

Sarnoff Corporation
201 Washington Rd.
Princeton, NJ 08543-5300

February 1, 2006

Mail Control Number 137295

Mr. Todd J. Jackson, CHP
Senior Health Physicist
Commercial and R&D Branch
Division of Nuclear Materials Safety
US Nuclear Regulatory Commission
Region 1
475 Allendale Road
King of Prussia, PA 19406-1415

MS 16
J-6

03029879

RECEIVED
REGION 1
2006 FEB - 6 PM 3: 25

Subject: Response to NRC Requests; Radioactive Material License No. 29-28005-01

Dear Mr. Jackson,

We are responding to various emails requesting additional information on our Fe-55 and Am-241 sources where we were asked to provide details on these sources, pertaining to our byproduct material license renewal application.

1. Regarding our Fe-55 sources, NER9041, we are relisting these on our inventory for Question 5 Radioactive Material Possession Limits as unsealed sources with a maximum amount of 50 uCi. We have enclosed a copy of an email from Paul Barboni from Perkin Elmer regarding NEN's Manufacturing Division. We have enclosed an updated response to Question 5 Radioactive Material Possession Limits, dated December 2005 that shows a maximum possession amount of 50 uCi. We have also enclosed an updated response to Question 6 Purpose for Which Licensing Material Will be Used in which we recalculated the unity rule inventory calculation.
2. Regarding our Am-241 source, we have revised our response to Question 5 Radioactive Material Possession Limits, listing one source with a maximum possession limit of 10 uCi. As stated above, this response is attached. We have also attached all documentation received from Amersham regarding the QCR-2 set which contains the Am-241 source. This documentation includes an email from Amersham, a general drawing of the source along with its ISO/ANSI certificate, a copy of NUREG-1556 Section 5 regarding broads cope/R&D licenses and a 4 page document that describes this gamma reference source.

We hope that this resolves our outstanding issues. Please feel free to contact us again as you continue processing our license renewal application.

Very truly yours,



Therese Perrette CIH, CSP
Safety Manager

cc: Jim Matey, Sarnoff Radiation Safety Officer
Dennis Lawyer, NRC

137295

NUCLEAR MATERIALS

From: "JAMES MATEY" <jmatey@sarnoff.com>
To: Lori Podolak <Lori.Podolak@qsa-global.com>
Date: 2/8/06 4:07PM
Subject: Re: Am-241 Source Part of QCR.2

Lori,

Thanks,

Jim Matey

Lori Podolak wrote:

> James,

>

> The documentation I provided to you in your original request can be
> forwarded to the USNRC to support your response.

>

> Lori

>

> Lori Podolak

> Product Licensing Specialist

> QSA Global Inc.

> 40 North Avenue

> Burlington, MA 01803

>

>

>>>> "JAMES MATEY" <jmatey@sarnoff.com> 02/08/06 2:33 PM >>>

>>>>

> Dear Lori,

>

> Thanks again for your help. I need to ask for one more favor.

>

> Several of the items you provided have proprietary markings on them.

> Our NRC representative

> cannot accept copies of those items without an OK from you. On the

> basis of our correspondence

> I am confident that you would have no objections to us providing any

> information you provided to us

> to the NRC, but I need a statement to that effect. Unfortunately, we

> are about to hit a time deadline

> at the NRC, so I need a response ASAP.

>

> A reply to all to this email stating that Sarnoff can provide copies of

>

> our earlier correspondence regarding

> the Am-241 source to the NRC would do the trick.

>

> Best regards,

>

> Jim Matey

>

> Lori Podolak wrote:

>

>> James,

>>

>> Sorry for the delay in getting back to you but I had to contact our

>>

> German office for details on this product code as it has been replaced
> by QCR.310. The product code you referenced was found by my colleague
> in an old Amersham catalog from 1979.

>

>> I have attached a general drawing of the source along with an

>>

> ISO/ANSI certificate which classifies the source as meeting ANSI N542
> 77C34343. This source set, along with most of the sources Amersham used
> to distribute but that are now distributed under our ISOTRAK brand, are
> primarily intended for distribution to broad scope and/or research and
> development licensees. Typically those licensees do not require sources
> that have a documented SSDR and often include authorization for
> radioactive material in "Any" form.

>

>> Based on the construction of the source and its ANSI classification

>>

> the AMR.151 source (now referenced as AMR.1152 under our current
> catalog), is a sealed source, but it does not have a Sealed Source and
> Device Registry Sheet. Distribution, as I've described above to broad
> scope/R&D licensees is authorized under USNRC NUREG-1556 Vol 3, Section
> 5. Although I do not know what authorization existed under your license
> which allowed you to originally receive this source, Section 5.1.1 of
> this NUREG further states that certain sources of low activity can be
> licensed by regulators for use as calibration and reference sources even
> if they do not have an SSDR. The activity of the sources in this source
> set meets these criteria. If your license does not currently allow this
> condition, and you wish to retain possession and use of this source set,
> I would recommend you request approval to use these sources based on the
> conditions in this section. (I have attached a copy for your info).

