

U.S. NRC Well Logging Sealed Sources

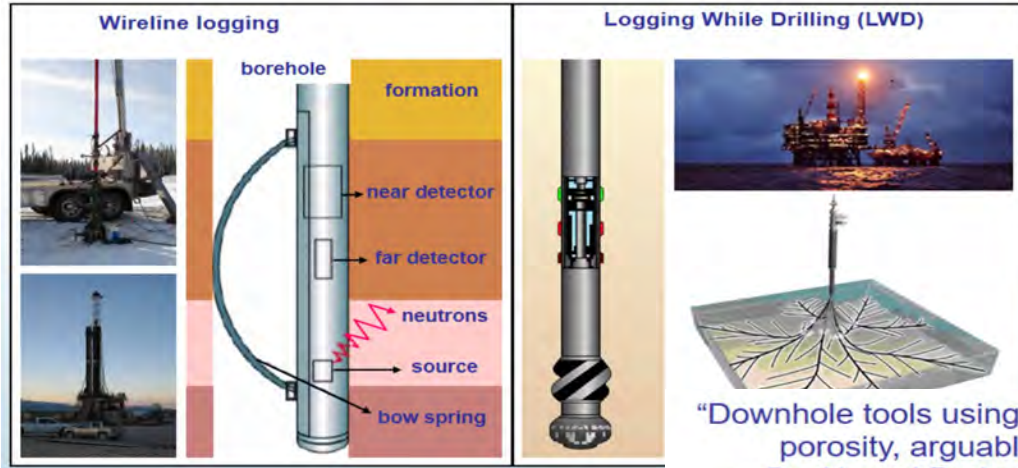
Jason vonEhr
Health Physicist
U.S. NRC Region IV
11 October 2019

Brief Recap of Well Logging

Cs-137

Am-241 + Be

Cf-252

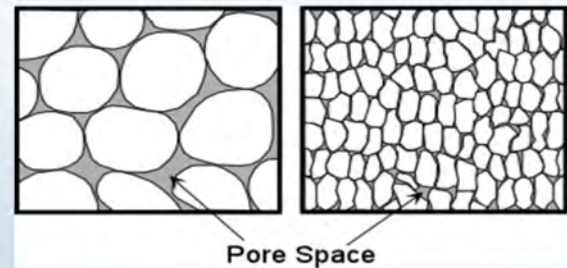


"Downhole tools using such sources provide the most accurate estimate of porosity, arguably the most important petrophysical parameter."
– Dr. Ahmed Badruzzaman, Senior Staff Research Scientist, Chevron

Density



Porosity & Permeability



Challenge Question

What is the significance of sealed source design for well logging?

Objectives for NRC Well Logging Sealed Sources Presentation

Introduce and review:

- What are the commonly used radioisotopes?
- Where do they come from?
- How are sources made?
- What are the important Source Design Principles?
- What Specifications apply?
- How are these tested & managed?
- Who is responsible?
- Regulatory, Manufacturers, End-Users

Source Design Considerations

- The design of logging sources is usually constrained by the geometric considerations of physical dimensions *and* center of activity which are imposed on the source design by the customer's bull plug 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 during use



Tested and Approved Materials

Locations in the US may only use, possess or store sealed sources and meters containing sealed sources that:

Have been issued a Registration of Safety Evaluation of Sealed Source or Device by the NRC, or an Agreement State

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES
SAFETY EVALUATION OF SEALED SOURCE
(AMENDED IN ITS ENTIRETY)

NO: MA-1059-S-191-S DATE: May 8, 2007 PAGE 1 OF 10

SOURCE TYPE: Well Logging Source

MODEL: CDC.CY3; CDC.CY4; CDC.CY5; CDC.CY6; CDC.CY8; CDC.CY10;
CDC.CY11; CDC.CY13; CDC.CY14; CDC.CY15; CDC.CY16

DISTRIBUTOR: **QSA Global, Inc.**
(Formerly AEA Technology QSA, Inc.)
40 North Avenue
Burlington, MA 01803

