Important aspects in design approval of special form radioactive material

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BAM (Federal Institute for Materials Research and Testing)

9 technical departments and 2 service departments:

1 Analytical Chemistry
2 Chemical Safety Engineering
3 Containment Systems for Dangerous Goods
4 Materials and Environment
5 Materials Engineering
6 Materials Protection and Surface Technologies
7 Safety of Structures
8 Non-Destructive testing
9 Component Safety

S Quality Infrastructure

Z Internal Services

Divisions:
3.1 Dangerous Goods Packaging
3.2 Tanks for Dangerous Goods
3.3 Safety of Transport Containers
3.4 Safety of Storage Containers
BAM is the competent authority in Germany for the approval of special form radioactive material.

BAM has prepared a „Guideline for design approval of special form radioactive material“, which should be published shortly by the Federal Ministry of Transport.

**Special form radioactive material- a category of transport regulations**

*Definition (IAEA, SSR-6, § 239):*

„Special form radioactive material shall mean either an indispersible solid radioactive material or a sealed capsule containing radioactive material.“
Requirements for special form radioactive material

One dimension not less than 5 mm (IAEA, SSR-6, § 602)

Capsule can be opened only by destroying (IAEA, SSR-6, § 604)

Tests (IAEA, SSR-6, § 603, §§ 704 to 711)

- impact test (drop from a height of 9 m)
- percussion test (free drop of 1.4 kg from a height of 1 m)
- heat test (800°C, 10 min)
- bending test

IAEA, TS-G-1.1, § 603.1: ...
…must be able to survive...tests...at any time of its working life.

Quality assurance (IAEA, SSR-6, § 306)

- Quality assurance programmes ...shall be established and implemented for the design, manufacture, testing, documentation, use, maintenance and inspection of all special form radioactive material....

Activity limit permitted in Type A packages is higher (A₁ instead of A₂
Quality assurance- what is checked by BAM?

General measures for quality assurance

- qualification, organization, documentation…

Quality assurance in production

- certification and inspection of safety relevant materials,
- working and test instructions for all important steps of production,
- supervision of measurement and test equipment,
- qualification of staff…

Quality assurance in operation

- instructions for use and maintenance
- specification of a safe life limit
- arrangements before transport,
- feedback about long-term properties…
Common Problems

- leak test methods
- weld seam quality
- safety level after use (or the specification of a safe life limit)
## Limiting condition for volumetric leak tests - a minimum void

Example for a medical source with an inner free volume smaller than 0.5 mm$^3$

<table>
<thead>
<tr>
<th>Leak test method</th>
<th>Minimum void in capsule (mm$^3$)</th>
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<tbody>
<tr>
<td>Vacuum bubble</td>
<td></td>
</tr>
<tr>
<td>glycol or isopropyl alc.</td>
<td>10</td>
</tr>
<tr>
<td>water</td>
<td>40</td>
</tr>
<tr>
<td>pressurized bubble with isoprop alc.</td>
<td>10</td>
</tr>
<tr>
<td>Liquid nitrogen bubble</td>
<td>2</td>
</tr>
<tr>
<td>Helium pressurization</td>
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(Aston, D. at all, *The Specification and Testing of Radioactive Sources Designed as `Special Form` under the IAEA Transport Regulations, Rep. EUR 8053, CEC, Luxembourg (1982)*)
BAM started a research programme with test capsules with changeable free inner volume and artificial leaks.
Weld seam quality

- detailed welding instructions with specification of weld seam geometry,

- specification of maintenance intervals for laserwelding equipment,

- destructive testing in addition to visual inspection and leak test.
Safety during life time

IAEA, TS-G-1.1, § 603.1:

„…special form radioactive material must be able to survive severe mechanical and thermal tests analogous to Type B(U) packages without undue loss or disposal of radioactive material at any time of its working life.“
Fields of application – a wide range of environmental conditions

Medicine
Research Laboratory
Density measurement in cement production
Density measurement in potash mining
Source protective containers after 10 years in an unsoiled environment
Source protective containers after 8 years in brown coal mining
Factors influencing the safe life limit of sealed sources

**Design**
- material
- wall thickness
- welding quality, surface finishing

**Content**
- radiation effects
- pressure built up

**Conditions of use**
- atmosphere (corrosion)
- temperature
- mechanical load
- improper use
Calculation of Gamma Induced Displacements with MCNP (Monte Carlo N- Particle Transport Code)

- done by the Research Centre Dresden-Rossendorf
- calculation models for typical source designs:

- activities up to 100 TBq
- life time 30 years

→ Calculated number of DPA (Displacements per Atom) does not cause steel embrittlement.
A practical validation is desirable.
Assessment of safe life limits for special form radioactive material

- **BAM expects information about:**
  - conditions of use
  - instructions for use and maintenance
  - pre-shipment measures
  - arrangements for getting feedback

- Applicants have to specify the safe life limit.

- Approval certificates should include the safe life limit or a reference to the document where it is specified
Extension or revival of the special form status

- **Basis for an extension can be:**
  - additional risk analysis
  - evaluation of users` experience
  - examination of retrieved sources

- **Basis for a revival for a final transport:**
  - there is no a suitable concept, BAM has so far never reactivated a special form status, a solution should be found in transport by exemption
Conclusion

A detailed audit of quality assurance programmes by the competent authority contributes to guaranteeing the required safety level of special form radioactive material. It can often be a benefit to the applicant - in every case it is a benefit to safety. Our experience in Germany shows that there are only a few incidents with untight sealed special form sources which have been used for a longer time. This demonstrates that our approach is appropriate.
### Types of stainless steel commonly used for source capsules

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<td>X5CrNi18-10</td>
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Corrosion as a property of a system

- **Concentration**
  - Cl\(^{-}\)-content
  - Temperature

- **Medium**
  - pH-value
  - Inhibitor
  - Redoxsystem

- **Material**
  - Composition
  - Surface
  - Microstructure
  - Treatment
  - Element distribution

- **Construction**
  - Gap
  - Heat transfer
  - Stream condition
  - Ventilation

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ISSPA Workshop 2014, Washington
26.02.2014