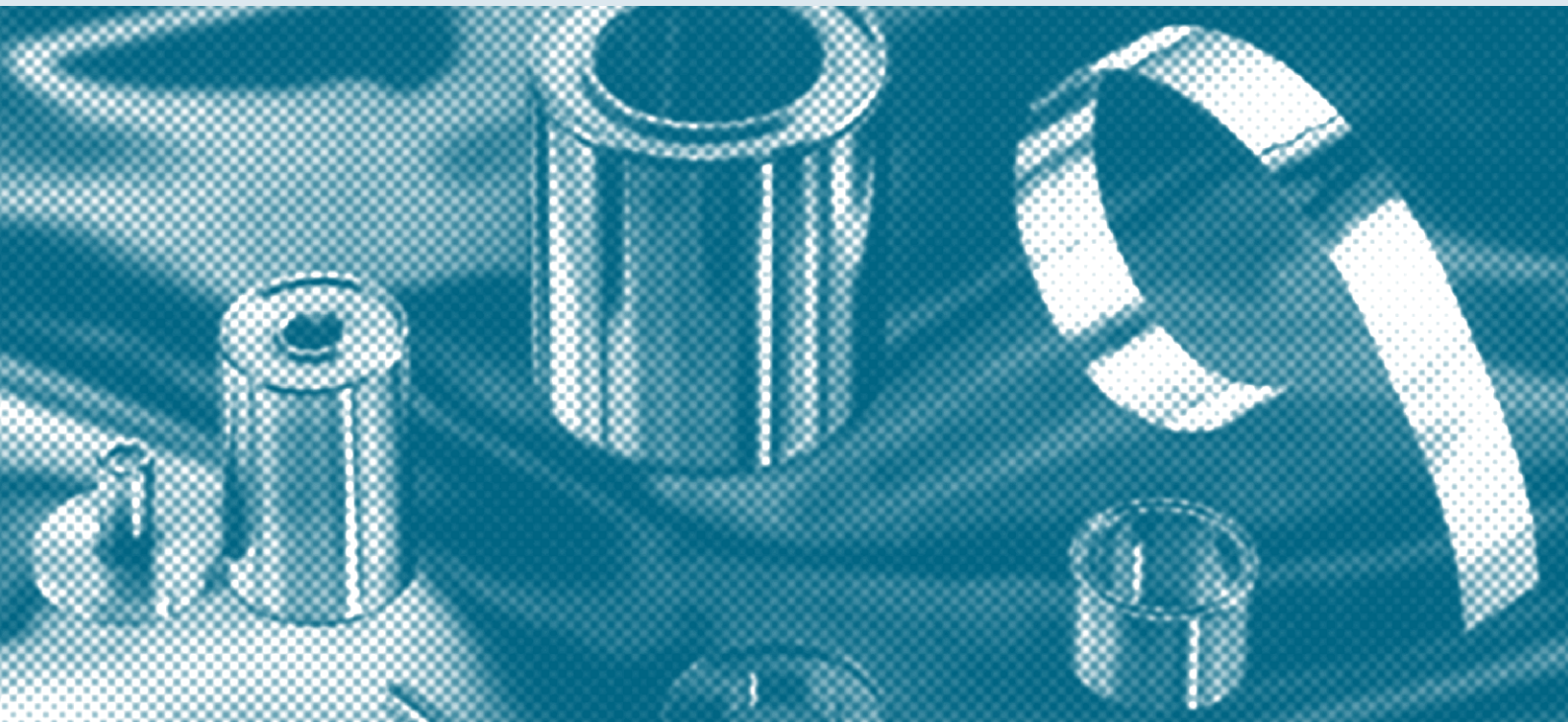


Sealed Radiation Sources

Product Information



Applications

Products

Quality Control

Technical Information

Source Safety

Electron capture detection

X-Ray gauging

Moisture Gauging

Level Gauging

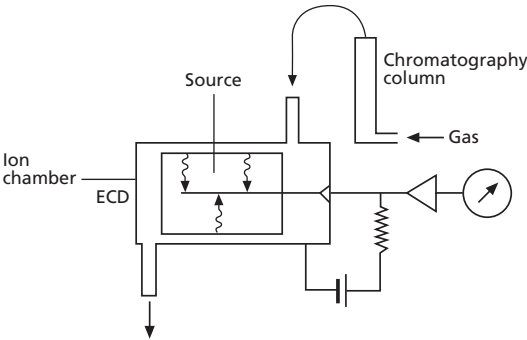
Thickness gauging

Electron capture detection

Technique

A cylindrical ion chamber containing a low energy beta source maintains a standing current with a stream of pure argon. When material with a high electron affinity enters the chamber, the ion current falls and this is displayed. Some instruments also have a gas chromatography column attached which enables specific compounds to be measured when the atmosphere is already heavily contaminated by other pollutants.

Geometry



Applications

- Nuclear industry
Sulphur hexafluoride in accelerators
Hydrogen in air
- Chemical industry
Carbon tetrachloride in air
Sulphur hexafluoride manufacture
- General industry
Solvent fumes from processing or degreasing
Gas leaks
- Security
Explosive detection
Chemical agent detection

Sensitivities

Sulphur hexafluoride 1 part in 10^{11} parts of air
Nitro compounds 1 part in 10^9 parts of air

Sources

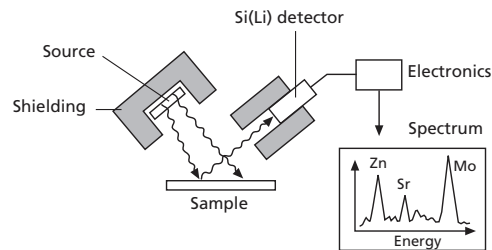
Nuclide	Typical activity	See page
Iron-55	185MBq (5 mCi)	B24
Nickel-63	370MBq (10mCi)	B29

X-Ray fluorescence

Technique

Primary radiation from the radioisotope source excites atoms of the elements present in the sample, removing electrons from the sub-shells around the nucleus. X-ray characteristic of each element are emitted as electrons from the outer shells and move to fill the gaps created in the inner shells. The shell from which the electron is removed determines the series of X-rays produced. The intensity of the X-ray is indicative of the concentration of the particular element in the sample. Since radioisotopes emit specific radiations, a limitation results on the range of elements whose characteristic X-ray can be excited. Thus a series of nuclides is employed in order that excitation of all elements from silicon to uranium can be achieved.

Geometry



Applications

- Alloy analysis for checking stock, scrap sorting and checking components
- In mining, analysis of material excavated from pits and cores, chippings and slurries from drilling operations
- Analysis of electroplating solutions
- General chemical analysis
- Lead in paint analysis

Sources

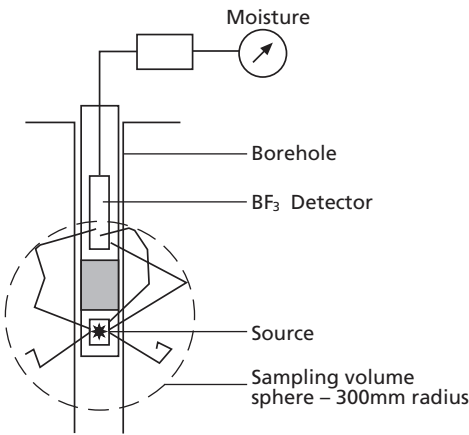
Nuclide	Energy	Typical elemental range of excitation		See page
		KX-rays	LX-rays	
Iron-55	5.9–6.5keV (Mn LX-rays)	Silicon-Vanadium	Nobium-Tin	B24
Curium-244	12-23keV (Pu LX-rays)	Titanium-Selenium	Cerium-Lead	B23
Americium-241	60keV (γ -rays)	Zirconium-Antimony	Tungsten-Uranium	B1

Moisture gauging

Technique

Fast neutrons emitted by the source are moderated by collision with hydrogen atoms in moisture contained in the material. These moderated or thermal neutrons are detected by a neutron detector (usually a boron trifluoride (BF_3) proportional counter) to give a measure of the concentration of hydrogen atoms.

Geometry



Applications

- Soil moisture content for agricultural and construction use
- Moisture content of materials in silos
- Continuous moisture content gauging in raw materials supplies, e.g. gravel, wood chips, etc.
- Prompt gamma neutron activation analysis

Sources

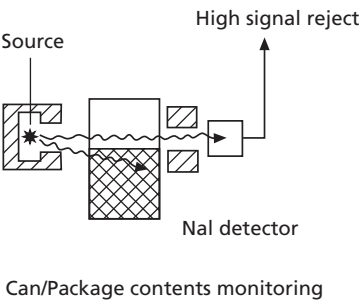
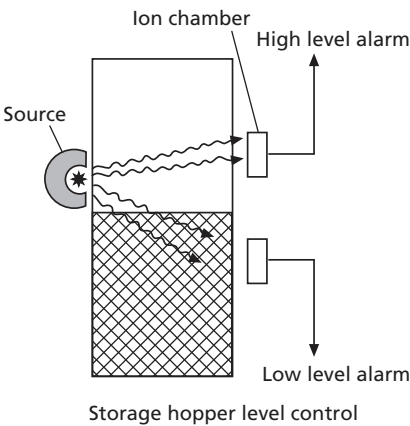
Nuclide	Typical activity	See page
Americium-241/Beryllium	1.11-9.25GBq (30-250mCi)	B6
Californium-252	2MBq ($54\mu\text{Ci} \sim 0.1\mu\text{g}$)	B14

Level gauging

Gamma switching technique

The transmission of gamma radiation through a container is affected by the level contents. The intensity of the transmitted radiation is measured and used to activate switches when pre-set intensity levels are reached.

Geometry



Applications

Storage hopper level control

- Switch can be used to operate high level and low level alarms or pumps switch control.

Nuclide		See page
Caesium-137	Typical path length 7-1000cm	B8
Cobalt-60		B20

Activity according to dimensions of container and wall thickness.

Can/Package contents monitoring

- Switch can be used to operate reject control for up to 10cm of low atomic number material.

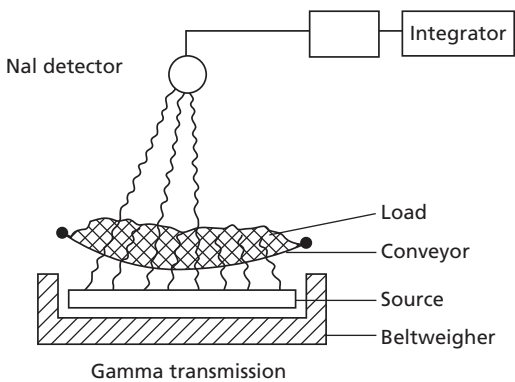
Nuclide	Activity	See page
Americium-241	3.7GBq (100mCi)	B1

Thickness gauging

Transmission thickness technique

The source and the detector are placed on opposite sides of the material to be measured. Gamma or beta radiation transmitted through the sample is then directly related to the sample thickness, provided the density of the material is constant.

Geometry



Applications

Gamma gauging

- Thickness gauging of sheet metal, glass, plastic and rubber at thicknesses greater than 500mg/cm².
- Belt weighing, giving mass (kg/m²) flowing on conveyor belt.

Measure range

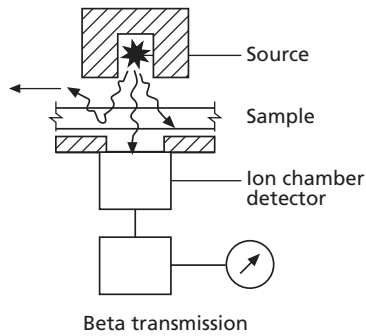
Nuclide	Activity	Belt weight	Gauging thickness	See page
Americium-241	0.37-37GBq (10-1000mCi)	10-100kg/m ²	up to 10mm in steel	B1
Caesium-137	0.37-37GBq (10-1000mCi)	30-200kg/m ²	up to 100mm in steel	B8
Cobalt-60	37MBq-0.37GBq (1-10mCi)	100-400kg/m ²		B20

- Non contact measurement and control of liquids, solids or slurries in pipelines.

Nuclide	Activity	See page
Caesium-137	0.37-37GBq (10-1000mCi)	B8

Thickness gauging

Geometry



Applications

Beta Gauging

- Thickness gauging of thinner plastics, thin sheet metal, rubbers, textiles and paper, e.g. 1-1000mg/cm²
- The “weighing” of cigarettes
- Measurement of dust and pollutant levels on filter paper samples, e.g. 0.1-200mg/m³ dust.

Measure range

Nuclide	Half thickness (mg/cm ²)	Useful measurement range (mg/cm ²)	See page
Promethium-147	5	1 to 15	B30
Krypton-85	23	5 to 100	B27
Strontium-90 / Yttrium-90	90	25 to 100	B32

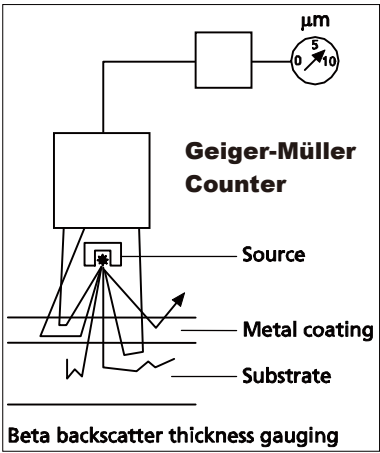
Activities according to nuclide and application, 37MBq to 37GBq (1 to 1000mCi)

Thickness gauging

Beta backscatter thickness technique

The intensity of beta radiation which is scattered back from thin samples is related to thickness and atomic number.

Geometry



Applications

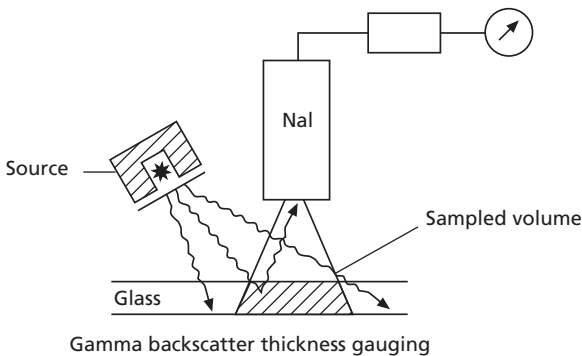
- The thickness gauging of paper plastic and rubber on steel rolls.
- The measurement of a coating thickness on a substrate, providing there is sufficient difference in density or atomic number between coating and substrate. Coating range <1-100mm depending on source and materials.

Nuclide	Activity	See page
Promethium-147	37-185MBq (1-5mCi)	B30
Krypton-85	37-185MBq (1-5mCi)	B27
Strontium-90/Yttrium-90	37-185MBq (1-5mCi)	B32

Gamma backscatter thickness technique

The intensity of backscattered radiation from the sample is measured to give sample thickness or mean atomic number. Used for the measurement of substances of low atomic number for which transmission measurements are not sufficiently sensitive.

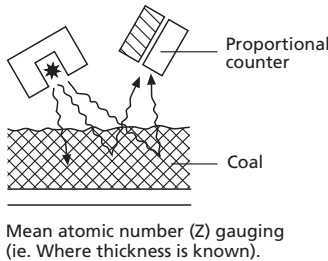
Geometry



Applications

Thickness gauging

Measurement of light alloys, glass, plastics, rubber for which beta sources are not suitable, (e.g. greater than $500\text{mg}/\text{cm}^2$), access only available from one side, (e.g. tube wall thickness gauging).



Measurement range

Nuclide	Activity	Material	Thickness	Accuracy	See page
Americium-241	3.7GBq (100mCi)	Glass	1-10mm	$\pm 0.03\text{mm}$	B1
		Plastic	1-30mm	$\pm 0.05\text{mm}$	
Caesium-137	1.85GBq (50mCi)	Glass	>20mm	$\pm 0.1\text{mm}$	B8

Americium-241

Americium-241/Beryllium

Caesium-137

Californium-252

Cobalt-57

Cobalt-60

Curium-244

Iron-55

Krypton-85

Nickel-63

Promethium-147

Strontium-90

Sources for well logging

Other products on request

Americium-241

γ and Primary X-ray Sources

Disc Sources, Beryllium Window

Americium-241 incorporated in a ceramic enamel, sealed in a welded monel capsule with brazed beryllium window; the active component is recessed into a stainless steel support with tungsten alloy backing.