MANUFACTURERS: **QSA Global, Inc.**
40 North Avenue
Burlington, MA 01803

Well Logging Source Specification & Design

The Standards

Criteria used to establish a system of classification for sealed radioactive sources based on performance specifications related to radiation safety

- Organizations involved in the development of standards for sealed sources:
 - **ANSI** – American National Standards Institute
 - ANSI/HPS N43.6 - “Sealed Radioactive Sources – Classification”
 - **HPS** – Health Physics Society
 - **ISO** – International Organization for Standardization
 - ISO-2919 - “Radiation Protection – Sealed Radioactive Sources – General Requirements and Classification”

The Standards

- The standards establish a system of classification of sealed radioactive sources **based on test performance**
- The standards specify:
 - *General requirements*
 - *Performance tests*
 - *Production tests*
 - *Marking*
 - *Certification*

The Standards

- The tests fall into several groups including exposure to abnormally high and low temperatures and a variety of mechanical tests.
- Each test can be applied in several degrees of severity.
- The criterion for pass or fail depends on leakage of the contents of the sealed radioactive source.
- The standards provide a set of tests by which sealed source manufacturers can evaluate the safety of their products in use.
- Allows regulators and users to determine the types of sources that are suitable for specific applications.
- The standards make no attempt to classify the design, construction, or calibration of sources in terms of the radiation emitted.

Criteria for Sources (NRC)

§10 CFR 39.41 Design and performance criteria for sources

- (a) A licensee may use a sealed source for use in well logging applications if—
- (1) The sealed source is doubly encapsulated;
 - (2) The sealed source contains licensed material whose chemical and physical forms are as insoluble and nondispersible as practical; and
 - (3) Meets the requirements of paragraph (b), (c), or (d) of this section.
- (b) For a sealed source manufactured on or before July 14, 1989, a licensee may use the sealed source, for use in well logging applications if it meets the requirements of USASI N5.10-1968, "Classification of Sealed Radioactive Sources," or the requirements in paragraph (c) or (d) of this section.
- (c) For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well logging applications if it meets the oil-well logging requirements of ANSI/HPS N43.6-1997, "Sealed Radioactive Sources-Classification."
- (d) For a sealed source manufactured after July 14, 1989, a licensee may use the sealed source, for use in well logging applications, if—
- (1) The sealed source's prototype has been tested and found to maintain its integrity after each of the following tests:
 - (i) Temperature. The test source must be held at -40°C for 20 minutes, 600°C for 1 hour, and then be subject to a thermal shock test with a temperature drop from 600°C to 20°C within 15 seconds.
 - (ii) Impact Test. A 5 kg steel hammer, 2.5 cm in diameter, must be dropped from a height of 1 m onto the test source.
 - (iii) Vibration test. The test source must be subject to a vibration from 25 Hz to 500 Hz at 5 g amplitude for 30 minutes.
 - (iv) Puncture test. A 1 gram hammer and pin, 0.3 cm pin diameter, must be dropped from a height of 1 m onto the test source.
 - (v) Pressure test. The test source must be subject to an external pressure of 1.695×10^7 pascals [24,600 pounds per square inch absolute].
- (e) The requirements in paragraph (a), (b), (c), and (d) of this section do not apply to sealed sources that contain licensed material in gaseous form.
- (f) The requirements in paragraphs (a), (b), (c), and (d) of this section do not apply to energy compensation sources (ECS). ECSs must be registered with the Commission under § 32.210 of this chapter or with an Agreement State.

