EXPERT KNOWLEDGE
FAILURE ANALYSIS
OF ELASTOMER COMPONENTS

SHORT VERSION

An offer of

O RING
PRÜFLABOR
RICHTER

TESTING CONSULTING DEVELOPING

Source: www.o-ring-prueflabor.de
Information as of 03/2019

High Permanent Deformation –
If the Gasket is "Stuck"

Authors:
Dipl.-Ing. Bernhard Richter,
Dipl.-Ing. (FH) Ulrich Blobner

A high permanent deformation is the cause of failure if a seal fails significantly before its age-related service life limit or considerably before the user's service life expectancy due to a lack of elastic re-deformation.
A frequent reason for this is insufficient vulcanization, which means a manufacturing defect due to faulty process control. In practice, peroxide crosslinked EPDM and HNBR materials are particularly frequently affected because the degree of crosslinking cannot be significantly improved by post-tempering.
In addition, there may be a significant influence of the polymer in the formulation if it either has a glass transition temperature (TG) too high or if crystalline sequences can form in the polymer structure. This mainly affects FFKM and FEPM as well as special FKM materials (high TG) or HNBR and EPDM materials (crystalline sequences). However, this is relatively easy to detect by carrying out a compression set at elevated temperatures according to ISO 815-1 (e.g.

150°C) using both method A (relaxation at test temperature) and method B (relaxation at room temperature). If the results differ by more than 20-30% points, this can become critical.
A further cause can be found in the formulation if it contains high levels of plasticizers (often with EPDM). If the plasticizers are washed out of a seal by ambient fluids or outgassed, this can also lead to high permanent deformation.
A poor installation space can also cause a failure due to high permanent deformation if the degree of deformation of the gasket is too low due to an over-sized groove depth or a faulty gasket design. Typical for this cause of damage is a permanent deformation (residual height of the seal = groove depth) without a significant increase in hardness.
In the case of an impermissible thermal or chemical impact, a significant increase in hardness often occurs in addition to the permanent deformation. In addition, the gasket breaks even under slight bending stress or shows crack formation.

Damage Pattern and Problematic Areas

It is normal for an elastomer seal to deform permanently under the influence of temperature and mediums. The damage analysis must determine whether this deformation was the cause of a leak. Important characteristics to be analyzed at the damage seal are: remaining seal height in relation to installation space, rubber elasticity, significant change in hardness or volume.

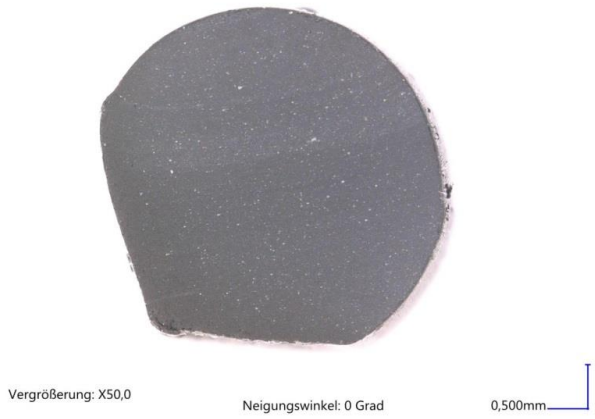

Fig. 1: Cross-section of a damaged O-ring: short-term overheating leads to local flattening in the area of heat input

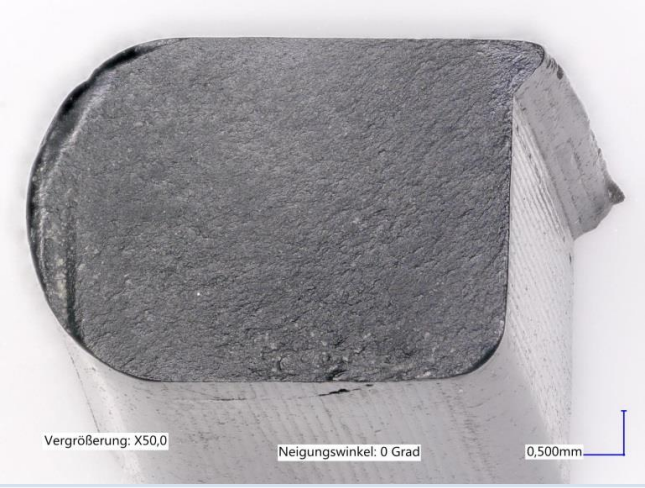

Fig. 2: Permanent deformation and complete embrittlement (see cross-sectional structure) of an O-ring due to thermal overload.

Fig. 3: Permanent deformation of an O-ring due to chemical degradation - the stronger degree of deformation in the left area can be clearly seen (medium side)

Differentiation from Similar Types of Damage

At first glance, the cross-section of an O-ring that has failed due to excessive abrasion can be confused with a high permanent deformation.

Preventative Measures

To avoid this damage, in most cases it is sufficient to deal with four aspects when designing a gasket: temperature/time demand of the gasket, degree of deformation, material and processing quality.
When designing the installation space, it must be ensured that certain minimum degrees of deformation are ensured, for O-rings at least 10%.
In addition, the specifications for formulation properties in ISO 3601-5 can help to maintain an appropriate state of the art.

Practical Tips (Testing Possibilities / Standard Recommendations)

The compression set test (ISO 815-1) is very easy to perform and provides good information as to whether a material has a tendency to high permanent deformation or not. It is also advisable to always define limit values for compression set measurements on finished parts, both according to Method A and Method B.

O-Ring Prüflabor Richter GmbH
Kleinbottwarer Str. 1
71723 Großbottwar

Telefon 07148 / 16602-0
Fax 07148 / 16602-299
info@o-ring-prueflabor.de
www.o-ring-prueflabor.de

Geschäftsführer:
Dipl.-Ing. Bernhard Richter
Ust-ID-Nr. DE 277600966
Steuer-Nr. 71342/02407 FA LB

Sitz der Gesellschaft:
Großbottwar
Amtsgericht Stuttgart
HRB 737482

Volksbank Ludwigsburg
IBAN DE96 6049 0150 0820 5810 03
SWIFT GENODES1LBG