Review of Material Requirements of the IAEA Transport Regulations for LSA-II and LSA-III

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Classification of LSA Material (Simplified)

LSA-I

- uranium/thorium: ores, natural, depleted
- material with unlimited A_2 value
- material with homogeneous activity concentration ≤ 30 x exempt limit

LSA-II

- water with tritium (< 0.8 TBq/l)
- solids or gases with average activity concentration **≤ 10^{-4} A_2/g**
- liquids with activity concentration ≤ 10^{-5} A_2/g

LSA-III

- solids (excluding powders) with average activity concentration **≤ 2 x 10^{-3} A_2/g**

Differences between LSA-III Material and Solid LSA-II Material

Increased activity content of LSA-III material

- 20-fold average specific activity

Compensating requirements for LSA-III material

- solid material excluding powders
- low solubility (→ leaching test)
- activity homogeneity
  - LSA-II: activity distributed throughout the material
  - LSA-III: activity distributed throughout a solid or collection of solids or activity essentially uniformly distributed in a solid binding agent
- IP-3 package if not under exclusive use

Purpose and Approach of the Review

Questions to be answered

- Is the required leaching test justified with respect to its contribution to transport safety?
- Are the other current material requirements sufficient to justify the 20-fold specific activity limit of LSA-III material (2 x 10^{-3} A_2/g) ?
- Are other additional requirements needed to guarantee a sufficient safety level for the transport of LSA-III material?

Approach

1. Review of accident scenarios for LSA given in TS-G-1.1
2. Dose calculations for transport and handling accidents applying actual knowledge on airborne release behaviour and atmospheric dispersion

Background: Solid LSA-II Specific Activity Limit and the Q System

Reasoning for solid LSA-II specific activity limit

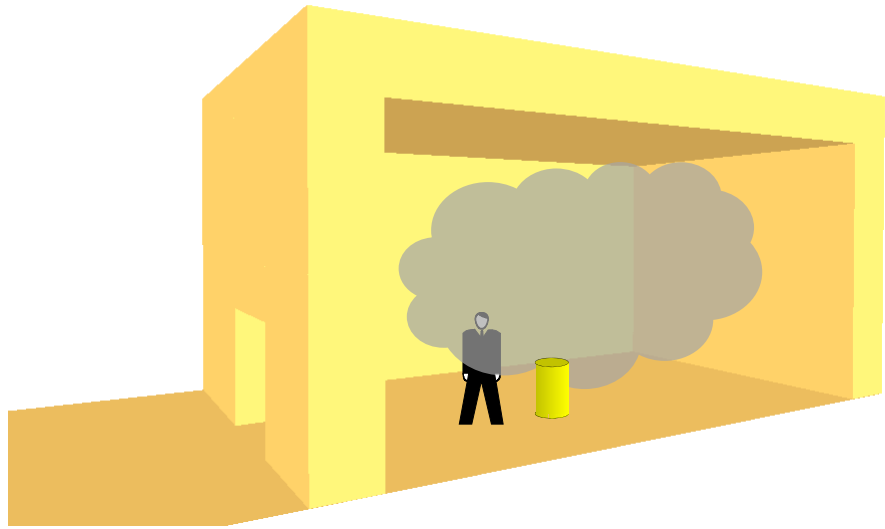
- "[…] it is most unlikely that a person would remain in a dusty atmosphere long enough to inhale more than **10 mg** of material." (TS-G-1.1)
- Q system: activity intake is limited to **10^{-6} A_2**

⇒ specific activity of solid LSA-II up to **10^{-4} A_2/g** is safe.

Q system approach for exposure from inhalation (TS-G-1.1)

- storeroom of 300 m³
- 4 room air changes per hour
- adult breathing rate of 3.3×10^{-4} m³/s
- 30 min of exposure

⇒ uptake factor of approximately **10^{-3}**



The Leaching Test for LSA-III Materials

Scenario given in the Advisory Material TS-G-1.1 (601.2)

- rain entering the package
- material in packaging is surrounded by water for one week
- handling accident → estimated liquid release fraction **10^{-2}** to 10^{-3}
- uptake factor 10^{-4} to **10^{-3}** (see Q system: 300 m³ storeroom)

⇒ Activity content in water must not exceed **0.1 A_2** to limit activity intake to 10^{-6} A_2.

Criticism

- limited plausibility of scenario
  - typical IP-2 and IP-3 packages are rain resistant
  - improbable sequence of events (penetrating rain, 1 week leaching, accident)
- Artificial link to Q system leads to inconsistency with LSA concept (limited specific activity).
- Airborne release from mechanical impact is more relevant than leaching.