Key Criteria Well Logging Sources

§10 CFR 39.41 Design and performance criteria for sources

- Doubly Encapsulated;
- Insoluble and Non-Dispersible as practical; and
- Meets Requirements
 - USASI N5.10-1968, “ or
 - ANSI/HPS N43.6-1997
- Maintains Integrity after each of the following tests:
 - (i) **Temperature** - held at -40°C for 20 minutes, 600°C for 1 hour, and then be subject to a thermal shock test
 - (ii) **Impact Test** - 5 kg steel hammer, 2.5 cm in diameter, must be dropped from a height of 1 m
 - (iii) **Vibration test** - subject to a vibration from 25 Hz to 500 Hz at 5 g amplitude for 30 minutes
 - (iv) **Puncture test** - A 1 gram hammer and pin, 0.3 cm pin diameter, must be dropped from a height of 1 m
 - (v) **Pressure test** - subject to an external pressure of 1.695×10^7 pascals [24,600 pounds per square inch absolute]

***Note: The requirements in paragraphs (a), (b), (c), and (d) of this section do not apply to energy compensation sources (ECS). ECSs must be registered with the Commission under § 32.210 of this chapter or with an Agreement State.

Source Classification

ANSI / ISO 97E66646



Radioactive Sealed Source Certificate and Test Report

AEA Technology
QSA Inc.

40 North Avenue

Burlington, MA 01803

Telephone (781) 272-2000

Telephone (800) 815-1383

Facsimile (781) 273-2216

Model: *AMN.CY1*

Radionuclide: *AM241*

Nominal Activity: *19.000 Ci*

Product Code No: *AMNQ5478*

Description: *Am-241/Be neutron source*

Capsule: *X2151*

ANSI/ISO Classification: *97E66646*

Special Form Certificate No: *GB/391/S-85*

Source Classification

ANSI / ISO 97E66646

- **97** – year of the approval of the ANSI Standard followed to determine the classification.
- **C / E** –
 - **C** would indicate that the activity of the sealed source does not exceed the limit established in Table 3.
 - **E** would indicate that the activity of the source exceeds the limit in Table 3.
- **(1st #) “6”** – performance criteria for temperature.
- **(2nd #) “6”** – performance criteria for external pressure.
- **(3rd #) “6”** – performance criteria for impact.
- **(4th #) “4”** – performance criteria for vibration.
- **(5th #) “6”** – performance criteria for puncture



Radioactive Sealed Source Certificate and Test Report

Model: AMN.CY1 Radionuclide: AM241 Nominal Activity: 19.000 Ci

Product Code No: AMNQ5478

Description: Am-241/Be neutron source

ANSI/ISO Classification: 97E66646

Capsule: X2151

Special Form Certificate No: GB/391/S-85

AEA Technology

QSA Inc.

40 North Avenue

Burlington, MA 01803

Telephone (781) 272-2000

Telephone (800) 815-1383

Facsimile (781) 273-2216

Manufacturer's source certificate

Note: Table 3 is the “Specified Activity Level to Radionuclide Group” from ISO Standard 2919, and relates radiotoxicity (Annex A) to design criteria. Exceeding Table 3 values results in the effect of fire, explosion, corrosion, and radiotoxicity to the design evaluation.

What is the significance of sealed source design for well logging?

Tested and Approved Materials

The results of the testing are noted on the SSDR for:

- Thermal
- Impact
- Vibration
- Puncture
- Pressure

PROTOTYPE TESTING:

The source designs have been tested or assessed in accordance with ISO 2919:1999(E) and given the following performance classifications per ANSI/HPS N43.6-1997:

<u>Model Number</u>	<u>Capsule</u>	<u>ANSI Classification</u>
CDC.CY3	X2170/1	97C6X646
	X2170/2	97C6X646
	X2061/2	97C66646
		97C66646

Sealed source classification - Logging

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	4	3	5	1	1
	Source to be used in device	4	3	5	1	1
Medical	Radiography	3	2	3	1	2
	Gamma teletherapy	5	3	5	2	4
	Brachytherapy (6) ¹⁾	5	3	2	1	1
	Surface applicators ²⁾	4	3	3	1	2
Gamma gauges (medium and high energy)	Unprotected source	4	3	3	3	3
	Source in device	4	3	2	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]	4	3	3	2	3
	Categories II, III and IV ³⁾	5	3	4	2	4
Ion generators ³⁾	Chromatography	3	2	2	1	1
	Static eliminators	2	2	2	2	2
	Smoke detectors ²⁾	3	2	2	2	2

1) Sources of this nature may be subject to severe deformation in use. Manufacturers 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.

