Experience With the Use of Metallic Gaskets

W. Anspach[1], E. Pollmann[2], H. Weiss[3]

[1]*NUKEM GmbH, Alzenau*
[2]*NUKEM GmbH, Alzenau (until the end of 1988)*
[3]*Busak + Luyken, Stuttgart, Federal Republic of Germany*

INTRODUCTION

In the Federal Republic of Germany a possible path for intermediate storage of spent fuel elements is the use of transport and storage casks.

Intermediate storage of spent fuel in casks is approved for a period not exceeding 40 years. Since this concept for intermediate storage in transport and storage casks technically envisages a zero activity release a significant role is allocated to the cask orifices and their leak-tightness during the storage period.

Only metal gaskets can therefore be considered to ensure long-term leak-thightness.

NUKEM decided at an early stage in favour of the use of HELICOFLEX* metal gaskets, since only this type of gasket possesses, on the one hand, practically all properties of an elastomer gasket with regard to the flexible behaviour, but also assures, on the other hand, the long-term leak-tightness arising from the use of metal materials.

NUKEM now possesses some ten years of experience in the use of metal gaskets on transport and storage casks.

In use, the gaskets have been subjected both to purely static and to dynamic loads at different temperature levels. In detail, the gaskets have been used in the following casks and test programms:

- TN 1300 transport and storage cask /1/.

- TN 900 transport and storage cask.

---

* Trademark of LCL CEFILAC Etanchéité

- NUKEM THTR transport and storage cask.

- TN-AVR 2 transport and storage cask.

- TS 28V transport and storage cask /3/.

- Performance of tests.

STRUCTURE AND CHARACTERISTICS OF METAL GASKETS

Structure of Gasket

The basic structure of the metal gaskets /4/ used in all the cases is mentioned in figure 1 (see appendix).

The gasket consists of an annular helical spring with a single or double metal lining. The sealing effect is obtained from plastic deformation of the metal lining, which possesses a greater deformability than the materials enclosing it. These materials form the flat sealing faces of the flange, and the internal helical spring, the windings of which are located closely adjacent to one another.

The helical spring is designed in such a way that uniform and continuous compression of the metal lining onto the sealing face is assured.

Characteristics of Gasket

The behaviour of the metal gasket /4/ is given in figure 2 (see appendix).

The compression and decompression cycle is characterized by an increasing flattening of the deformation curve. The lack of accordance between the decompression curve and the compression curve can be attributed to hysterisis phenomena in combination with an irreversible deformation.

The elastic restitution is also pointed out. Within this range of compression, tightness of the seal is always guaranteed.

EXPERIENCE

The following is a report of experience in the use of metal seals gained in conjunction with the applications mentioned in the introduction. No special attention is devoted to a specific application, but, rather, the influencing parameters are discussed in general.

Materials Selection/Materials Combination

In discussions with the manufacturer the following gasket structure was selected for the applications envisaged:

- Spring Material

  As material either Inconel X 750 Tl or Nimonic 90 was recommended. Both materials have good relaxation properties and are, furthermore, resistant against corrosion. A low relaxation characteristic is of absolute necessity, in order to ensure an adequately large restoring force in the spring during the storage period, since this is an important parameter of tightness.

- Inner Lining

  Here, stainless steel AiSi 304L or Inconel 600 were selected as materials. There are, in this case, no special considerations requiring attention, unless the stainless steel material is selected for cost reasons.

- Outer Lining

  The manufacturer has, in this context, recommended the materials aluminium and silver as alternatives, in order to achieve the specification. The sealing efficiency can be regarded as identical in both cases.

  In case of silver as outer lining material, higher compression forces must be applied in order to obtain the same sealing effect as with aluminium.

Surface Qualitiy of the Mating Flanges

An essential factor which influences the tightness of the overall system is the surface qualitiy of mating flanges, and that, of course, of the gaskets themselves.

In order to achieve tightnesses of the magnitude specified for intermediate storage greater than 1E-7 mbar l/s for each barrier, the surface roughness characteristic data as shown in table 1 has to be machined, too /4/.

The table 1 shows, that one has to assure a surface roughness between 1.6 μm and 3.2 μm for the selected outer lining.

outer lining	roughness N8 3.2 µm	N7 1.6 µm	N6 0.8 µm
aluminium	x	x	x
silver	x	x	o

x = normal use
o = special use

Table 1: Surface Roughness

This data is to be understood as applying to an axial installation and stressing. An extremely important point for machining is the fact that machining grooves must run only in direction of the gasket line.

For radial installation the manufacturer prescribes surface roughness in the range of:

$$0.4 - 0.8\ \mu m$$

It has, in practice, not proved possible to achieve the required tightness by adjusting only the surface roughness of the mating flanges. The gasket was destroyed during installation. Nor did the use of various lubricants lead to success; here, too, the destruction of the gasket was observed.

Only the application of a Mikroflon coating to the gasket itself and the use of lubricants made it possible to install the gasket safely and achieve the required leakage rate.

