Regulatory Aspects of Clearance and Recycling of Metallic Material forming Part of Buildings of Nuclear Facilities in Germany

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Overview

- Metallic materials as parts of buildings
- Problem / Objective
  - how to perform clearance of these metals without removing them from the building structure
- Clearance regulations in Germany
  - clearance of metals (unconditional and for melting)
  - clearance of buildings
  - comparison
- Strategy for successful clearance of metals as parts of buildings
- Conclusions
Material

- Metallic materials as part of buildings of nuclear installations:
  - reinforcement in concrete
  - anchor slabs
  - pipework buried in concrete
  - steel liners in rooms and in water basins
  - anchor rails that are welded to the reinforcement steel

- These materials
  - remain in the building until the clearance process
  - require special considerations during decommissioning
Objective

- Release as much of this material as possible for recycling
  - by melting in conventional foundries or
  - by melting in a controlled recycling plant for reuse in the nuclear field
- Use only one type of clearance procedure
  - no distinction between
    - clearance process for building surfaces and
    - clearance process for metals on these surfaces
  - this approach saves considerable effort

- This approach is limited to contamination on metal
  - activation requires separate consideration
Problem

- Problem:
  - on the one hand these metallic materials cannot/shall not be removed from the buildings prior to their demolition
  - on the other hand they can only be fully characterised when being removed

- Competent authority has to grant clearance of materials
  - that may not be fully characterised by measurements,
  - but for which a significant part of the information required for clearance is inferred
    - from the operational history
    - from conclusions by analogy
    - from other sources
EXAMPLES
Example: Reinforcement Steel in Concrete
Example:
Steel Liners on Concrete Surfaces
Example:
Pipes embedded in Concrete
Anchor rails
- steel profiles that are tightly fixed to the reinforcement steel
- embedded in concrete
- usually flush with the building surface

Example from a conventional building showing how anchor rails are embedded in concrete walls
CLEARANCE REGULATIONS IN GERMANY
Relevant Parts of the German Clearance Regulations (1)

- Clearance in Radiation Protection Ordinance (*Strahlenschutzverordnung*)
  - general requirements: section 29
  - clearance levels (values): Annex III
  - further requirements: Annex IV

- Clearance levels are laid down in large table in Annex III for each clearance option
  - nuclide specific
  - contains CL values for ~300 nuclides
Relevant Parts of the German Clearance Regulations (2)

- Options for unconditional clearance:
  - of materials for reuse, recycling or disposal including building rubble of less than 1000 Mg/a
  - of building rubble and soil of more than 1000 Mg/a
  - of nuclear sites
  - of buildings for reuse or demolition

- Options for clearance for a specific purpose:
  - of solid materials with up to 100 Mg/a and up to 1,000 Mg/a for disposal on landfills
  - of (solid and liquid) materials with up to 100 Mg/a and up to 1,000 Mg/a for disposal by incineration
  - of buildings for demolition
  - of metal scrap for melting
## Relevant Parts of the German Clearance Regulations (3)

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**Annex III Table 1 RPO**

**Exemptions and clearance levels**

Additional notes:
- Co-60 values highlighted in red for emphasis.
- Extract from Annex III Table 1 RPO.
- Exemption values and clearance levels.
Clearance Regulations in Germany
The Issue with Metals as part of Buildings

Question:
■ What is the problem of clearing metals as part of buildings?

Answer:
■ The differences in the CL values and the differences in requirements for clearance of buildings and of metals!

Question:
■ Why should one try to clear metals in the same way as buildings?

Answer:
■ Because it is much easier to use just one measurement device and clearance method and to treat the metals as part of the building
Clearance Regulations in Germany Buildings (1)

- Clearance options for buildings:
  - for reuse (or dismantling) – unconditional clearance option
  - for dismantling only – no reuse between clearance measurements and dismantling (standard case for NPP)

- Clearance levels:
  - based on EU RP 113/114
  - higher values for clearance for dismantling only apply
  - expressed as values in Bq/cm²
    - activity penetrated into the volume is projected onto the surface
Clearance Regulations in Germany Buildings (2)

- **Averaging area for buildings:**
  - 1 m² for buildings for reuse (unconditional option)
  - > 1 m² (often 10 m²) for buildings for demolition

- **Measurements**
  - usually carried out with (collimated) in situ gamma spectrometry or contamination monitors
  - takes into account penetration depth of contamination into the surface
Clearance Regulations in Germany

Metals

- Clearance options for metals:
  - unconditional clearance – reuse, recycling (and disposal)
  - for recycling by melting only – metal must not be reused before recycling

- Clearance levels:
  - unconditional: general CL of Germany
  - for melting: based on EU RP 89/101/117
  - expressed as values in Bq/g (additional surface related values apply for unconditional clearance)

- Averaging criteria:
  - 1,000 cm² for surface contamination values
  - several 100 kg for mass related CL
How to compare clearance regulations for buildings and metals?

