EXPERT KNOWLEDGE

FAILURE ANALYSIS

OF ELASTOMER COMPONENTS

SHORT VERSION

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TESTING CONSULTING DEVELOPING

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Incorrect Installation Space –
Details Can Make the Difference

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Installation spaces are required to deform seals in a controlled manner, regardless of the assembly forces (= force shunt principle).
Since elastomers do not have ideal elastic properties, but rather behave viscoelastically, the elastic recovery also depends on the degree of deformation. Too little deformation leads to a faster loss of the elastic recovery. For this reason, static O-rings are deformed or compressed by at least 10%. If the deformation is too high, e.g. 50%, excessive stresses can occur within the seal at elevated temperatures, which can lead to internal stress cracks which then propagate to the outside.
Sharp edges, e.g. unrounded grooves, must be avoided as they can produce small cuts that can propagate under operating conditions.
If the sealing potential of O-rings is to be safely exploited, the structure of the surface (meaning the machining process) should also be specified in addition to the usual surface parameters.

Cross structures to the circumferential direction must be avoided. With dynamic seals, the surface quality should ensure a minimum of friction and wear. In addition to the roughness depth, the contact area percentage is also important. Regardless of the influence of the gap dimensions on eccentricity, it must be ensured that no unacceptable gap penetration occurs under maximum pressure, see **Fig. 1**.

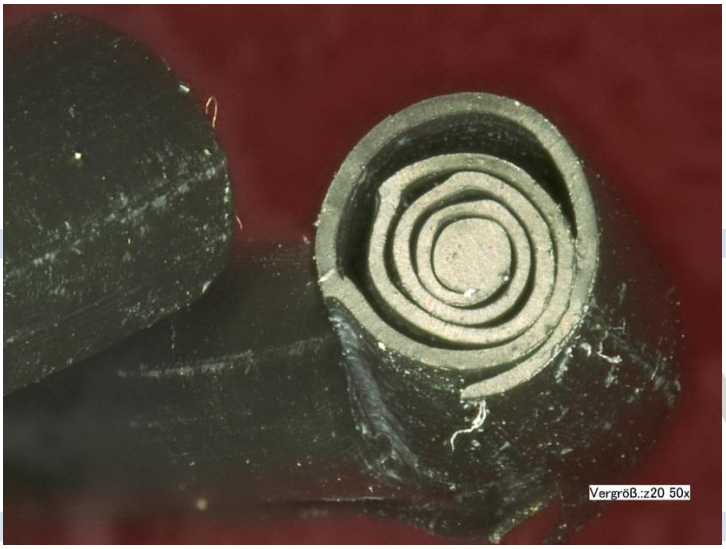

Fig. 1: Effect of a sharp-edged groove design - the O-ring peels off at the groove edge (350 bar pressure, gap 0.05 mm)

Since elastomers can be regarded as incompressible at first approximation, the installation space must always contain more volume than the seal can take in the worst case.

Damage Pattern and Problematic Areas

A typical groove overfill can be recognized by compressed (already during assembly) or frayed edges. Material drives on both sides are typical for this type of damage, see **Fig. 2**.

Fig. 2: O-ring cross-section after a typical groove overfill: The squeezed areas can be seen above and below.

If the deformation is too large, stress cracks appear in **Fig. 3** inside the seal and then propagate outwards.

Fig. 3: EPDM O-ring, destroyed by excessive deformation and thermal impact (stress cracks)

In the case of damage caused by sharp-edged installation spaces, straight-line incisions are often noticeable.
Incorrect installation spaces often lead to failures after rather short operating times. Small leaks (sweat leaks) caused by unsuitable surfaces, on the other hand, often only occur after several hundred hours of operation.

Differentiation from Similar Types of Damage

The damage caused by poor installation spaces can often only be distinguished from the similar damage caused by assembly or manufacturing faults with the aid of the installation space drawing.

Preventative Measures

Probably the most simple and effective preventive measure is the training of seal users, especially in the field of design. Furthermore, existing sealant solutions should not be copied one-to-one for new applications. Even the smallest changes (e.g. change of the surface treatment method) can have severe consequences.

Practical Tips (Testing Possibilities / Standard Recommendations)

There is a wide range of standards including, literature and recommendations from gasket manufacturers for the correct design of installation spaces.
The most important standard for the design of grooves for O-rings is **ISO 3601-2** (Edition 2016-07: Fluid Power Systems – O-rings – Part 2: Housing Dimensions for General Applications). For various other sealant forms there are separate standards.