Table 1. Classification of sealed source performance

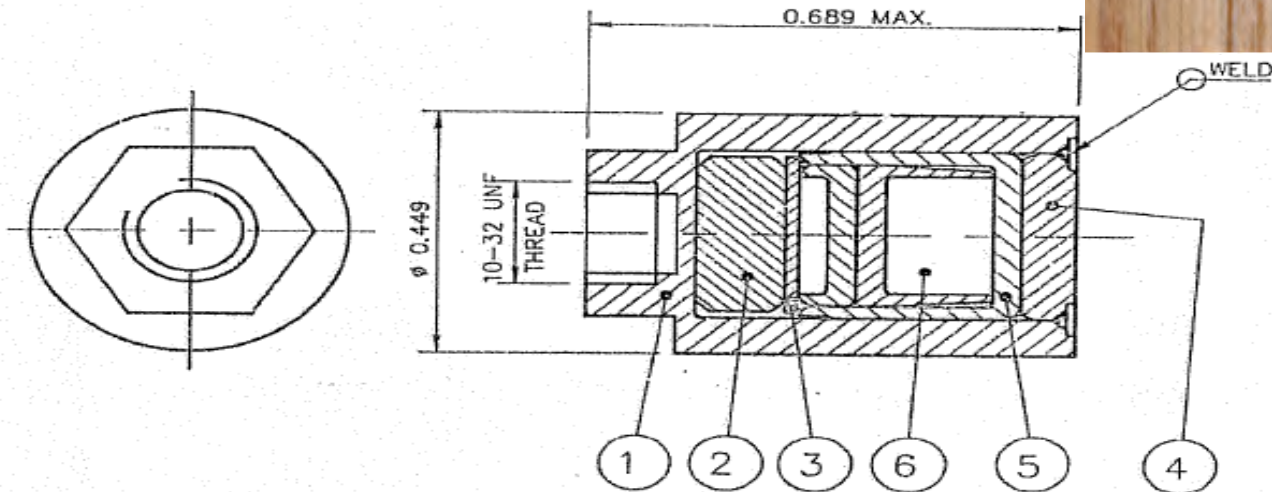
Test	Class						
	1	2	3	4	5	6	X
Temperature	No test	-40°C (20min) +80°C (1 h)	-40°C (20min) + 180°C (1h)	-40°C (20min) + 400°C (1 h) and thermal shock to 20°C	-40°C (20min) +600°C (1h) and thermal shock to 20°C	-40°C (20min) +800°C (1 h) and thermal shock to 20°C	Special test
External pressure	No test	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

A Closer Look...

Well Logging Source (QSA Global)

Model CDC.CY13
(X2112/3 Capsule Code)

