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.

isotrak™

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Nuclitec

5. Geometry reference sources

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.

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).

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

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.

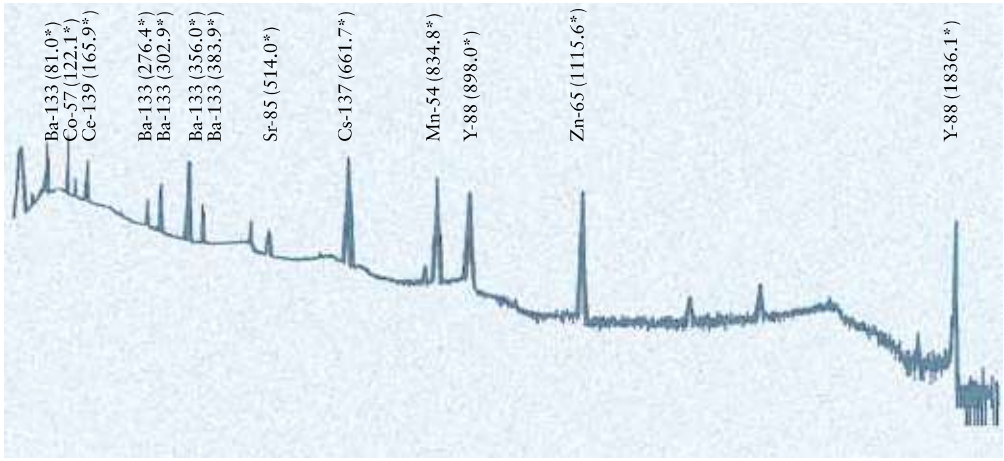
Availability

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

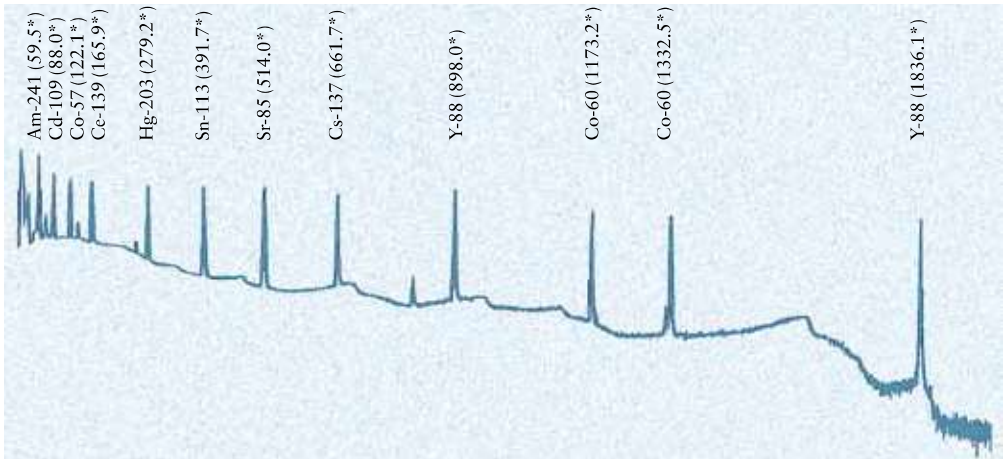
5. Geometry reference sources

5.1 General information

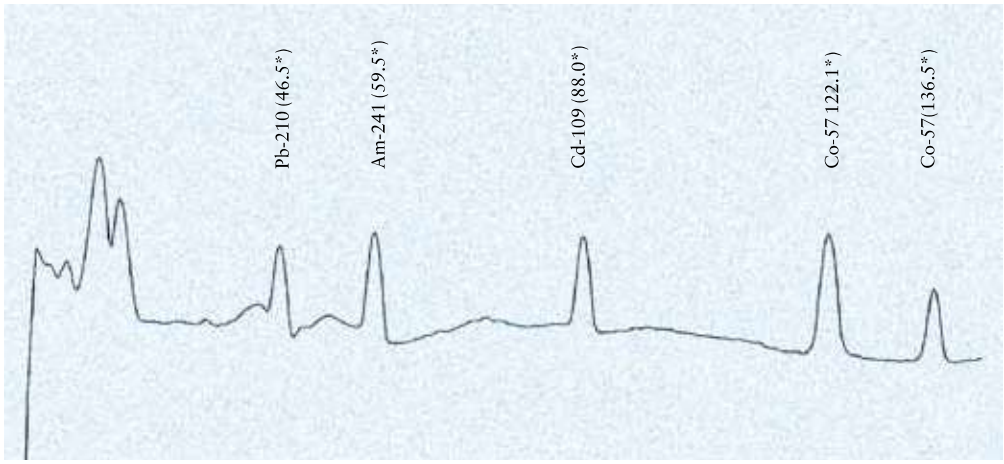
The mixtures of radionuclides are recommended by NIST (USA) and PTB (Germany) for calibrating high resolution gamma-ray spectrometers. Typical spectra are shown below.