These sources are designed for applications where the NpL X-rays are also required.

Nominal activity*		Capsule	Typical photon output in		Product code
GBq	mCi		photons/s per steradian 17 keV	59.9 keV	
0.37	10	X.130/4	1.9×10^6	8.6×10^6	AMC13044
1.11	30	X.131/4	7.0×10^6	2.6×10^7	AMC13145
3.7	100	X.131/4	1.0×10^7	6.7×10^7	AMC13146
3.7	100	X.134/4	1.8×10^7	7.8×10^7	AMC13446

Tolerance $\pm 10\%$
(except -10% to +0% for AMC13146 and AMC13446 used in USA)

Recommended working life: 10 years

Quality control

Wipe Test I
Immersion test II
Bubble test III

Np L x-ray emission is measured in narrow beam geometry using a Si(Li) detector.

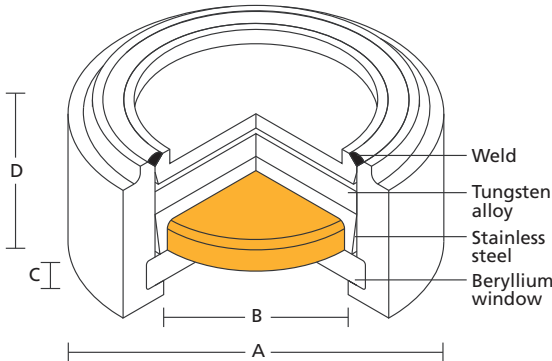
59.5keV γ -ray emission is measured in narrow beam geometry using a thin NaI detector.

Spectral purity is checked using Si (Li), Ge and NaI detectors.

Neutron emission

All Americium-241 sources emit 0.3n/s per MBq ($\sim 10^4$ n/s per Ci) due to (α ,n) reactions with the low atomic number elements (for example, Si, Al, O) in the active material.

X.130, 131, 134



Capsule dimensions and safety performance testing

Capsule	Overall diam.	Active diam.	Window thick.	Overall thick.	Safety perf. testing ANSI/ISO class	testing IAEA spec. form	US-Model number
	'A'mm	'B'mm	'C'mm	'D'mm			
X.130/4	8.0	4.2	0.95-1.05	5.0	C64344	YES	AMCL
X.131/4	10.8	7.2	0.95-1.05	5.0	C64344	YES	AMCL
X.134/4	15.0	10.6	0.95-1.05	5.0	C64344	YES	AMCL

Americium-241

γ and Primary X-ray Sources

Disc Sources, Stainless Steel Window

Americium-241 incorporated in a ceramic enamel, sealed in a welded stainless steel capsule.

Nominal activity*		Capsule	Typical photon output in photons/s per steradian 59.5keV	Product code
GBq	mCi			
3.7	100	X.91	53.0×10^6	AMC16
11.1	300	X.92	150.0×10^6	AMC17
18.5	500	X.97	280.0×10^6	AMC18
37.0	1000	X.93	500.0×10^6	AMC19
111.0	3000	X.94	1.2×10^9	AMC30
185.0	5000	X.95	2.0×10^9	AMC50

* Tolerance $\pm 10\%$

Recommended working life: 15 years

Quality control

Wipe Test I
Immersion Test II
Bubble Test III

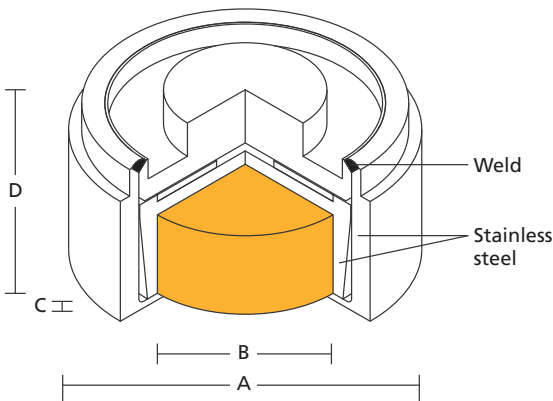
59.5keV γ -ray emission is measured in narrow beam geometry using a thin NaI detector.

Spectral purity is checked using Si (Li), Ge and NaI detectors.

Neutron emission

All Americium-241 sources emit 0.3n/s per MBq ($\sim 10^4$ n/s per Ci) due to (α ,n) reactions with the low atomic number elements (for example, Si, Al, O) in the active material.

X.91-95, 97



Capsule dimensions and safety performance testing

Capsule	Overall diam.	Active diam.	Window thick.	Overall thick.	Safety perf. class	testing	US-Model ref.
	'A'mm	'B'mm	'C'mm	'D'mm		IAEA spec. form	
X.91	10.8	7.5	0.2-0.25	6.0	C64444	YES	AMC.16
X.92	15.0	12.0	0.2-0.25	6.0	C64444	YES	AMC.17
X.93	30.0	25.0	0.2-0.25	6.0	C64444	YES	AMC.19
X.94	36.0	31.0	0.25-0.3	8.0	E64444	YES	AMC.30
X.95	45.0	40.0	0.25-0.3	8.0	E64444	YES	AMC.50
X.97	22.0	18.0	0.2-0.25	6.0	C64444	YES	AMC.18

Americium-241

γ and Primary X-ray Sources

Disc Sources, Stainless Steel Window

Americium-241 incorporated in ceramic enamel, sealed in a welded stainless steel capsule.

Sources codes AMC 62-66 are designed for backscatter applications; the active ceramic is recessed into a tungsten alloy insert.

Nominal activity*		Capsule	Typical photon output in photons/s per steradian 59.5keV	Product code
MBq	mCi			
37	1	X.10/2	$7.2 - 10.0 \times 10^5$	AMC62
111	3	X.10/2	$2.3 - 3.1 \times 10^6$	AMC63
370	10	X.10/2	$7.2 - 10.0 \times 10^6$	AMC64
1110	30	X.11	24.0×10^6	AMC65
3700	100	X.11/1	53.0×10^6	AMC66

* Tolerance $\pm 10\%$

Recommended working life: 15 years

Quality control

Wipe Test I

Immersion Test II

Bubble Test III

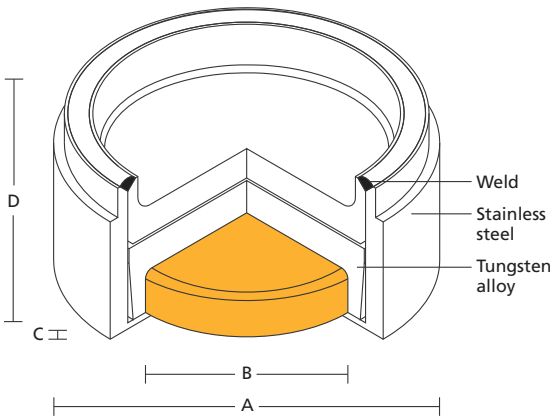
59.5keV γ -ray emission is measured in narrow beam geometry using a thin NaI detector.

Spectral purity is checked using Si (Li), Ge and NaI detectors.

Neutron emission

All Americium-241 sources emit 0.3n/s per MBq ($\sim 10^4$ n/s per Ci) due to (α ,n) reactions with the low atomic number elements (for example, Si, Al, O) in the active material.

X.10, 11



Capsule dimensions and safety performance testing

Capsule	Overall diam.	Active diam.	Window thick.	Overall thick.	Safety perf. testing		US-Model ref.
	'A'mm	'B'mm	'C'mm	'D'mm	ANSI/ISO class	IAEA spec. form	
X.10/2	8.0	4.2	0.2-0.25	5.0	C64545	YES	AMC.D2
X.11	10.8	7.2	0.2-0.25	5.0	C66544	YES	AMC.D3
X.11/1	10.8	8.0	0.2-0.25	5.0	C66544	YES	AMC.D3

Americium-241

γ and Primary X-ray Sources

Point Sources

Americium-241 incorporated in a ceramic bead (AMC21 to AMC25) or cylindrical ceramic pellet (AMC26), sealed in a welded stainless steel capsule.

Nominal activity*		Capsule	Typical photon output in photons/s per steradian 59.5keV	Product code
MBq	mCi			
74	2	X.100	1.0×10^6 **	AMC21
518	14	X.101/2	7.0×10^6	AMC24
1665	45	X.102	$16.2\text{-}21.9 \times 10^6$	AMC25
7400	200	X.108	5.5×10^7	AMC26

* Tolerance $\pm 10\%$

** Tolerance $+25\%$, -10%

Recommended working life: 15 years

Quality control

Wipe Test I

Immersion Test II

Bubble Test III

59.5keV γ -ray emission is measured in narrow beam geometry using a thin NaI detector.

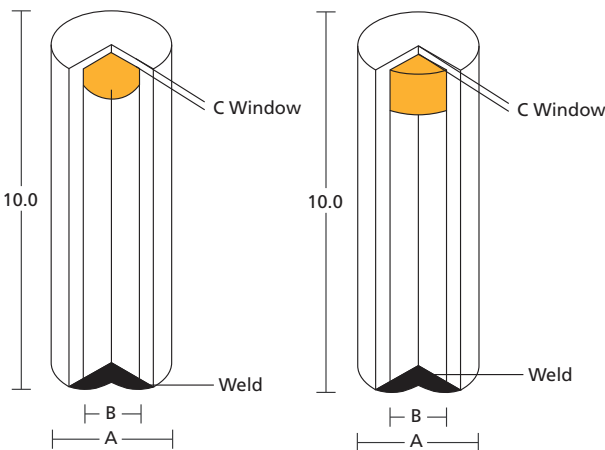
Spectral purity is checked using Si (Li), Ge and NaI detectors.

Neutron emission

All Americium-241 sources emit 0.3n/s per MBq ($\sim 10^4$ n/s per Ci) due to (α ,n) reactions with the low atomic number elements (for example, Si, Al, O) in the active material.

X.100-102

X.108



Capsule dimensions and safety performance testing

Capsule	Overall diam.	Active diam.	Window thickness	Safety performance testing		US-Model ref.
	'A'mm	'B'mm	'C'mm	ANSI/ISO class	IAEA special form	
X.100	2.0	1.0	0.2-0.25	C64444	YES	AMC.Pn
X.101/2	3.0	2.0	0.2-0.25	C64444	YES	AMC.Pn
X.102	4.0	3.0	0.2-0.25	C64444	YES	AMC.Pn
X.108	7.0	5.0	0.2-0.3	C64444	YES	AMC.Pn

Americium-241

γ and Primary X-ray Sources

Line Sources

Americium-241 incorporated in ceramic beads, sealed in a welded stainless steel capsule.

Nominal activity*		Capsule	Typical photon output in photons/s per steradian 59.5keV	Product code
GBq	mCi			
3.7	100	X.1213	$37\text{-}44 \times 10^6$	AMCK5490
4.8	130	X1213	$42\text{-}58 \times 10^6$	AMCK6693
3.7	100	X103	$45\text{-}55 \times 10^6$	AMC36
18.5	500	XN49/1	$22.5\text{-}30 \times 10^7$	AMCK445

* Tolerance $\pm 10\%$

Recommended working life: 10 years

Quality control

Wipe Test I
Immersion Test II
Bubble Test III

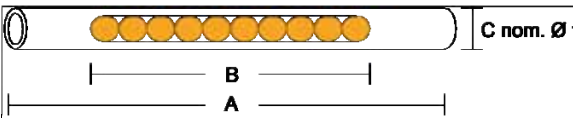
59.5keV γ -ray emission is measured in narrow beam geometry using a thin NaI detector.

Spectral purity is checked using Si (Li), Ge and NaI detectors.

Neutron emission

All Americium-241 sources emit 0.3n/s per MBQ ($\sim 10^4$ n/s per Ci) due to (α ,n) reactions with the low atomic number elements (for example, Si, Al, O) in the active material.

X.1213/XN49/1/X103



Safety performance testing

Capsule	Overall Length "A" mm	Active Length "B" mm	Source Diameter "C" mm	Safety Perf. Testing		US Model Ref.
				ANSI/ISO Class	IAEA spec. form	
X.1213	30	20	3.4 Nom.	C64344	YES	AMC.L1
X103	30	20	2.85 Nom.	C64444	YES	AMC.36
XN49/1	90	80	2.80 Nom.	C64334	NO	No

Americium-241/Beryllium

Neutron Sources Source Emission Data

Neutron emission:	$\sim 6 \times 10^7 \text{ n/s per TBq}$ ($\sim 2.2 \times 10^6 \text{ n/s per Ci}$)
Air kerma rate:	\sim Air kerma rate at 1m of $0.6 \mu\text{Gy/h per GBq}$ ($\sim 2.5 \text{ mR/h at 1m per Ci}$)
Neutron dose rate:	$0.6 \mu\text{Sv/h at 1m per GBq}$ ($2.2 \text{ mrem/h at 1m per Ci}$)

Note

Neutron emission depends on the ratio of Beryllium to Americium Oxide. The optimum ratio can be determined upon customer request.

(α -n) beryllium neutrons sources also emit a significant number of low energy neutrons.
($\sim 23\%$ below 1MeV with mean energy 400keV)

Cylinder sources

Compacted mixture of Americium oxide with beryllium metal, doubly encapsulated in welded stainless steel.

Nominal activity		Emission *	Capsule	Product code
MBq	mCi			
37	1	2.2×10^3	X.2	AMN11
111	3	6.6×10^3	X.2	AMN13
370	10	2.2×10^4	X.2	AMN15
1110	30	6.6×10^4	X.2	AMN16
1110	30	6.6×10^4	X.21	AMN168
3700	100	2.2×10^5	X.2	AMN17
11100	300	6.6×10^5	X.2	AMN18

* Tolerance $\pm 10\%$

Recommended working life: 15 years

Quality control

Wipe Test I, Immersion Test II, Bubble Test III

Neutron emission measured against standards using BF_3 /wax moderator system.

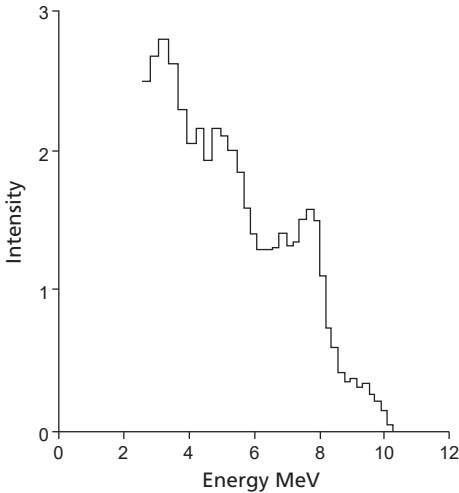
The test report includes a statement of the neutron emission.

Calibration for Am-241/Be neutron sources

Special calibrations of neutron emissions can be made on these sources and certificates issued by the National Physics Laboratory in Teddington, England.

