

Leakage testing of sealed sources

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1 Introduction

- ▶ BAM, as the competent authority in Germany for special form radioactive material approvals and for type testing of sealed sources, has comprehensive knowledge, experience and equipment for leakage testing of sealed sources.
- ▶ BAM uses exclusively leakage test methods by non radioactive means, based on a relationship between volumetric leakage rate and loss of radioactive material according to the International Standard ISO 9978
- ▶ BAM has to assess the boundary conditions and limiting values for applicability of test methods for different source designs
- ▶ BAM started a research programme for leakage testing of sources with a very small void and/or very small leak capillaries.

2 Leakage test methods used by BAM

General remarks: ▶ various source designs require different test methods

- ▶ limiting valves for leaktightness of sealed sources
 - 0.2 kBq activity release after tests according ISO 2919, after manufacturing and in use
 - 2 kBq activity release after tests according to the IAEA regulations TS-R-1 for special form radioactive material
- ▶ 2 kBq is equivalent to $1 \times 10^{-7} \text{ Pa}\cdot\text{m}^3/\text{s}$ (for non leachable solid content) and $1 \times 10^{-5} \text{ Pa}\cdot\text{m}^3/\text{s}$ (for leachable solid content, liquied or gases) [IAEA Advisory Material TS-G-1.1, Para 603.3]



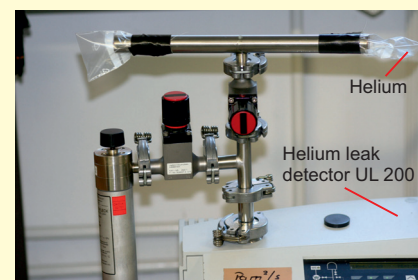
Various sealed sources designs

Helium test



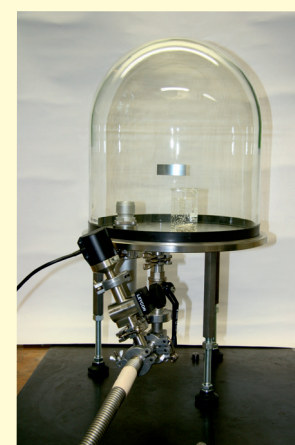
Dummy of a Caesium Cs-137 source prepared with a test adapter

- The object is evacuated and connected to the dedector, the suspect areas are covered by a suitable, gas -tight enclosure filled with Helium.



Leakage test of the weld seams on both sides of the rod source

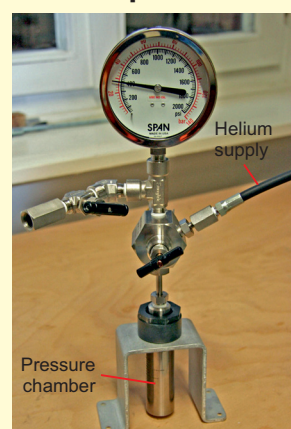
Vacuum bubble test



- Sealed source is to submerge completely in a evacuated fluid (ethylen glycol, isopropylalcohol).
- After reducing absolut pressure in the chamber to between 15 and 25 kPa bubble emanating is to observe for at least 1 min.

Test equipment with vacuum chamber

Helium pressurization test



Helium pressurization test equipment

- Sealed source is placed in the pressure chamber.
- Chamber is pressurized to a given Helium pressure p for a given time t.
- The cleaned sealed source is transfered to a vacuum chamber for Helium leakage rate measurement.

Equation applies for display leakage rate:

$$q_R = (q_L \cdot p/p_0) \cdot (1 - e^{-q_L \cdot t/(p_0 \cdot V)}) \cdot e^{-q_L \cdot T/(p_0 \cdot V)}$$

Equation for determining the Standard Helium leakage rate:

$$q_L = (q_1 \cdot p_0) / p \cdot e^{((\ln q_1 / q_2) / (T_2 - T_1)) \cdot T_1}$$

Liquid nitrogen bubble test



- Sealed source is to immerse in liquid nitrogen for a period of 5 min (ISO 9978).
- After transfer into the test fluid (i.e. methanol, ethylen glycol, isopropylalcohol) bubble emanating is to observe for at least 1 min.
- The detection value is $1.0 \times 10^{-6} \text{ Pa}\cdot\text{m}^3/\text{s}$.

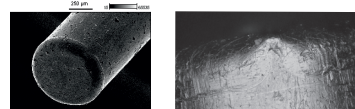
Bubble stream induced by a leak specified by a Standard He-Leakage rate of $5.2 \times 10^{-4} \text{ Pa}\cdot\text{m}^3/\text{s}$

3 BAM research programme on small voids and small capillaries

- Objectives:**
- ▶ Applicability of volumetric leak test methods for smaller voids than specified in Table 1
 - ▶ Boundary conditions for keeping the detection values specified in Table 2



Design of a Ir-129 source for medical use, free volume inside is 0.5 mm^3



Artificial leak by leaving out welding points

Design of the test capsule void is varied from 0.5 to 80 mm^3 and leak size values are varied from by $10^{-4} \text{ Pa}\cdot\text{m}^3/\text{s}$ to $10^{-7} \text{ Pa}\cdot\text{m}^3/\text{s}$

Table 1: Minimum void as a precondition for volumetric leakage test methods [according to IAEA Advisory Material TS-G-1.1]

Leak test method	Minimum void in capsule [mm ³]
Vacuum bubble test	
- Glycol or isopropyl alcohol	10
- Water	40
- Pressurized bubble with isopropyl alcohol	10
Liquid nitrogen bubble	2
Helium pressurization	10

Table 2: Detection and limiting values [according to ISO 9978]

	Standard Helium leakage rate [Pa·m ³ ·s ⁻¹]		
	Detection Value	Limiting value	
		Non leachable content	Leachable or gaseous content
Helium test	$10^{-8} - 10^{-10}$	10^{-6}	10^{-8}
He pressurization test	$10^{-6} - 10^{-8}$	10^{-6}	10^{-8}
Vacuum bubble test	10^{-6}	10^{-6}	unsuitable
Liquid nitrogen bubbletest	10^{-6}	10^{-6}	10^{-6}

First results:

- ▶ He pressurize test for leaks $> 1 \times 10^{-4} \text{ Pa}\cdot\text{m}^3/\text{s}$ is not suitable due to fast escape of Helium.
- ▶ For immersion in liquid nitrogen a period of 5 min is to short for source design with leak sizes $< 1 \times 10^{-4} \text{ Pa}\cdot\text{m}^3/\text{s}$ and voids $< 10 \text{ mm}^3$; significant longer periods up to 90 min could be necessary for bubble emanating.
- ▶ Vacuum bubble test and liquid nitrogen bubble test are applicable also for source designs with smaller voids than specified in Table 2.