>

>> I hope this is helpful to you.

>>

>> Regards,

>>

>> Lori Podolak

>>

>> Lori Podolak

>> Product Licensing Specialist

>> QSA Global Inc.

>> 40 North Avenue

>> Burlington, MA 01803

>>

>>

>>

>> On October 10th 2005, we changed our name to QSA Global Inc.

>> As QSA Global Inc., we remain committed to providing you with the

>>

> same level of world class service you have come to expect from AEA

> Technology QSA, Inc.

>

>>

> *****

>

>> This transmission contains information which may be confidential and

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>
>
>> which may also be privileged. It is intended for the named addressee
>>
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>> only. Unless you are the named addressee, or authorized to receive it
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>> on behalf of the addressee you may not copy or use it, or disclose it
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>> to anyone else. If you have received this transmission in error
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>> contact the sender. Thank you for your cooperation.
>>
>>
> *****
>
>> For more information about QSA Global Inc., formerly
>> AEA Technology QSA Inc., please visit
>> our website at <http://www.qsa-global.com>
>>
>>
>>
>
>

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James R. Matey

jmatey@sarnoff.com
www.sarnoff.com
609-734-2868
609-734-2873 (FAX)

Mailing Address:
Sarnoff Corporation
201 Washington Rd.
Princeton, NJ 08543-5300

Shipping Address:
Sarnoff Corporation
201 Washington Rd.
Princeton, NJ 08540-6449

Administrative Assistant:
Elizabeth (Liz) Jones
609-734-2644

CC: Therese Perrette <tperrette@sarnoff.com>, Dennis Lawyer <DRL1@nrc.gov>

Question 5 - Radioactive Material Possession Limits

Element & Mass Number	Chemical/Physical Form	Maximum Amount Possessed at Any One Time
Hydrogen-3	any	100 mCi
Carbon-14	any	5 mCi
Phosphorous-32	any	10 mCi
Phosphorous-33	any	20 mCi
Sulfur-35	any	20 mCi
Calcium-45	any	1 mCi
Iodine-125	pre-labeled or Abound@ compounds	10 mCi
Iodine-131	pre-labeled or Abound@ compounds	10 mCi
Manganese-54	sealed source series 1744 (Amersham Model QCR2)	10 uCi
Iron-55	any	50 uCi
Cobalt-60	sealed source series 1744 (Amersham Model QCR2)	10 uCi
Barium-133	sealed source series 1744 (Amersham Model QCR2)	10 uCi
Cesium-137	sealed source series 1744 (Amersham Model QCR2)	10 uCi
Cesium-137	sealed source (Amersham Model CDC-803)	3 mCi
Mercury-203	sealed source series 1744 (Amersham Model QCR2)	20 uCi
Americium-241	sealed source series 1744 (Amersham Model QCR2)	10 uCi
Americium-241	sealed sources (Amersham Models AMC-21 and AMC-2084)	10 mCi per source and 12 mCi total
Iron-55	Sealed sources (Isotope Products Model XFB Series)	100 mCi per source and 200 mCi total

Replaces October 2005 Page 1

Question 8 - Training for Individuals Working In or Frequenting Restricted Areas.

Question 6 - Purpose for Which Licensed Material Will be Used

The Sarnoff Corporation is a world class research and development organization which uses radioactive material in the course of research and development in electronics, technology, communications, nanotechnology and biotechnology. Unsealed radioactive material is generally used in biochemistry and biotechnology laboratory experiments. Sealed sources are generally used in instrument calibrations or physics experimentation that require gamma rays of known energy.

Iodine-125 and iodine-131 will be obtained as pre-labeled or "bound" compounds. There will be no radio-iodinations conducted under this license.

There will be no human use of radioactive materials conducted under this license.

There will be no use of radioactivity in laboratory animals under this license.

There will be no "field experiments" where radioactive material is released to the environment for testing or study.

There will be no commercial manufacturing or distribution of devices or products containing licensed radioactivity.

Decommissioning Funding Consideration

NRC regulation 30.35 (as amended, see Federal Register / Vol. 68, No. 192 / Friday, October 3, 2003) requires decommissioning planning and funding assurance if license possession limits for radionuclides with half lives in excess of 120 days exceed certain activity levels. The following table shows all requested radionuclides with half lives over 120 days. The sum of the ratios rule applies for more than one radionuclide. The evaluation makes use of Table G1 from the NRC Consolidated Guidance About Materials Licenses – Program Specific Guidance about Academic, Research & Development ... On the basis of that guidance, the licensee will be exempt from the requirements of 10 CFR 30.35(a)-(f) if the sum of the contributions from sealed and unsealed source is less than one. The contributions are computed as the ratios of the nominal licensed activity divided by the appropriate value from table G1.

The sum of the ratios totaled for both sealed and unsealed sources is less than one. Since the sum of the ratios is less than one, the licensee will be exempt from the requirements of 10 CFR 30.35(a)-(f).