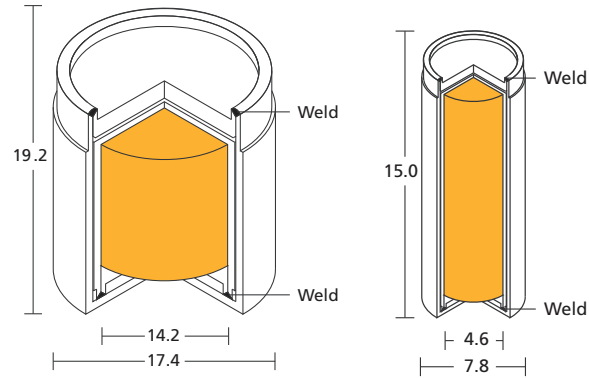
Neutron spectrum

Spectrum reproduced by courtesy of LORCH, E.A.
Int J. Appl. Radiat. Isotopes, 24, 590, 1973



X.2

X.21



Safety performance testing

Capsule	ANSI/ISO classification	IAEA special form	US-Model number
X.2	E66646	YES	AMN.PE1
X.21	C65545	YES	AMN.PE5

Americium-241/Beryllium

Neutron Sources Source Emission Data

Neutron emission:	$\sim 6 \times 10^7 \text{ n/s per TBq}$ ($\sim 2.2 \times 10^6 \text{ n/s per Ci}$)
Air kerma rate:	\sim Air kerma rate at 1m of $0.6 \mu\text{Gy/h per GBq}$ ($\sim 2.5 \text{ mR/h at 1m per Ci}$)
Neutron dose rate:	$0.6 \mu\text{Sv/h at 1m per GBq}$ ($2.2 \text{ mrem/h at 1m per Ci}$)

Note

Neutron emission depends on the ratio Beryllium to Americium Oxide. The optimum ratio can be determined upon customer request.

(α -n) beryllium neutrons sources also emit a significant number of low energy neutrons.
($\sim 23\%$ below 1MeV with mean energy 400keV)

Cylinder sources

Compacted mixture of Americium oxide with beryllium metal, doubly encapsulated in welded stainless steel.

Nominal activity		Emission *	Capsule	Product code
GBq	Ci			
18.5	0.5	1.1×10^6	X.3	AMN19
37	1	2.2×10^6	X.3	AMN22
111	3	6.6×10^6	X.4	AMN23
185	5	11×10^6	X.14	AMN24
370	10	20×10^6	X.14	AMN25

* Tolerance $\pm 10\%$

Recommended working life: 15 years

Quality control

Wipe Test I
Immersion Test II
Bubble Test III

Neutron emission measured against standards using BF_3 /wax moderator system.

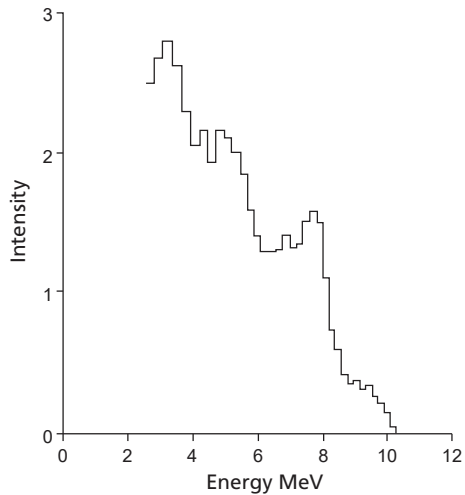
The test report includes a statement of the neutron emission.

Calibration for Am-241/Be neutron sources

Special calibrations of neutron emissions can be made on these sources and certificates issued by the National Physics Laboratory in Teddington, England.

Neutron spectrum

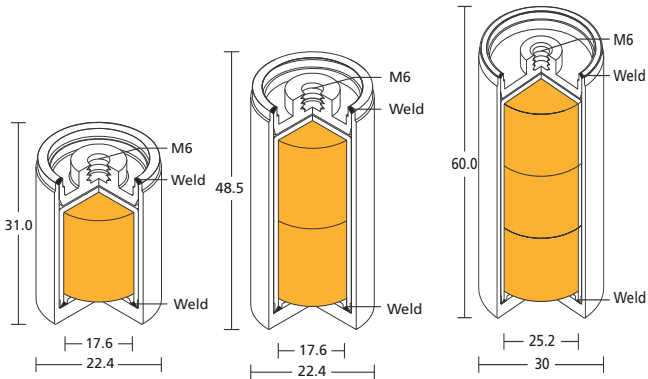
Spectrum reproduced by courtesy of LORCH, E.A.
Int J. Appl. Radiat. Isotopes, 24, 590, 1973



X.3

X.4

X.14



Safety performance testing

Capsule	ANSI/ISO classification	IAEA special form	US-Model number
X.3	E66545	YES	AMN.PE2
X.4	E66545	YES	AMN.PE3
X.14	E66545	YES	AMN.PE4

Caesium-137

Gamma Sources

Sources contain the radionuclide as a pellet of Caesium ceramic.

Encapsulation is in welded stainless steel. Sources are supplied with single X.7 or double encapsulation X.8

Nominal activity *		Product code	Product code
MBq	mCi	(X.7)	(X.8)
37	1	CDC701	CDC801
74	2	CDC702	CDC802
111	3	CDC703	CDC803
185	5	CDC704	CDC804
370	10	CDC705	CDC805
555	15	CDC70550	CDC80550
740	20	CDC706	CDC806
925	25	CDC70650	CDC80650
1.11×10^3	30	CDC707	CDC807
1.85×10^3	50	CDC708	CDC808
3.7×10^3	100	CDC709	CDC809
7.4×10^3	200	CDC710	CDC810
11.1×10^3	300	CDC711	CDC811

* Tolerance: Single encapsulated sources -5%, +20%
Double encapsulated sources -10%, +15%

Recommended working life: 15 years

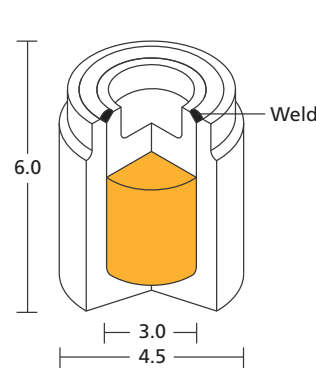
Quality control

Wipe Test I

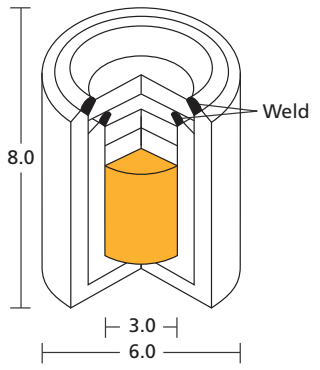
Immersion Test II

Bubble Test III

X.7



X.8



Safety performance testing

Capsule	ANSI/ISO classification	IAEA special form	US-Model number
X.7	C66545	YES	CDC.700
X.8	C66546	YES	CDC.800

Caesium-137

Gamma Sources

Sources contain the radionuclide as a pellet of Caesium ceramic.

Encapsulation is in welded stainless steel. Sources are supplied with double encapsulation X.9.

Nominal activity *		Product code (X.9)
GBq	Ci	
18.5	0.5	CDC90
37	1.0	CDC91
74	2.0	CDC92
111	3.0	CDC93

* Tolerance: -0%, +25%

Recommended working life: 15 years

Quality control

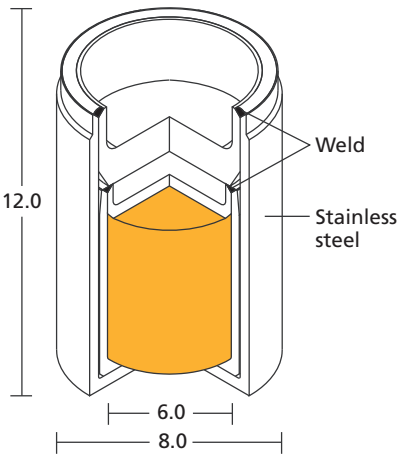
Wipe Test I

Immersion Test II

Bubble Test III

Cs-134 impurity < 1% of Cs-137

X.9



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C66646	YES	CDC.93

Caesium-137

Gamma Sources

Sources contain the radionuclide as a pellet of Caesium ceramic or fused glass, doubly encapsulated in welded stainless steel.

Nominal activity *		Product code	Product code
MBq	mCi	X38/2	X38/4
37	1	CDC3801	
74	2	CDC3802	
111	3	CDC3803	
185	5	CDC3804	
370	10	CDC3805	
740	20	CDC3806	
1.11×10^3	30	CDC3807	
1.85×10^3	50	CDC3808	
3.7×10^3	100	CDC3809	
7.4×10^3	200	CDC3810	
11.1×10^3	300	CDC3811	
18.5×10^3	500		CDC3820
37×10^3	1000		CDC3821
74×10^3	2000		CDC3822
11.1×10^4	3000		CDC3823
14.8×10^4	4000		CDC3824
18.5×10^4	5000		CDC3825
22.2×10^4	6000		CDC3826
25.9×10^4	7000		CDC3827
29.6×10^4	8000		CDC3828
33.3×10^4	9000		CDC3829
37.0×10^4	10000		CDC38210

* Tolerance: -10%, +15%

Recommended working life: 15 years

Quality control

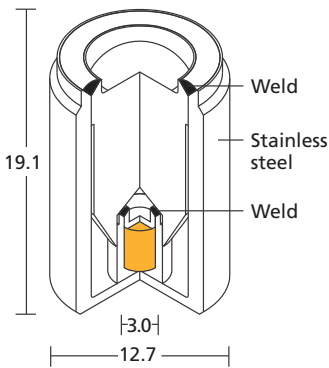
Wipe Test I

Immersion Test II

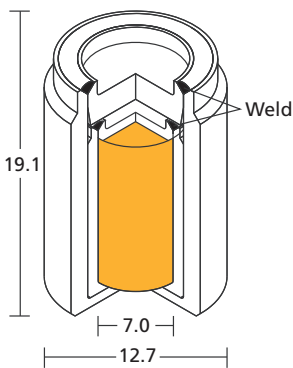
Bubble Test III

Cs-134 impurity < 1% of Cs-137

X.38/2



X.38/4



Safety performance testing

Capsule	ANSI/ISO classification	IAEA special form	US-Model number
X.38/2	C66646	YES	CDC.700
X.38/4	C66646	YES	CDC.711m

Caesium-137

Gamma Sources

Sources contain the radionuclide as a pellet of Caesium ceramic, doubly encapsulated in welded stainless steel.

Nominal activity *		Product code	Product code
MBq	mCi	VZ-79/1	VZ-1508/2
3.7	0.1	CDC7901	CDCB1901
7.4	0.2	CDCB1683	CDCB1902
14.8	0.4		CDCB1903
18.5	0.5	CDC7902	CDCB1904
37	1.0	CDC7903	CDCB1905
55.5	1.5	CDCB1595	CDCB1906
74	2.0	CDC7904	CDCB1907
92.5	2.5	CDCB1758	CDCB1908
110	3.0	CDC7905	CDCB1909
148	4.0		CDCB1910
185	5.0	CDC7906	CDCB1911
222	6.0	CDCB1611	CDCB1912
260	7.0	CDCB1805	CDCB1913
300	8.1	CDC7907	CDCB1914
370	10.0	CDC7908	CDCB1915
550	14.9	CDC7909	CDCB1916
629	17.0	CDCB1601	CDCB1917
740	20.0	CDC7910	CDCB1918
925	25.0	CDC7911	CDCB1919
1.1 x 10 ³	30.0	CDC7912	CDCB1920
1.3 x 10 ³	35.1	CDCB1605	CDCB1921
1.48 x 10 ³	40.0		CDCB1922
1.6 x 10 ³	43.2	CDCB1785	CDCB1923
1.85 x 10 ³	50.0	CDC7913	CDCB1924
2.2 x 10 ³	59.5	CDCB1684	CDCB1925
2.8 x 10 ³	75.7	CDC7914	CDCB1926
3 x 10 ³	81.1	CDCB1746	CDCB1927
3.7 x 10 ³	100.0	CDC7915	CDCB1928
5.5 x 10 ³	148.6	CDC7916	CDCB1929
5.92 x 10 ³	160.0	CDCB1665	CDCB1930
6.7 x 10 ³	181.0	CDCB1792	CDCB1931
7.4 x 10 ³	200.0	CDC7917	CDCB1932
9.25 x 10 ³	250.0	CDC7918	CDCB1933
9.62 x 10 ³	260.0	CDCB1847	CDCB1934
11 x 10 ³	297.3	CDC7919	CDCB1935
12.2 x 10 ³	329.7	CDCB1793	CDCB1936
13 x 10 ³	351.4	CDC7920	CDCB1937
13.7 x 10 ³	370.3	CDCB1848	CDCB1938
14 x 10 ³	378.4	CDCB1794	CDCB1939
15 x 10 ³	405.4	CDC7921	CDCB1940
16.65 x 10 ³	450.0	CDCB1856	CDCB1941
18.5 x 10 ³	500.0	CDC7922	CDCB1942

* Tolerance: ±10%

Recommended working life: 15 years

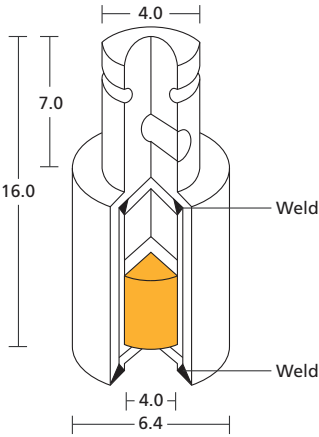
Quality control

Wipe Test I

Immersion Test II

Bubble Test III

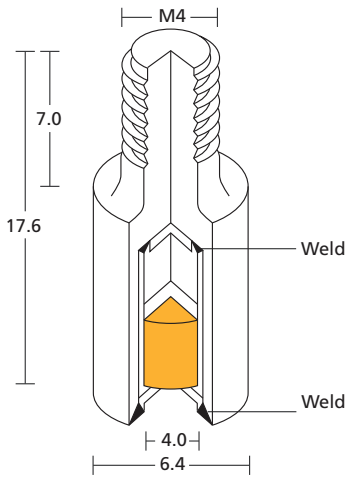
VZ-79/1



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C66646	YES	CDC.P4

VZ-1508/2



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C66646	YES	CDC.P4

Caesium-137

Gamma Sources

Sources contain the radionuclide as a pellet of Caesium ceramic, doubly encapsulated in welded stainless steel.

Nominal activity *		Product code
MBq	mCi	VZ-259/2
3.7	0.1	CDC5901
18.5	0.5	CDC5902
37	1.0	CDC5903
74	2.0	CDC5904
110	3.0	CDC5905
185	5.0	CDC5906
300	8.1	CDC5907
370	10.0	CDC5908
550	14.9	CDC5909
740	20.0	CDC5910
925	25.0	CDC5911
1.11×10^3	30.0	CDC5912
1.85×10^3	50.0	CDC5913
2.8×10^3	75.7	CDC5914
3.7×10^3	100.0	CDC5915
5.5×10^3	148.6	CDC5916
7.4×10^3	200.0	CDC5917
9.25×10^3	250.0	CDC5918
11.1×10^3	297.3	CDC5919
13×10^3	351.4	CDC5920
15×10^3	405.4	CDC5921
18.5×10^3	500.0	CDC5922

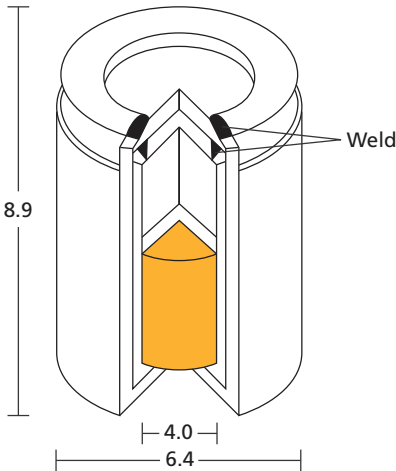
* Tolerance: $\pm 10\%$

Recommended working life: 15 years

Quality control

Wipe Test I
Immersion Test II
Bubble Test III

VZ-259/2



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C64444	YES	CDC.P4

Caesium-137

Gamma Sources

Stainless steel outer capsule holds stainless steel inner capsule containing Caesium-137 as compressed pellets of Caesium chloride. Both stainless steel capsules welded.

