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Supplement of

Requirements for inventory models of radioactive waste

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Requirements for inventory models of radioactive waste

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Bundesamt
für die Sicherheit
der nuklearen Entsorgung



Agenda

- Company profile
- Project aim
- Approach & results
 - Type of waste
 - Regulatory framework
 - Requirements of inventory systems
 - Uncertainties & sensitivity
- Summary
- Conclusion



Company profile

Radiation Protection
Nuclear Engineering
Decommissioning



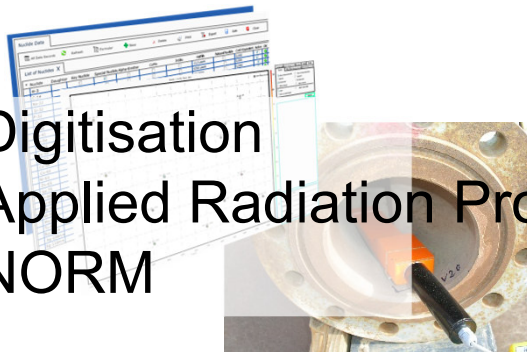
Dismantling
Radiation Measurements
Radiation Protection Officers



Radwaste Disposal
Mining
Environmental Management



Digitisation
Applied Radiation Protection
NORM



Plants
Processes
Energy





Project aim

Background:

Federal Office for the Safety of Nuclear Waste Management (BASE) reviews the **preliminary safety investigations** within the German **site selection** procedure governed by the German Site Selection Act

Tasks:

Development of a **compilation (phase & host rock related) & scientific justification** of the requirements for compiling an inventory model for high-level radioactive waste:

- Mandatory parameters within the inventory model
- General assessments of the existing uncertainties of the inventory data and their potential impact on repository-relevant aspects (sensitivity)

➤ Heat generating waste

B

- Irradiated fuel assemblies
- Irradiated fuel cans

V

- Vitrified reprocessing waste

S

- Other reprocessing waste, e.g. compacted waste

A

- General waste (unless restricted to a specific waste stream)