A typical gamma spectrum for the NG1 radionuclide mixture



A typical gamma spectrum for the NG3 radionuclide mixture

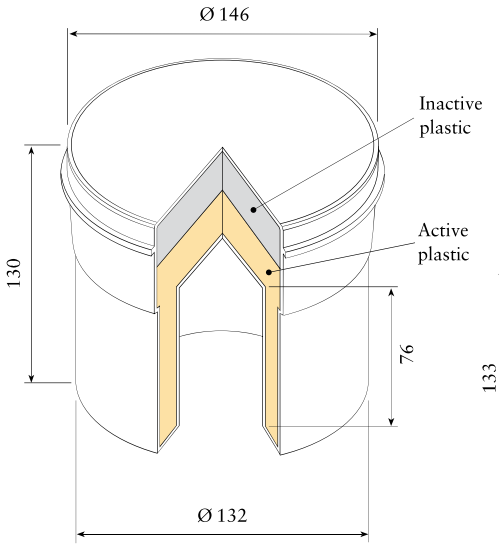


A typical gamma spectrum for the NG4 radionuclide mixture

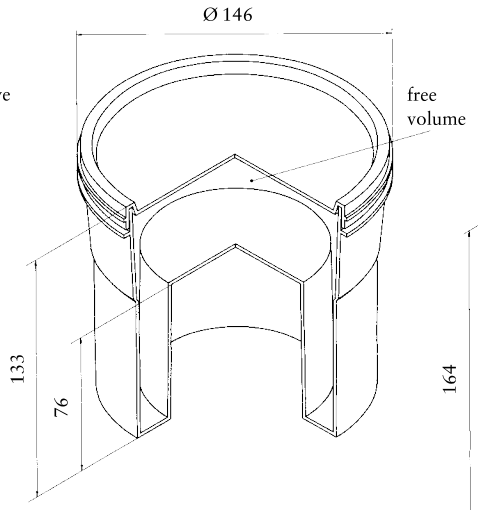
5.2 1 litre Marinelli beakers for Ge spectrometers

Application

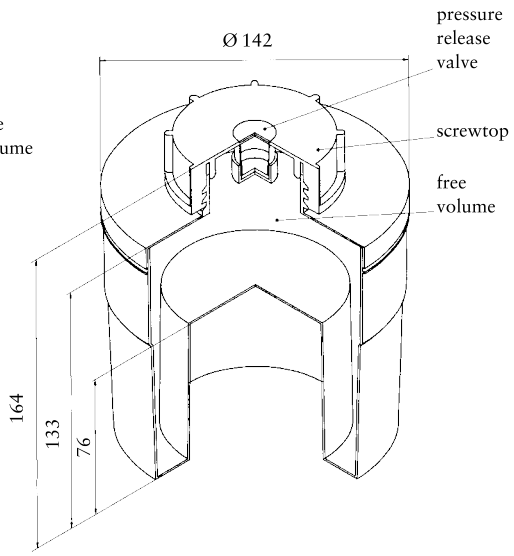
Marinelli beakers are used when the radioactivity to be measured is low and the limits of detection require special geometries of the sample container in order to maximise the counting efficiency of the measurement system. The use of solid reference sources minimises contamination risk and avoids calibration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



Bore diameter 77mm or 85mm



Bore diameter 77mm or 85mm



Bore diameter 85mm

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).

