

The reference spectra for the 2002 IAEA intercomparison for low-level gamma-ray spectrometry.

1. Detectors and electronics

Two detectors were employed: A 33 % Canberra HPGe detector, to be denoted SMALL from this point on, and a 96.3 % Ortec HPGe detector, to be denoted BIG. A 10 cm thick, tight-fitting lead castle in all directions except the front shielded the BIG detector. The SMALL detector was not shielded at all.

The associated electronics as well as some specifications are shown in Table 1. The original datasheets and dimensional information obtained by other means are shown in Appendix A.

Table 1: Main detector specifications

	SMALL	BIG
efficiency	33 %	96.3 %
resolution at 1333 keV	1.84 keV	1.82 keV
HV	Ortec 459	Emetron EHV-6000
amplifier	Ortec 572	Ortec 571
ADC	Northern NS-623	Canberra Accuspec card

2. The spectra

Three kinds of spectra were acquired on each detector: Background spectra, calibration spectra and test spectra.

2.1. Background spectra

Since the presence of large samples shields the detector from the environment, two background spectra were acquired for the SMALL detector: One with nothing present near the detector, and one with a 500 ml Marinelli beaker filled with distilled water present. These two spectra are denoted BGSMALLPOINT and BGSMALLMARI. For the BIG detector, only one background spectrum was acquired, denoted BGBIGPOINT, because the expected count rates from the pill-box samples are much higher than from the background, and moreover originate from radionuclides not present in the background, as opposed to the natural radioactivity measurements in Marinelli beakers on the SMALL detector.

2.2. Calibration spectra

Peak-to-total spectra

Six single-nuclide point sources were measured at 10 cm distance from the BIG and the SMALL detector and at 20 cm distance from the BIG detector. The latter counting geometry had already been calibrated in the past with a variety of traceable point sources, allowing for determination of the activity of these sources. This efficiency

was verified once again with the mixed radionuclide point source described in the next subsection. The relevant data are shown in Table 2.

Table 2: Sources and spectra for peak-to-total ratio determination. The activities are stated with uncertainties due to counting statistics only.

source	activity on May 1 2001, 12:00 GMT	spectrum name
Am-241	??	Am241BIG, Am241SMALL
Cd-109	31.6 kBq \pm 4 %	Cd109BIG, Cd109SMALL
Cs-137	35.5 kBq \pm 1 %	Cs137BIG, Cs137SMALL
Zn-65	40.4 kBq \pm 2 %	Zn65BIG, Zn65SMALL
Sn-113	79.8 kBq \pm 1 %	Sn113BIG, Sn113SMALL
Mn-54	35.5 kBq \pm 1 %	Mn54BIG, Mn54SMALL
Co-57	27.8 kBq \pm 1 %	Co57BIG, Co57SMALL

Point-source spectra

A certified point source QCD1 was purchased from Amersham. The original specification sheet is shown in Appendix A. this source was counted at 30 cm and 20 cm from the BIG detector, as well as on the end cap, and at 20 cm and 10 cm from the SMALL detector, as well as on the end cap. The spectra are denoted as QCDBIG30, QCDBIG20, QCDBIG0, QCDSMALL30, QCDSMALL10 and QCDSMALL0.

Pillbox on BIG detector

At Analytics Inc. Oak Ridge, a pill-box was filled with 100 ml resin at a density of 1.15 g/cm³, containing certified activity levels shown in Appendix A. This pillbox was counted on the BIG detector until 1 % precision was obtained in the Cs-134 sum peak at 1174 keV. The spectrum is denoted PICBIG.

Marinelli on SMALL detector

At Analytics Inc. Oak Ridge, a 500 ml Marinelli beaker was filled with 500 ml resin at a density of 1.15 g/cm³, containing certified activity levels shown in Appendix A. This beaker was counted on the SMALL detector until 1 % precision was obtained in the Cs-134 sum peak at 1174 keV. The spectrum is denoted MARICSMALL.

2.3. Test spectra

Test samples with known activity levels were obtained from Analytics Inc., Oak Ridge, and from the IAEA. The activity levels were to be kept secret from everybody involved up to the end of the intercomparison meeting, so no specification can be given in this document.