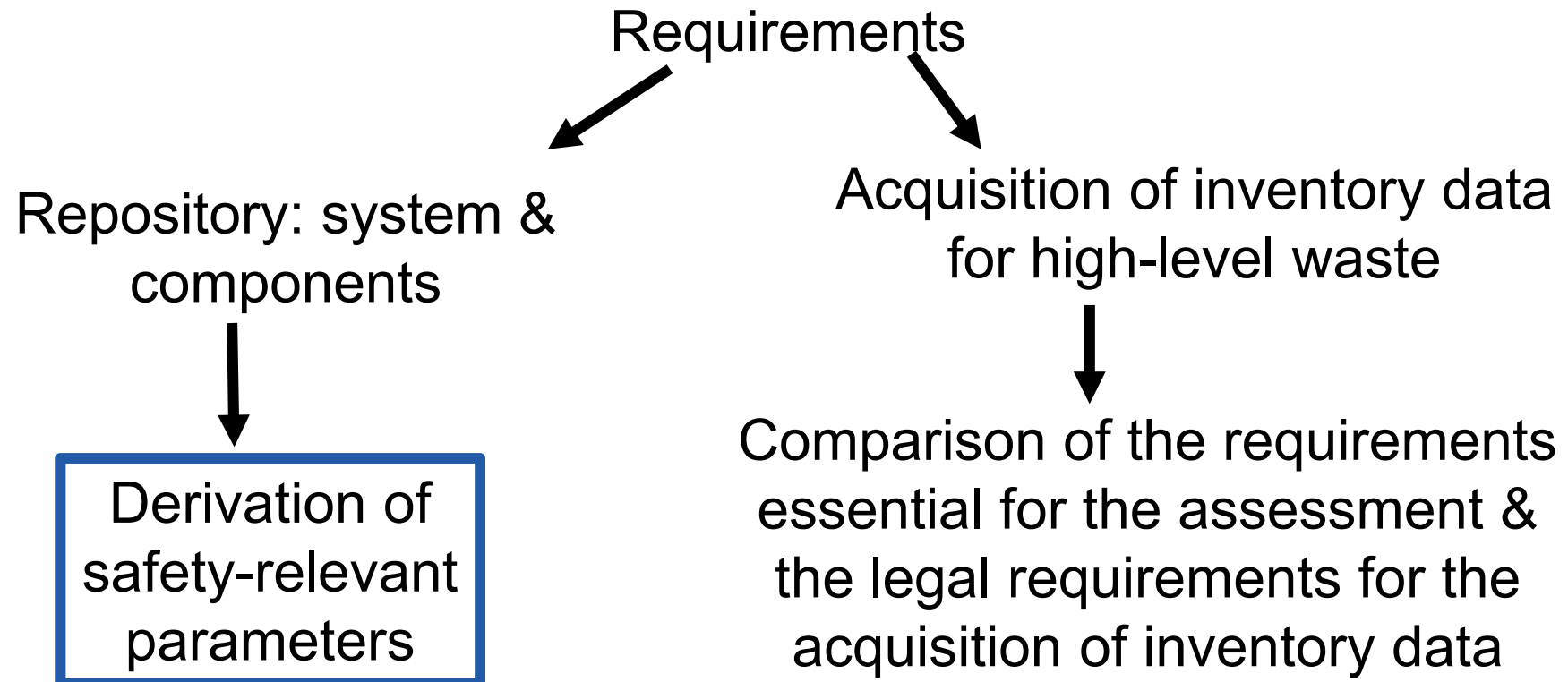


REGULATORY FRAMEWORK



Regulatory Framework





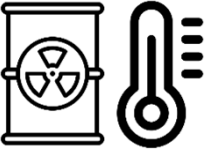
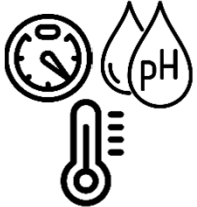
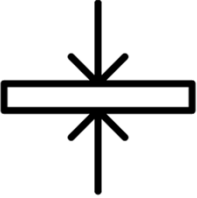
Description of the regulatory framework for the inventory



German laws (e. g. StandAG), sub-statutory regulations (e. g. EndlSiAnfV, AtEV), best-practice docs (ESK, public reports), int. Guidelines (e.g IAEA,NEA)



Safety-relevant parameters

- Effective multiplication factor $\times ?$
- Radionuclide discharge (mass & quantity) from the area of the essential barriers 
- Additional annual effective dose for individuals 
- Body dose  
- Temperature at the container surface 
- Temperatur, pH-value & pressure in the storage area 
- Thickness of the container coating or of the final storage container 



REQUIREMENTS FOR INVENTORY SYSTEMS



Requirements for inventory systems

Development of req. for inventory models corresponding to the state-of-the-art in science & technology (S&T)

National specifications

- FEP-catalogue evaluation
- Impact of extended interim storage

Gorleben preliminary safety analysis (rock salt), ANSICHT (clay rock), CHRISTA (crystalline rock)

Requirements (#58) for inventory models

International requirements

Review on international S&T

Transfer to the German programme

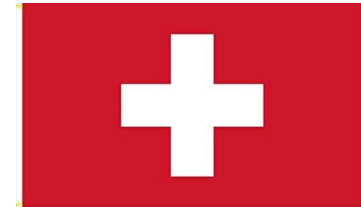
Reports from France, Switzerland, Finland, Sweden, Canada

Transfer of the identified international req. (#279) to the German programme



Requirements for inventory systems: International

Analysis of the international state-of-the-art in S&T (1):



➤ **Long-term safety** requirements (which)



Compliance with safety-relevant parameters

- Radiological (e.g. annual dose)
- non-radiological (e.g. hazard quotient)

➤ Derivation of the requirements for inventory models from **the repository concept & the waste data** (how)

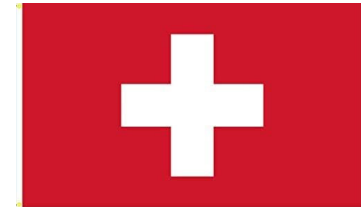


All input parameters of model calculations performed within the framework of the safety analysis