- different types of CL: Bq/cm² vs. Bq/g
- different values of CL: the CL for buildings cannot be converted by a standard factor into CL for metals
  - reason: different scenarios
- different averaging criteria:
  - ~10 m² for buildings vs. 0.1 m² for metals (surface)
  - several 100 kg for metals (bulk)

Solution:

- show that application of CL for buildings also for metals in buildings will not lead to violation of 10 µSv/a dose criterion
STRATEGY FOR CLEARANCE OF METALS AS PART OF BUILDINGS
Clearance of Metals as Part of Buildings
What can happen to the Metal?

- When **metal** is cleared together with the **building**, it will be dismantled together with the building structure.
- Dismantling will **destroy** the metal structure and render it **unsuitable** for direct **reuse**.
  - **Metal** has to be brought to **recycling** by **melting**.

Example: conventional building demolition.
Clearance of Metals as Part of Buildings
Relation of both Sets of CL (1)

- Assumption:
  - contamination on metal surface equals CL for buildings (expressed in Bq/cm²)
- What is the mass related activity of the metal (Bq/g)?
  - depends on thickness! ($\rho = 7.8 \text{ g/cm}^3$)

<table>
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<tr>
<th>Nuclide</th>
<th>CL for buildings, demol. [Bq/cm²]</th>
<th>metals, recycl. [Bq/g]</th>
<th>Activity in [Bq/g] for a thickness of</th>
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<td>Sr-90+</td>
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Clearance of Metals as Part of Buildings
Relation of both Sets of CL (2)

- Result of comparison:
  - if the nuclide vector is rich in Co-60 and thickness of the metal \( \geq 7 \) mm:
    - even if CL for buildings (3 Bq/cm\(^2\) for Co-60) is fully exhausted, the CL for metals are complied with

- But what if the metal
  - is thinner than 7 mm or
  - has a nuclide vector rich in Cs-137+?
    - then a more detailed line of argument is required!
1) What is the total activity on metals remaining in the building of an NPP?
   ■ assume overall area covered with metal structures in an NPP building to be cleared as around 1,000 m²
   ■ assume that CL for buildings are fully exhausted and that the nuclide vector is rich in Cs-137+ (unfavourable case)
   ■ total activity around 70 MBq
   ■ total mass around 78 Mg (1 cm thickness, \( \rho = 7.8 \text{ g/cm}^3 \))

2) Real activity will be much smaller than 70 MBq
   ■ calibration of the measurement instruments
   ■ nuclide vector uses conservative activity composition (overestimation of real activity)
   ■ clearance measurements will never exhaust CL by 100 %
3) **Real activity** on metal surfaces will correspond to about 0.4 Bq/g (related to nuclide vector rich in Cs-137+)
   - this is less than the corresponding CL of about 0.6 Bq/g

4) This activity is compatible with the scenarios that have led to the CL for metals for recycling by melting
   - dose criterion 10 µSv/a will be complied with
5) **Averaging criteria** for metals are also complied with:

- example:
  - averaging area 10 m² on building surfaces
  - thickness of wall cladding 0.5 cm
  - one measurement covers 390 kg of metal
  - compatible with assumptions in RP 89

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<th>Thickness [cm]</th>
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- surface related CL play no role for clearance of metal scrap for recycling
Clearance of Metals as Part of Buildings
Metal inside Building Structures

- What about cross contamination (dust) of metallic structures inside building structures during demolition?
- When building rubble is crushed, reinforcement steel is removed
  - possible cross-contamination from residual activity in dust
- Question: Is this a relevant pathway?
- Answer: No! Assume dust layer of 0.01 cm on steel rod of \( r = 0.5 \) cm:

\[
 f = \frac{2\pi r l d \rho_{dust}}{\pi r^2 l \rho_{iron}} = \frac{2\pi \cdot 0.5 \cdot 0.01 \cdot 2.3}{\pi \cdot 0.5^2 \cdot 7.8} \approx 1 \%
\]

- mass related activity of metal will be less than 1 % of residual activity in rubble
CONCLUSIONS
Conclusions

- **Clearance of metals as part of buildings**
  - significantly simplifies overall clearance procedure
    - no separate procedure for all metallic parts
  - allows continuation of measurements on building surfaces also on metallic objects with same device and same CL

- **Radiological evaluation** shows that
  - compliance with clearance requirements for buildings (CL, averaging area) will also guarantee compliance
  - with clearance requirements for metal scrap for melting

- **Metallic material (scrap) is separated during (conventional) dismantling** of the building
  - will automatically be brought to recycling by melting as it is no longer fit for reuse