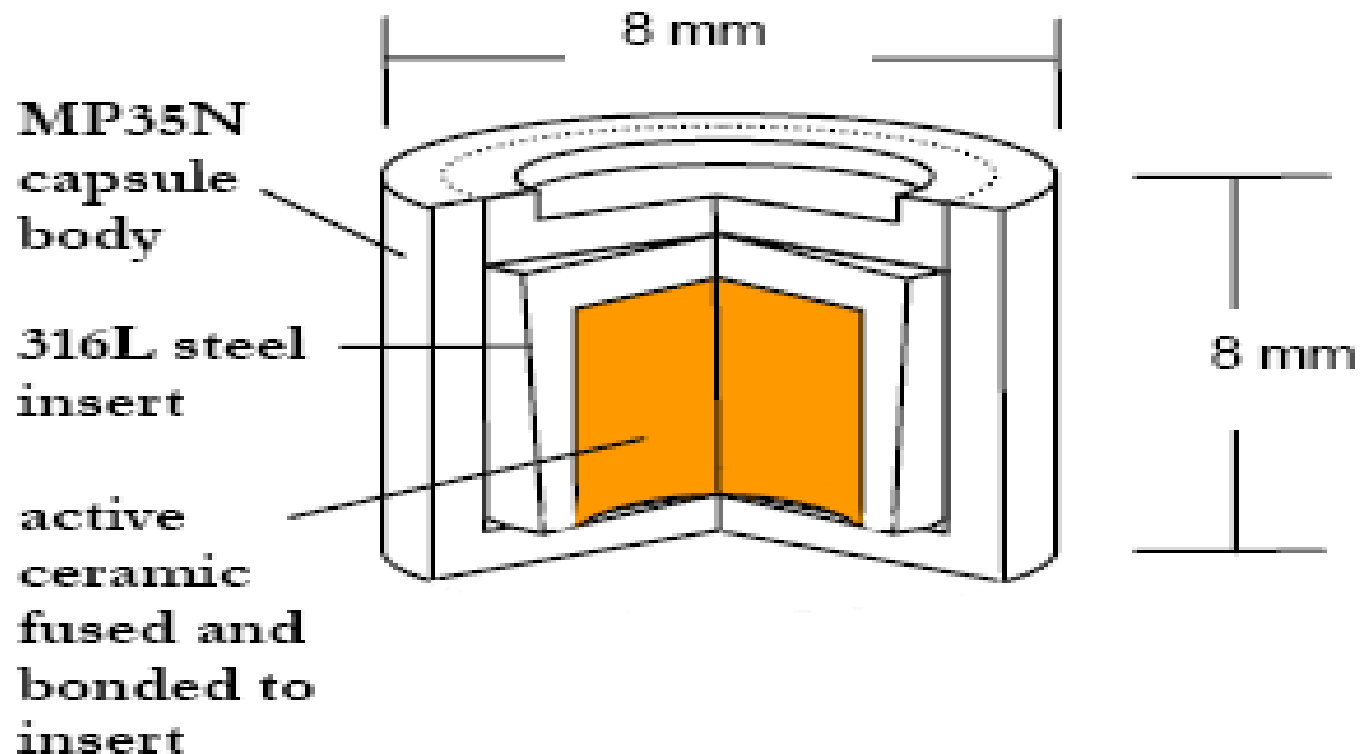
(Dimensions are in inches.)



Item	Description	Material	No off
1	SHEATH BODY	ARMCO	1
2	SPACER	TUNGSTEN	1
3	SHIM	SILVER	1
4	LID	ARMCO	1
5	ASSEMBLY OF CELL X1187		1
6	ACTIVE MATERIAL		—

Inner Capsule for Sealed Source

X1187 Inner encapsulation



Sealed Source Device Registry

- Identifies Registered Device

- Device Type
- Model
- Manufacturer

- Identifies RA Materials

- Isotope
- Maximum Activity

- Specifies Leak Testing

REGISTRY OF RADIOACTIVE SEALED SOURCES AND DEVICES SAFETY EVALUATION OF DEVICE		
NO.: TX058651075	DATE: December 17, 1998	PAGE 1 OF 3
DEVICE TYPE:	Well Logging Source	
MODEL:	NSR-F (H-142108 or H-357068)	
DISTRIBUTOR:	Schlumberger Technology Corporation 300 Schlumberger Drive Sugar Land, TX 77478 (281) 285-8775	
MANUFACTURER:	Gammatron, Inc. 5703 Ethridge Drive Houston, Texas 77087	
ISOTOPE:	Americium-241	MAXIMUM ACTIVITY: 20 Ci (0.74 TBq)
LEAK TEST FREQUENCY:	6 months	
PRINCIPAL USE:	(F) Well Logging	
CUSTOM DEVICE:	YES <input checked="" type="checkbox"/> NO	
CUSTOM USER:		

What is the Significances of Sealed Source Design for Well Logging?