Requirements for inventory systems: International

Analysis of the international state-of-the-art in S&T (1):



➤ Requirements on the **quality & scope** of the inventory data (what)



Knowledge dossiers: Compilation of qualified information on all safety-relevant waste properties

- based on the best available experimental knowledge & expert judgment
- verification according to an accepted QA standard

➤ **Implementation** of the requirements in the programme (how)



Inventory data refer to reference waste or reference containers



Requirements for inventory systems

Requirements for waste-specific inventory data:

Group	Example	# of identified requirements		
		B	V	S
General	<i>waste type, number of fuel rods</i>	5	1	1
Geometrical	<i>volume, length</i>	15	3	3
Physical	<i>mass, density</i>	2	2	2
Material	<i>(component-specific) composition</i>	6	3	4
Chemical	<i>(component-specific) chemical composition</i>	1	1	1
Radiological	<i>(component-specific) radionuclide inventory, total activity</i>	6	4	4
Thermal	<i>decay power</i>	1	1	1

B – fuel assembly V – vitrified reprocessing waste S – other reprocessing waste



Requirements for inventory systems

Further requirements for inventory systems:

Requirements	Group	Example
Reference waste	chemical, geometrical, physical, thermal	<i>fission gas release</i>
Repository containers & their components	geometrical, physical, material, thermal	<i>metal surface size</i>
Final storage package	general, geometrical, material, radiological, thermal	<i>void volume, moisture</i>
Requirements depending on the geochemical environment	chemical	<i>release-specific, e.g. metal corrosion rate</i>
	chemical	<i>transport-specific, e.g. colloid formation</i>



UNCERTAINTIES & SENSITIVITY



Uncertainties & Sensitivity

Assessments of the existing

Uncertainties: inventory data

Sensitivity: potential impact of uncertainties on repository-relevant aspects

Semi-quantitative estimation

Evaluation of the sensitivity

- waste-specific inventory **data uncertainties**
- **bandwidths** (conceptual inaccuracies) of the waste-specific inventory data

- **safety-relevant parameters** with regard to the waste-specific inventory data
- repository design, operation and post-closure phase (**factors**) with regard to the waste-specific inventory data

FEP-catalogue, international state-of-the-art S&T, scientific literature



Uncertainties & Sensitivity

Approach for determining the uncertainties:

1. Development of correlations between the inventory data
 - most important **influencing** and **influenced** variables
2. Semi-quantitative (minor, medium, large) estimation of data uncertainties based on
 - determination method of the respective parameter
 - requirements for the determination method
 - existing information on uncertainties (literature)
3. Semi-quantitative (minor, medium, large) estimation of the bandwidth
 - data availability for the respective parameter

Inventory data	Data uncertainty	Bandwidth
Burn-up of the nuclear fuel	minor	large