In Seibersdorf, the IAEA mixed two reference materials and supplied two such mixtures for measurement, denoted MIX1 and MIX2. Upon receipt, the materials were placed in the same type of Marinelli beakers as used at Analytics Inc., sealed with an inner lid of 3 mm thick Lucite glued in place with acrylic kit, and counted

immediately as well as after three weeks decay time on the SMALL detector. Right after sealing, MIX1 was counted during 2 days. MIX2 was given a long counting time of 23h35 to get excellent statistics, as well as short acquisition times of 20 and 6 minutes to get poor statistics. The short acquisition times were divided in two halves, one half counted just before the long count and one immediately after, so changes in equilibrium should have a minor effect on the expected peak area ratios between excellent and poor statistics spectra.

After three weeks, more measurements were done for MIX1 and MIX2. Both were counted during 1 hour on the SMALL detector, and MIX2 was counted for an additional 3 minutes to get a “poor statistics” spectrum.

The spectra are denoted MIX1NEQLONG, MIX2NEQLONG, MIX2NEQ20, MIX2NEQ6, all before equilibrium was achieved, and MIX1EQ, MIX2EQ and MIX2EQ3, after equilibrium was achieved. The “long” MIX2 spectrum was analysed with the IRI software, knowing and using the radionuclides and peak energies involved, to get reference peak areas and energies. The results are given in MIX2NEQLONG_REF.

At Analytics Inc., a Marinelli beaker of the same dimensions and matrix density as the calibration one was prepared, and a 100 ml pillbox sample of higher density (1.6 g/ml) than the calibration one. The pillbox sample was counted on the BIG detector for the same duration as the pillbox calibration source, and also during 1 hour. The spectrum are denoted PITBIG and PITBIG60. The Marinelli beaker was counted on the SMALL detector for the same duration as the calibration source, and also during 1 hour. The spectra are denoted MARITSMALL and MARITSMALL60.

Appendix A –specification sheets

BIG detector original specsheet

BIG Detector

QUALITY ASSURANCE DATA SHEET

GEM Series HPGe (High-Purity Germanium) Coaxial Detector System

Model and Serial Numbers

Detector Model No. GEM-90210-P
Cryostat Configuration POP TOP
Dewar Model —

Important Reference Data

Ship Date 12-11-90
Serial No. 30-T PH0190A
When calling Customer Service, always reference this Detector Serial No.

Cryogenic Information

Dewar Capacity — Static Holding Time — Detector Cool-Down Time 12 hrs.

Dimensions

Crystal Diameter 75.5 mm
Crystal Length 97.1 mm
End Cap to Crystal 4 mm
Total Active Volume — cc
Absorbing Layers
Aluminum 1.0 mm
Inactive Germanium 0.7 mm