5.2 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/cm³]	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

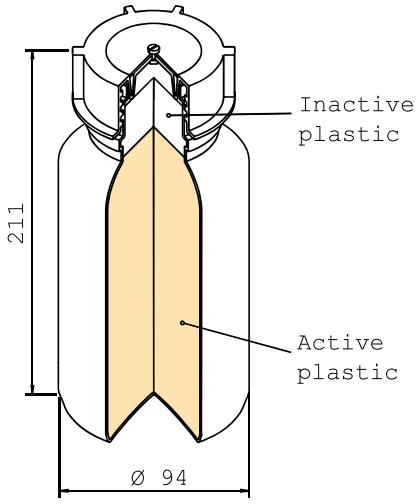
Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm³]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	0.97	QCRB1241
88-1836keV	Mixture NG2: Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	37	0.97	QCRB1243
60-1836keV	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.



container supplied by Eckert & Ziegler Nuclitec

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/cm³. 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.

Ordering information [1)]

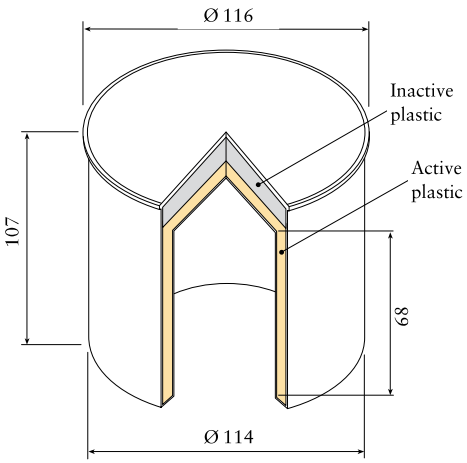
Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm³]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	0.97	QCRB1073
60-1836keV	Mixture NG3: Am-241, Cd-109, Co-57, Ce-139, Hg-203, Sn-113, Sr-85, Cs-137, Co-60, Y-88	40	0.97	QCRB1204
662keV	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.

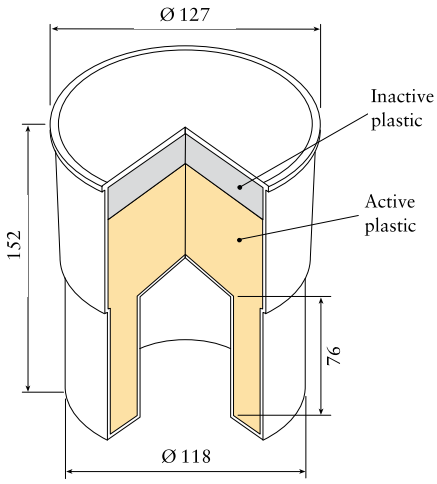
5.4 Marinelli beakers - type GA-MA

Construction

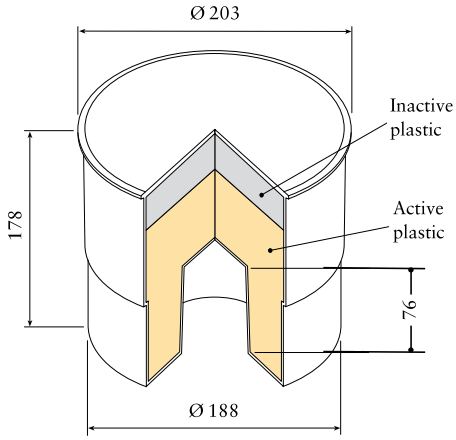
The beakers are constructed from polyethylene, and are resistant to acids and most organic solvents. The radioactive material is homogeneously incorporated in a special water-equivalent plastic matrix. The bore diameter is 77mm.



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/cm³]	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

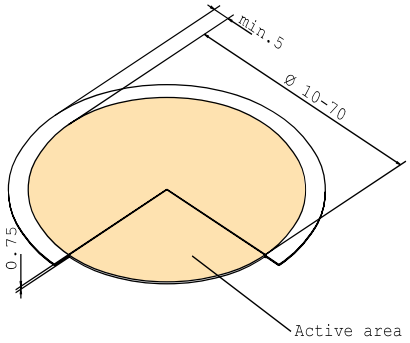
Application

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)]

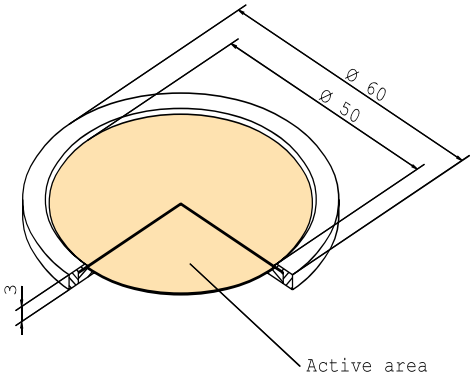


Energy range	Radionuclide(s)	Nominal total activity [kBq]	Active diam. [mm]	Overall diam. [mm]	Product code
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	40	50	QCRB1027
80-1836keV	Mixture NG1: Ba-133, Co-57, Ce-139, Sr-85, Cs-137, Mn-54, Zn-65, Y-88	44	50	60	QCRB2491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