Uncertainties & Sensitivity

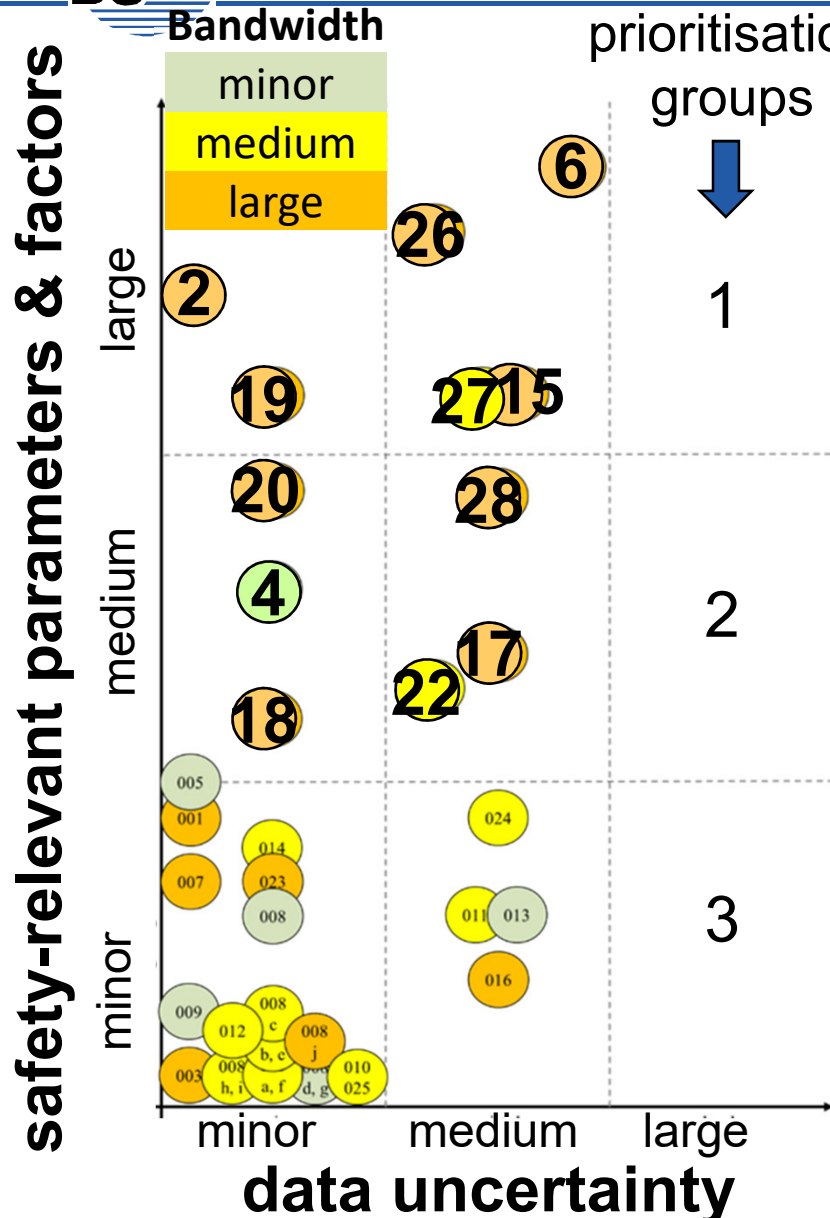
Approach for determining the sensitivity:

1. Identification of
 - safety-relevant parameters with regard to the waste-specific inventory data
→ 7 identified safety-relevant parameters
 - repository design, operation and post-closure phase factors with regard to the waste-specific inventory data
→ 3 identified factors
2. Evaluation of correlations between waste-specific inventory data and safety-relevant target variables or factors (incl. justification)
 - Correlation given? Correlation significant?

Inventory data	Safety-relevant parameters							Factors		
	1	2	3	4	5	6	7	1	2	3
Burn-up of the nuclear fuel	Y	N	Y	Y	Y	Y	Y	Y	Y	Y



Summary: Classification of inventory data into prioritisation groups



Prioritisation group 1

- 6 (component-specific) chemical comp.
- 26 fissile materials & their isotopic comp.
- 2 date of removal from the reactor core (discharge)
- 19 burn-up of the nuclear fuel
- 27 mass of heavy metal
- 15 (component-specific) Rn-inventory

Prioritisation group 2

- 28 decay power
- 20 radiation dose rate
- 4 classification of spent fuel assembly
- 17 gaseous (and volatile) radionuclides
- 22 metals
- 18 (initial) enrichment level



Conclusion

Key data identification of high-level radioactive waste inventories



Safety Assessments

- Site selection earlier stages, e.g. planning
- Repository operational stage
- Repository Closure
- Repository Post-closure & long term



Open questions

- Research needed
 - Instant Release Fraction (IRF)
 - Repository containers
- Determination of uncertainties should not be underestimated



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Report will be available online:



Bundesamt
für die Sicherheit
der nuklearen Entsorgung

[BASE - Abgeschlossene Forschungsprojekte \(bund.de\)](https://www.bund.de)



**THANK YOU FOR YOUR
ATTENTION!**

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