High Voltage Bias

Recommended Operating Bias, POSITIVE 3500 V

Performance Specifications*

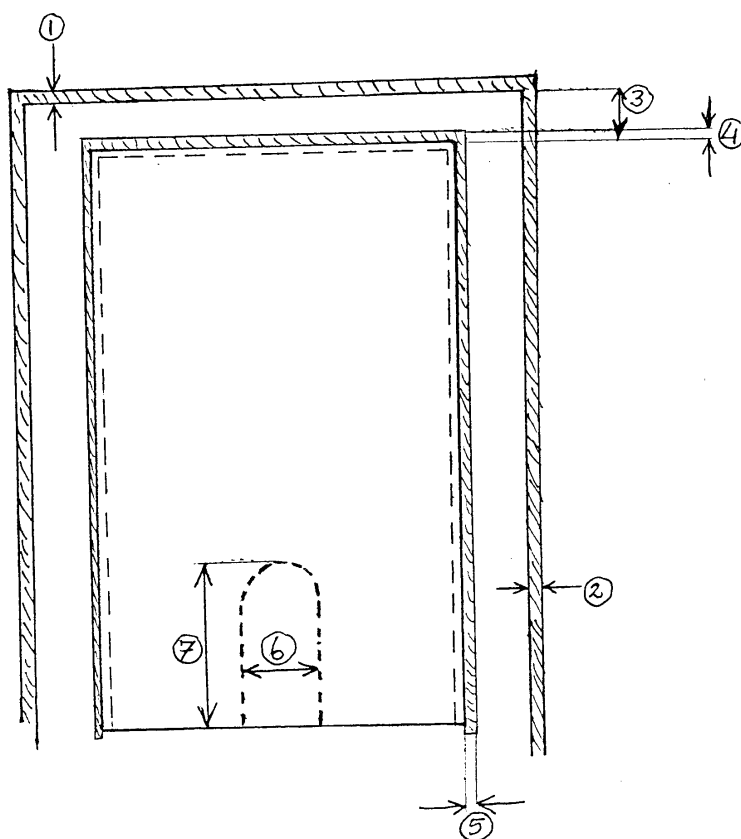
	Warranted	Measured	Amplifier Time Constant
Resolution (FWHM) at 1.33 MeV, ⁶⁰ Co	<u>2.10</u> keV	<u>1.82</u> keV	<u>6</u> μs
Peak-to-Compton Ratio, ⁶⁰ Co	<u>80:1</u>	<u>97.1</u>	<u>6</u> μs
Relative Efficiency at 1.33 MeV, ⁶⁰ Co	<u>90</u> %	<u>96.3</u> %	<u>6</u> μs
Peak Shape (FWTM/FWHM), ⁶⁰ Co	<u>2.00</u>	<u>1.84</u>	<u>6</u> μs
Peak Shape (FWFM/FWHM), ⁶⁰ Co	<u>3.00</u>	<u>2.41</u>	<u>6</u> μs
Resolution (FWHM) at 122 keV, ⁵⁷ Co	<u>1200</u> eV	<u>964</u> eV	
Other	<u>Capsule NUCA #1854</u>		
	<u>Crye PH-2 #2332</u>		

Data Certified By GBarrow Date 12-11-90

*Measured at a nominal rate of 1000 counts/s unless otherwise specified.

BIG detector more dimensions as specified by ORTEC

Wanted specifications



- 1 mm ① thickness top of end-cap
- 1.6 mm ② thickness side of end-cap
- 4 mm ③ distance from inside end-cap to top of crystal
- 0.05 mm ④ thickness top of mounting-cup
- 0.5 mm ⑤ thickness side of mounting-cup
- 10.8 mm ⑥ width of removed core
- 85.3 mm ⑦ height of removed core

SMALL detector original specsheet

DETECTOR SPECIFICATIONS AND PERFORMANCE DATA

Specifications

Model GC3319-7600SL

Serial Number b 91126

The purchase specifications and therefore the warranted performance of this detector are as follows :

Active volume cc Relative efficiency 33 %

Resolution 1.9 keV (FWHM) at 1.33 MeV

 keV (FWTM) at 1.33 MeV

.950 keV (FWHM) at 122 keV

 keV (FWTM) at

Peak/Compton 57 :1 Cryostat well diameter mm Well depth mm

Cryostat description or Drawing Number if special Horizontal dipstick, type 7600SL

Physical Characteristics

Geometry Coaxial one open end, closed end facing window

Diameter 56 mm Active volume cc

Length 57 mm Well depth mm

Distance from window 5 mm Well diameter mm

Electrical Characteristics

Depletion voltage (+) 4000 Vdc

Recommended bias voltage Vdc (+) 4500 Vdc

Leakage current at recommended bias .01 nA

Preamplifier test point voltage at recommended voltage - .6 Vdc

Capacitance at recommended bias / pF

Resolution and Efficiency

With amp time constant of 4 μ s

Isotope	⁵⁷ Co	⁶⁰ Co*			
Energy (KeV)	122	1332			
FWHM (keV)	.861	1.84			
FWTM (keV)		3.47			
Peak/Compton		64.2:1			
Rel. Efficiency		33.2%			