Radioactive material inserted into double / triple encapsulated capsule body, then enclosed in a source housing which is inserted into downhole tools

Well logging sources are:

- rugged
- sealed / encapsulated
- pressure resistant
- temperature resistant
- shock / vibration tolerant
- impact tested
- puncture resistant

Sealed Source Certificate

Source Model

Test Results

Source Serial number

Facsimile: (781) 273-2216

Radioactive Sealed Source Certificate and Test Report

Model: *CDC.CY3* Radionuclide: *CS137* Nominal Activity: *1.78 Ci*
 Product Code No: *CDCK8400* ANSI/ISO Classification: *97C66646*
 Description: *CDCK7426 CS-137 OWL SOURCE IN GPV-Q* Special Form Certificate No: *USA/0630/S-96*
 Capsule: *X2170/2+GPV-Q*

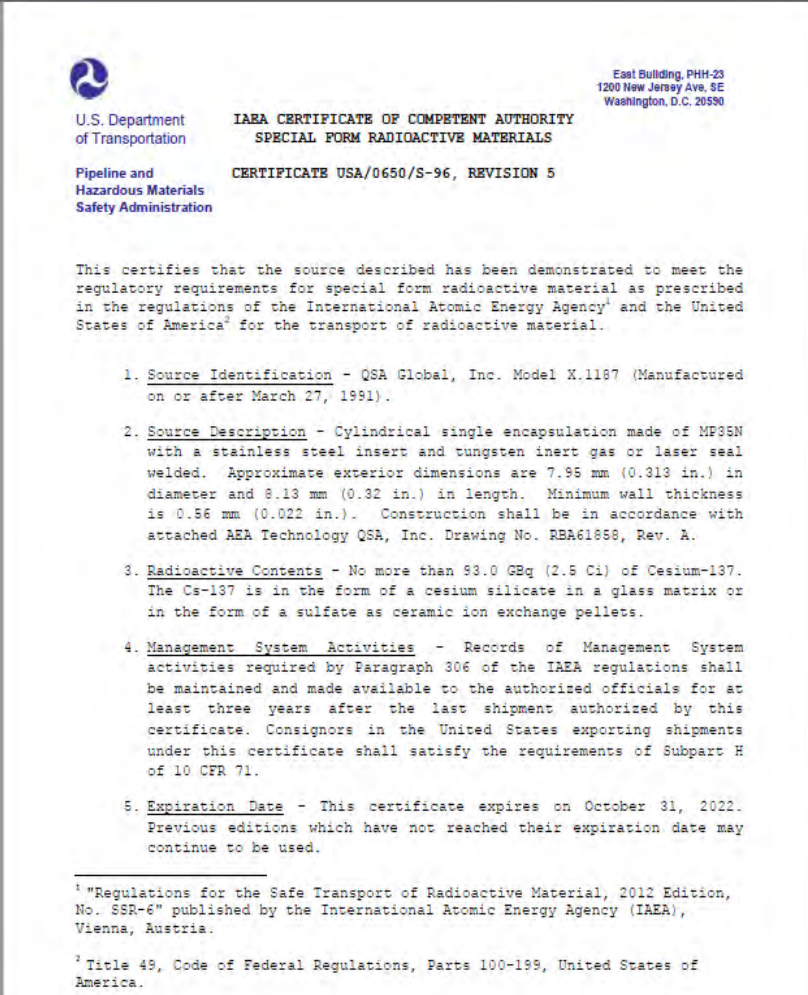
Classifications are based on testing of specimen sources and give the levels expected from the production sources.
 Recommended Working Life: 15 Years
 See other side for explanation.