Unity Rule Worksheet for Decommissioning for NRC License

J. R. Matey, Sarnoff Corporation, Princeton, NJ 08543-5300
609-734-2868

Today 12/28/2005

Nuclide	Manufacturer	Model #	Nominal Licensed			Sealed	NRC G1 UnSealed Decom	NRC G1 Sealed Decom	NRC G1 Contribution
			Activity (mCi)	Half life (years)	Half life (days)		Limit (uCi)	Limit (uCi)	Nominal
Am-241	Amersham	AMC-2084	10	433	158045	TRUE	1.0E+01	1.0E+08	1.0E-04
Am-241	Amersham	AMC-21	2	433	158045	TRUE	1.0E+01	1.0E+08	2.0E-05
Am-241	Amersham	QCR-2	0.0100	433.00	158045	TRUE	1.0E+01	1.0E+08	1.0E-07
Ba-133	Amersham	QCR-2	0.0100	10.80	3942	TRUE	1.0E+04	1.0E+11	1.0E-10
Co-60	Amersham	QCR-2	0.0100	5.27	1924	TRUE	1.0E+03	1.0E+10	1.0E-09
Cs-137	Amersham	CDC-803	3	30	10950	TRUE	1.0E+04	1.0E+11	3.0E-08
Cs-137	Amersham	QCR-2	0.0100	30.00	10950	TRUE	1.0E+04	1.0E+11	1.0E-10
Fe-55	Isotope Products	XFB	50	2.7	986	TRUE	1.0E+05	1.0E+12	5.0E-08
Mn-54	Amersham	QCR-2	0.0100	0.86	313	TRUE	1.0E+04	1.0E+11	1.0E-10
C-14			5	5730.00	2091450	FALSE	1.0E+05	1.0E+12	5.0E-02
Ca-45			1	0.45	163	FALSE	1.0E+04	1.0E+11	1.0E-01
Fe-55			0.05	2.7	986	FALSE	1.0E+05	1.0E+12	5.0E-04
H-3			100	12.33	4500	FALSE	1.0E+06	1.0E+13	1.0E-01

Unity Rule Sum 25.1%

Fe-55
email from Perkin Elmer
pg 1 of 2

Subject: RE: NER 9041 Fe-55 Source
From: "Wesley" <wesvanpelt@att.net>
Date: Thu, 10 Nov 2005 16:14:26 -0500
To: <jmatey@sarnoff.com>
CC: <WesVanPelt@att.net>

Jim,

I know the two local RSOs at BMS. (Mike Vala and Larry Gaines) Let me know if you want to network into BMS that way.

Best regards,
Wes
Wesley R. Van Pelt, PhD, CIH, CHP
Wesley R. Van Pelt Associates, Inc.

-----Original Message-----

From: JAMES MATEY [mailto:jmatey@sarnoff.com]
Sent: Thursday, November 10, 2005 10:33 AM
To: Barboni Paul
Cc: Van Pelt Wesley R.; Therese Perrette; Dennis Lawyer
Subject: Re: NER 9041 Fe-55 Source

Dear Paul,

Thanks for your help. We will followup and will pass back our findings.

Best regards,

Jim Matey

Barboni, Paul wrote:

James,

It's a bit before my time, but here's my understanding of the history of NEN's Sources Manufacturing division. The products you refer to were never acquired or manufactured by PerkinElmer, but rather was part of New England Nuclear Sources Manufacturing that became a unit of DuPont

Merck

Pharmaceuticals back in the 1990s. DuPont Merck Pharmaceuticals (which was acquired by and is now Bristol-Myers Squibb) discontinued and sold its Sealed Sources manufacturing in 2000 to another company. I know I don't have the information you seek, and we usually refer customers to BMS in hopes that they can provide some information on the history of NEN's sources.

Paul Barboni
Customer Technical Support Specialist
PerkinElmer Life and Analytical Sciences
710 Bridgeport Avenue
Shelton CT 06484
Telephone: 1 800 762-4000
Fax: 1 203 925-6718

-----Original Message-----

From: JAMES MATEY [mailto:jmatey@sarnoff.com]
Sent: Tuesday, November 08, 2005 6:11 PM
To: LAS Product Info
Cc: Therese Perrette; Dennis Lawyer
Subject: NER 9041 Fe-55 Source

*Fe55
email from PerkinElmer
pg 2 of 2*

Dear Sirs,

I am in possession of two Fe-55 sources, Model NER 9041 SN NS81-157-1 and NS81-144-1, dated 9/82 and 6/82 respectively. They were produced by your predecessor company, New England Nuclear.

These have been on our NRC license as sealed sources for many years. Our license is up for renewal and the license examiner at the NRC cannot find any information about these sources in his sealed source registry. In the absence of such information, we may be compelled to carry the

sources

as unsealed sources.

Can you provide any information about these sources which could help us complete our license renewal in this matter.