Tests are performed following IEEE standard test ANSI/IEEE std325-1986

* measured with 2 μ sec shaping time & baselinerestorcer high rate

Tested by: [Signature] Date: 29 January 1991

Approved by: [Signature] Date: 29 January 1991

SMALL dimensions

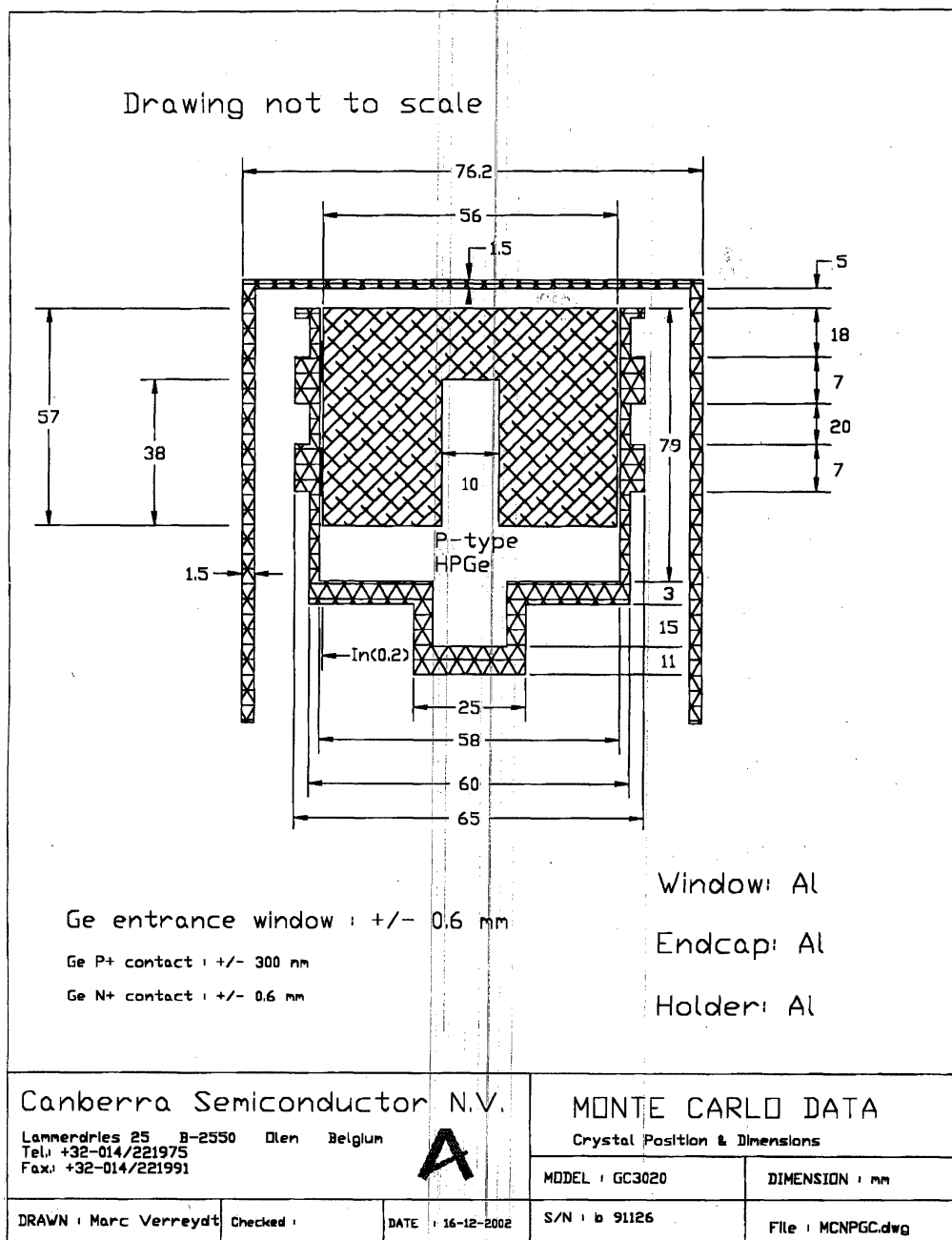
16/12 '02 13:53 FAX 32 14 221991

CANBERRA

→ CPB

002/002

32 14 221991



QCD1 certificate

Amersham Laboratories

72001

5896



ISSUED BY: Nycomed Amersham plc
Radiation & Radioactivity
Calibration Laboratory
Amersham Laboratories
White Lion Road
Amersham
Buckinghamshire
HP7 9LL

