

Performance of Elastomer Seals in Transport and Storage casks

M. Jaunich, M. Weber, A. Kömmling, U. Zencker,
D. Wolff, H. Völzke

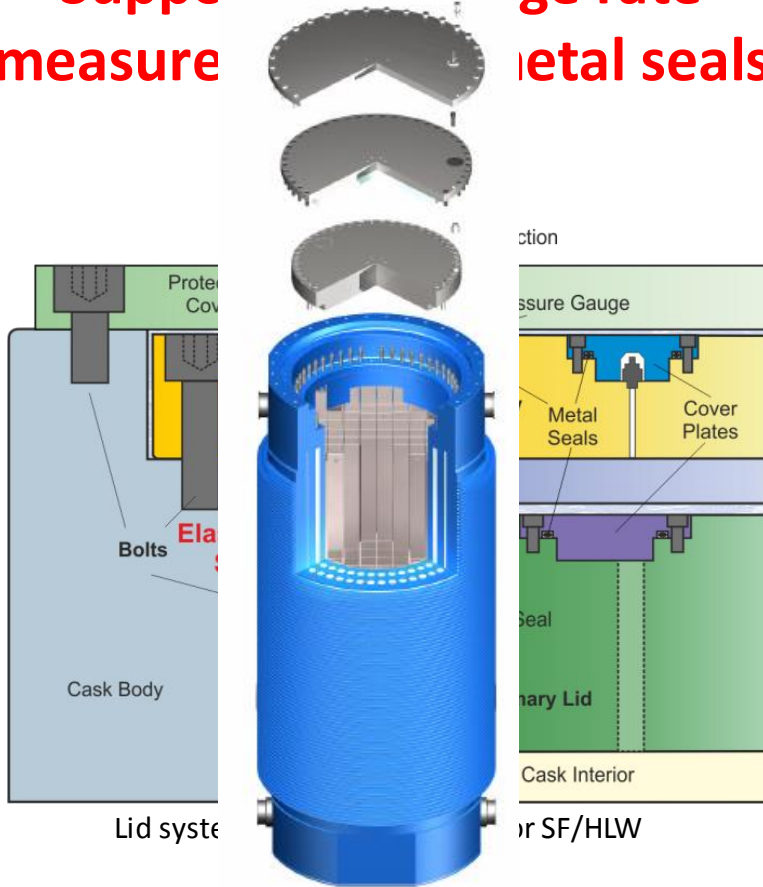
**BAM Federal Institute for Materials Research and Testing
Division 3.4 „Safety of Storage Containers“
Germany**

Outline:

1. Use in Containers / Motivation
2. Behaviour at Low Temperatures
3. Ageing Investigations
4. Numerical Simulation of Elastomer Behaviour
5. Summary

DPC for SF and HLW

Support for leakage rate measure
metal seals



Containers for low and intermediate level waste with negligible heat generation
Closure system - leak tightness