The Mikroflon coating proved to be a suitable means to achieve submission of the matel gaskets to circumferencial stressing without causing destruction, and for achievement of the required tightness (in this case, water-tightness).

Examples for installation of gaskets in axial, radial and circumferencial position are given in figure 3 (see appendix).

Installation of the Gasket

In order to ensure optimum efficiency of the metal gaskets, the flanges must always be tightened absolutely uniformly. This is one of the main requirements.

Nature of Stressing

Finally, not only the nature of installation, but also the nature of stressing should be discussed.

All static and quasi-static stresses are absorbed without difficulty by the gasket.

Even under dynamic axial stress (e.g. a drop flat onto the lid side), no difficulties arise with system tightness provided that the loads of the gasket remain within the elastic restitution range (see figure 2). Leaks can occur above this limit value, since it is then, that the sealing principle of plastic deformation of the outer lining is out off operation. It depends on the reason, that the gasket is, naturally, suitable for once-only use.

Under a dynamic radial load (e.g. drop onto the shell or edge of lid) in an axial installation, contradictory requirements result. In order to optimally configure the sealing effect, relatively high roughness figures are required in the axial direction.

On the other hand, extremely smooth surfaces must be selected for radial movement, in order to avoid to the greatest extent possible impairment of sealing efficiency.

Procedure for Thightness Tests

Presentation of tightness testing methods can be dispensed with at this point. However, it is to indicate the difficulties which can occur during the testing of tightness.

Figure 4 (see appendix) illustrates the testing of a barrier gasket. Due to the requirement that the flanges must be uniformly tightened, a metal sealing barrier exists upstream the actual gasket. No, or scarcely any, helium thus acts on the gasket itself.

The procedure for helium leak-tightness test is then thus that the gasket has a compression to a remaining gap of some 0.2 mm, and tightness tested. This value is then used as the acceptance value.

The permissibility of this procedure was determined in tests on small gaskets of identical torus diameter.

In another case mentioned in figure 5 (see appendix), the following problem resulted:

It is necessary to validate the tightness of a gasket which is not subjected with helium from the cavity.

Proof of tightness can be furnished in various ways:

- Injection of helium into the cavity and subsequent placement of the lid in position. Here, however, the problem arises that no defined helium atmosphere can be specified in the cavity (helium chamber). The detection sensitivity is low.
- Use of a double gasket, with the outer gasket having a larger torus

diameter, and consisting of an elastomer material.
With a non-compressed inner gasket and a compressed outer gasket, a defined helium atmosphere can be attained, and the sensitivity of the information obtained enhanced.
The problem with this variant, however, was the fact that the elastomer gasket became saturated with helium. This leads to the effect, that one need a longer time for detection of tightness of the seal.

Therefore, now a third variant was applied:

- Use of a double metal gasket, with, here too, an outer gasket of larger torus diameter.
  This system makes it possible to eliminate all the disadvantages noted, to improve detection sensitivity, and shorten the test itself.

ASSESSMENT

Given consistent application of the experience gained, and taking into account the conditions specified by the manufacturer, the use of metal gaskets for transport and storage casks now presents no further difficulties.

The requirements made with regard to tightness and long-term suitability have been proved.

REFERENCES

/1/ H. Keese et al., "The TN 1300 Transport/Storage Cask System", Proceedings of the 7th International Symposium on Packaging and Transportation of Radioactive Materials, Vol. 1, 1983, pp 242 - 247

/2/ R. Laug et al., "Drop Test of a Type B(U)-Package onto a Real Target Concerning Handling Accident in an Intermediate Storage Facility", Proceedings of the 9th International Symposium on Packaging and Transportation of Radioactive Materials, 1989

/3/ G. Sert et al., "High Capacity Cask (TN 28V) and International Transport Systems for the Return Shipment of Vitrified High-Activity-Waste", Proceedings of the 9th International Symposium on Packaging and Transportation of Radioactive Materials, 1989