ISSUED FOR: AEA Technology plc
Isotrak
329 Harwell
Didcot
Oxfordshire
OX11 0QJ

Description Product code: QCD1

Source number: 2821QB

This mixed radionuclide gamma-ray reference source contains the nine radionuclides listed below.

Measurement and accuracy Reference time: 1200 GMT on 1 May 2001

Parent radionuclide	Gamma-ray energy (keV)	Gamma-rays per second	Combined Type A uncertainty	Combined Type B uncertainty	Expanded uncertainty	Calibration start date	Calibration finish date
Cadmium-109	88.03	734	± 0.2 %	± 3.2 %	± 6.3 %	23/10/2000	23/10/2000
Cobalt-57	122.1	663	± 0.1 %	± 0.8 %	± 1.5 %	12/12/2000	12/12/2000
Cerium-139	165.9	826	± 0.1 %	± 0.8 %	± 1.5 %	15/09/2000	15/09/2000
Mercury-203	279.2	2216	± 0.1 %	± 0.6 %	± 1.2 %	20/03/2001	20/03/2001
Tin-113	391.7	2367	± 0.3 %	± 1.6 %	± 3.3 %	23/10/2000	23/10/2000
Strontium-85	514.0	4523	± 0.1 %	± 1.4 %	± 2.7 %	23/02/2001	23/02/2001
Caesium-137	661.6	2819	± 0.1 %	± 1.0 %	± 2.1 %	05/09/2000	05/09/2000
Yttrium-88	898.0	7144	± 0.1 %	± 0.9 %	± 1.7 %	17/01/2001	19/01/2001
Cobalt-60	1173	3794	± 0.1 %	± 0.8 %	± 1.6 %	10/05/2000	10/05/2000
Cobalt-60	1333	3797	± 0.1 %	± 0.8 %	± 1.6 %	10/05/2000	10/05/2000
Yttrium-88	1836	7552	± 0.1 %	± 0.8 %	± 1.5 %	17/01/2001	19/01/2001

The calibration date is provided for added information only, and must not be confused with the reference date. It is the reference date that must be used in all calculations relating to the values of activity.

Approved Signatory

Date of issue

30th April 2001

B D D Singleton

Page 1 of 2 pages

Nycomed Amersham

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ANALYTICS

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CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

64921A-11

500 mL Solid in 500 mL Marinelli Beaker

This standard radionuclide source was prepared gravimetrically from calibrated master solutions. The Am-241 was calibrated by liquid scintillation counting. All other radionuclides were calibrated in an ion chamber that was calibrated by the National Physical Laboratory, Teddington, U.K., and is directly traceable to national standards.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

U.S. Patent 4,430,258; U.K. Patent GB2,149,194B; CA. Patent 1,196,776.
Density of solid matrix 1.15 g/cc.

CALIBRATION DATE: November 1, 2002 12:00 EST

ISOTOPE	ACTIVITY (dps)	HALF-LIFE	TOTAL UNCERTAINTY (%)	SYSTEMATIC UNCERTAINTY (%)	RANDOM UNCERTAINTY (%)
Am-241	3353	4.322 E2 y	5.0	4.0	1.0
Cd-109	39214	462.6 d	5.0	4.7	0.3
Ce-139	1325	137.6 d	5.0	4.7	0.3
Co-57	884	271.79 d	5.0	4.7	0.3
Cs-134	5529	754.2 d	5.0	4.7	0.3
Cs-137	1106	3.007 E1 y	4.8	4.5	0.3
Hg-203	2666	46.61 d	5.0	4.7	0.3
Mn-54	1564	312.1 d	5.0	4.7	0.3
Sn-113	2391	115.1 d	5.0	4.7	0.3
Y-88	3914	106.6 d	5.0	4.7	0.3
Zn-65	3191	244.3 d	5.0	4.7	0.3

*99% confidence level.