Definition of a Transport Accident Scenario

Accident Scenario

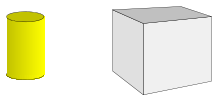
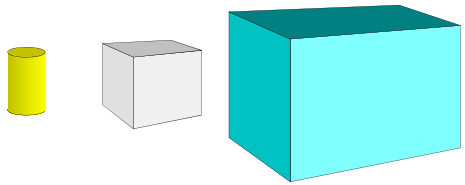
- road or rail accident
- impact as 9 m Type B drop test
- package 200 l, 1 m³, 10 m³
- LSA-II or LSA-III material
- maximum specific activity

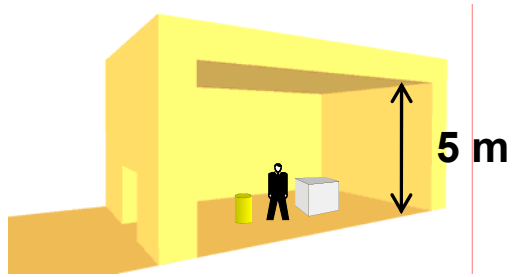
Experimental release data

- drop height up to 27 m
- powders / cement
- with / without cladding
- variation of package dimensions
- measurement of airborne dust concentration

→ release fractions [Lange et al., PTSSRM, 2007]

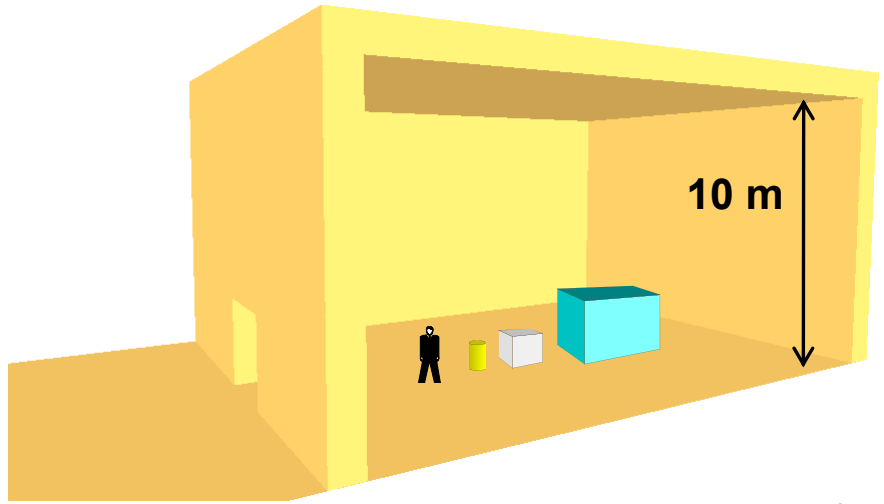
Definition of Handling Accident Scenarios

	Small Storeroom	Large Storeroom
Dimension	10 m x 6 m x 5 m	20 m x 15 m x 10 m
Volume	300 m³	3000 m³
Drop Height	3 m	6 m
Packages	200 l 1 m³ 	200 l 1 m³ 10 m³ 



Assumptions

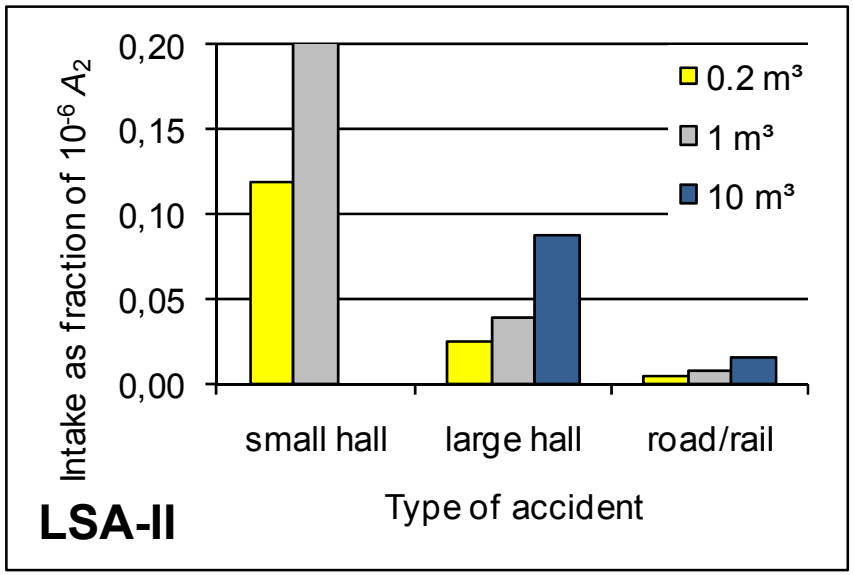
- Package content
  - LSA-II: highly dispersible powder
  - LSA-III: cement
- duration of exposure 5 min (inhalation)