Thanks,

James R. Matey
Radiation Safety Officer
Sarnoff Corporation
Princeton NJ 08543-5300

AM-241
Email from Amersham
pg 1 of 2

email amersham 11.15.05
Subject: [Fwd: Am-241 Source Part of QCR.2]
Date: Tue, 15 Nov 2005 19:29:39 -0500
From: "JAMES MATEY" <jmatey@sarnoff.com>
To: Therese Perrette <tperrette@sarnoff.com>

Subject: Am-241 Source Part of QCR.2
Date: Mon, 14 Nov 2005 09:46:05 -0500
From: "Lori Podolak" <Lori.Podolak@qsa-global.com>
To: <jmatey@sarnoff.com>

James,

Sorry for the delay in getting back to you but I had to contact our German office for details on this product code as it has been replaced by QCR.310. The product code you referenced was found by my colleague in an old Amersham catalog from 1979.

I have attached a general drawing of the source along with an ISO/ANSI certificate which classifies the source as meeting ANSI N542 77C34343. This source set, along with most of the sources Amersham used to distribute but that are now distributed under our ISOTRAK brand, are primarily intended for distribution to broad scope and/or research and development licensees. Typically those licensees do not require sources that have a documented SSDR and often include authorization for radioactive material in "Any" form.

Based on the construction of the source and its ANSI classification the AMR.151 source (now referenced as AMR.1152 under our current catalog), is a sealed source, but it does not have a Sealed Source and Device Registry Sheet. Distribution, as I've described above to broad scope/R&D licensees is authorized under USNRC NUREG-1556 Vol 3, Section 5. Although I do not know what authorization existed under your license which allowed you to originally receive this source, Section 5.1.1 of this NUREG further states that certain sources of low activity can be licensed by regulators for use as calibration and reference sources even if they do not have an SSDR. The activity of the sources in this source set meets these criteria. If your license does not currently allow this condition, and you wish to retain possession and use of this source set, I would recommend you request approval to use these sources based on the conditions in this section. (I have attached a copy for your info).

I hope this is helpful to you.

Regards,

Lori Podolak

Lori Podolak
Product Licensing Specialist
QSA Global Inc.
40 North Avenue
Burlington, MA 01803

On October 10th 2005, we changed our name to QSA Global Inc.
As QSA Global Inc., we remain committed to providing you with the same level of world class service you have come to expect from AEA Technology QSA, Inc.

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Page 1

Am-241
Email from Amersham
pg 2 of 2

email amersham 11.15.05
to anyone else. If you have received this transmission in error please
contact the sender. Thank you for your cooperation.

For more information about QSA Global Inc., formerly
AEA Technology QSA Inc., please visit
our website at <http://www.qsa-global.com>

VZ-1240andISOCerti.pdf Name: VZ-1240andISOCerti.pdf
 Type: Acrobat (application/pdf)
 Encoding: base64

from

Name: Pages

NUREG-1556 Vol 3

Rev 1

App1 for

Pages from NUREG-1556 Vol 3 Rev 1 App1 for SSDR Evaluation.pdf

SSDR

Evaluation.pdf

Type: Acrobat

(application/pdf)

Encoding: base64

VZ-1240

Am241
ISO/ANSI Certificate

Amersham Buchler GmbH & Co KG Postfach 11 49 D-38001 Braunschweig

CERTIFICATE

of
radioactive source integrity

QKQ 269

Amersham Buchler
GmbH & Co KG
Gieselweg 1
D-38110 Braunschweig
Postfach 11 49
D-38001 Braunschweig
Tel. (05307) 930-0
Fax (05307) 930-293
Fax-Zentrale 930-237

Amersham
The Health Science Group

Title : Gamma reference source,
Assembly drawing : VZ-1240/2
Nuclides : see enclosure
Radiotoxicity group : see enclosure
Maximum activity : 4 MBq

Classification : C.34343

Test sources : The assessed classification is based on results
of gamma reference sources according to
drawing VZ-1240/1E.
(see also certificate QKQ 200/1 to
QKQ 200/4)

Test carried out in accordance with recommendation of:
BS 5288; ISO 2919; ANSI N542; DIN 25 426, part 1.

Test method	Temperature	Pressure	Impact	Vibration	Puncture	Unit

i. A. Schuch
.....
Development

20 October 1994

Date

A. Mumm
.....
Amersham Buchler

Amersham Buchler
GmbH & Co KG
Sitz Braunschweig, Registergericht
Braunschweig, HRA 8621