Impurities: γ -impurities <0.1%

Certificate of Calibration
SRS 64921A-11

P O NUMBER BUY10281, Item 1

SOURCE PREPARED BY: M. Taskaeva
M. Taskaeva, Radiochemist

Q A APPROVED: M. Taskaeva 11-5-02

Composition of Water-Equivalent Solid Standards

The solid standard is actually a solid polyester polymer plastic. The approximate elemental composition is: Carbon 72.1%, Hydrogen 6.0%, and Oxygen 21.9%. The hazards associated with this compound are equivalent to other plastics such as Nalgene bottles, marinelli beakers, plastic bags and gloves. The material is a hard solid which is classified not hazardous by the hazardous materials standards for flammability, reactivity, corrosivity, or combustibility.



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CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

64922A-11

100 mL Solid in 125 mL PP Nalgene Jar

This standard radionuclide source was prepared gravimetrically from calibrated master solutions. The Am-241 was calibrated by liquid scintillation counting. All other radionuclides were calibrated in an ion chamber that was calibrated by the National Physical Laboratory, Teddington, U.K., and is directly traceable to national standards.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

U.S. Patent 4,430,258; U.K. Patent GB2,149,194B; CA. Patent 1,196,776.
Density of solid matrix 1.15 g/cc.

CALIBRATION DATE: November 1, 2002 12:00 EST

ISOTOPE	ACTIVITY (dps)	HALF-LIFE	TOTAL UNCERTAINTY (%)	SYSTEMATIC UNCERTAINTY (%)	RANDOM UNCERTAINTY (%)
Am-241	5403	4.322 E2 y	5.0	4.0	1.0
Cd-109	63190	462.6 d	5.0	4.7	0.3
Ce-139	2136	137.6 d	5.0	4.7	0.3
Co-57	1424	271.79 d	5.0	4.7	0.3
Cs-134	8909	754.2 d	5.0	4.7	0.3
Cs-137	1782	3.007 E1 y	4.8	4.5	0.3
Hg-203	4297	46.61 d	5.0	4.7	0.3
Mn-54	2519	312.1 d	5.0	4.7	0.3
Sn-113	3853	115.1 d	5.0	4.7	0.3
Y-88	6306	106.6 d	5.0	4.7	0.3
Zn-65	5142	244.3 d	5.0	4.7	0.3

*99% confidence level.

Impurities: γ -impurities <0.1%

Certificate of Calibration
SRS 64922A-11

P O NUMBER BUY10281, Item 2

SOURCE PREPARED BY: M. Taskaeva
M. Taskaeva, Radiochemist

Q A APPROVED: W. M. J. 11-502

Composition of Water-Equivalent Solid Standards

The solid standard is actually a solid polyester polymer plastic. The approximate elemental composition is: Carbon 72.1%, Hydrogen 6.0%, and Oxygen 21.9%. The hazards associated with this compound are equivalent to other plastics such as Nalgene bottles, marinelli beakers, plastic bags and gloves. The material is a hard solid which is classified not hazardous by the hazardous materials standards for flammability, reactivity, corrosivity, or combustibility.



ANALYTICS

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CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

64923-11

500 mL Solid in 500 mL Marinelli Beaker

This standard radionuclide source was prepared gravimetrically from calibrated master solutions. The Eu-152 was calibrated by the Department Des Applications Et De La Metrologie Des Rayonnements Ionisants (DAMRI), Paris, France, as Number 25200. All other radionuclides were calibrated in an ion chamber that was calibrated by the National Physical Laboratory, Teddington, U.K., and is directly traceable to national standards.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

U.S. Patent 4,430,258; U.K. Patent GB2,149,194B; CA. Patent 1,196,776.
Density of solid matrix 1.15 g/cc.