Nominal activity *		Capsule	Product code
TBq	Ci		
1.11	30	R6000	RSL6000
1.85	50	R6010	RSL6010
3.70	100	R6020	RSL6020
7.40	200	R6030	RSL6030
16.65	450	R6040	RSL6040
44.40	1200	R6050	RSL6050
81.40	2200	R6060	RSL6060

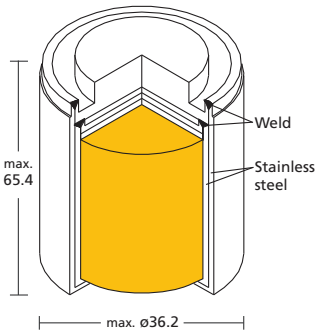
* Tolerance $\pm 20\%$

Recommended working life: 15 years

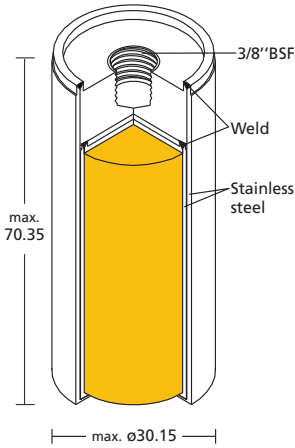
Quality control

Wipe Test I
Bubble Test III
Helium Pressurization Test

**R6000-R6060
excl. R6050**



R6050



Safety performance testing

Capsule	max. overall dim ($\varnothing \times L$ mm)	US-Model number	ANSI/ISO classification	IAEA spec.
form				
R6000	12.5 x 17.9	RSL6000	E63646	YES
R6010	14.7 x 20.4	RSL6010	E63646	YES
R6020	17.5 x 22.9	RSL6020	E63646	YES
R6030	21.3 x 26.4	RSL6030	E63646	YES
R6040	27.1 x 28.4	RSL6040	E63545	YES
R6050	30.2 x 70.4	RSL6050	E63545	YES
R6060	36.2 x 65.4	RSL6060	E63545	YES

Californium-252

Spontaneous Fission Neutron Sources

Nuclear Data

Californium-252 decays by α -emission and spontaneous fission emitting neutrons.

Half-life (α -decay): 2.73 years

Half-life (spontaneous fission): 85.5 years

Half life (effective): $2.645 (\pm 0.008)$ years

Neutron emission: 2.3×10^9 n/s per mg Cf-252

Average neutron energy: ~ 2 MeV

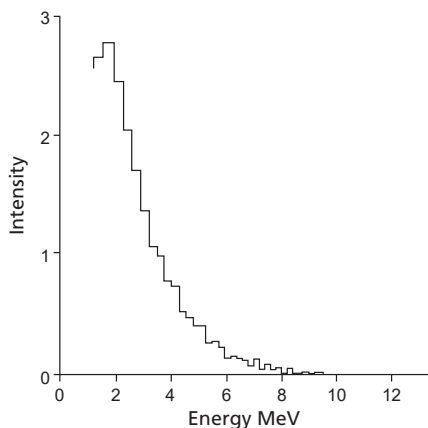
Equilibrium γ -exposure rate
(from unshielded source): \sim Air kerma rate at 1m of 1.4mGy/h
per mg of Cf-252
(1.6×10^2 mR/h at 1m /mg Cf-252)

Neutron dose rate:
 ~ 23 mSv/h at 1m /mg of Cf-252
(~ 2.3 rem/h at 1m /mg of Cf-252)

Specific activity:
 ~ 20 GBq/mg Cf-252
(~ 536 mCi/mg Cf-252)

Neutron Spectrum

Spectrum reproduced by courtesy of LORCH, E.A.
Int J. Appl. Radiat. Isotopes, 24, 590, 1973



Composition

Californium-252 is in the form of a cermet of californium oxide and palladium metal, or as a refractory composite material. Low activity sources ($< 1 \mu\text{g}$) may contain a Cf-252 compound deposited or ion-exchanged onto a substrate within the capsule.

Encapsulation

High activity sources are doubly encapsulated in welded stainless steel, MP35N or zircalloy capsules.

Recommended working life: 15 years

Quality control

Weld validation is accomplished by taking pre-production weld sections prior to all production batches.

Wipe Test I, Immersion Test II

Bubble Test III and/or Helium leak test

A cermet is a composite material containing both ceramic and metallic materials.

Measurement and National Lab Traceability

Neutron emissions are measured with He or BF₃/wax moderator systems and compared with national lab traceable standards.

Each test report includes a statement of the neutron emission. All sources can be made with closely matched neutron emissions with tolerances within $\pm 5\%$. Special terms may apply.

Upon customer request, certified primary traceability to a national laboratory can be provided. Special terms may apply.

Oil Well Logging Applications

The X1 capsule is available with an MP35N outer capsule. Other Cf-252 source designs may be used as inner capsules within ARMCO 17.4PH and MP35N outer capsules. Further information can be provided on request.

Reactor Start-Up Sources

Eckert & Ziegler Nuclitec GmbH offers a range of special reactor neutron start-up sources and neutron inspection probes for the nuclear industry. Enquiries are invited for the design and manufacture of both primary Cf-252 sources and SbBe secondary sources.

Custom Design and Services

Eckert & Ziegler Nuclitec GmbH offers specialist product design, installation and retrieval services.

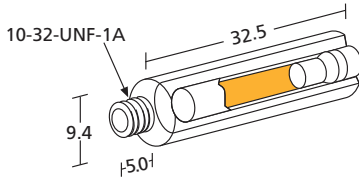
Californium-252

Spontaneous Fission Neutron Sources

Savannah River Capsules

This design is the original Cf-252 capsule design created by the US Department of Energy at their South Carolina facility on the Savannah River. It is popular in many applications.

Savannah River Long (SRL)



Sources up to 2mg can be manufactured in the Savannah River Long capsule design (or the old X.224). Outer capsules are available in stainless steel or zircalloy:

SRL - stainless steel containing X1 or X33 inners

SRL - zircalloy containing X1 or X33 inners

X.224 (same dimensions as the SRL) - stainless steel

Safety performance testing

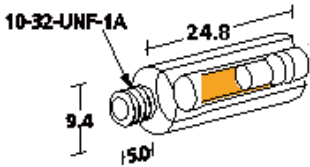
Capsule	ANSI/ISO classification	IAEA special form	US-Model number
SRL/X.1 inners	C66545	YES	CVN.CY7
SRL/X.33 inners	C64444	YES	CVN.CY8
X.224	C64545	YES	CVN.CY6

Nominal content	Nominal activity*	Emission	Product code with –capsule–	
CF-252		n/s	SRL	
1ng	20KBq	0.5 μ Ci	2.3 x 10 ³	CVN-SRL-001ng-S
100ng	2MBq	54 μ Ci	0.23 x 10 ⁶	CVN-SRL-100ng-S
500ng	10MBq	268 μ Ci	1.15 x 10 ⁶	CVN-SRL-500ng-S
1 μ g	20MBq	536 μ Ci	2.3 x 10 ⁶	CVN-SRL-001 μ g-S
5 μ g	100MBq	2.7mCi	1.15 x 10 ⁷	CVN-SRL-005 μ g-S
10 μ g	200MBq	5.4mCi	2.3 x 10 ⁷	CVN-SRL-010 μ g-S
20 μ g	400MBq	10.7mCi	4.6 x 10 ⁷	CVN-SRL-020 μ g-S
50 μ g	1GBq	27mCi	1.15 x 10 ⁸	CVN-SRL-050 μ g-S
100 μ g	2GBq	54mCi	2.3 x 10 ⁸	CVN-SRL-100 μ g-S
200 μ g	4GBq	107mCi	4.6 x 10 ⁸	CVN-SRL-200 μ g-S
500 μ g	10GBq	270mCi	1.15 x 10 ⁹	CVN-SRL-500 μ g-S
1mg	20GBq	540mCi	2.3 x 10 ⁹	CVN-SRL-001mg-S
2mg	40GBq	1.08Ci	4.6 x 10 ⁹	CVN-SRL-002mg-S

* Tolerance -10%, +20% S indicates material S = stainless
Z = Zircalloy

* Custom activities can be supplied within 12 weeks.

Savannah River Short (SRS)



Sources up to 1mg can be manufactured in the Savannah River Short capsule design. Outer capsules are available in stainless steel or zircalloy:

SRS - stainless steel containing X1 or X33 inners

SRS - zircalloy containing X1 or X33 inners

Safety performance testing

Capsule Model	ANSI/ISO classification		IAEA special form	US-number
SRS/X.1 inners	C64544	CVN.CY14	YES	
SRS/X.33 inners	C64444	CVN.CY15	YES	

Nominal content	Nominal activity*		Emission	Product code with –capsule–SRS
Cf-252			n/s	
1ng	20KBq	0.5μCi	2.3 x 10 ³	CVN-SRS-001ng-S
100ng	2MBq	54μCi	0.23 x 10 ⁶	CVN-SRS-100ng-S
500ng	10MBq	268μCi	1.15 x 10 ⁶	CVN-SRS-500ng-S
1.0μg	20MBq	536μCi	2.3 x 10 ⁶	CVN-SRS-001μg-S
2.0μg	40MBq	1.07mCi	4.6 x 10 ⁶	CVN-SRS-002μg-S
5μg	100MBq	2.7mCi	1.15 x 10 ⁷	CVN-SRS-005μg-S
10μg	200MBq	5.4mCi	2.3 x 10 ⁷	CVN-SRS-010μg-S
20μg	400MBq	10.7mCi	4.6 x 10 ⁷	CVN-SRS-020μg-S
50μg	1GBq	27mCi	1.15 x 10 ⁸	CVN-SRS-050μg-S
100μg	2GBq	54mCi	2.3 x 10 ⁸	CVN-SRS-100μg-S
200μg	4GBq	107mCi	4.6 x 10 ⁸	CVN-SRS-200μg-S
400μg	8GBq	214mCi	9.2 x 10 ⁸	CVN-SRS-400μg-S
1mg	20GBq	540mCi	2.3 x 10 ⁹	CVN-SRS-001mg-S

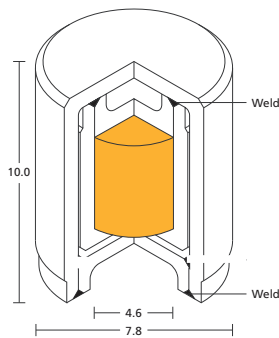
S

* Tolerance -10%, +20% S indicates material S = stainless

Z = Zircalloy

* Custom activities can be supplied within 12 weeks.

X.1



Sources up to 500µg can be manufactured in the X1 capsule design. Outer capsules are available in stainless steel or zircalloy:

Safety performance testing

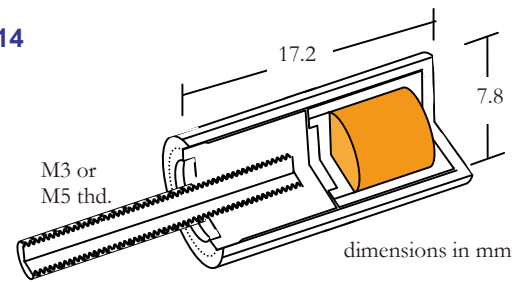
ANSI/ISO classification	IAEA special form	US-Model number
C66544	YES	CVN.CY2

Nominal content Cf-252	Nominal activity*	Emission n/s	Product code with –capsule– X1
1ng	20KBq	0.5µCi	2.3 x 10 ³
100ng	2MBq	54µCi	0.23 x 10 ⁶
500ng	10MBq	268µCi	1.15 x 10 ⁶
1.0µg	20MBq	536µCi	2.3 x 10 ⁶
2.0µg	40MBq	1.07mCi	4.6 x 10 ⁶
5µg	100MBq	2.7mCi	1.15 x 10 ⁷
10µg	200MBq	5.4mCi	2.3 x 10 ⁷
20µg	400MBq	10.7mCi	4.6 x 10 ⁷
50µg	1GBq	27mCi	1.15 x 10 ⁸
100µg	2GBq	54mCi	2.3 x 10 ⁸
200µg	4GBq	107mCi	4.6 x 10 ⁸
400µg	8GBq	214mCi	9.2 x 10 ⁸

* Tolerance -10%, +20% S indicates material S = stainless
M = MP35N
Z = Zircalloy

* Custom activities can be supplied within 12 weeks.

X.2014

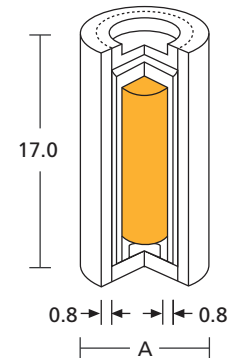


The X.2014 is an extended X.1 capsule with a female M3 threaded lid. An M3 (X.2014) or M5 (X2014/1) handling rod can be provided. Activities are available up to 8GBq (400 µg).

Safety performance testing

Capsule	ANSI/ISO classification	IAEA special form	US-Model number
X2014	C66544	YES	CVN.CY12
X2014/1	C66544	YES	CVN.CY12

X.33, 35



Safety performance testing

Capsule form	diam. 'A' mm	ANSI/ISO classification	IAEA special
X.33	7.8	C66545	YES
X.35	9.5	C64545	YES

Nominal content Cf-252	Nominal activity*	Emission n/s	Capsule	Product code
500µg	10GBq	268mCi	1.15 x 10 ⁹	X.33 CVN330
1mg	20GBq	536mCi	2.3 x 10 ⁹	X.33 CVN331
2mg	40GBq	1.07Ci	4.6 x 10 ⁹	X.35 CVN352
3mg	60GBq	1.61Ci	6.9 x 10 ⁹	X.35 CVN353

* Tolerance -10%, +20%

* Custom activities can be supplied within 12 weeks.

Californium-252

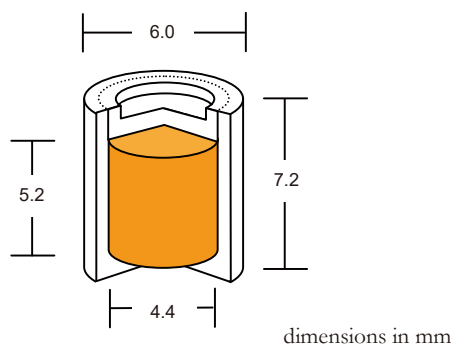
Spontaneous Fission Neutron Sources

Low Activity Sources

Singly encapsulated low activity point sources are available in the XN.146 and X.1167 capsules. A variety of holders and handling aids can be provided with these sources.

Activities are available in the range 0.02MBq - 10MBq (1ng – 500ng) (2.3×10^3 n/s – 1.15×10^6 n/s).

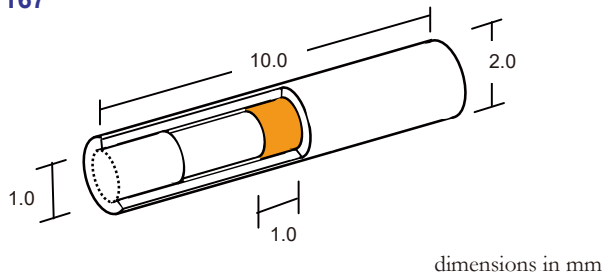
XN.146



Safety performance testing

Capsule	ANSI/ISO Classification	IAEA special form	US-Model number
XN.146	C66544	YES	CVN.CY11

X.1167



Safety performance testing

Capsule	ANSI/ISO Classification	IAEA special form	US-Model number
X.1167	C64444	NO	CVN.CY9

Shipping Containers

Several designs of approved Type-A shipping containers are available. The maximum shipping activity is limited to 5,000μg by the Type-A Special Form limit for Cf-252.

Container		Permitted Content	Weight	Size
98201A	(disposable)	13μg	5.4kg	280mm
991	(purchased)	80μg	152kg	851mm
SC-991	(returnable)	80μg	152kg	851mm
SC-1825A	(returnable)	200μg	371kg	878mm
SC-3009A	(returnable)	1,500μg	1,050kg	1,150mm
SC-1858E	(returnable)	2,000μg	1,370kg	1,272mm
SC-3613A	(returnable)	3,600μg	2,500kg	1,340mm
SC-3614A	(returnable)	5,000μg	2,900kg	1,705mm
SC-1858G	(returnable)	3,600μg	10,390kg	5,133mm

Cobalt-57

γ and Primary X-ray Sources

Disc Sources

Cobalt-57 is incorporated as an ion exchange resin pellet and sealed in a welded stainless steel capsule.

