.0
					1.244	5.7	0.487	45.9
					1.279	1.1	0.752	4.4
					1.296	5.6	0.816	23.6
					1.348	43.7	0.867	5.6
					1.412	5.1	0.920	2.7
					1.677	21.6	0.925	7.0
					2.164	5.0	1.596	95.4
				2.521	3.4			
Ce-141	32.5d	β^-			0.436	70.5	0.145	48.4
					0.580	29.5	0.036	17% X-rays
Ce-144	284.9d	β^-			0.185	19.6	0.034	0.2
					0.238	3.9	0.041	0.3
					0.318	76.5	0.053	0.1
							0.080	1.4
						0.134	11.1	
via Pr-144m	7.2m	β^-			0.109	0.03	0.059	0.1
					0.473	0.01		
					1.544	0.01		
		it			99.95			
via Pr-144	17.3m	β^-			0.810	1.1	0.697	1.3
					2.299	1.0		
					2.996	97.9		
Pm-147	2.62y	β^-			0.225	100.0		

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon		
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	
Eu-152	13.3y	β^-			0.176	1.8	0.122	28.4	
					0.385	2.4	0.245	7.5	
					0.696	13.8	0.344	26.6	
					1.475	8.2	0.411	2.2	
					0.733	0.02	0.444	2.8	
							71.8	0.779	13.0
			β^+					0.867	4.2
								0.964	14.5
								1.086	9.9
								1.112	13.6
								1.213	1.4
								1.299	1.6
								1.408	20.9
Gd-153	242.0d	ec				100.0	0.070	2.4	
							0.075	0.1	
							0.083	0.2	
							0.089	0.1	
							0.097	29.5	
							0.103	21.1	
Tb-160	72.3d	β^-			0.438	4.5	0.087	13.2	
					0.479	10.0	0.197	5.1	
					0.551	3.4	0.216	3.9	
					0.573	47.0	0.299	26.9	
					0.788	6.5	0.765	2.0	
					0.871	26.8	0.879	29.5	
							0.962	9.8	
							0.966	25.0	
							1.178	15.2	
							1.200	2.3	
Tm-170	128.6d	β^-			0.884	24.0	0.084	3.3	
					0.968	75.9			
W-185	75.1d	β^-			0.307	0.1	0.125	0.02	

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon		
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	
Ir-192	73.8d	β^-			0.432	99.9			
					0.079	0.1	0.201	0.5	
					0.256	5.6	0.206	3.2	
					0.536	41.6	0.283	0.2	
					0.672	48.1	0.296	28.7	
				ec			4.7	0.309	29.8
								0.317	83.0
								0.374	0.7
								0.416	0.7
								0.468	47.7
								0.485	3.1
								0.489	0.4
								0.589	4.5
					0.604	8.1			
					0.613	5.3			
					0.885	0.3			
					1.061	0.1			
Au-198	2.70d	β^-			0.290	1.3	0.412	95.5	
					0.962	98.7	0.676	1.1	
							1.088	0.2	
Au-199	3.14d	β^-			0.245	18.9	0.050	0.3	
					0.295	66.4	0.158	36.9	
					0.453	14.7	0.208	8.4	
Tl-201	3.04d	ec				100.0	0.031	0.3	
							0.032	0.3	
							0.135	2.8	
							0.166	0.2	
							0.167	10.6	
Hg-203	46.6d	β^-			0.212	100.0	0.279	81.4	
Tl-204	3.78y	β^-			0.763	97.4	0.068-0.080	1.5%	
		ec				2.6		X-rays	
Po-208	2.90y	α	5.115	100.0					
Po-209	102y	α	4.625	0.5			0.261	0.2	
			4.880	79.4			0.263	0.1	
			4.883	19.9			0.896	0.3	
Pb-210	22.3y	β^-			0.017	82.0	0.047	4.5	
					0.063	18.0			
via Bi-210	5.01d	β^-			1.162	100.0			
via Po-210	138.4d	α	5.305	100.0					

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
Po-210	138.4d	α	5.305	100.0				
Ra-226	1600y	α	4.602 4.785	5.6 94.5			0.186	3.3
daughters Rn-222	3.83d	α	4.988 5.489	0.07 99.93				
Po-218	3.05m	α β^-	6.003	99.98		0.256	0.02	
Pb-214	26.8m	β^-			0.191 0.496 0.678 0.735 1.030	2.2 1.0 48.2 43.0 5.6	0.053 0.242 0.295 0.352	1.1 7.5 19.2 36.9
Bi-214	19.9m	α β^-	5.448	0.01			0.274	0.2
					0.822 1.066 1.151 1.253 1.423 1.505 1.540 1.727 1.892 3.270	2.9 5.9 4.3 2.7 8.5 18.0 18.2 3.2 7.6 16.1	0.609 0.665 0.768 1.120 1.378 1.765 2.204	46.9 1.6 5.0 15.5 4.1 16.2 5.3
Po-214	165 μ s	α	7.687	100.0				
Pb-210 and daughters not necessarily in equilibrium								
Ac-227	21.77y	α, β^-	4.938 4.951	0.6 0.6	0.021 0.036 0.045	9.9 34.5 54.2	0.009 0.084 0.087 0.100	0.03 0.02 0.02 0.04
Th-228	1.91y	α	5.138 5.177 5.211 5.340	0.04 0.2 0.4 27.6			0.084 0.132 0.166 0.216	1.2 0.1 0.1 0.3