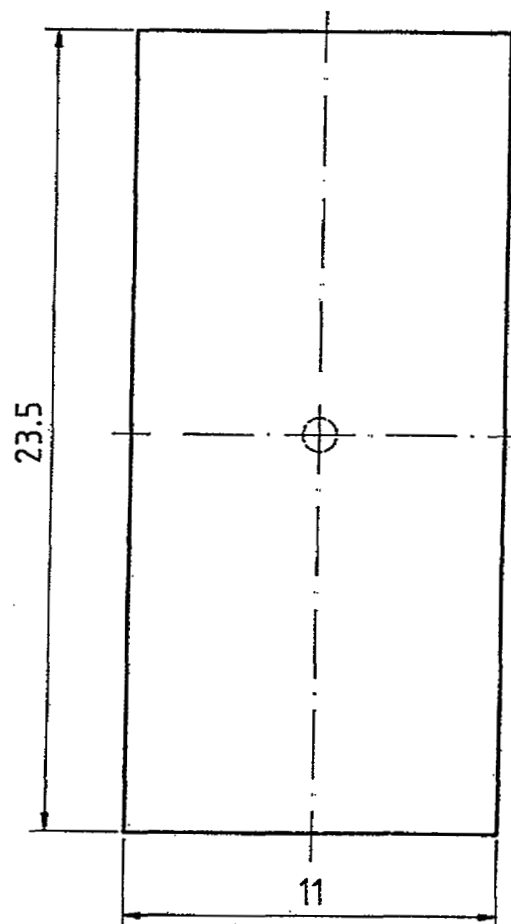
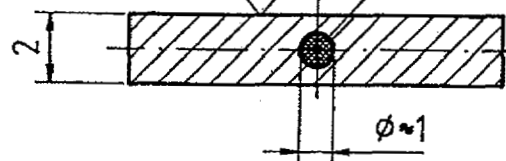
Persönlich haftende Gesellschafterin:
Amersham Buchler GmbH,
Sitz Braunschweig, Registergericht
Braunschweig HRB 638

Geschäftsführer:
Dr. Anthony J. D'Eustachio
Vorsitzender des Aufsichtsrates:
Wolfgang Büsselberg

Deutsche Bank AG Braunschweig
BLZ 270 700 30, Konto 0168815
Postgiroamt Hannover
BLZ 250 100 30, Konto 3133 30-300

engraving

activity incorporated
in organic ion
exchange bead
or in ceramic



various nuclides		DIN ISO 2768 f m c		Surface	Scale 5:1	acrylic glass
		Date	Name	GAMMA- REFERENCE SOURCE		
		Drawn 26.09.94	Bu.			
		Appr.	<i>CE-M</i>			
		Amersham The Health Science Group			VZ-1240/2	Page
Issue	Change	Date	Name	EDV No. 06\VZ1240BE		pag.

5 GENERAL POLICIES AND PROCEDURES

5.1 SEALED SOURCE AND DEVICE DESIGNS THAT DO NOT REQUIRE EVALUATION AND REGISTRATION

The provisions of 10 CFR 30.32(g) apply to all sealed sources and devices used by NRC specific licensees and requires registration of the product by NRC. However, the possession and use of certain products do not require the evaluation and registration of the product by NRC or Agreement States. Specifically, evaluation and registration of the following products should be handled as indicated below by the license reviewer.

5.1.1 CALIBRATION AND REFERENCE STANDARDS

Calibration and reference sources may be licensed without registration by NRC or Agreement States if the sources do not exceed the following:

- For beta and/or gamma emitting material – 3.7 MBq (100 μ Ci) or ten times the quantity specified in Section 30.71, Schedule B, 10 CFR Part 30, whichever is greater.
- For alpha emitting material – 0.37 MBq (10 μ Ci).

The above values were chosen because they represent a minimal hazard to public health and safety. To license these sources, license reviewers need to identify the isotope in Item 6 of the NRC materials license (NRC Form 374), use the statement "calibration or reference sources" in Item 7, and state the maximum quantity for each source in Item 8. Both possession and distribution to specific licensees may be authorized.

NRC does not authorize combining, also referred to as "bundling," exempt quantity sources in products for commercial distribution. NRC's position on bundling can be found in NRC Generic Letter 99-01: "Recent Nuclear Material Decision on Bundling Exempt Quantities," dated May 3, 1999. In some specific applications the use of multiple calibration sources is permitted as specified by the provisions of 10 CFR 30.15(a)(9). To manufacture and distribute a device with multiple calibration sources, the applicant must satisfy the applicable requirements for licensing (10 CFR 32.14).

GENERAL POLICIES AND PROCEDURES

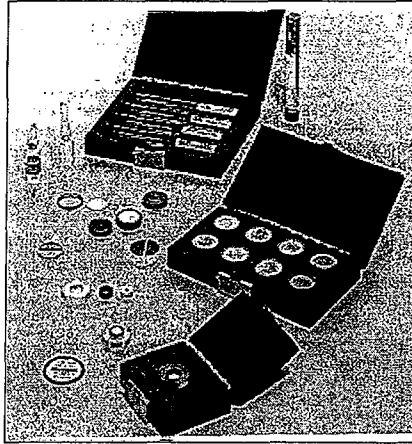


Figure 5.1 Calibration and Reference Sources. *Calibration and reference sources may not need evaluation and registration by NRC or Agreement States.*

5.1.2 PRODUCTS USED IN RESEARCH AND DEVELOPMENT OR BY BROAD SCOPE LICENSEES

Sealed sources or devices containing sealed sources that are intended only for use under research and development or broad scope licenses need not be registered by NRC or the Agreement State if the following is valid:

- For unregistered sources, or registered sealed sources not possessed and used in accordance with the registration – the licensee is qualified by sufficient training and experience and has sufficient facilities and equipment to safely use and handle the requested quantity of radioactive material.
- For registered sealed sources contained in unregistered devices – the licensee is qualified by sufficient training and experience and has sufficient facilities and equipment to safely use and handle the requested quantity of radioactive material in unshielded form.