Nominal activity		Typical photon output in photons/s per steradian 122keV + 136keV	Product code
MBq	mCi		
37	1	2.4×10^6	CTC2
111	3	7.2×10^6	CTC3
370	10	24.0×10^6	CTC4

Recommended working life: 5 years

The sources emit γ -rays (principally 122keV and 136keV) and some fluorescent W KX-rays produced in the source backing. The impurity of other cobalt isotopes (Co-56, Co-58, Co-60) is $< 0.2\%$ of the Co-57 activity and is determined by γ -spectrometry.

Co-56 and Co-58 emit a wide range of γ -rays, energies 511keV-3.45MeV.

Co-60 emits γ -rays of energies 1.17MeV and 1.33MeV.

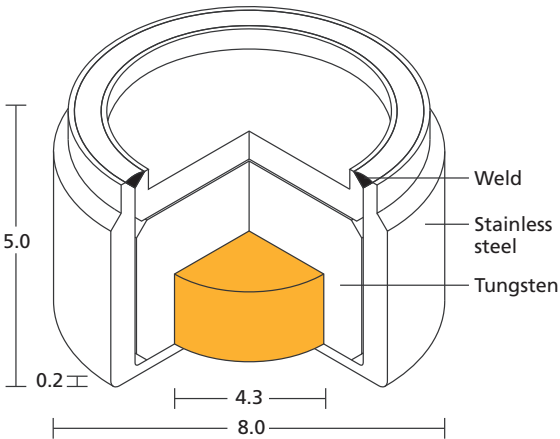
Quality control

Wipe Test I

Immersion Test II

Photon emission and γ -impurities checked using a Ge-detector.

X.10/5 *
VZ-2762



Safety performance testing

ANSI/ISO classification number	IAEA Special Form	US-Model
C64545	No	CTC.D1

* X.10/5 manufactured according to drawing VZ-2762

Cobalt-57

γ and Primary X-ray Sources

Point Sources

Cobalt-57 is incorporated as an ion exchange resin pellet and sealed in a welded stainless steel capsule.

Nominal activity*		Capsule	Typical photon output in photons/s per steradian 122keV + 136keV	Product code
MBq	mCi			
37	1	X.100	2.5×10^6	CTC10022
111	3	X.100	7.5×10^6	CTC10033
37	1	X.100/2	2.6×10^6	CTC10122
111	3	X.100/2	7.2×10^6	CTC10124

* Tolerance +20%, -10%

Recommended working life: 5 years

The sources emit γ-rays (principally 122keV and 136keV) and some fluorescent W KX-rays produced in the source backing. The impurity of other cobalt isotopes (Co-56, Co-58, Co-60) is < 0.2% of the Co-57 activity and is determined by γ-spectrometry.

Co-56 and Co-58 emit a wide range of γ-rays, energies 511keV-3.45MeV.

Co-60 emits γ-rays of energies 1.17MeV and 1.33MeV.

Quality control

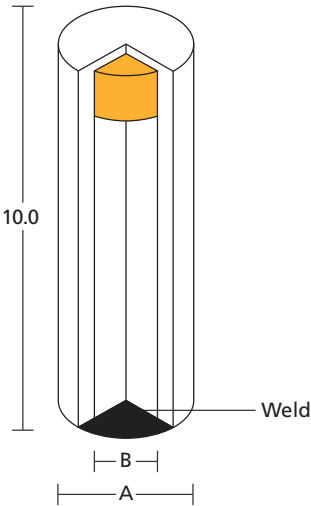
Wipe Test I

Immersion Test II

Photon emission and γ-impurities checked using a Ge-detector.

X.100 *
VZ-2760

X.101/2 **
VZ-2761



Capsule dimensions and safety performance testing

Capsule	Overall diam. 'A' mm	Active diam. 'B' mm	Safety performance testing	
			ANSI/ISO classification	US-Model number
X.100	2.0	1.0	C64444	CTC.P2
X.101/2	3.0	2.0	C64444	CTC.P1

* X.100 manufactured according to drawing VZ-2760

** X.101/2 manufactured according to drawing VZ-2761

Cobalt-60

X.2163

Gamma Sources

Metal cylinders of Co-60 doubly encapsulated in welded stainless steel capsules.

Nominal activity *		Product code
GBq	Ci	
37	1	CKUNZ001
74	2	CKUNZ002
111	3	CKUNZ003
148	4	CKUNZ004
185	5	CKUNZ005

* Tolerance: +25%, -10%

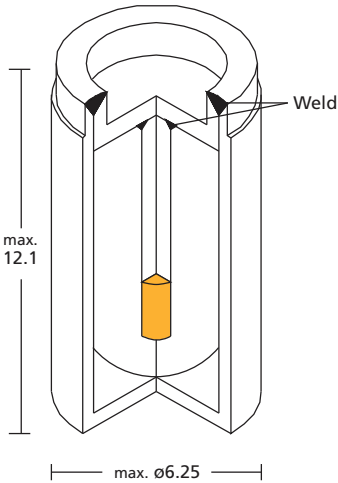
Recommended working life: 15 years

Quality control

Wipe Test I

Immersion Test II

Bubble Test III



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C63545	YES	CKC.P6

Cobalt-60

Gamma Sources

Metal cylinders of Co-60 encapsulated in welded stainless steel capsules.

Nominal activity *		Product code	Product code
MBq	mCi	VZ-1486/3	VZ-64/1
3.7	0.1	CKCB2002	CKC6401
18.5	0.5	CKCB2006	CKC6402
37	1.0	CKCB2008	CKC6403
74	2.0	CKCB2011	CKC6404
110	3.0	CKCB2012	CKC6405
185	5.0	CKCB2013	CKC6406
300	8.1	CKCB2016	CKC6407
370	10.0	CKCB2017	CKC6408
550	14.9	CKCB2018	CKC6409
740	20.0	CKCB2019	CKC6410
925	25.0	CKCB2020	CKC6411
1.1 x 10 ³	30.0	CKCB2021	CKC6412
1.5 x 10 ³	40.0	CKCB2022	CKC6413
1.85 x 10 ³	50.0	CKCB2023	CKC6414
2.2 x 10 ³	60.0	CKCB2025	CKC6415
2.8 x 10 ³	75.0	CKCB2027	CKC6416
3.7 x 10 ³	100.0	CKCB2029	CKC6417
5.5 x 10 ³	148.6	CKCB2034	CKC6418
7.4 x 10 ³	200.0	CKCB2037	CKC6419
9.25 x 10 ³	250.0	CKCB2039	CKC6420
11 x 10 ³	297.3	CKCB2040	CKC6421
15 x 10 ³	405.4	CKCB2043	CKC6422
18.5 x 10 ³	500.0	CKCB2044	CKC6423
22.2 x 10 ³	600.0	CKCB2046	CKC6424
25.9 x 10 ³	700.0	CKCB2047	CKC6425
29.6 x 10 ³	800.0	CKCB2049	CKC6426
33.3 x 10 ³	900.0	CKCB2050	CKC6427
37 x 10 ³	1000.0	CKCB2051	CKC6428

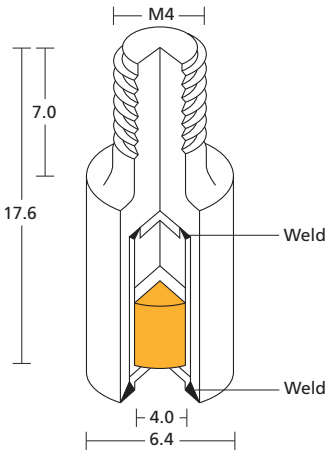
* Tolerance: ±10%

Recommended working life: 15 years

Quality control

Wipe Test I
Immersion Test II
Bubble Test III

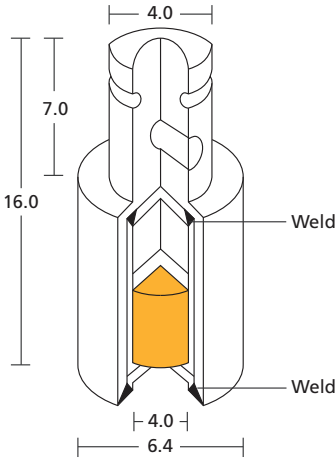
VZ-1486/3



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C66646	YES	CKC.P4

VZ-64/1



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C66646	YES	CKC.P4

Cobalt-60

VZ-260/2

Gamma Sources

Metal cylinders of Co-60 encapsulated in welded stainless steel capsules.

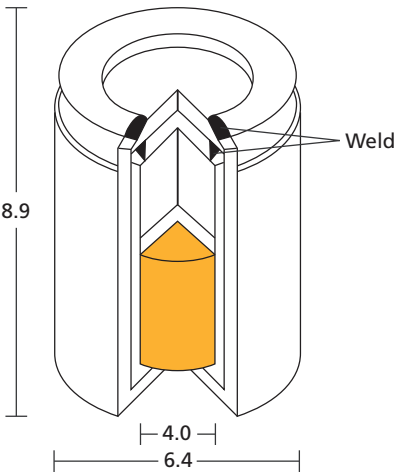
Nominal activity *		Product code
MBq	mCi	
3.7	0.1	CKC6001
18.5	0.5	CKC6002
37	1.0	CKC6003
74	2.0	CKC6004
110	3.0	CKC6005
185	5.0	CKC6006
300	8.1	CKC6007
370	10.0	CKC6008
550	14.9	CKC6009
740	20.0	CKC6010
925	25.0	CKC6011
1.1 x 10 ³	30.0	CKC6012
1.5 x 10 ³	40.0	CKC6013
1.85 x 10 ³	50.0	CKC6014
2.2 x 10 ³	60.0	CKC6015
2.8 x 10 ³	75.0	CKC6016
3.7 x 10 ³	100.0	CKC6017
5.5 x 10 ³	148.6	CKC6018
7.4 x 10 ³	200.0	CKC6019
9.25 x 10 ³	250.0	CKC6020
11 x 10 ³	297.3	CKC6021
15 x 10 ³	405.4	CKC6022
18.5 x 10 ³	500.0	CKC6023
22.2 x 10 ³	600.0	CKC6024
25.9 x 10 ³	700.0	CKC6025
29.6 x 10 ³	800.0	CKC6026
33.3 x 10 ³	900.0	CKC6027
37 x 10 ³	1000.0	CKC6028

* Tolerance: ±10%

Recommended working life: 15 years

Quality control

Wipe Test I
Immersion Test II
Bubble Test III



Safety performance testing

ANSI/ISO classification number	IAEA special form	US-Model
C64444	YES	CKC.P4

Curium-244

γ and Primary X-ray Sources

Curium-244 incorporated in a ceramic enamel, sealed in a welded monel capsule with brazed beryllium window; the active component is recessed into a tungsten backing.

Nominal activity*		A	B	Typical photon output in	Product
GBq	mCi	mm	mm	photons/s per steradian	code
17keV Pu LX-rays					
0.37	10	10.8	7	0.8×10^6	CLC10990
1.11	30	10.8	7	2.4×10^6	CLC11564
3.7	100	10.8	7	7.8×10^6	CLC11562
7.4	200	10.8	7	15.0×10^6	CLC11377

* Tolerance $\pm 10\%$

Nominal activity*		A	B	Typical photon output in	Product
GBq	mCi	mm	mm	photons/s per steradian	code
17keV Pu LX-rays					
0.37	10	8	4	0.8×10^6	CLC11932
1.11	30	8	4	2.4×10^6	CLC11284
3.7	100	8	4	7.8×10^6	CLC11933

* Tolerance $\pm 10\%$

Recommended working life: 10 years

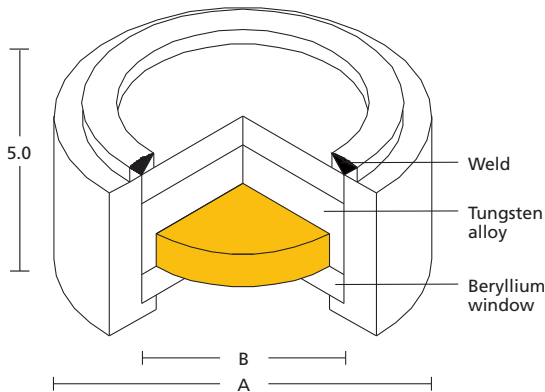
Quality control

Wipe Test I
Immersion Test II
Bubble Test III

Neutron emission

All Curium-244 sources emit $\sim 3.6 \times 10^3$ n/s per GBq due to spontaneous fission and (α, n) reactions with the low atomic number elements (e.g. Si, Al, O) in the active material.

VZ-3069



Capsule dimensions and safety performance testing

Overall testing diam. 'A' mm form	Active	Window	Safety performance	
	diam. 'B' mm	thickness 'C' mm	ANSI/ISO classification	IAEA special
8.0	4	1	C64343	YES
10.8	7	1	C64344	YES

Iron-55

Primary X-ray Sources

Annular Sources

Iron-55 electrodeposited as iron metal on a copper ring with tungsten alloy backing, sealed in a welded stainless steel capsule with 0.3mm beryllium window.

Nominal activity		Photon output in photons/s per steradian Mn KX-rays	Product code
MBq	Ci		
37	1	0.75×10^6	IEC8753
185	5	3.8×10^6	IEC8755
740	20	15×10^6	IEC8758

Recommended working life: 5 years

Quality control

Wipe Test I

Immersion Test II

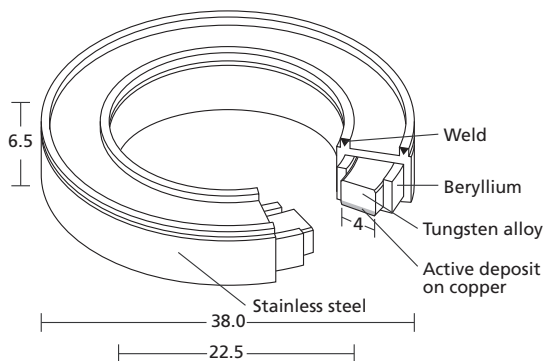
Photon emission checked by proportional counter. Spectral purity checked by radionuclide assay of raw material.

Total γ -impurities $>100\text{keV}$ (Mn-54 + Fe-59) $< 0.02\%$

Principal emission: Mn KX-rays, 5.9keV

X.87/5 *

VZ-2879



Safety performance testing

ANSI/ISO classification	US-Model number
C33344	IEC.A2

* X.87/5 manufactured according to drawing VZ-2879

Iron-55

Primary X-ray Sources

Disc Sources

Iron-55 electrodeposited as iron metal on the face of a copper disc, sealed in a welded monel capsule with brazed 0.25mm beryllium window.

Nominal activity		Capsule	Typical photon output in photons/s per steradian Mn KX-rays	Product code
MBq	mCi			
37	1	X.133	0.7×10^6	IEC1331
185	5	X.133	3.5×10^6	IEC1332
370	10	X.133	7×10^6	IEC1333
740	20	X.133	14×10^6	IEC1335
1850	50	X.133	35×10^6	IEC1336
3700	100	X.133	70×10^6	IEC1337
37	1	X.330	0.6×10^6	IEC3301
185	5	X.330	3×10^6	IEC3302
370	10	X.330	6×10^6	IEC3303
740	20	X.330	12×10^6	IEC3305

Recommended working life: 10 years

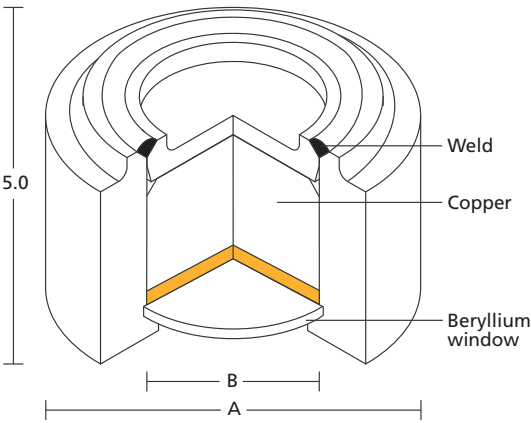
Quality control

Wipe Test I
Immersion Test II
Bubble Test III

Photon emission checked by proportional counter. Spectral purity checked by radionuclide assay of raw material.

