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State of the Scientific and Technical Knowledge about Limiting Temperatures in the Repository Site Selection Process of Germany

with Simultaneous Consideration to Europe and other European Repositories

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Intention and Goal of the study:

The major goal of this research study is to provide a basis for the assessment of specific temperature limits for host rocks **(rock salt, clay, crystalline)** to be applied within the process of site selection in Germany.

§27 (4) Site Selection Act 2017

"(4) For precautionary reasons, a **temperature limit of 100°C** is assumed on the outer surface of the containers with highly radioactive waste as long as the maximum physically possible temperatures in the respective host rocks have not yet been determined due to pending research work."

Examples of Temperature Ranges in National Comparison

Country	Host Rock	Outer Surface of the Waste Container	Buffer/-material	Temperature Regulation Host Rock
Germany	rock salt	100 °C, Site Selection Act 2017 (phase 1)	./.	./.
	clay rock			
	cryst. rock			
Finland	cryst. rock	expected: 95 °C (non-saturated bentonite buffer)	100 °C bentonite buffer	65 °C expected
France	clay rock	90 °C - 100 °C	100 °C bentonite buffer	90 °C (storage cabin)
Switzerland	Opalinus clay	max. 140 °C – 160 °C	125 °C (in the outer space of the bentonite buffer)	70 °C - 95 °C at the border buffer /host rock

Reference: modified after Bracke et al., 2019, urn:nbn:de:0221-2019111520402

Conclusions: (see also attached Poster)

- The repository concepts concerning the maximum temperature on the outer surface of the containers with HLW show significant differences. Depending on the host rock and buffer material, the **temperature varies between 80°C to 230 °C (USA)**.
- **Except for Germany**, national regulations do not define temperature limits; however, general requirements on design temperature were found.
- **There are no regulatory requirements** regarding a specific temperature limit for a final repository without relation to a specific concept of host rock.
- Requirements on **retrievability/recovery** exist, but are not related to temperature limits in a repository.

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National Regulations on Temperatures in other Countries

The object of this research study is to provide a basis for the assessment of specific temperature limits for host rocks to be applied within the process of site selection in Germany (see § 27 (4) Site Selection Act 2017). Therefore, national regulations of thirteen countries were evaluated to compare the requirements on temperature limits and/or on retrievability/recovery.

The study describes the current "repository concepts and temperature settings" of selected countries and provides an overview of considerations on the design of repositories.

Temperature Ranges in National Comparison

Country	Host Rock	Outer Surface of the Waste Container	Buffer/-material	Temperature Regulation Host Rock	Retrievability/ Recovery
Belgium	clay rock	max. 100 °C	< 100 °C for bentonite, expected: 65 °C - 80 °C	expected: 55 °C - 70 °C	retrievability is requested by law
Germany	rock salt	100 °C Site Selection Act 2017 (phase 1)	./.	./.	retrievability is requested by law
	clay rock				
	crystalline rock				
Finland	crystalline rock	expected: 95 °C (non-saturated bentonite buffer) resp. 75 °C (saturated bentonite buffer)	100 °C bentonite buffer	65 °C expected	planning has considered the retrievability in the post-closure phase
France	clay rock	90 °C - 100 °C	100 °C for bentonite	90 °C (storage cabin)	retrievability is requested by law
	crystalline rock	90 °C	90 °C	100 °C	./.
Great Britain	not specified	100 °C (HAW) 50 °C (LLW and ILW)	./.	./.	./.
Japan	crystalline rock	./.	100 °C	./.	repository concept considers also methods of retrievability
Canada	crystalline rock	-50 °C - 100 °C	./.	./.	no
Russia	crystalline rock	./.	100 °C	./.	no
Sweden	crystalline rock	< 100 °C	< 100 °C	./.	no
Switzerland	Opalinus clay	max. 140 °C - 160 °C	125 °C (in the outer space of the bentonite buffer)	70 °C - 95 °C at the border buffer/ host rock	retrievability is requested by law
	crystalline rock	126 °C	103 °C	98 °C	no request for a retrievability concept, at that time
Spain	crystalline rock	./.	100 °C	./.	no
South Korea	crystalline rock	./.	100 °C bentonite buffer, (125 °C)	./.	./.
USA	tuff	230 °C (350 °C – 370 °C inner temp. limit)	no buffer/backfill	200 °C, max. 230 °C	yes

Reference: modified after Bracke et al., 2019, urn:nbn:de:0221-2019111520402

Conclusions

- The repository concepts concerning the maximum temperature on the outer surface of the containers with highly radioactive waste show significant differences. Depending on the host rock and buffer material, the **temperature varies between 80°C to 230 °C**.
- **No temperature limits** were found in **national regulations**, but some general requirements on design temperatures.
- **There are no regulatory requirements** regarding a specific temperature limit for a final repository without relation to a specific concept of host rock.
- Requirements on **retrievability/recovery** exist, but are not related to temperature limits in a repository.

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