NRC has granted broad scope licensees the authority to use sealed sources and/or devices that have been fabricated by or obtained from licensed vendors without prior NRC or Agreement State review and registration. However, broad scope licensees also have the responsibility for appropriately evaluating the sealed source or device and conducting activities responsibly and safely. For example, for Type A specific licensees of broad scope, 10 CFR 33.13(c)(3)(iii) requires the review and approval of these safety evaluations by the radiation safety committee. This is especially important with the advent of emerging medical technologies used under 10 CFR Part 35. U.S. Food and Drug Administration reviews for medical efficacy of a product cannot be substituted for this evaluation. The review should determine if a source or device can be safely used from a radiological standpoint and provide adequate radiological protection for its intended use at the institution. This review should be commensurate with the level of risk that could be reasonably anticipated from the source or device for its intended use and likely accident

Gamma reference sources

Rectangular type

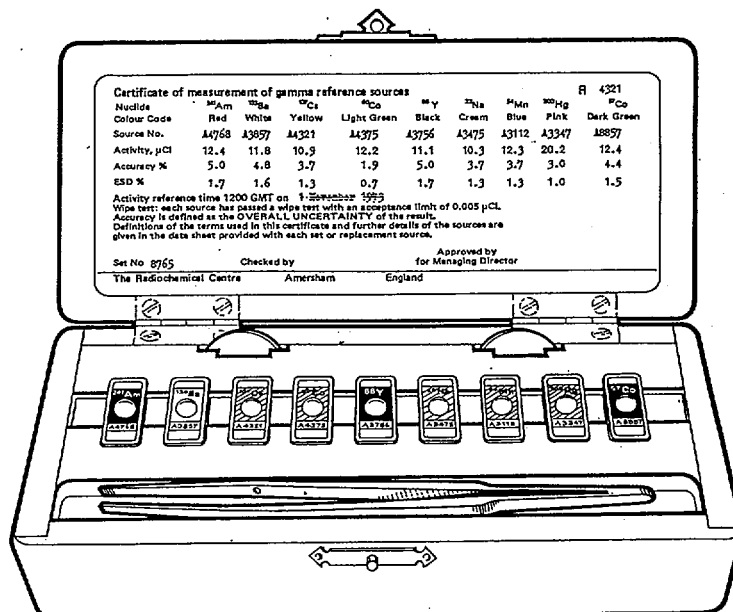
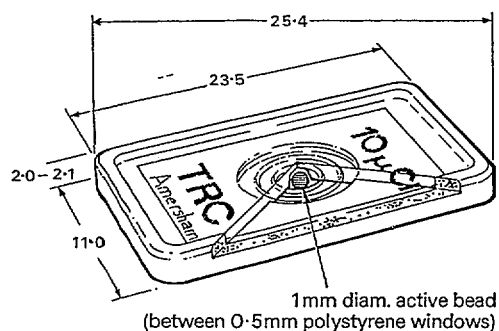
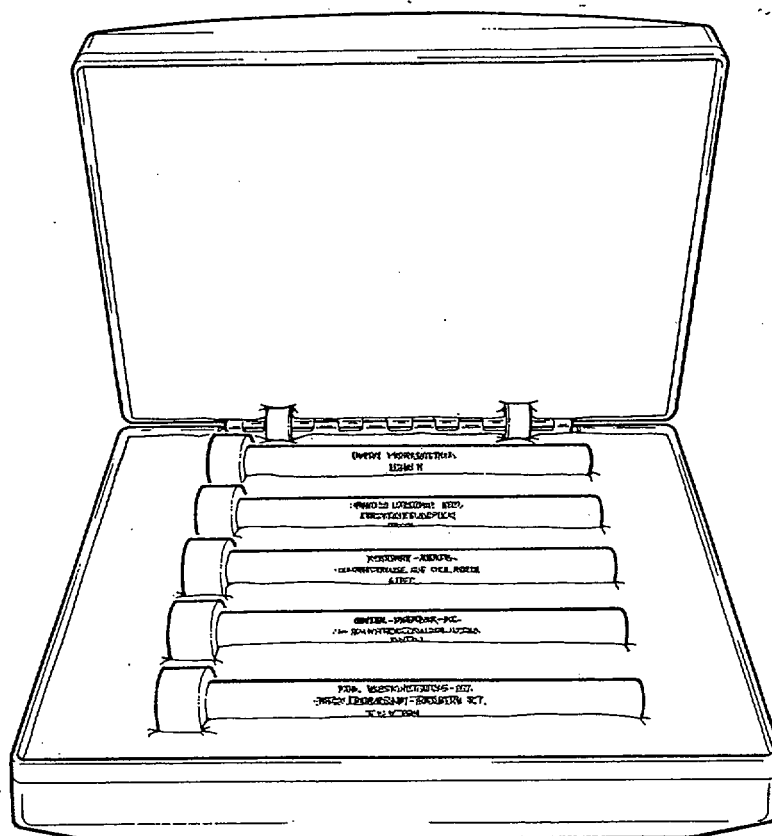
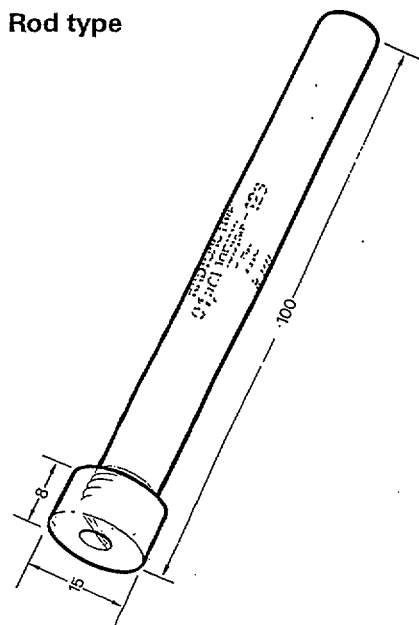