Total γ -impurities >100keV (Mn-54 + Fe-59) <0.02%
Principal emission: Mn KX-rays, 5.9keV

X.133/0* X.330**
VZ-2877 VZ-2878



Capsule dimensions and safety performance testing

Capsule Model number	Overall diam.	Active diam.	Window diam.	Safety performance	
	'A'mm	'B'mm	'C'mm	ANSI/ISO classification	US-
X.133	15.0	10.0	12.0	C54344	IEC.D2
X.330	8.0	3.5	4.5	C54243	IEC.D1

* X.133/0 manufactured according to drawing VZ-2877
** X.330 manufactured according to drawing VZ-2878

Iron-55

Primary X-ray Sources

Nickel Coated Sealed Sources

Iron-55 electrodeposited as iron metal on the face of a copper substrate, 12.5mm diameter 3mm thick covered with a protective nickel layer.

The sources are corrosion resistant.

Photon emission checked by proportional counter. Spectral purity checked by radionuclide assay of raw material.

Disc and line sources to other dimensions can be supplied.

Nominal activity		Photon output in photons/s per steradian Mn KX-rays	Product code
MBq	mCi		
37	1	0.65×10^6	IEC121
185	5	3.25×10^6	IEC122
370	10	7.25×10^6	IEC123
740	20	14.50×10^6	IEC125
1850	50	36.25×10^6	IEC126

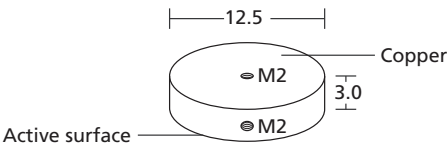
Recommended working life: 5 years

Quality control

Wipe Test I

Immersion Test II

X.0709*
VZ-2937



Safety performance testing

ANSI/ISO classification	US-Model number
C44342*	IEC.A1

*C33232 in USA

* X.0709 manufactured according to drawing VZ-2937

Krypton-85

Beta Sources

Low bremsstrahlung, high output sources

Krypton-85 gas is encapsulated in welded titanium capsules with a 25µm thick titanium window. Each capsule has a copper fill tube at the back, which is sealed by cold welding and then soldering. The inclusion of a welded back cap provides a secondary seal to protect the cold welded copper tube and provides improved mechanical strength.

A protective window shield is included with each source to protect the window during transportation and handling. It also absorbs the beta dose from the source, making it easy for the user to handle and load into gauging devices.

Nominal activity *		Capsule	Product code
GBq	mCi		
3.7	100	X.1088	KAC10881
7.4	200	X.1088	KAC10882
11.1	300	X.1088	KAC10883
14.8	400	X.1088	on request

* Tolerance ±10%

Recommended working life: 10 years

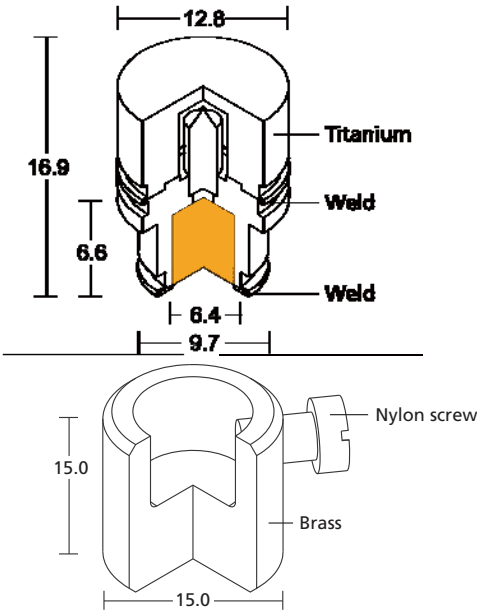
Quality control

Windows are Helium leak tested to $< 10^{-8}$ mBar l⁻¹ sec⁻¹ before filling.

Emanation test V + VI

Sources are measured using a 2π thin windowed ion change and the resulting ion current compared against Eckert & Ziegler Nuclitec GmbH reference standards.

X.1088*
VZ-2832



Safety performance testing

ANSI/ISO classification	US-Model number
C43332	KAC.D3

* X.1088 manufactured according to drawing VZ-2832

Krypton-85

Beta Sources

Low bremsstrahlung, high output sources

Krypton-85 gas is encapsulated in welded titanium capsules with a 25µm thick titanium window. Capsules are sealed either by cold welding a copper filling tube or crimping a silver washer. The crimped silver washer sources are only filled to sub atmospheric pressures. The inclusion of a welded back cap provides a secondary seal and improved mechanical strength.

A protective window shield is included with each source to protect the window during transportation and handling. It also absorbs the beta dose from the source, making it easy for the user to handle and load into gauging devices.

Nominal activity *		Capsule	Product code
GBq	mCi		
3.7	100	X.1114	KAC11401
7.4	200	X.1114	KAC11402
11.1	300	X.1114	KAC11403
18.5	500	X.1114	KAC11405
37.0	1000	X.1114	KAC11410
1.85	50	X.1266/3	KACK5565
7.4	200	X.1266/3	KACK7807
11.1	300	X.1266/3	KACK5674
18.5	500	X.1266/3	KACK7654
37.0	1000	X.1266/3	KACK8148

* Tolerance ±10%

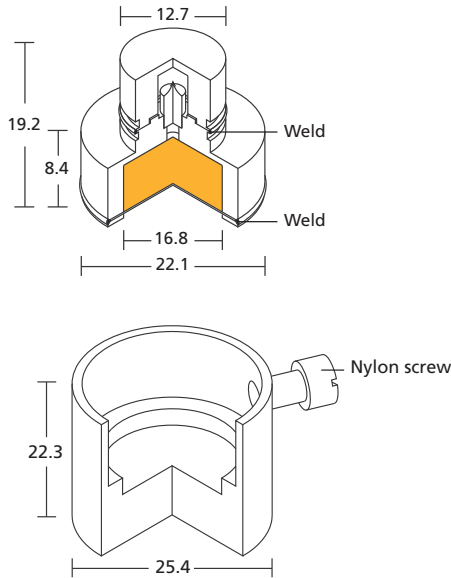
Recommended working life: 10 years

Quality control

Windows are Helium leak tested to $< 10^{-8}$ mBar l⁻¹ sec⁻¹ before filling. Emanation test V + VI

Sources are measured using a 2π thin windowed ion change and the resulting ion current compared against Eckert & Ziegler Nuclitec GmbH reference standards.

X.1114* VZ-2820

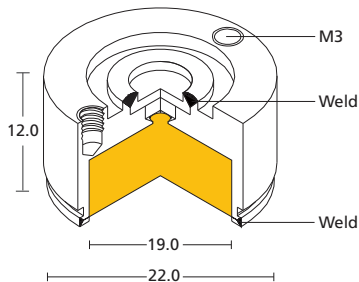


Safety performance testing

Capsule number	ANSI/ISO classification	US-Model
VZ-2820	C33332	KAC.D1
VZ-2866	C42341	None

* X.1114 manufactured according to drawing VZ-2820

X.1266* VZ-2866



* X.1266 manufactured according to drawing VZ-2866

Nickel-63

Beta Sources

Nickel-63 is electroplated on one face of a thin (0.05mm) nickel or nickel alloy (monel) foil.

These substrates minimize the loss of ion current occurring at elevated temperatures due to the diffusion of the active layer.

Nickel alloy foil is recommended for detectors where the natural springiness of the foil is used to retain the source.

Nickel-63 can be directly plated onto custom designed holders.

The maximum practical activity loading for efficient emission is 370MBq/cm² (~10mCi/cm²).

US-Model numbers

Products with a US-Model-Number and additional QC Tests are available on request.

Model NBC refers to plated foils. Model NBCD refers to directly plated holders.

Nominal activity		On nickel foil 24 x 10mm*	30 X 10mm*
MBq	mCi	Product code	Product code
37	1	NBC1	NBC11
111	3	NBC2	NBC12
370	10	NBC3	NBC13
555	15	NBC4	NBC14

*acc. to drawing VZ-2728-001

Nominal activity		On monel foil 24 x 10mm**	30 X 10mm**
MBq	mCi	Product code	Product code
37	1	NBC21	NBC31
111	3	NBC22	NBC32
370	10	NBC23	NBC33
555	15	NBC24	NBC34

**acc. to drawing VZ-2722-001

Other areas are available with lengths between 10-50mm and widths between 3-30mm.

Quality Control

Beta emission checked using a 2π ion chamber

Nickel-63 sources will gradually tarnish under normal atmospheric conditions. This results from exposure to air and is aggravated by moisture and, in a confined space, by the effect of beta radiation on air.

Nickel-63 sources should therefore be removed from their packaging on receipt and stored under inert atmosphere such as dry argon prior to use.

Promethium-147

Beta Sources

Line Sources

Promethium-147 incorporated in an enamel, mounted in a glued titanium capsule with 5µm titanium window over the active area.

Nominal activity*		Active Length	Active Width	Overall Length	Dimensions Width	Product code
GBq	mCi	mm	mm	mm	mm	
18.5	500	50	3	63	13	PHCB4831
25	676	50	3	63	13	PHCB1861

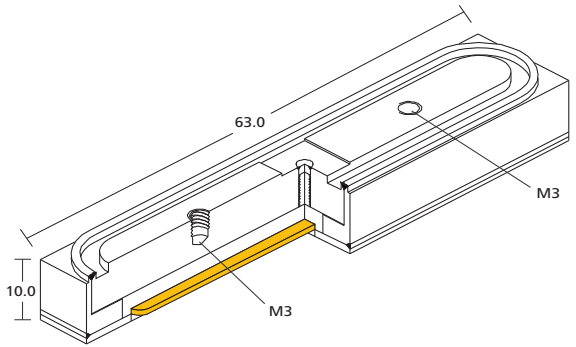
* Tolerance -10%, +25%

Recommended working life: 5 years

Quality Control

Wipe test I

VZ-1590/1



Safety performance testing

ANSI/ISO classification	US-Model number
C33222	PHC.C2

Promethium-147

Beta Sources

Disc Sources

Promethium-147 incorporated in an enamel, mounted in a glued titanium capsule with 5µm titanium window, welded.

Nominal activity*		Active diameter mm	Overall diameter mm	Product code
GBq	mCi			
3.7	100	15.6	22	PHC80951
7.4	200	15.6	22	PHC80952
18.5	500	15.6	22	PHC80955

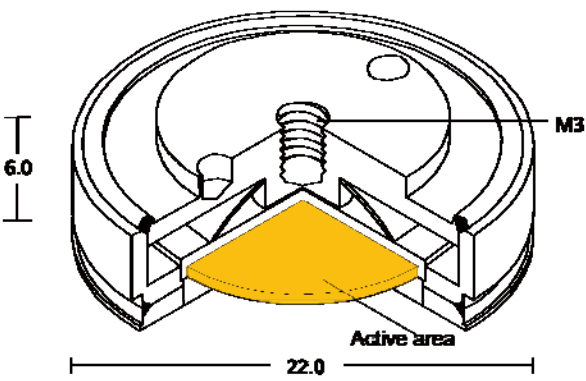
* Tolerance -10%, +25%

Recommended working life: 5 years

Quality Control

Wipe Test I

VZ-464



Safety performance testing

ANSI/ISO classification	US-Model number
C33222	PHC.C1

Strontium-90 (+ Yttrium-90)

Beta Sources

Disc Sources (ceramic)

A Strontium-90 compound incorporated on a ceramic insert, doubly encapsulated in stainless steel, inner capsule with 25µm stainless steel window; outer capsule with 50µm stainless steel window.

Nominal activity *		Capsule	Product code
MBq	mCi		
74	2	X.117	SIF1171
370	10	X.117	SIF1174
740	20	X.117	SIF1175
1850	50	X.117	SIF1176
3700	100	X.117	SIF1177

* Tolerance ±25%

A Strontium-90 compound incorporated on a ceramic insert, single encapsulated in stainless steel with with 0.1mm stainless steel window.

Nominal activity *		Capsule	Product code
MBq	mCi		
74	2	X.2453/1	SIFB12009
185	5	X.2453/1	SIFB11884
555	15	X.2453/1	SIFB11369
1850	50	X.2453/1	SIFB11885
3700	100	X.2453/1	SIFB12010

* Tolerance ±15%

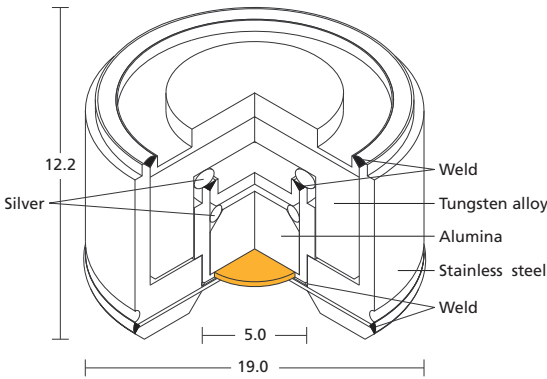
Recommended working life: 10 years

Quality control

Wipe Test I

Immersion Test II

X.117*
VZ-2523



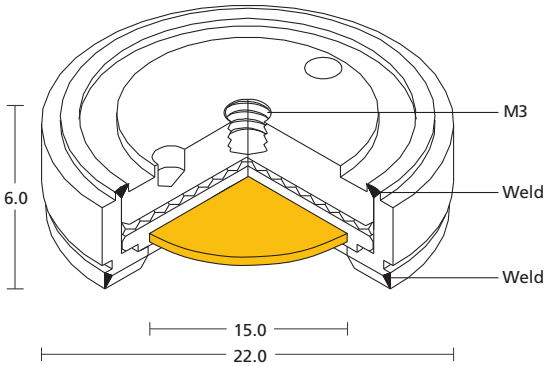
Safety performance testing

ANSI/ISO classification	IAEA special form	US-Model number
C64444**	YES	SIF.D1

* X.117 manufactured according to drawing VZ-2523

** ANSI/ISO classification for USA: C64343

VZ-2453/1



Safety performance testing

ANSI/ISO classification
C43324

Strontium-90 (+ Yttrium-90)

Point Disc Sources (ceramic)

Strontium-90 incorporated in a 1mm diameter ceramic bead, sealed in a welded stainless steel capsule, window thickness 0.05mm.

Nominal activity *		Product code
MBq	mCi	
3.7	0.1	SIFB10088
37	1	SIFB10089
370	10	SIFB10090

* Tolerance $\pm 30\%$

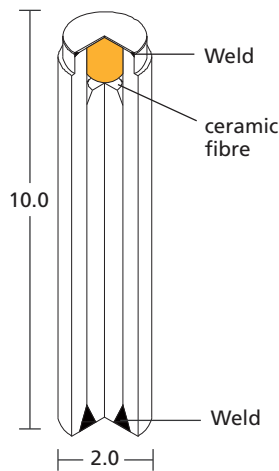
Recommended working life: 10 years

Quality control

Wipe Test I

Immersion Test II

X.111*
VZ-2931



Safety performance testing

ANSI/ISO classification	US-Model number
C54343	SIF.P1

* X.111 manufactured according to drawing VZ-2931

74GBq (2Ci) Caesium-137 gamma well-logging Source US-Model number CDC.CY4

Description

The design of logging sources is usually constrained by the geometric considerations of dimensions and position of the center of activity which are imposed on the source design by the customers' bull plug and/or logging tool design. There is also usually a requirement for the source to have external features on the source to allow ease of handling in use. Eckert & Ziegler Nuclitec GmbH offers such sources for the major well logging companies world wide. These sources can either be designed based on standard inner tested sources which have IAEA Special Form certificates or can be designed and prototype tested as a completely new source design. All gamma well logging sources meet and usually exceed the criterion for well logging as contained in ANSI N.542-1977 and also meet the more stringent requirements of the Texas Regulations for Control of Radiation: 25 Texas Administrative Code §289.253(l)(1)(c) and the Louisiana Administration Code 33:XV.2017.A.3. The materials used in encapsulations also comply with the recommendations of NACE standard MR 01 – 75 for materials for use down bore holes in a sour gas environment.