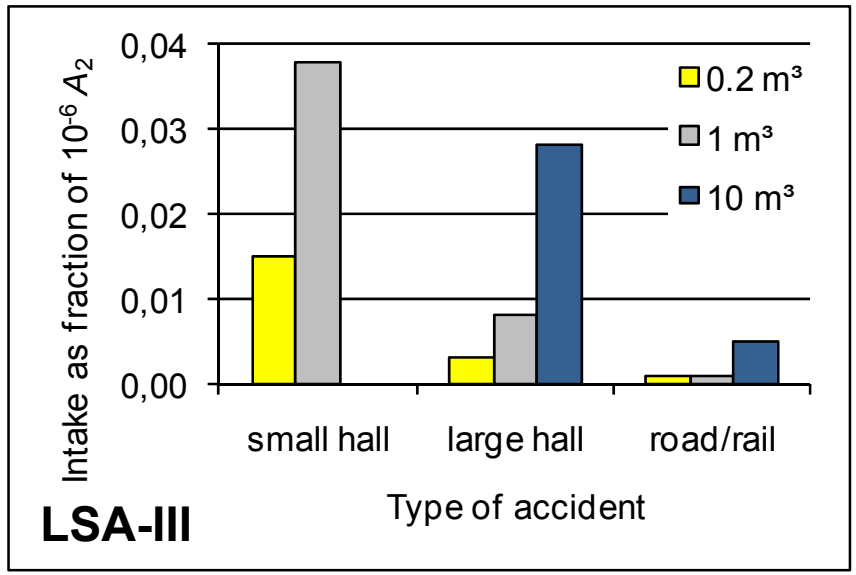


Results of Accident Scenarios

- Activity intake is far below 10^{-6} A_2 (50 mSv) for all scenarios.
- LSA-III results are clearly below LSA-II results.
- The potential effect of limited homogeneity of LSA-III is of no concern.

⇒ Limitation of LSA-III to non-powder solids justifies 20-fold specific activity.





River Immersion Scenario for LSA-III Material

Immersion Scenario

- loss of package on inland waterway
- river with 100 m^3/s
- immersion for 7 days
- assumed activity loss 10 A_2 (10% of conveyance limit)
- 2 l/d drinking water consumption downstream

Results

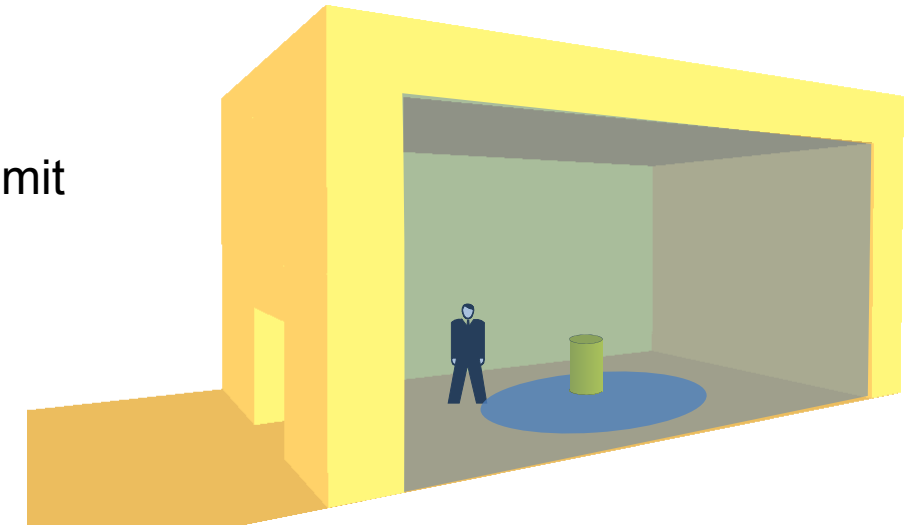
- Potential activity intake 500 m downstream is more than 2 orders of magnitude below 10^{-6} A_2 ($\Rightarrow$ < 1 mSv)

$\Rightarrow$ Even with conservative assumptions the leaching scenario is no relevant hazard.

Handling Accident with Water in LSA-III Package

Storeroom Scenario (300 m³)

- specific activity 10^{-4} A_2/g
  - 10-fold LSA-II liquid activity limit
  - factor 20-1000 above leaching test limit
- handling accident → water spill
- 50% relative humidity from water spill
- 30 min exposure (late detection)



Results

- Potential intake more than 1 order of magnitude below 10^{-6} A_2

⇒ Even with conservative assumptions the leaching scenario is no relevant hazard.

Conclusions

- The limitation of LSA-III material to non-powder solids is sufficient to guarantee a potential exposure from accident release below 50 mSv.
- This statement remains valid even under consideration of a potential non homogeneous activity within the limits of the Advisory Material TS-G-1.1.
- The contribution of the low solubility requirement for LSA-III to transport safety is of minor importance.
- **Therefore, the leaching test for LSA-III material could be omitted without a relevant influence on transport safety.**

Thank you!