Fig. 37

OCR.1/11

Rod type



OCR.5210

Fig. 38

Dimensions in mm

Gamma reference sources

Two types of γ -reference sources are available.

Rectangular type, see fig. 37

For use in the calibration of gamma spectroscopy and counting equipment; calibrated sources can be used to determine the detector counting efficiency.

^{207}Bi , ^{56}Co and ^{152}Eu emit a multiplicity of gamma lines; sources of these nuclides are intended to be used for the determination of relative efficiency curves for Ge(Li) γ -detectors.

Rod type, see fig. 38

Designed primarily for consistency checking of well-type crystal detectors.

Quality control

Wipe test A

For rectangular sources:

Photon emission and purity checked using a Ge(Li) detector.

For rod sources:

Photon emission checked against standards using NaI well crystal.

Prototype testing

rectangular sources

ANSI classification, C24244

rod sources

ANSI classification, C23233

Source sets

Rectangular type sources, see fig. 37

A set consists of calibrated sources of eight or nine different nuclides, displayed in a polished wooden box together with an adaptor plate, forceps and positron absorbers. The calibration certificate is retained in the lid of the box.

Rod type sources, see fig. 38

A set, code QCR.5210, consists of five uncalibrated sources covering the energy range 0.014–1.33 MeV. The sources are supplied in a storage box.

The active material, absorbed in a 1mm diameter ion-exchange bead, is sealed by ultrasonic welding between clear polystyrene windows which are mounted in a plastic frame. The active bead is visible and at the geometric center of the source. Labels permanently sealed within the sources are visible through the clear plastic windows, are colored to indicate the nuclide and carry the serial number. Each source is supplied in a plastic storage box with adaptor.

The active material is adsorbed on ion-exchange material and sealed in a plastic capsule attached to a handling rod.

The rod is colored to indicate the nuclide.

Each source is supplied in a plastic storage box.

Unshielded packs

(dimensions: 176mm long, 84mm wide, 50mm high)
code QCR.1—comprises 10 μCi sources (20 μCi for ^{203}Hg)

code QCR.11—comprises 1 μCi sources (2 μCi for ^{203}Hg)

Note: γ -exposure rate at 150mm from top surface box is 2.5mR/h (max) for QCR.1; 0.25mR/h (max) for QCR.11.

Shielded packs

(dimensions: 220mm long, 145mm wide, 143mm high)

code QCR.2—comprises 10 μCi sources (20 μCi for ^{203}Hg)

code QCR.12—comprises 1 μCi sources (2 μCi for ^{203}Hg)

The box has integral lead shielding to reduce the surface exposure rate to <2.5mR/h for QCR.2 (<0.25mR/h for QCR.12).

It weighs 6kg and is fitted with a lock and key.