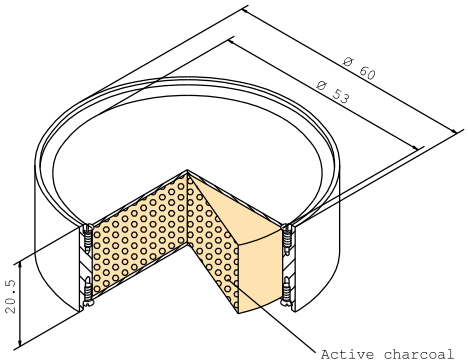
Construction

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



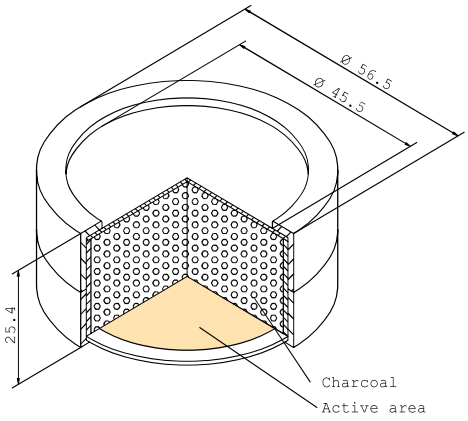
homogeneously activated type

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm³]	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).

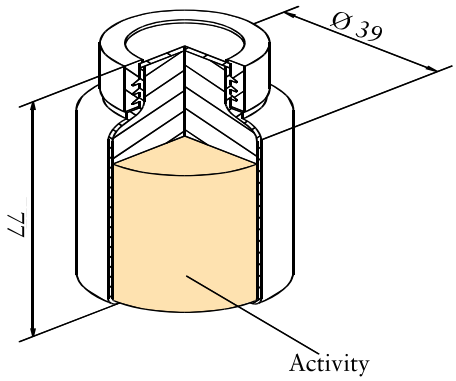
Ordering information - face loaded type



faceloaded type

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm³]	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

5.7 Bottles / Beakers - SG-type



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.

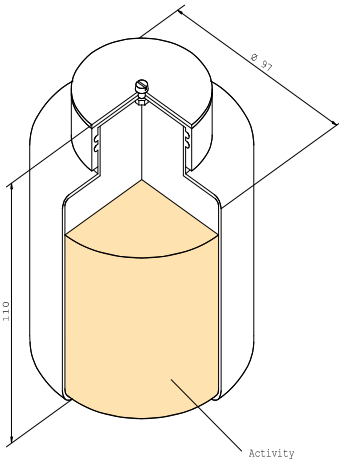
These sources are mainly used in France.
Please supply the empty containers.

Ordering information - Type SG50T - Drawing: VZ-1892

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm³]	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

5.7 Bottles / Beakers - SG-type

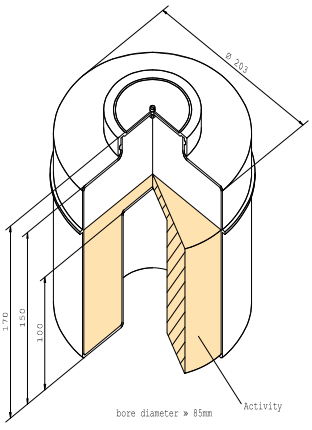
Ordering information - Type SG500 - Drawing: VZ-1841



500ml bottle - type SG500

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm³]	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

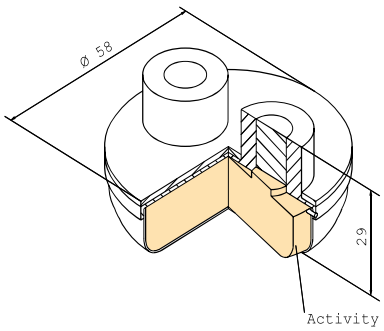
Ordering information - Type SG3000 - Drawing: VZ-2084