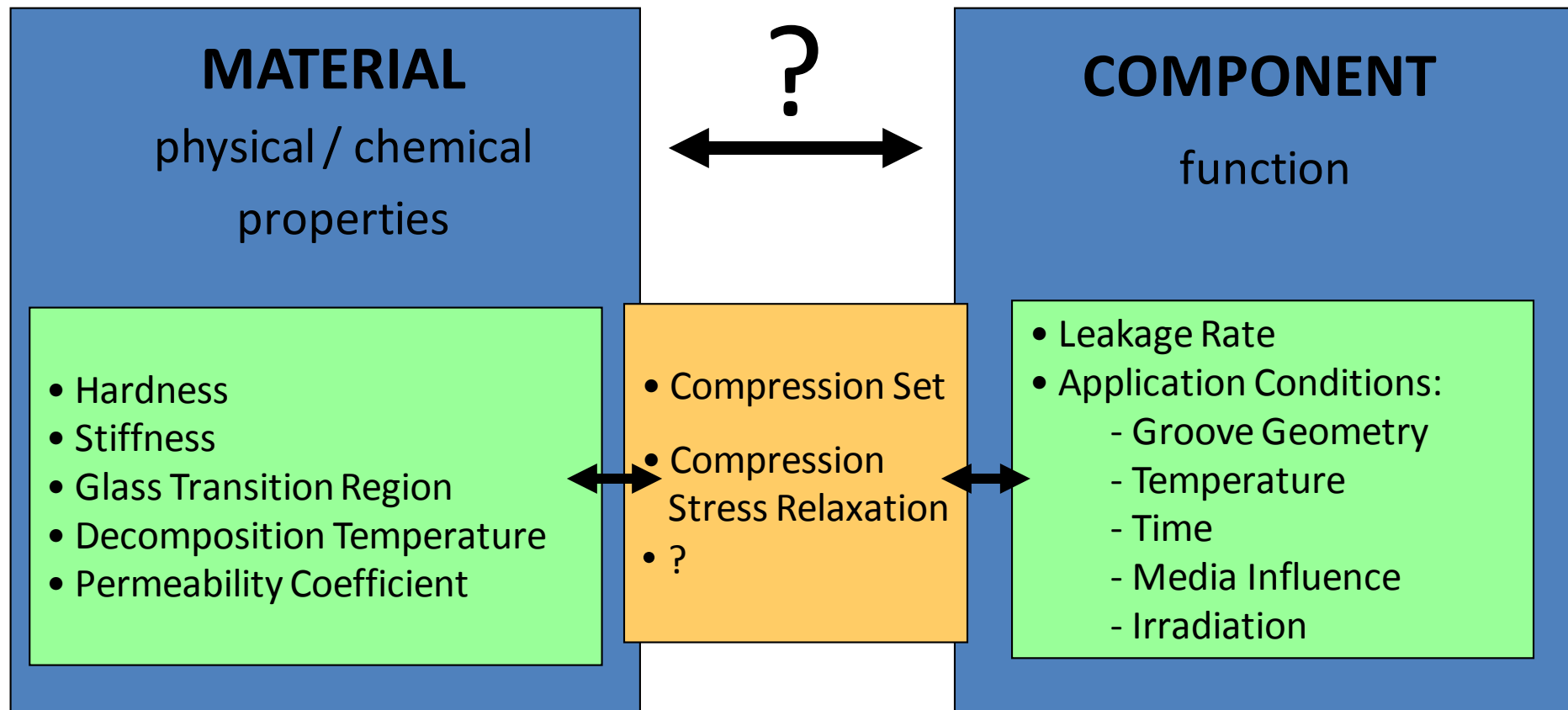


Sources: www.endlagerung.de; www.gns.de

Combination of transport and storage requirements result in the **following challenges**:

- Continuous gamma irradiation
(crosslinking/chain scission)
- Large temperature range
(from -40 °C up to >100 °C)
- Static force conditions
but highly dynamic events possible
- Long-term application (40 years)

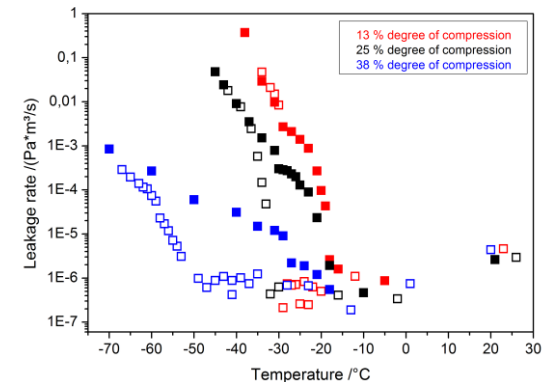
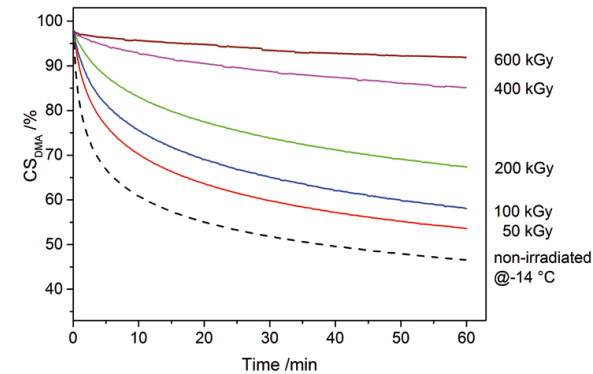
1. Motivation



- develop methods for investigation
- define proper criteria (material selection, ageing evaluation)
- evaluate seals performance