Gamma reference sources

nuclide and half title	principal photon energies MeV	%	source type†	colour code	nominal activity* μCi	accuracy of calibration overall uncertainty	ESD	individual code	sources availability	included in sets**
americium-241										
(433y)	0.014	13.3	rod	red	1	-5%, +30%		AMR.121	D*	QCR.1/2
	0.018	18.9	rect	red	10	±5%		AMR.151	D8	QCR.11/12
	0.021	4.9	rod	red	0.1	uncalibrated		AMR.5210	D2	
	0.026	2.5								
	0.0595	35.3								
barium-133										
(10.8y)	0.030-0.036	~123	rect	white	10	±5%	1.7%	BDR.151	D8	QCR.1/2
	0.080	2.4	rect	white	1	-5%, +30%	2.3%	BDR.121	D*	QCR.11/12
	0.081	33.8	rod	silver	0.1	uncalibrated		BDR.5210	D2	QCR.5210
	0.276	7.1								
	0.303	18.7								
	0.356	61.9								
	0.384	8.9								
bismuth-207										
(+ lead-207m)	numerous photon		rect	grey	10	uncalibrated		BIR.1510	D2	—
(38y)	energies		rect	grey	10	calibrated		BIR.151	D8	—
	0.072-1.770MeV					(specification on request)				
	(see page 000)									
cadmium-109										
(+ silver-109m)	0.022-0.026	102.3	rect	yellow	10	uncalibrated		CUR.1510	D4	—
(453d)	0.088	3.6	rect	white	10	calibrated		CUR.151	D*	—
						(specification on request)				
cesium-137										
(+ barium-137m)	0.032-0.038	8.0	rect	yellow	10	±4%	1.3%	CDR.151	D8	QCR.1/2
(30.1y)	0.662	85.1	rect	yellow	1	-5%, +30%	2.0%	CDR.121	D*	QCR.11/12
			rod	yellow	0.1	uncalibrated		CDR.5210		QCR.5210
cobalt-56										
(78.8d)	numerous γ-energies		rect	light green/10		uncalibrated		CWR.1510	D8	—
	0.511-3.452MeV		rect	white	10	calibrated		CWR.151	D*	—
	(see page 000)					(specification on request)				
cobalt-57										
(270.5d)	0.006-0.007	~55	rect	dark green	10	±5%	1.7%	CTR.151	D8	QCR.1/2
	0.014	9.4	rect	dark green	1	-5%, +30%	2.0%	CTR.121	D*	QCR.11/12
	0.122	85.2	rod	dark green	0.1	uncalibrated		CTR.5210	D4	QCR.5210
	0.136	11.1								
	0.692	0.16								
cobalt-60										
(5.27y)	1.173	99.86	rect	light green	10	±2%	0.7%	CKR.151	D8	QCR.1/2
	1.333	99.98	rect	light green	1	-5%, +30%	1.3%	CKR.121	D*	QCR.11/12
			rod	light green	0.1	uncalibrated		CKR.5210	D2	QCR.5210
europium-152										
(13.0y)	numerous γ-energies		rect	ilac	10	uncalibrated		EFR.1510	D2	—
	0.122-1.408MeV		rect	ilac	10	calibrated		EFR.151	D8	—
	(see page 000)					(specification on request)				
iodine-129										
(1.57 × 10 ⁷ y)	0.030-0.035	~69	rod	amber	0.1	uncalibrated		ISR.5210	D2	QCR.5210
	0.040	7.5								
iron-55										
(2.7y)	0.006	~28	rect	light blue/ white	50	uncalibrated		IER.5510	D8	—
manganese-54										
(312.5d)	0.835	100	rect	light blue	10	±4%	1.3%	MFR.151	D8	QCR.1/2
			rect	light blue	1	-5%, +30%	2.3%	MFR.121	D*	QCR.11/12
			rod	light blue	0.1	uncalibrated		MFR.5210	D6	—
mercury-203										
(46.6d)	0.071-0.085	12.8	rect	pink	20	±4%	1.5%	MBR.251	D8	QCR.1/2
	0.279	81.5	rect	pink	2	-5%, +30%	2.0%	MBR.221	D*	QCR.11/12
selenium-75										
(+ arsenic-75m)	0.010-0.012	~52.6	rod	dark blue	0.1	uncalibrated		SCR.5210	D6	—
(118.5d)	0.121	15.7								
	0.136	54.0								
	0.265	56.9								
	0.280	23.9								
	0.401	11.7								

Gamma reference sources

nuclide and half life	principal photon energies MeV	%	source type†	colour code	nominal activity* μCi	accuracy of calibration overall uncertainty	ESD	individual code	sources availability	included in sets**
sodium-22‡										
(2.60y)	0.511	181	rect	cream	10	±4%	1.3%	SKR.151	D8	QCR.1/2
	1.275	99.95	rect	cream	1	-5%, +30%	2.0%	SKR.121	D*	QCR.11/12
			rod	gold	0.1	uncalibrated		SKR.5210	D2	—
tellurium-123m										
(119.7d)	0.027-0.032	~50	rect	violet	10	uncalibrated		TQR.1510	D8	—
	0.159	83.5	rect	violet	10	calibrated: (specification on request)		TQR.151	D*	—
yttrium-88										
(106.6d)	0.014-0.016	~60	rect	black	10	±5%	1.7%	YER.151	D8	QCR.1/2
	0.898	93.2	rect	black	1	-5%, +30%	2.3%	YER.121	D*	QCR.11/12
	1.836	99.4	rod	black	0.1	uncalibrated		YER.5210	D6	—
	2.734	0.6								

†source types: rect.—rectangular type
rod—rod type

‡rectangular type ²²Na sources should be covered with absorbers (~200mg/cm² thickness) to ensure the positrons are annihilated close to the source. Absorbers are provided in the sets.

*activity tolerance:

rect type: -0, +25% (calibrated); ±25% (uncalibrated)

rod type: ±20%

**availability of sets:

QCR.1/2—D4

QCR.11/12—D*

QCR.5210—D6