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
			5.423	71.7				
daughters of Th-228								
Ra-224	3.62d	α	5.449	5.1			0.241	4.0
			5.686	94.9				
Rn-220	55.6s	α	5.749	0.1			0.550	0.1
			6.288	99.9				
Po-216	145ms	α	5.989	0.002			0.805	0.002
			6.779	100.0				
Pb-212	10.6h	β^-			0.158	5.1	0.115	0.6
					0.334	82.6	0.239	43.4
					0.573	12.3	0.300	3.2
Bi-212	1.01h	α	5.607	0.4			0.040	1.0
			5.769	0.6			0.288	0.3
			6.051	25.2			0.328	0.1
			6.090	9.7			0.453	0.3
		β^-					0.727	6.8
					0.625	1.9	0.785	1.1
					0.733	1.4	0.893	0.4
					1.519	4.5	0.952	0.1
					2.246	55.2	1.079	0.6
							1.513	0.3
							1.621	1.5
							1.679	0.1
							1.806	0.1
Po-212	300ns	α	8.785	100.0				
Th-229	7340y	α	4.798	1.3			0.031	2.5
			4.815	9.3			0.086	3.4
			4.837	4.8			0.125	1.1
			4.845	56.2			0.137	1.2
			4.901	10.2			0.148	1.1
			4.968	6.0			0.156	1.2
			4.979	3.2			0.194	4.4
			5.050	5.2			0.211	3.2
			5.052	1.6				
Th-230	75400y	α	4.621	23.4			0.068	0.4
			4.687	76.3				
Pa-231	32760y	α	4.734	8.5			0.027	11.1
			4.951	22.9			0.284	1.7
			5.014	25.4			0.300	2.4
			5.030	20.0			0.303	2.5
			5.059	11.0			0.330	1.4
U-232	69.80y	α	5.137	0.3			0.058	0.2
			5.264	30.9			0.129	0.1
			5.320	68.8				

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
U-233	159250y	α	4.729	1.9				
			4.784	14.9				
			4.824	82.7				
U-234	245710y	α	4.723	28.4			0.053	0.1
			4.775	71.4				
U-235	7.04x10 ⁸ y	α	4.325	4.8			0.109	1.5
			4.364	1.8			0.144	11.0
			4.368	15.8			0.163	5.1
			4.396	58.0			0.186	57.2
			4.415	5.8			0.202	1.1
			4.506	1.6			0.205	5.0
			4.556	2.4				
4.598	2.3							
Pu-236	2.90y	α	5.614	0.2			0.048	0.07
			5.721	30.7			0.109	0.02
			5.768	69.1				
U-236	2.34x10 ⁷ y	α	4.335	0.2			0.049	0.1
			4.445	22.4				
			4.496	77.5				
Np-237	2.14x10 ⁶ y	α	4.640	5.9			0.029	15.2
			4.665	2.8			0.087	12.3
			4.766	8.0			0.118	0.17
			4.771	25.0			0.143	0.43
			4.788	48.0			0.151	0.23
			4.804	1.5			0.195	0.19
			4.817	2.5				
4.874	4.3							
via Pa-233	27.0d	β^-			0.157	25.1	0.075	1.3
					0.174	16.4	0.087	2.0
					0.232	48.5	0.104	0.9
					0.274	5.5	0.271	0.3
					0.572	4.5	0.300	6.6
							0.312	38.6
							0.341	4.5
							0.375	0.7
							0.399	1.4
							0.416	1.7
Pu-238	87.7y	α	5.358	0.1			0.043	0.04
			5.457	28.8			0.011	13% X-rays
			5.499	71.0			to 0.022	

9.5 Nuclear decay scheme data

Radio-nuclide	half life	Decay mode	Alpha		Beta		Photon	
			Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]	Energy [MeV]	Intensity [%]
U-238	4.47x10 ⁹ y	α	4.150	23.0			0.050	0.1
daughters in equilibrium								
Th-234	24.1d	β^-			0.086	2.8	0.063	4.0
					0.106	6.2	0.092	2.7
					0.106	18.0	0.093	2.7
					0.199	72.5	0.113	0.3
Pa-234m	1.17m	β^-			2.282	98.2	0.074	0.01
							0.766	0.2
							1.001	0.6
U-234	245710y	α	4.604	0.2			0.053	0.1
			4.723	28.4				
			4.775	71.4				
Pu-239	24110y	α	5.106	11.5			0.039	0.01
			5.144	15.1			0.052	0.03
			5.156	73.3				
Pu-240	6560y	α	5.022	0.01			0.045	0.04
			5.124	27.0				
			5.168	72.9				
Am-241	433y	α	5.388	1.4			0.026	2.4
			5.443	12.8			0.033	0.1
			5.486	85.2			0.043	0.1
			5.512	0.2			0.060	35.9
			5.544	0.3			0.070	0.6
Pu-241	14.4y	β^-			0.021	100.0		
Pu-242	3.74x10 ⁵ y	α	4.856	23.5			0.045	0.04
			4.901	76.5				
Am-243	7360y	α	5.178	1.1			0.044	5.9
			5.233	10.6			0.075	67.4
			5.276	88.0				
			5.319	0.1				
			5.349	0.2				
Cm-244	18.1y	α	5.763	23.0			0.043	0.020
			5.805	77.0			0.099	0.001
							0.153	0.001
Cf-252	2.65y	α	6.076	15.2			0.043	0.02
			6.118	81.6			0.100	0.01

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