Vulnerability Assessment for Sabotage during Nuclear Transport in Germany

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Motivation

Nuclear Security Series No. 13, Nuclear Security Recommendations on Physical Protection of Nuclear Material and Nuclear Facilities:

- Radioactive material has to be protected against unauthorized removal since it could have significant consequences if dispersed or used otherwise for a malicious act.
- …the State should define protection requirements that correspond to the level of potential radiological consequences.
Motivation


![Diagram of physical protection measures flowchart]

**FIG. 1.** Defining physical protection measures to account for all risks.
Revision of German DBT for Nuclear Material Transports

-> major effects with respect to sabotage

Latest revision of associated guidelines (drafts)

-> new categorization scheme

Requirements and measures
### Motivation

Sabotage leads to unacceptable radiological consequences: „Sabotage-relevant (FS)“

### Results in six Categories:

<table>
<thead>
<tr>
<th>Material</th>
<th>Form</th>
<th>Cat. I</th>
<th>Cat. II</th>
<th>Cat. III</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Plutonium³</td>
<td>Unirradiated</td>
<td>2 kg or more</td>
<td>Less than 2 kg but more than 500 g</td>
<td>500 g or less but more than 15 g</td>
</tr>
<tr>
<td>2. Uranium-235</td>
<td>Unirradiated</td>
<td>5 kg or more</td>
<td>Less than 5 kg but more than 1 kg</td>
<td>1 kg or less but more than 15 g</td>
</tr>
<tr>
<td></td>
<td>Uranium enriched to 20% ²³⁵U or more</td>
<td>10 kg or more</td>
<td>Less than 10 kg but more than 1 kg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Uranium enriched to 10% ²³⁵U but less than 20% ²³⁵U</td>
<td>n.a.</td>
<td>10 kg or more</td>
<td>1 kg or less but more than 15 g</td>
</tr>
<tr>
<td></td>
<td>Uranium enriched above natural but less than 10% ²³⁵U</td>
<td>n.a.</td>
<td>n.a.</td>
<td>1 kg or less but more than 15 g</td>
</tr>
<tr>
<td>3. Uranium-233</td>
<td>Unirradiated</td>
<td>2 kg or more</td>
<td>Less than 2 kg but more than 500 g</td>
<td>500 g or less but more than 15 g</td>
</tr>
<tr>
<td>4. Irradiated fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Motivation

Nuclear Material Transport categorized as

Cat I FS
Cat II FS
Cat III FS

-> additional requirements:

- prevent unacceptable consequences
- ...
Motivation

Within licensing process…

… the applicant has to (i. a.)
  - categorize the Nuclear Material Transport,
  - to prove that there are no unacceptable radiological consequences as a result of a sabotage

… the Competent Authority proves with the help of third party experts whether the requirements are fulfilled

For Categorization and for proving effectiveness of additional measures:
Assessing radiological consequences
Assessment of Potential Consequences of Sabotage during Nuclear Transport

First step: Categorization regarding Sabotage

- Sabotage affects cask
- No additional structures are considered
- No measures

Assessment:
- Damage Pattern of:
  - Cask
  - Inventory
- Airborne Release Fraction (ARF) of inventory (respirable aerosols)
- Aerosol transport process from the inside of the cask to the environment
Assessment of Potential Consequences of Sabotage during Nuclear Transport

Second step:
- Determination of dispersion of respirable particles
- Dose calculation
Assessment of Potential Consequences of Sabotage during Nuclear Transport

Definition of boundary conditions:

- What are unacceptable radiological consequences?
- Dose for one person or a group?
- Distance?
- Locations?
- Exposure for which period?
- Velocity of wind?
- Rain?
- …
Assessment of Potential Consequences of Sabotage during Nuclear Transport

If the Nuclear Material Transport is categorized as „sabotage-relevant“ (FS) additional measures have to be added.

One requirement: Unacceptable radiological consequences have to be prevented.
Challenges

Two main questions:

- What could be suitable measures?
- How can the effectiveness of the systems be proved?
Challenges

What could be suitable measures?

- Add as much material around the cask that no sabotage act leads to any radiological consequences
  - Passive measure
  - Heavy
  - Large-sized
  - Heat removal
  - ...

- Add less material around the cask to mitigate the damage of cask and inventory and with this the release of particles
  - Passive measure
  - Maybe heavy
  - Maybe large-sized
  - Sufficiency
  - ...
Challenges

What could be suitable measures?

- Add active systems like sprinkling systems/foams to wash out particles
  - Active system
  - Need of triggering
  - Efficiency
  - …
Challenges

How can the effectiveness of the systems be proved?

- Performing experiments
- Numerical simulations
- Inspections of implemented measures
Summary

- Revision of German DBT for Nuclear Material Transports: Major effects with respect to sabotage
- Revision of guideline (draft): New categorization regarding sabotage followed by new requirements
- Precise assessment of radiological consequences needed
- Challenges resulting from the new regulations (suitable measures, prove efficiency)
Thanks for your attention!