High Integrity Encapsulation

The inner capsule can be made from high quality AISI316L stainless steel or more usually from Armco 17-4PH stainless steel in a heat treated condition, to give it the required mechanical properties, or the multiphase alloy MP35N in the cold worked aged condition. The outer capsule is made from Armco 17-4PH stainless steel in a heat treated condition, to give it the required mechanical properties, or the multiphase alloy MP35N in the cold worked aged condition. The material certification used for a source can be supplied on request. The source is designed to withstand any of the forces subjected to it in use without deformation.

Safety

The Cs-137 is contained in a ceramic form which is either in the form of a high temperature glass fused into AISI 316L stainless steel insert or a sintered ceramic Alumino-Silicate pellet. The Cs-137 in this form is geometrically and mechanically stable and insoluble in most solvents. The leachability of Cs137 from these ceramics exceeds the requirements of ANSI N452, 1977 (ISO 292 – 1980) which defines non-leachable.

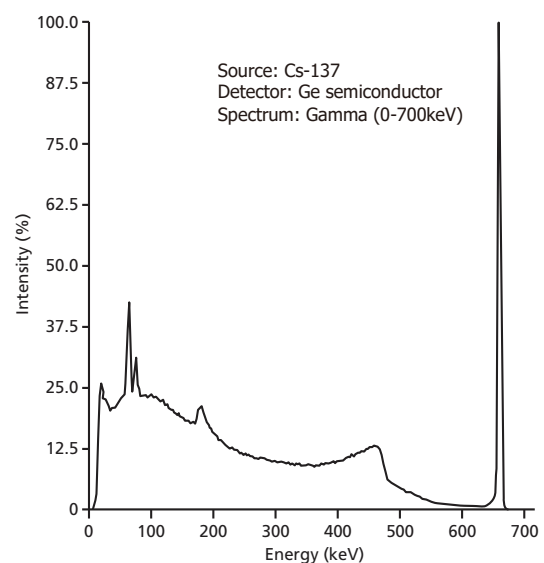
Quality Control

Sources are sealed by high quality Laser or Tungsten Inert Gas autogenous welding. Pre and post production weld trials are carried out for each batch of sources made and these welds are sectioned and examined for penetration and weld quality. Each production source undergoes a high pressure test which consists of cycling the source at 25,000 psi. Sources can be certified for use and tested at 30,000 psi or higher on request. Each source is leak and contamination tested as required by ISO 9978. Sources can also be examined by X-radiography. Each inner is measured in a re-entrant ion chamber using standards traceable to a national laboratory.

Quality Assurance

All sources are manufactured to a Quality Plan approved to ISO 9001 (2000) by LRQA (Lloyds Register Quality Assurance).

Gamma Spectrum



Measurement Assurance

Participation in intercomparison programs with NIST and other national laboratories assures output measurement accuracy.

Enquiries for standard product, variations of standard products or design of new source assemblies are welcome.

Stable Output

Source to source outputs for a given product code vary by greater than ± 12%. Tighter tolerances may be maintained on request. The active component is mechanically stable and the design of the source eliminates the possibility of the activity moving within that due to radioactive decay.

Loading facilities

Source loading into customer supplied bull plugs or nose cones and testing of the assembly is available on request.

Regulatory Approval

All gamma well logging sources are registered with the USA Nuclear Regulatory Commission (NRC) for use in well logging. In addition they comply with the stringent requirements of the Texas Regulations for Control of Radiation: 25 Texas Administrative Code §289.253(l)(1)(c) and the Louisiana Administration Code 33:XV.2017.A.3. They also comply with the NACE standard MR 01 – 75 for corrosion resistance of materials for use down bore holes in sour gas environments. All sources also have a current Special Form Certificate from a Competent Authority.

Source Inspection and Re-encapsulation

In some cases used sources can be removed from bull plugs and inspected, tested, re-certified and re-encapsulated in new bull plugs. Further information can be provided on request.

Safety performance testing

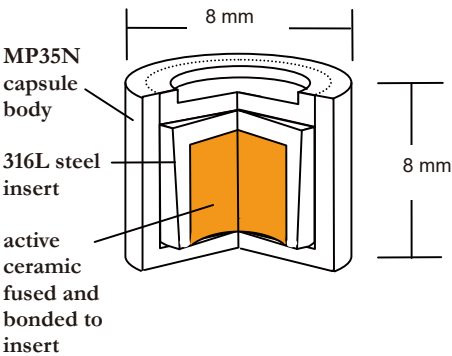
Capsule	US-Model Number	ANSI/ISO class	IAEA spec. form	Maximum Activity
X1187	N/A	C66544	YES	74 GBq, 2 Ci
X2069	CDC.CY8	C66546	YES	1.11 GBq, 0.3 Ci
X2074	CDC.CY4	C66646	YES	129.5 GBq, 3.5 Ci

Other activities are available on request

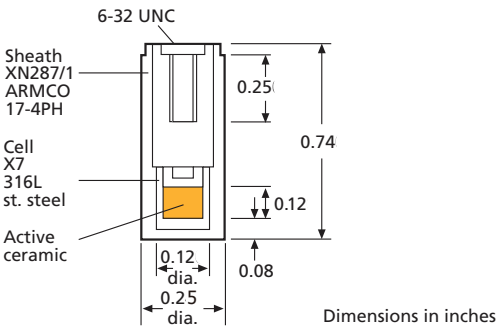
Other Nuclides

Co-60, Am-241 and other nuclides can be provided for gamma well-logging applications. Further information can be provided on request.

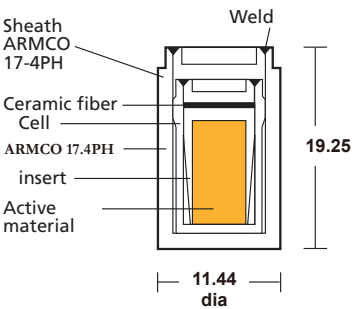
X1187 Inner encapsulation



X2069 US Model No. CDC.CY8



X2074 US Model No. CDC.CY4



Am-241/Be Neutron Well-Logging Source US-Model number AMN.CYn series

Description

The design of logging sources is usually constrained by the geometric considerations of dimensions and position of the center of activity which are imposed on the source design by the customers' bull plug and/or logging tool design. There is also usually a requirement for the source to have external features on the source to allow ease of handling in use. These sources can either be designed based on standard inner tested sources which have IAEA Special Form certificates or can be designed and prototype tested as a completely new source design. All neutron well logging sources meet and usually exceed the criterion for well logging as contained in ANSI N.542-1977 and also meet the more stringent requirements of the Texas Regulations for Control of Radiation. Part 36 108(a)(3) and the Louisiana Administration Code 33:XV.2017.A.3. The materials used in encapsulations also comply with the recommendations of NACE standard MR 01 – 75 for materials for use down bore holes in a sour gas environment.

High Integrity Encapsulation

The inner capsule can be made from high quality AISI316L stainless steel or from Armco 17-4PH stainless steel in a heat treated condition, to give it the required mechanical properties, or the multiphase alloy MP35N in the cold worked aged condition. The outer capsule is made from Armco 17-4PH stainless steel in a heat treated condition, to give it the required mechanical properties, or the multiphase alloy MP35N in the cold worked aged condition. The material certification used for a source can be supplied on request. The source is designed to withstand any of the forces subjected to it in use without deformation.

Active Material

The Am-241/Be used in sources is in the form of an intimate mixture of americium oxide and beryllium metal that has been compacted at high pressure to form a robust insert.

The ratio of beryllium to americium oxide may vary in the range 2:1 to 20:1 depending on the design and neutron output required.

(α -n) beryllium neutrons sources may emit a significant number of low energy neutrons.
(~23% below 1MeV with mean energy 400keV)

Quality Control

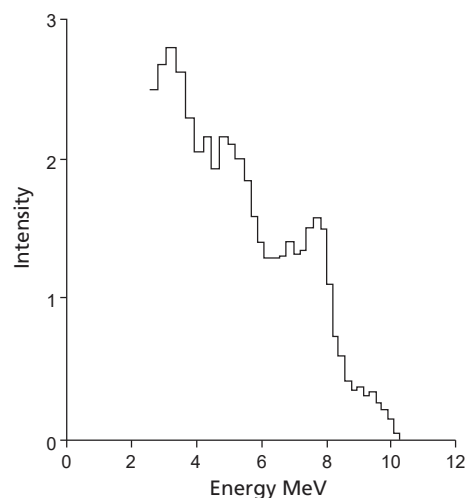
Sources are sealed by high quality Laser or Tungsten Inert Gas autogenous welding. Pre and post production weld trials are carried out for each batch of sources made and these welds are sectioned and examined for penetration and weld quality. Each production source undergoes a high pressure test which consists of cycling the source at 25,000 psi. Sources can be certified for use and tested at 30,000 psi or higher on request. Each source is leak and contamination tested as required by ISO 9978. Sources can also be examined by X-radiography. Each inner is measured in a re-entrant ion chamber using standards traceable to a national laboratory.

Quality Assurance

All sources are manufactured to a Quality Plan approved to ISO 9001 (2000) by LRQA (Lloyds Register Quality Assurance).

Neutron Spectrum

Spectrum reproduced by courtesy of LORCH, E.A.
Int J. Appl. Radiat. Isotopes, 24, 590, 1973



Product Specification

Isotope: Americium-241, Half Life: 433 years
Licensing: Registered as NRC model No. AMN.CYn series
Recommended working life: 15 years
ANSI/ISO classification: E66544 (minimum)
Closure Method: Tungsten Inert Gas Welding
Pellet Composition: Am-241 Oxide powder mixed with Beryllium powder and pressed into a pellet under pressure.
Capsule Materials: Armco 17-4pH stainless steel outer capsule/AISI Type 316L inner capsule.
Pressure Rating: 25,000psi (30,000psi or higher available on request).
Source Identification: Each source bears engraved data for identification and traceability. Additional labeling as required in the Texas Regulations for control of Radiation: 25 Texas Administrative Code §289.253 and the Louisiana Administration Code 33 can be added if needed.
Specific Activity: ~111GBq/g (~3Ci/g)
Certification: Documentation that source has passed Quality Assurance and Measurement Tests is provided.
Chemical Purity: Highest grade Am-241 Oxide available.
Isotopic Purity: 95%

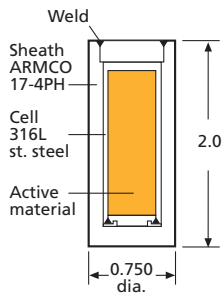
Nominal activity GBq	Activity Ci	Emission n/s	Capsule	Product code	US-Model number
111	3	6.6 x 106	X.2064	AMN2643	AMN.CY3
185	5	1.1 x 107	X.2064	AMN2645	AMN.CY3
111	3	6.6 x 106	X.2065	AMN2653	AMN.CY4
185	5	1.1 x 107	X.2065	AMN2655	AMN.CY4
185	5	1.1 x 107	X.2066	AMN2655	AMN.CY5
111	3	6.6 x 106	X.2067	AMN2673	AMN.CY7 *
185	5	1.1 x 107	X.2067	AMN2675	AMN.CY7 *
370	10	2.0 x 107	X.2007	AMN2071	AMN.CY10
740	20	4.0 x 107	X.2007	AMN2072	AMN.CY10

* Source no longer approved for manufacture in the USA.

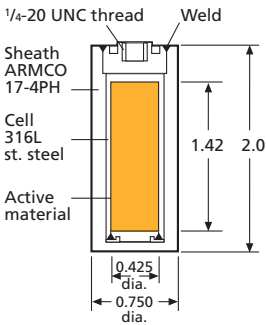
Nuclear Data: Americium-241

half-life	type of decay	Particle energies and transition probabilities		Electromagnetic transitions	
		energy MeV	transition probability	photon energy MeV	photons emitted per disintegration
433 years	α	5.387	1.60%	0.026	2.500%
		5.442	12.50%	0.033	0.100%
		5.484	85.20%	0.043	.100%
		5.511	0.20%	0.0595	35.300%
		5.543	0.34%	0.099	0.020%
		others low		0.103	0.020%
				0.125	0.004%
				others low	
				Np LX-rays ~40%	
				(0.012-0.022)	

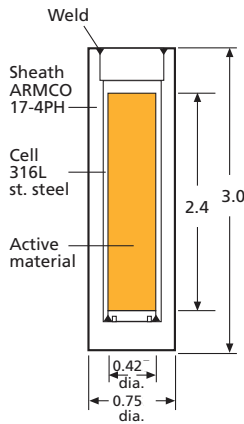
X.2064



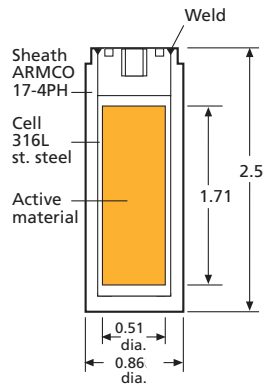
X.2065



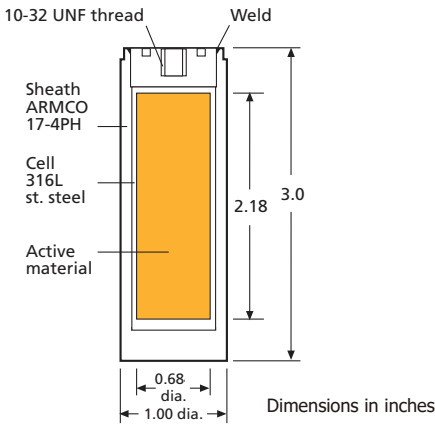
X.2066



X.2067



X.2007



Source emission data

Neutron emission: $\sim 6 \times 10^7$ n/s per TBq ($\sim 2.2 \times 10^6$ n/s per Ci)
Air kerma rate: \sim Air kerma rate at 1m of $0.6 \mu\text{Gy/h}$ per GBq
($\sim 2.5 \text{mR/h}$ at 1m per Ci). Neutron dose rate: $0.6 \mu\text{Sv/h}$ at 1m
per GBq (2.2mrem/h at 1m per Ci).

Measurement Assurance

Participation in intercomparison programs with NIST and other national laboratories assures output measurement accuracy.

Enquiries for standard product, variations of standard products or design of new source assemblies are welcome.

Stable Output

Source to source outputs for a given product code vary by greater than $\pm 12\%$ ($\pm 10\%$ for AMN2072). Tighter tolerances may be maintained on request. The active component is mechanically stable and the design of the source eliminates the possibility of the activity moving within the source. So the only variation of source output with time is that due to radioactive decay.

Loading facilities

Source loading into customer supplied bull plugs or nose cones and testing of the assembly is available on request.

Regulatory Approval

All neutron well logging sources are registered with the USA Nuclear Regulatory Commission (NRC) for use well logging. In addition they comply with the stringent requirements of the Texas Regulations for Control of Radiation: 25 Texas Administrative Code §289.253(l)(1)(c) and the Louisiana Administration Code 33:XV.2017.A.3. They also comply with the NACE standard MR 01 – 75 for corrosion resistance of materials for use down bore holes in sour gas environments. All sources also have a current Special Form Certificate from a Competent Authority.

Source Inspection and Re-encapsulation

In some cases used sources can be removed from bull plugs and inspected, tested, re-certified and re-encapsulated in new bull plugs. For further information about this service, please enquire.

Cf-252 Neutron Well-Logging

Cf-252 can be used as an alternative to Am/Be in neutron well-logging applications. Sources may be encapsulated in either Am/Be or Cs-137 designs. Further information can be provided on request.

See section B15 for information on Cf-252 products.