Source Serial Number	Measurements		Leakage Test		Contamination Test	Other Tests Description
	Measurement	Date	Type Date Passed	Type Date Passed	Type Date Passed	
<i>A5464</i>	<i>1,290 nGy/s (1.61 Ci)</i>	<i>Apr-22-2008</i>	<i>M May-20-2008</i>	<i>D Apr-18-2008</i>	<i>A Oct-06-2008</i>	<i>CPGCS-V 1575</i>

IAEA - Certificate of Competent Authority

“Special Form Certificate”

- Must be presented for air transport (IATA)
 - Tied to a source model
 - Download from RMIS (legacy) documents
-
- ✓ Special form radioactive materials are either:
 - nondispersible solid radioactive material or
 - sealed capsule containing radioactive materials
 - ✓ The Competent Authority (Gov. Agency) certifies that the design specifications have been implemented
 - ✓ Each certificate is assigned an identification mark with VRI/Number/Type Code
 - VRI - Vehicle Registration ID code country issuing
 - Number - assigned by competent authority
 - Type code – S = Special form
 - -96 – “generic” symbol



The image shows a sample of an IAEA Certificate of Competent Authority, Special Form Radioactive Materials. The certificate is issued by the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration. It certifies that the source described has been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in the regulations of the International Atomic Energy Agency and the United States of America for the transport of radioactive material. The certificate includes five numbered sections: 1. Source Identification, 2. Source Description, 3. Radioactive Contents, 4. Management System Activities, and 5. Expiration Date. The certificate expires on October 31, 2022.

U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration

East Building, PHM-23
1200 New Jersey Ave. SE
Washington, D.C. 20550

IAEA CERTIFICATE OF COMPETENT AUTHORITY
SPECIAL FORM RADIOACTIVE MATERIALS

CERTIFICATE USA/0650/S-96, REVISION 5

This certifies that the source described has been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in the regulations of the International Atomic Energy Agency¹ and the United States of America² for the transport of radioactive material.

1. Source Identification - QSA Global, Inc. Model X.1187 (Manufactured on or after March 27, 1991).
2. Source Description - Cylindrical single encapsulation made of MP35N with a stainless steel insert and tungsten inert gas or laser seal welded. Approximate exterior dimensions are 7.95 mm (0.313 in.) in diameter and 8.13 mm (0.32 in.) in length. Minimum wall thickness is 0.56 mm (0.022 in.). Construction shall be in accordance with attached AEA Technology QSA, Inc. Drawing No. RBA61858, Rev. A.
3. Radioactive Contents - No more than 93.0 GBq (2.5 Ci) of Cesium-137. The Cs-137 is in the form of a cesium silicate in a glass matrix or in the form of a sulfate as ceramic ion exchange pellets.
4. Management System Activities - Records of Management System activities required by Paragraph 306 of the IAEA regulations shall be maintained and made available to the authorized officials for at least three years after the last shipment authorized by this certificate. Consignors in the United States exporting shipments under this certificate shall satisfy the requirements of Subpart H of 10 CFR 71.
5. Expiration Date - This certificate expires on October 31, 2022. Previous editions which have not reached their expiration date may continue to be used.

¹ "Regulations for the Safe Transport of Radioactive Material, 2012 Edition, No. SSR-6" published by the International Atomic Energy Agency (IAEA), Vienna, Austria.

² Title 49, Code of Federal Regulations, Parts 100-199, United States of America.