3000ml bottle - type SG3000

Energy range	Radionuclide(s)	Nominal total activity [kBq]	Density [g/cm³]	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



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

Application

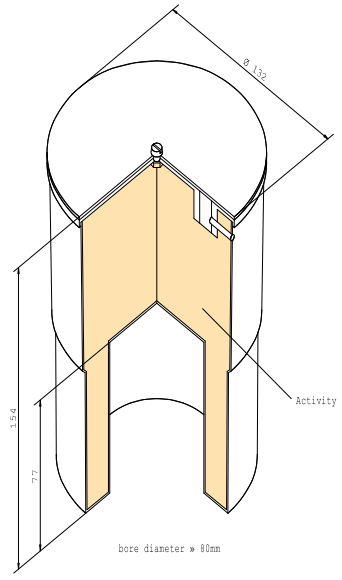
These simulated gas standards are intended for the calibration of high resolution gamma-ray spectrometers used for the measurement of noble gases. The mixed radionuclide standards cover an energy range of 60-1836keV, which covers the energy of photons emitted by Kr-85, Xe-127 and Xe-133 (81 - 574keV).

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

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/cm³]	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

5.9 Custom geometries

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.

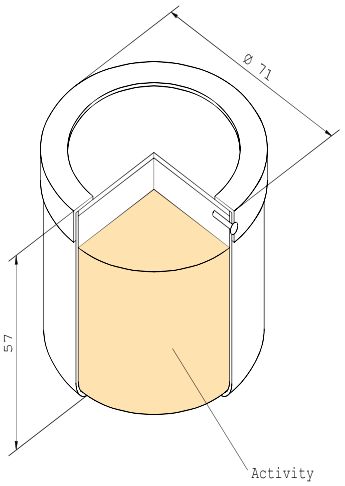
Please note:

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 equivalent
   or 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.

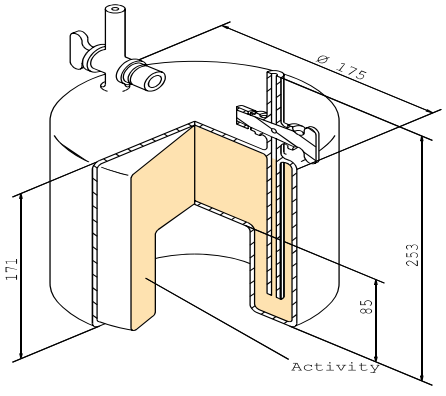
5.10 Examples for custom geometries

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'

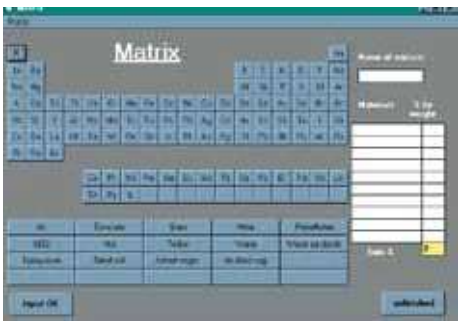
Application

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.

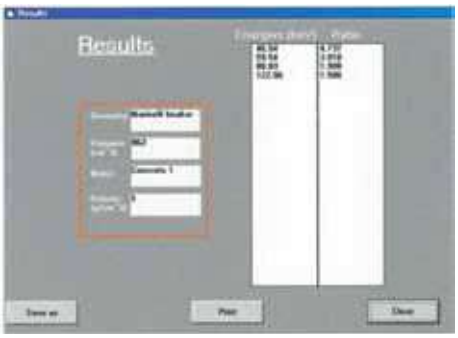
The advantages of Gamatool are:

- 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

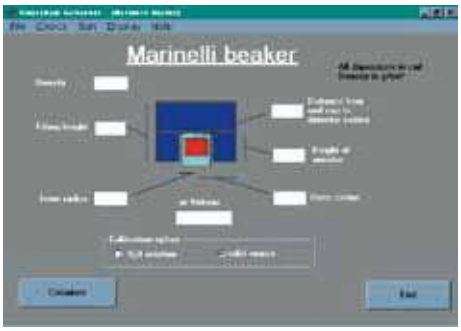
Further details on this computer program are available on request. Please contact your local Eckert & Ziegler Nuclitec office.



Choice - Matrix



Results - Correction factors



Choice - Geometry

Description	Product code
Gamatool self-absorption correction software	NIGB3059