Routine production checks

Special safety performance test on
prototypes

Measurements

Test reports

ISO.9001 International quality management
system standard

Quality control

Quality control of radiation can be divided into four main parts:

1. Routine production checks

Quality Assurance

Radiation sources are manufactured in accordance with a strict quality assurance program, details of which can be obtained on request.

Leakage and contamination tests

Stringent tests for leakage are an essential feature of radioactive sources production. They are based on ISO 9978. Some standard methods used for testing radiation sources are listed below.

Wipe test I

The source is wiped with a swab or tissue, moistened with ethanol or water, the activity removed is measured.

Limit: 200Bq

(Limit USA: 5nCi)

Immersion test II

The source is immersed in a suitable liquid at 50°C for at least 4 hours and the activity removed is measured.

Limit: 200Bq

(Limit USA: 5nCi)

Bubble test III

The source is immersed in water or a suitable liquid and the pressure in the vessel reduced to 13kPa (100mm Hg). No bubbles must be observed.

Krypton emanation test V

The source is held under reduced pressure for 24 hours. The content of the chamber is analysed for Krypton-85 by scintillation counting.

Limit: 370Bq

Krypton emanation test VI

The source is held under reduced pressure for 24 hours. The content of the chamber is analysed for Krypton-85 by scintillation counting. The test is repeated after at least 7 days.

Limit: 1.85kBq

Quality control

2. Special safety performance tests on prototypes

A radiation source must provide highest possible integrity together with minimum attenuation of the required radiation by the encapsulation materials. A compromise must sometimes be made, particularly for alpha, beta and low energy photon sources.

Safety must always be the prime consideration. Standards for the testing of sealed radioactive sources have been specified by ISO.2919 and ISO.9978.

ISO.2919 'Sealed radioactive sources — Classification'
ISO.9978 'Sealed radioactive sources — leak test methods'.

This classification system is modeled on USA standard US ANSI N43.6-1997 which also gives a number of comparable leak test methods.

3. Measurements

Each source of batch of sources is checked to ensure that the strengths of the sources supplied are within the limits specified. Wherever possible the results of these checks are indicated on the test report. The methods of specifying the strengths of sources are discussed under the heading specification on page E1 and details are included in the appropriate section of this catalog.

4. Test reports

A test report is supplied with each source or batch of sources. Where appropriate the following information is given:

- Product code
- Product description
- Capsule type
- ISO classification
- Special form certificate
- Serial number of source
- Measurement check
- Leakage check
- Contamination check

ISO.9001 International Quality Management System Standard

Eckert & Ziegler Nuclitec GmbH is approved to the International Quality Management System Standard ISO 9001: 2000.

This Quality Management System is a formal system which defines Quality Policy, describes the necessary organization in place to carry out the policy, and describes the procedures in place which are necessary to carry out and maintain the system. All production and quality control procedures are part of this system.

The System involves the thorough training of all staff, documentation of procedures, maintenance of records and the assessment and rectification of non-conformities.

Regular surveillance audits are made by Lloyd's Register Quality Assurance Ltd.*, to ensure that the high standards demanded by ISO.9001 are maintained by Eckert & Ziegler Nuclitec GmbH to all stages of the source production process from establishing the source specifications, through design, manufacture, test and measurement to dispatch and after sales service.

* Lloyd's Register Quality Assurance Ltd. (LRQA) is accredited by the National Accreditation Council for Certification Bodies.

Specifications – SI Units

Technical information

Technical information

Specification - SI Units

The International System (SI) units are a consistent set of units for use in all branches of science. The International Commission on Radiation Units and Measurements (ICRU) has published its recommendations on the quantities and units to be used in the measurement of ionizing radiations and activity.

Several countries have already adopted the new SI system and legislation now requires that SI units be used in the UK and Europe from 1st January 1986 onwards. Previously, our catalogs have contained both the old and the new units side by side, or appropriate conversion factors, and this will continue until the new system is accepted by the majority of users.

The quantity exposure rate is replaced by the quantity air kerma rate. The preferred SI units for air kerma rate are submultiples of Gray per second. A constant factor may be used to convert from exposure rate to air kerma rate. Quite simply, an exposure of 1 Roentgen per hour (1R/h becomes 2.425 microGray per second ($\mu\text{Gy/s}$), or 8.73 milligray per hour (mGy/h). Gamma radiation sources are specified in terms of the exposure rate or air kerma rate at a distance of 1 meter from the source and at this distance the strength of most sources is such that exposure rate will be in units of mR/h and air kerma rate will be in units of ($\mu\text{Gy/h}$). A conversion factor of 8.73 should therefore be used to convert from mR/h to $\mu\text{Gy/h}$

Sources previously specified in terms of equivalent activity may be converted to the new quantity and units by first converting to exposure rate using the appropriate exposure rate constant. A list of exposure rate constants used by Eckert & Ziegler Nuclitec GmbH for these sources is given in the examples. Conversion from exposure rate to air kerma rate is described in the previous paragraph and is also shown in the examples.

In this catalog, source strengths are quoted in appropriate SI units with the previously used quantities and units given alongside.

The following quick reference guide gives a useful summary of the relevant quantities, units, conversion factors and prefixes. Some useful examples are given.

Technical information

Quick reference guide to the use of SI units for gamma radiation sources

Specification of output

New quantity: Air kerma rate

Old quantity: Exposure rate or equivalent activity + exposure rate constant

New unit: Gray (Gy) per second (s)

Old unit: Roentgen (R) per hour (h)

Conversion of activity

Multiply value by 8.73 to convert from mR/hour to $\mu\text{Gy/h}$

Specification of activity

Quantity: Activity (content)

New unit: Becquerel (Bq)

Old unit: Curie (Ci)

Activity conversion

Multiply value by 37 to convert from kCi to TBq or Ci to GBq or mCi to MBq

Multiply value by 27.03 to convert from MBq to μCi or GBq to mCi or TBq to Ci

Radiation Protection

Quantity: Absorbed dose

New unit: Gray (Gy)

Old unit: rad

Quantity: Dose equivalent (biological dose)

New unit: Sievert (Sv)

Old unit: rem

Conversion

Multiply value by 10 to convert from rad to mGy or rem to mSv

Multiply value by 100 to convert from Gy to rad or Sv to rem

Prefixes for units

Sub multiples			Multiples		
10^{-3}	milli	m	10^3	kilo	k
10^{-6}	micro	μ	10^6	mega	M
10^{-9}	nano	n	10^9	giga	G
10^{-12}	pico	p	10^{12}	tera	T
10^{-15}	femto	f	10^{15}	peta	P
10^{-18}	atto	a	10^{18}	exa	E

Examples

Example of the conversion of outputs for an equivalent activity of 1 Curie

Nuclide	Exposure rate at 1m*	Air kerma rate at 1m
Cs-137	0.33R/h	2.9mGy/h
Co-60	1.30R/h	11mGy/h

* The value given are also the recommended exposure rate constant values in units of $\text{R m}^2 \text{h}^{-1} \text{Ci}^{-1}$

Examples of conversion for units of content activity

$1 \text{ Bq} = 2.703 \times 10^{-11} \text{ Ci} = 27.03 \text{ pCi}$	$1 \text{ nCi} = 3.7 \times 10^8 \text{ Bq} = 37 \text{ Bq}$
$1 \text{ kBq} = 2.703 \times 10^{-8} \text{ Ci} = 27.03 \text{ nCi}$	$1 \mu\text{Ci} = 3.7 \times 10^4 \text{ Bq} = 37 \text{ kBq}$
$1 \text{ MBq} = 2.703 \times 10^{-5} \text{ Ci} = 27.03 \mu\text{Ci}$	$1 \text{ mCi} = 3.7 \times 10^7 \text{ Bq} = 37 \text{ MBq}$
$1 \text{ GBq} = 2.703 \times 10^{-2} \text{ Ci} = 27.03 \text{ mCi}$	$1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq} = 37 \text{ GBq}$
$1 \text{ TBq} = 2.703 \times 10 \text{ Ci} = 27.03 \text{ Ci}$	$1 \text{ kCi} = 3.7 \times 10^{13} \text{ Bq} = 37 \text{ TBq}$

Technical information

Notes

Daughter Nuclides

Some daughter nuclides may not be in equilibrium with the parent nuclide when source is supplied. In cases where this may occur the transition probabilities for the daughter nuclides relate to disintegrations of each daughter; this is stated in the tables. Daughter nuclides with half-lives greater than the parent nuclide have not been listed since they would be present only in insignificant amounts.

Particular energies

For β -emission, the end-point energy is quoted.

Transition probabilities

These are expressed as percentages of the total number of nuclear transformations of the relevant nuclides. For electromagnetic transitions the probability of photo emission has been listed.

Abbreviations

Half-lives

y - years
d - days
h - hours
min - minutes
s - seconds
ms - milliseconds
 μ s - microseconds

Type of decay

e.c. - electron capture
i.t. - isomeric transition
s.f. - spontaneous fission

Photons emitted

IC - indicates that photons of the stated energy are $\sim 100\%$ internally converted.

Calibration

Some of the sources listed in this catalog can be calibrated. Certificates of measurement quote the results of air kerma rate at a specified distance.

Calibration uncertainty

The reported uncertainty is based on standard uncertainty multiplied by a coverage factor $k = 2$, providing a level of confidence of approximately 95%. (ISO Guide, 1995).

ANSI / ISO classification

Performance requirements

IAEA special form

Source working life

Source safety

1. Classification of sealed source performance

A radiation source must provide the highest possible integrity for its contents together with the minimum attenuation of the emitted radiation by the encapsulation materials which is consistent with safety and the intended use. However, safety must always be the prime consideration.

The International Organization for Standardization have issued a standard (ISO 2919:1999) which establishes a system of classification of sealed radioactive sources based on test performance. It also specifies production tests, marking and gives an example of a test report. Similar standards are ANSI/HPS N43.6-1997 published in the USA.

These standards, to quote from ISO2919, "...provides a set of tests by which the manufacturer of sealed radioactive sources can evaluate the safety of his products in use and by which the user of such sources can select types which are suitable for the required application, especially where the release of radioactive material with consequent exposure to ionizing radiation is concerned."

The suitability and safety of a source will depend on the intended application and the environment of use of which there will be a wide range. It is the customer's (users) responsibility to ensure the source and its specification is suitable and safe for his particular application and environment of use. This applies to standard products and especially to non-standard products or custom made designs. The information given here is intended for guidance. It is recommended that the standards should be consulted for detailed definitive information.

The standard tests for the classification of sealed source performance (ISO 2919) are given in Table 1. Examples of additional tests which may be required for specific applications are given in the appendix to ISO 2919.

Source safety

Table1. Classification of sealed source performance

Test	Class						
	1	2	3	4	5	6	X
Temperature	No test	-40°C (20min) +80°C (1 h)	-40°C (20min) + 180°C (1h)	-40°C (20min) + 400°C (1 h) and thermal shock to 20°C	-40°C (20min) +600°C (1h) and thermal shock to 20°C	-40°C (20min) +800°C (1 h) and thermal shock to 20°C	Special test
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	Special test
Impact	No test	50g from 1 m or equivalent imparted energy	200g from 1 m or equivalent imparted energy	2kg from 1 m or equivalent imparted energy	5 kg from 1 m or equivalent imparted energy	20kg from 1 m or equivalent imparted energy	Special test
Vibration	No test	3 times 10min 25 to 500Hz at 49m/s ² (5g _n) ¹⁾	3 times 10min 25 to 50Hz at 49m/s ² (5g _n) ¹⁾ and 50 to 90Hz at 0.635mm amplitude peak to peak and 90 to 500Hz at 96m/s ² (5g _n) ¹⁾	3 times 30min 25 to 80Hz at 1.5mm amplitude peak to peak and 80 to 2000Hz at 196m/s ² 20g _n) ¹⁾	Not used	Not used	Special test
Puncture	No test	1 g from 1 m or equivalent imparted energy	10g from 1m or equivalent imparted energy	50g from 1 m or equivalent imparted energy	300g from 1 m or equivalent imparted energy	1 kg from 1 m or equivalent imparted energy	Special test

1) Acceleration maximum amplitude

Notes to table 1.

- Details of the testing procedures are given in ISO.2919 and ANSI N43.6-1997. A further class X can be used where a special test procedure has been adopted.
- External pressure
100kPa=1 atmosphere (approximate)
- Impact test
The source, positioned on a steel anvil, is struck by a steel hammer of the required weight; the hammer has a flat striking surface, 25mm diameter, with the edges rounded.
- Puncture test
The source, positioned on a hardened steel anvil, is struck by a hardened pin, 6mm long, 3mm diameter, with hemispherical end, fixed to a hammer of the required weight.

Each test can be applied in several degrees of severity which is expressed as a five digit code representing the class numbers which describe the performance for each of the tests. The digits are preceded by the letter C or E indication respectively whether the activity of the source is greater or lesser than a prescribed amount. The limits depend on the toxicity etc of the active components (See ISO 2919) Compliance with the tests is determined by the ability of sealed source to maintain its leak tightness. The leakage tests are defined in ISO 9978.

Source safety

2.- Performance requirements for typical uses

Typical uses and minimum performance requirements (ISO 2919) are given in Table 2.

Table 2 Sealed source classification (performance) requirements for typical usage

		Sealed source class, depending on test				
		Temperature	Pressure	Impact	Vibration	Puncture
Radiography-Industrial	Sealed source Source to be used in device	4 4	3 3	5 5	1 1	1 1
Medical	Radiography Gamma teletherapy Brachytherapy (6) ¹⁾ Surface applicators ²⁾	3 5 5 4	2 3 3 3	3 5 2 3	1 2 1 1	2 4 1 2
Gamma gauges (medium and high energy)	Unprotected source Source in device	4 4	3 3	3 2	3 3	3 2
Beta gauges and sources for low-energy gamma gauges or x-ray fluorescence analysis ²⁾		3	3	2	2	2
Oil-well logging		5	6	5	2	2
Portable moisture and density gauge (including hand-held or dolly-transported)		4	3	3	3	3
General neutron source application (excluding reactor startup)		4	3	3	2	3
Calibration source activity >1 MBq		2	2	2	1	2
Gamma irradiation sources	Category 1 ²⁾ [3], [5] Categories II,III and IV ³⁾	4 5	3 3	3 4	2 2	3 4
Ion generators ³⁾	Chromatography Static eliminators Smoke detectors ²⁾	3 2 3	2 2 2	2 2 2	1 2 2	1 2 2
1) Sources of this nature may be subject to severe deformation in use. Manufactures and users may wish to formulate additional or special test procedures. 2) Excluding gas-filled sources. 3) "Source in device" or a "source assembly" may be tested.						

The requirements take into account normal usage but do not include exposure to fire, explosion or corrosion. The tests specified do not cover all usage situations and where conditions do not match those specified in Table 2 appropriate tests on an individual basis may be required.

Source safety

3. IAEA special form

Sealed sources which have passed the performance tests described in the regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), International Atomic Energy Agency (IAEA), No. TS-R-1 (ST-1, Revised) may be approved as Special Form Material by a National Competent Authority. Designation as Special Form allows an increase in the activity limits for shipment as a Type A package.

This catalogue indicates whether Special Form Certificate (SFC) were issued for approved items in the catalog.

RECOMMENDED WORKING LIFE OF SEALED RADIATION SOURCES

The Recommended Working Life (RWL) is the maximum period within which Eckert & Ziegler Nuclitec GmbH expects the source to meet its design requirements under proper conditions of environment and usage. A Source should be replaced within the Recommended Working Life or a proper assessment should be made to verify its suitability for continued use.

Eckert & Ziegler Nuclitec GmbH makes no warranties, expressed or implied, or guarantees as to how long any source can actually be safely used. Adverse environments, conditions, improper usage or materials combination in usage could affect the appearance and integrity of the source and it is the user's responsibility to carry out routine inspection and testing to determine when it should be replaced.

Eckert & Ziegler Nuclitec GmbH will determine the RWL based on the construction of the source, application, test data and operational experience.

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