Anatomy of a Gamma Ray Source

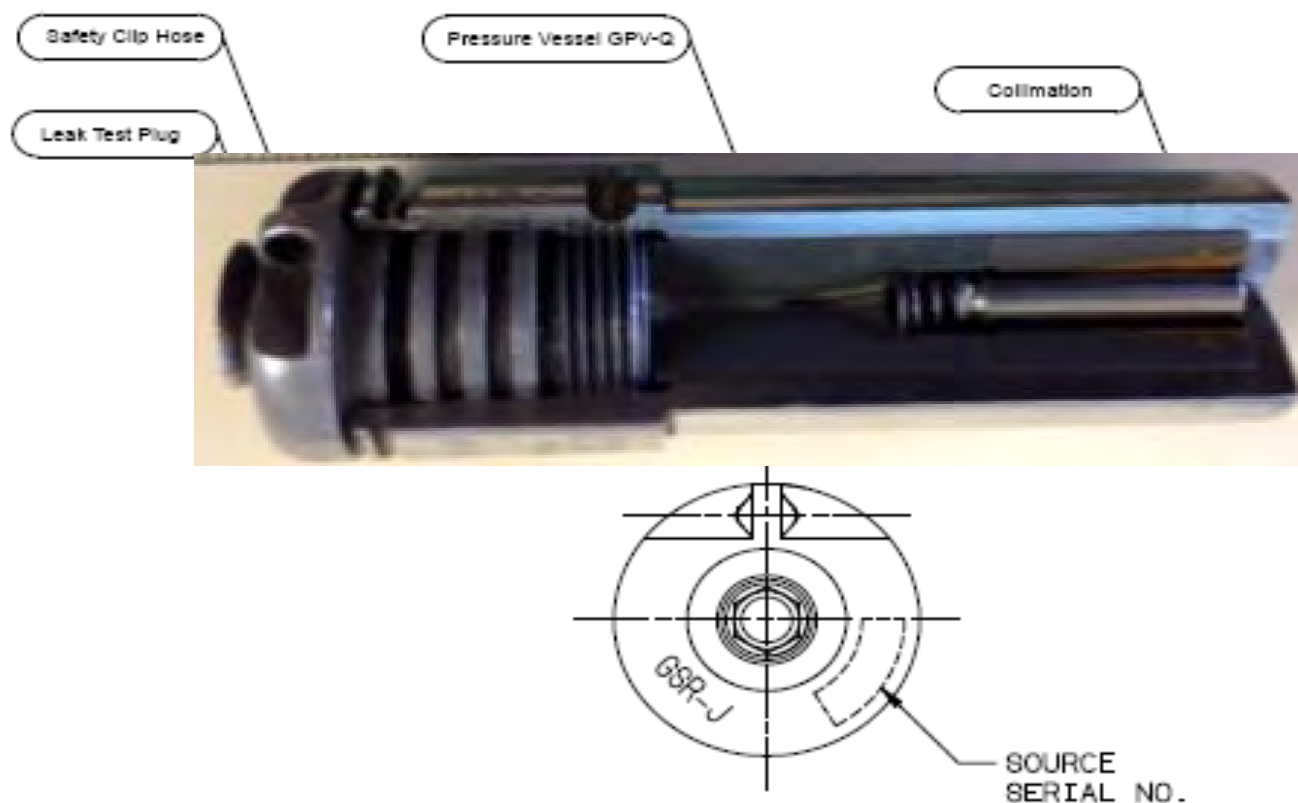


Figure 6-3: GSR-J in GPV-Q (with leak test plug)

What about the Sealed Source Design for Well Services Densitometers?

*** (Note: Not regulated under 10 CFR Part 39)

Sealed Source Classification - Densitometer

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	4	3	5	1	1
	Source to be used in device	4	3	5	1	1
Medical	Radiography	3	2	3	1	2
	Gamma teletherapy	5	3	5	2	4
	Brachytherapy (6) ¹⁾	5	3	2	1	1
	Surface applicators ²⁾	4	3	3	1	2
Gamma gauges	Unprotected source	4	3	3	3	3
	(medium and high energy) Source in device	4	3	2	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]	4	3	3	2	3
	Categories II, III and IV ³⁾	5	3	4	2	4
Ion generators ³⁾	Chromatography	3	2	2	1	1
	Static eliminators	2	2	2	2	2
	Smoke detectors ²⁾	3	2	2	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.

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Table 1. Classification of sealed source performance

Test	Class						
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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
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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 80 to 2000Hz at 196m/s ² 20g _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

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Introduce and review:

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- Where do they come from?
- How are sources made?
- What are the important Source Design Principles?
- What Specifications apply?
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- Who is responsible?
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Questions?