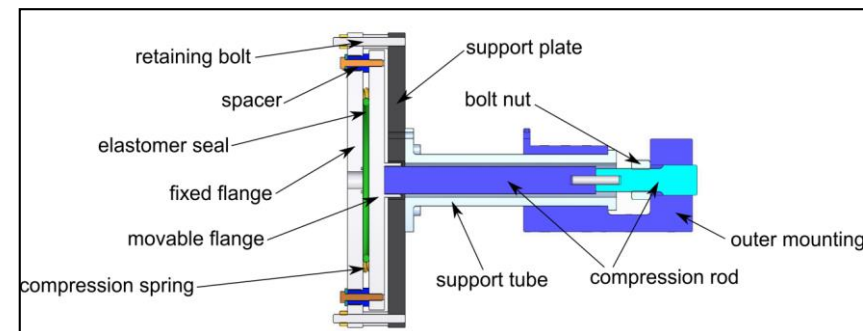
2. Behaviour at Low Temperatures

- For type B(U) packages full performance at $-40\text{ }^{\circ}\text{C}$ is required
- Investigation of:
 - temperature dependence of properties, e.g. Compression Set
 - Description of temperature dependence
 - sealing performance and influencing factors
 - Supercooling for leakage path formation
 - Influence of degree of compression



In addition:

- Equipment for quick partial release
 - quick: within a second
 - partial: from 25 % of compression to 23 % ($<0,2\text{ mm}$)



3. Ageing Investigations – our approach

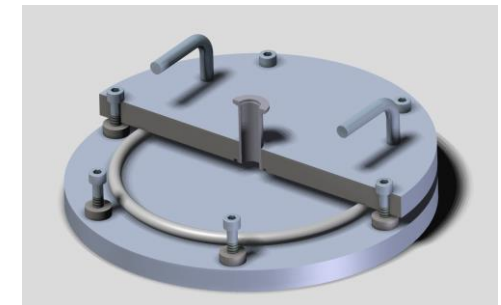
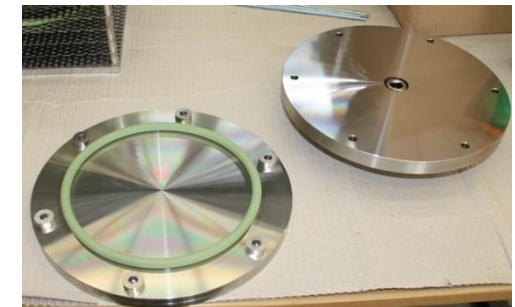
1. Ageing of **uncompressed** O-rings on punched sheets on a rack



2. Ageing **in compression** between plates



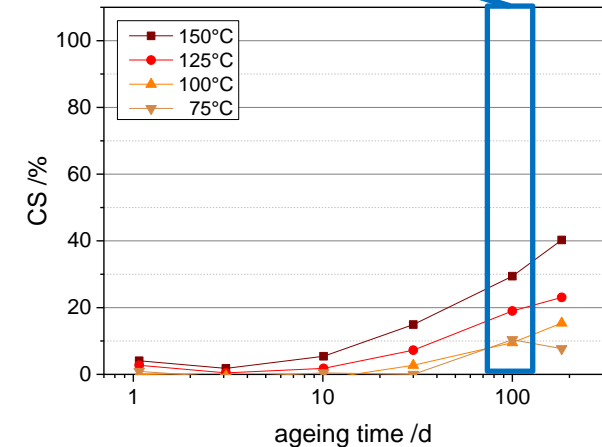
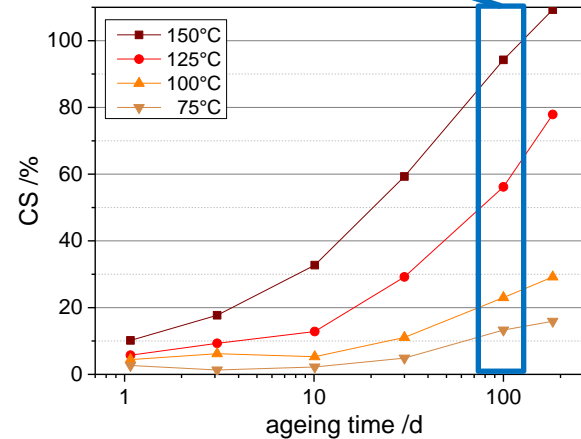
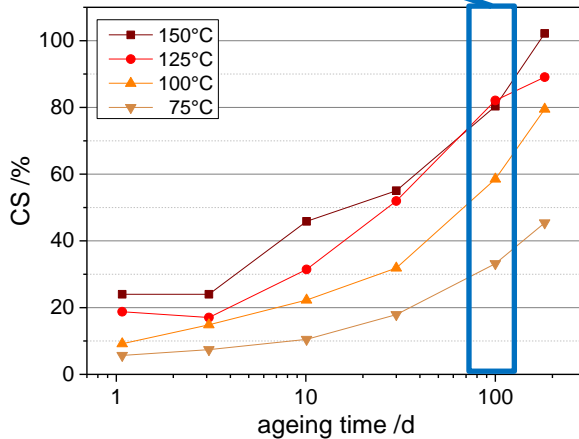
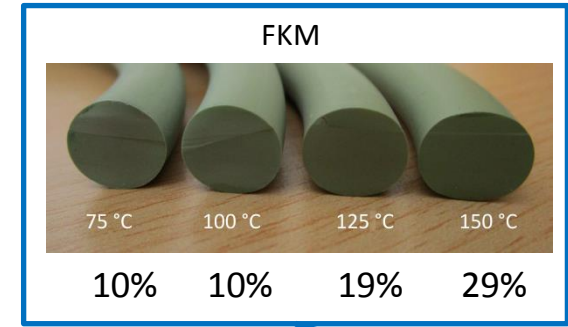
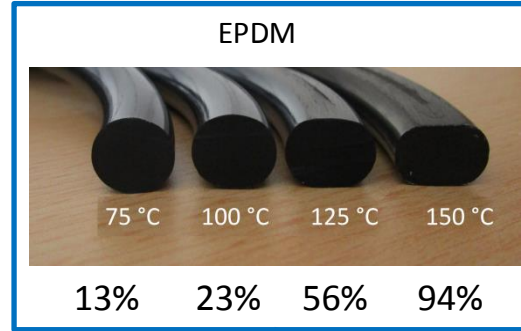
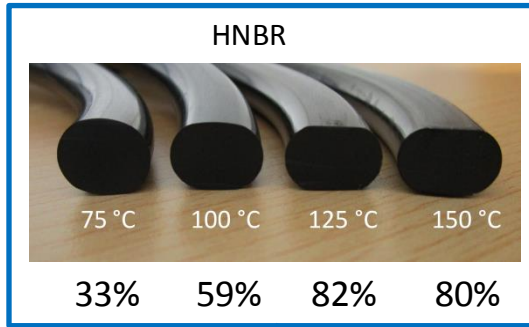
3. Component ageing of compressed O-ring **between flanges** for leakage rate measurements