/4/ Catalog, Metallic Gaskets
Busak + Luyken, 1988

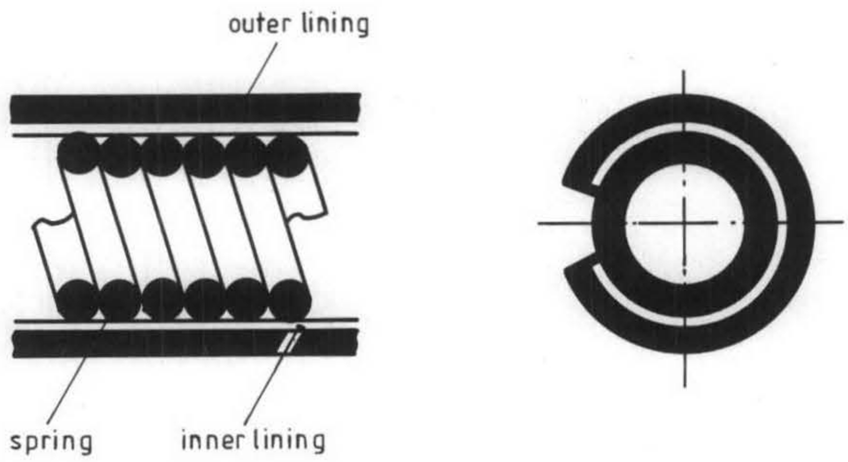

Figure 1 : Cut-away section

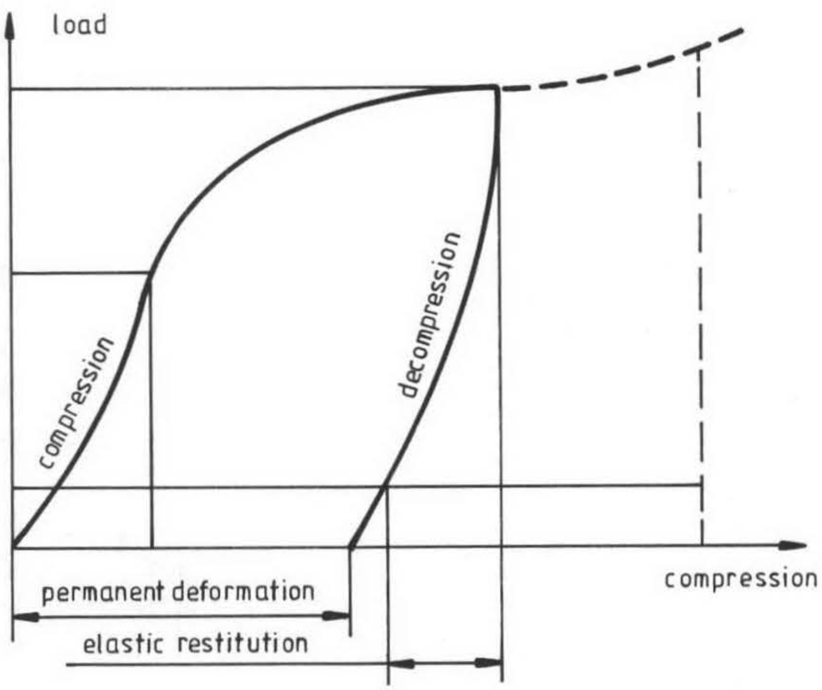

Figure 2: Deformation curve

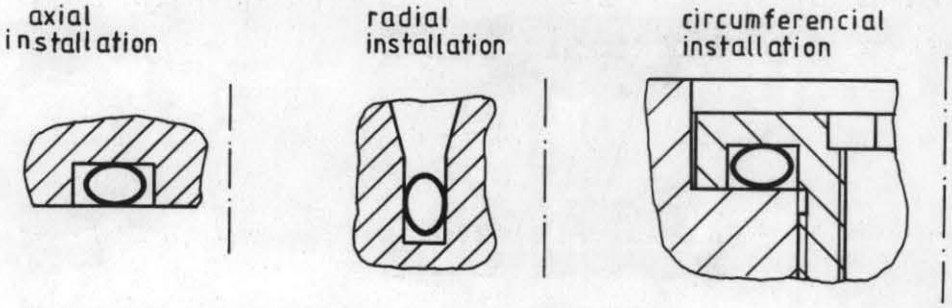

Figure 3 : Examples for installation

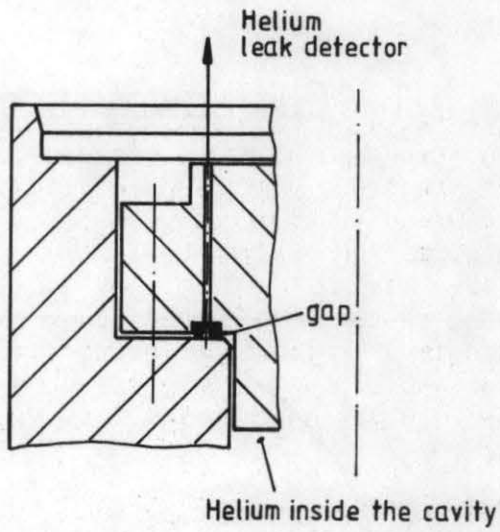

Figure 4 : Check of tightness

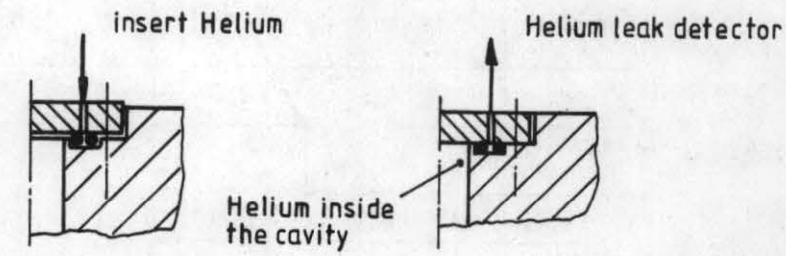

Figure 5 : Check of tightness