CALIBRATION DATE: November 1, 2002 12:00 EST

ISOTOPE	ACTIVITY (dps)	HALF-LIFE	TOTAL UNCERTAINTY (%)
Ba-133	1713	10.54 y	5.0
Co-60	1076	5.271 y	5.0
Eu-152	3739	1.352 E1 y	5.0
Cr-52	7903	27.70 d	5.0
Na-22	1073	950.4 d	5.0

*99% confidence level.

Impurities: γ -impurities <0.1%

Page 1 of 2

Certificate of Calibration
SRS 64923-11

P O NUMBER BUY10281, Item 3

SOURCE PREPARED BY: M. Taskaeva
M. Taskaeva, Radiochemist

Q A APPROVED: LM Mtz 11-5-02

Composition of Water-Equivalent Solid Standards

The solid standard is actually a solid polyester polymer plastic. The approximate elemental composition is: Carbon 72.1%, Hydrogen 6.0%, and Oxygen 21.9%. The hazards associated with this compound are equivalent to other plastics such as Nalgene bottles, marinelli beakers, plastic bags and gloves. The material is a hard solid which is classified not hazardous by the hazardous materials standards for flammability, reactivity, corrosivity, or combustibility.



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CERTIFICATE OF CALIBRATION

Standard Radionuclide Source

64924A-11

100 mL High Density Solid in 125 mL PP Nalgene Jar

This standard radionuclide source was prepared gravimetrically from calibrated master solutions. The Eu-152 was calibrated by the Department Des Applications Et De La Metrologie Des Rayonnements Ionisants (DAMRI), Paris, France, as Number 25200. All other radionuclides were calibrated in an ion chamber that was calibrated by the National Physical Laboratory, Teddington, U.K., and is directly traceable to national standards.

Radionuclide purity and calibration were checked by germanium gamma-ray spectrometry and liquid scintillation counting. The nuclear decay rate and assay date for this source are given below.

ANALYTICS maintains traceability to the National Institute of Standards and Technology through Measurements Assurance Programs as described in USNRC Reg. Guide 4.15, Revision 1.

Density of solid matrix 1.6 g/cc.

CALIBRATION DATE: November 1, 2002 12:00 EST

ISOTOPE	ACTIVITY (dps)	HALF-LIFE	TOTAL UNCERTAINTY (%)
Ba-133	1253	10.54 y	5.0
Co-60	799	5.271 y	5.0
Eu-152	2827	1.352 E1 y	5.0
Cr-52	7827	27.70 d	5.0
Na-22	1063	950.4 d	5.0

*99% confidence level.

Impurities: γ -impurities <0.1%

Certificate of Calibration
SRS 64924A-11

P O NUMBER BUY10281, Item 4

SOURCE PREPARED BY: M. Taskaeva
M. Taskaeva, Radiochemist

Q A APPROVED: MMT 11-502

Composition of High Density Solid Standards

The solid standard is actually a solid polyester polymer plastic with calcium carbonate added. The approximate elemental composition is: Carbon 40.5%, Hydrogen 2.85%, Oxygen 35.6%, and Calcium 21%. The hazards associated with this compound are equivalent to other plastics such as Nalgene bottles, marinelli beakers, plastic bags and gloves. The material is a hard solid which is classified not hazardous by the hazardous materials standards for flammability, reactivity, corrosivity, or combustibility.

MIX1 and MIX2 certificates



ANALYTICAL QUALITY CONTROL SERVICES

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Seibersdorf, 2002-11-12/19

Preparation of two mixed IAEA-RGU-1 and IAEA-RGTh-1 samples

Two 500g reference samples (M-1 and M-2) have been prepared by mixing appropriate amounts of the IAEA-RGU-1 and IAEA-RGTh-1 reference materials at the IAEA Seibersdorf Laboratory. Weighed aliquots of the two materials were mixed in the proportions given in the table below. The samples were blended for three hours each using a tubular mixer.

Mixed Sample Code	Mass of IAEA-RGU-1	Mass of IAEA-RTh-1
	[g]	
M-1	185	315
M-3	315	185

Samples were prepared by Zbigniew Radecki, AQCS, Chemistry Unit, Agency's Laboratories at Seibersdorf.