- Ageing at **4 temperatures**: 75°C, 100°C, 125°C, 150°C
- Ageing periods of **1 day up to 5 years** (at the moment 1 year samples are investigated)

3. Ageing Investigations – exemplary results

Compression set after 100 days of ageing

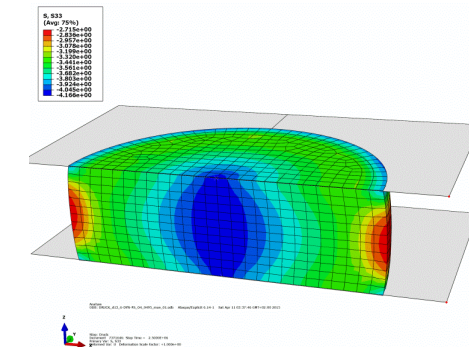
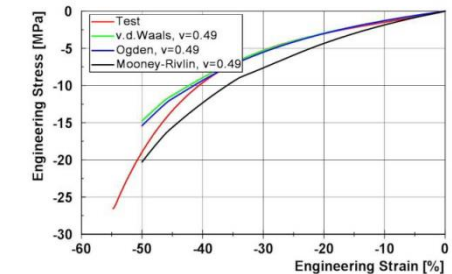
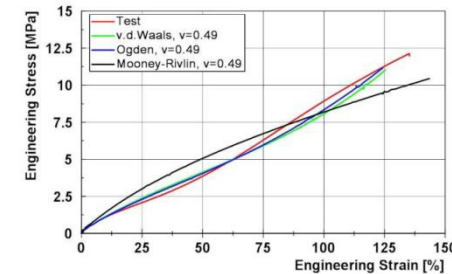


Outcome:

- HNBR and EPDM show strong ageing effects (FKM so far only limited effects)
- indications for inhomogeneous ageing at temperatures $\geq 125^\circ\text{C}$ (HNBR and EPDM)
- **extrapolation attempts - possible acceleration of ageing experiments is limited**

4. Numerical Simulation of Elastomer Behaviour

- **Application of numerical simulation** of cask behaviour under e.g. accident conditions **is increasing**
- To describe seal behaviour a corresponding material model is needed
 - Viscoelastic / hyperelastic behaviour
 - Temperature dependence
 - Strain rate dependence
 - Time dependent relaxation/creep
- Our actual approach includes material tests to generate data for commercial available material models (Ogden, Van der Waals)



5. Conclusion

- ✓ Elastomer seals are important components of transport and storage containers
- ✓ Elastomer seals show a complex material behaviour

- Several aspects are addressed to
 - generate in depth understanding
 - develop suitable methods
 - verify existing approaches
 - close open data gaps

