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CREEP INVESTIGATIONS ON ALUMINUM SEALS FOR APPLICATION IN RADIOACTIVE WASTE CONTAINERS

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In Germany spent nuclear fuel and high level radioactive waste is stored in interim storage containers with double lid systems. Those lids are equipped with metal seals (e.g. Helicoflex®) that ensure the safe enclosure of the inventory. The used metal seals consist of three components as can be seen in the cross-sectional view in Figure 1. The innermost part is a helical spring that is surrounded by an inner jacket made of stainless steel. The outer jacket that is made of a softer material which in case of assembly in the aforementioned storage containers is silver or aluminum (i.e. Al 99.5). During application the seal is compressed and due to the restoring force of the helical spring, the outer jacket is plastically deformed and adapts to the sealing surface. Hence, leakage paths are closed and the sealing function is generated. In Germany the above-mentioned containers are licensed for up to 40 years of interim storage, which in case extended storage becomes necessary before a final repository is available will have to be extended to even longer periods. Therefore, the evaluation of the long-term behavior of the seals is necessary, taking into account storage conditions, decay heat and possible mechanical loads as well.

At Bundesanstalt für Materialforschung und –prüfung (BAM) long-term investigations are being conducted in which seals are assembled in test flanges and aged at temperatures ranging from room temperature to 150°C for accelerated aging. The aged seals are tested semi-annually (after the first 6 months in which the seals are tested more frequently) regarding the sealing performance, the remaining seal force, and the useable resilience upon decompression. Results of these investigations have been published over the past years (e.g. Grelle, Wolff, Probst, Jaunich, & Völzke, 2017; Völzke, Wolff, Probst, Nagelschmidt, & Schulz, 2014). It was found that the seal force and the useable resilience decrease with time and temperature, which is in agreement with the result of other studies (Sassoulas et al., 2006; Wataru et al., 2016) as well. Geometry change of the outer jacket has been identified as the main reason for this seal behavior. At the prevailing operating temperatures and stresses the aluminum is subjected to creep deformation leading to a thinning of the outer jacket. Since the seal groove depth remains unchanged the helical spring expands, which in turn leads to a decrease of the generated spring and seal force.

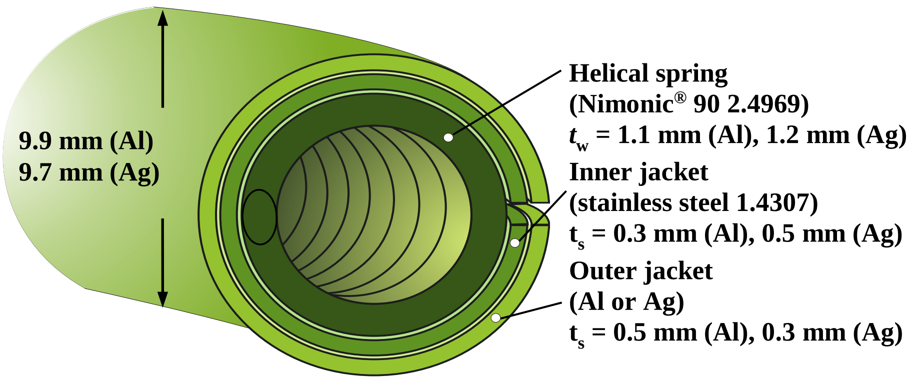

Figure 1. Cross-sectional View of Helicoflex® Metal Seal (according to Probst, Schulz, Jaunich, Wolff, & Voelzke, 2014)

Although the main reason for the change of seal parameters over time and temperature is known, a detailed characterization of the seal behavior and a reliable prediction of the parameter development for aging times that exceed the experimental time frame have not been possible, yet.

For deeper understanding of the aging processes, an investigation program, which is covered in this contribution, is conducted at Bundesanstalt für Materialforschung und –prüfung (BAM) that focusses on the behavior of the aluminum jacket and its influence on the long-term sealing performance. The program investigates properties of material samples as well as the behavior of the seal as a component.

Original sheet material of the same aluminum that is used for manufacturing of the seals is investigated in compression creep tests. For this, a DMA (dynamic mechanical analysis) machine is employed (here used for static tests) that allows for a measurement of the specimens deformation under forces of up to 500 N. The advantage of this method is that the original material can be tested in the same shape as used for the seals which is 0.5 mm thick sheet material. For investigation of tensile creep standard specimens are used, that were machined from surrogate material of the same composition and annealing condition.

Furthermore, aluminum seals that are cut into smaller segments are assembled in flanges and placed in heating chambers at temperatures ranging from 23°C to 150°C. After different periods of time from 3 days to 300 days the segments are taken out of the flanges and are investigated, thus giving information on different states of aging. Measurements of the development of the seal contact width and the aluminum jacket thickness are done with an optical microscope. Further investigations on the segments will include metallography and hardness measurements.

From the detailed material and component behavior including the results of the long-term seal force and useable resilience investigations a better understanding of the overall seal behavior can be gained. The aim is to contribute to the development of material models and analytical approaches for the prediction of the sealing behavior in dependence of time and temperature.

REFERENCES

Grelle, T., Wolff, D., Probst, U., Jaunich, M., & Völzke, H. (2017). *Material Investigation and Long-term Sealing Behavior of Helicoflex® Metal Seals used in Containers for Spent Nuclear Fuel*. Paper presented at the Waste Management Symposia 2017, Phoenix, Arizona, USA.

Probst, U., Schulz, S., Jaunich, M., Wolff, D., & Voelzke, H. (2014). Langzeituntersuchungen an Metalldichtungen für Transport- und Lagerbehälter für radioaktive Stoffe. In F. B. S. Kiefer (Ed.), *Dichtungstechnik Jahrbuch 2014* (pp. 162–173). Deutschland: ISGATEC.

Sassoulas, H., Morice, L., Caplain, P., Rouaud, C., Mirabel, L., & Beal, F. (2006). Ageing of metallic gaskets for spent fuel casks: Century-long life forecast from 25,000-h-long experiments. *Nuclear Engineering and Design, 236*(22), 2411–2417. https://doi.org/10.1016/j.nucengdes.2006.02.008

Völzke, H., Wolff, D., Probst, U., Nagelschmidt, S., & Schulz, S. (2014). Long term performance of metal seals for transport and storage casks. *Packaging, Transport, Storage & Security of Radioactive Material, 25*(1), 8–15. https://doi.org/10.1179/1746510914Y.0000000057

Wataru, M., Shirai, K., Béziat, A., Ledrappier, F., Vulliez, K., Deschamps, B., . . . Hüggenberg, R. (2016). *Ageing of HELICOFLEX® metallic gasket for spent fuel cask: results of sealing performances of a 100,000h campaign*. Paper presented at the 18th International Symposium on the Packaging and Transportation of Radioactive Materials, Kobe, Japan.

KEYWORDS

Aging, Creep, Interim storage, Long-term behavior, Metal seal, Radioactive waste