A handwritten signature in black ink, appearing to be 'h' followed by a flourish.

1.2.4 Ores

Both, **IAEA-RGU-1** and **IAEA-RGTh-1** reference materials were prepared on behalf of the International Atomic Energy Agency by the Canada Centre for Mineral and Energy Technology by dilution of a uranium ore BL-5 (7.09% U) and a thorium ore OKA-2 (2.89% Th, 219 µg U/g) with floated silica powder of similar grain size distribution, respectively. No evidence for between-bottles inhomogeneity was detected after mixing and bottling. BL-5 has been certified for uranium, ^{226}Ra and ^{210}Pb confirming that it is in radioactive equilibrium. The agreement between radiometric and chemical measurements of thorium and uranium in OKA-2 shows both series to be in radioactive equilibrium.

The **IAEA-RGK-1** material is produced from high purity (99.8%) potassium sulphate supplied by the Merck Company. The potassium property value and its uncertainty were obtained from repeated measurements performed at the Agency's Laboratories Seibersdorf and the results confirmed the value certified by Merck. The upper limits for the uranium and thorium property values were estimated by the Agency's Laboratories Seibersdorf using fluorimetry and activation analysis, respectively.

IAEA Code	RGU-1				RGTh-1				RGK-1				
Matrix	Ore				Ore				Potassium sulphate				
Reference date	-				-				-				
Date of Release	1987				1987				1987				
Unit Size / Price	500g		60 US \$		500g		60 US \$		500g		60 US \$		
Analytes	[mg/kg] ¹	95% C.I.	N	R/I	[mg/kg] ²	95% C.I.	N	R/I	[mg/kg] ³	95% C.I.	N	R/I	
K	< 20	-	-	I	200	100 - 300	45	I	448000	445000 - 451000	20	R	
Th	< 1	-	-	I	800	784 - 816	155	R	< 0.01	-	20	I	
U	400	398 - 402	-	R	6.3	5.9 - 6.7	145	R	< 0.001	-	20	I	
Radionuclides	Derived data												
	[Bq/kg]	95% C.I.	N	R/I	[Bq/kg]	95% C.I.	N	R/I	[Bq/kg]	95% C.I.	N	R/I	
	⁴⁰ K	< 0.63 [§]	-	-	I	6.3 [§]	3.1 - 9.5	45	I	14000 [§]	13600 - 14400	20	R
	²³² Th	< 4 [§]	-	-	I	3250 [§]	3160 - 3340	155	R				
	²³⁵ U	228 [§]	226 - 230	-	R	3.6 [§]	3.3 - 3.9	145	R				
	²³⁸ U	4940 [§]	4910 - 4970	-	R	78 [§]	72 - 84	145	R				
IAEA Report	IAEA/RL/148				IAEA/RL/148				IAEA/RL/148				

[1] Concentration calculated from the silica to BL-5 mass dilution ratio (based on the certified uranium content of BL-5)

[2] Concentration calculated from the silica to OKA-2 mass dilution ratio (based on the consensus mean value for the OKA-2 ore material)

[3] Concentration based on values determined at Agency's Laboratories, Seibersdorf

(N) Number of accepted results which were used to calculate the recommended or information values and their respective confidence intervals

(R/I) Classification assigned to the property value for analyte (Recommended/Information)

§ Natural radionuclide activity concentrations derived from the elemental concentrations on the basis of isotopic abundance and half-life data

Note: The standard deviation associated with the uranium concentration in IAEA-RGU-1 can be estimated from the 95% confidence interval assuming the 0.95 fractile of the Student's t-distribution is equal to 1.96

The values listed above were established on the basis of a gravimetric dilution of materials with known uranium, thorium and potassium composition. The details concerning the criteria for qualification as a recommended or information value can be found in the respective report which is available free of charge upon request. Orders for these materials should be sent to AQCS, Seibersdorf.

Pillbox and Marinelli beaker dimensions

Marinelli beaker and pillbox dimensions. The Marinelli material is LDPE, the pillbox Nalgene. The shaded area indicates a 500 ml and 100 ml volume, resp..

