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 02/2017

Thermal Overloading –

Temperature Alone is Rarely the Problem, It's the Wrong Combination of Temperature and Time

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

In contrast to metals, polymers have significantly lower operating temperatures. In the case of polymers, maximum permissible continuous temperatures can be easily defined on the basis of the melting point, whereas, this is somewhat more difficult in the case of elastomers since they do not have a melting point. If the decomposition temperature of elastomers would be the minimum criterion, the permissible operating times would be very short. For this reason, it is generally accepted that the permissible continuous temperature is the temperature at which an elastomer can be used for at least 1000 hours. The minimum criterion is usually the loss of elasticity, meaning that the elongation at break after 1000h in hot air (at the max. continuous operating temperature) must not decrease by more than 50% compared to the initial values.

Damage Pattern

In the event of thermal overloading over long periods of time, the O-ring or seal becomes brittle over the entire cross-section. When bending, the cracks appear preferably on the air side or on the sealing surfaces where the heat was applied.
EPDM compounds, whose base polymer consists only of carbon and hydrogen, usually show a sooty surface after overheating, which slightly stains when rubbed with the finger. Seals made of NBR rubber have a glossy surface after thermal overloading, whereas FKM elastomers bond with the mostly metal counter surface.
Short periods of severe overheating lead to fine deep cracks (scaling or embrittlement only at the edges), which only appear when the seals are pulled or bent, without the seal becoming brittle as a whole. Due to the short period of loading and the insulating effect of the rubber material, the excessive temperature cannot yet visibly damage the inner area.
The damage pattern of "overheating" is not always easy to distinguish from chemical degradation. In the case of chemical degradation, cracks are preferentially found on the product side; the seal itself is often still elastic, but breaks in the event of severe bending or pulling.

Problematic Areas

In the event of long-term overheating, the entire gasket is damaged more homogeneously - as in accelerated hot-air aging. In the case of short-term overheating, only the area where the excessive temperature is applied is often damaged.

Prevention

The following questions can help the practitioner avoid this damage:

- Are the actual temperature loads of the application known?
- What is the maximum continuous operating temperature of my elastomer material?
- Are there temperature peaks? How high, how long?
- Was the overheating caused by lack of lubrication? (e.g. overheating of a mechanical seal at the contact surfaces of the mechanical seal due to dry start-up)
- Does an energy input take place, e.g. by oscillations, which then leads to an internal warming?

Practical Tips

Experience has shown that formulation-related influences are underestimated. Even hot-air aging over 1-2 weeks or correspondingly long compression set trials are sufficient to show whether there is a state-of-the-art standard for the respective formulation (comparison with formulation specifications from ISO 3601-5 is recommended).

Fig. 1: Thermally damaged O-ring, completely hardened, cracks visible on contact surfaces during bending

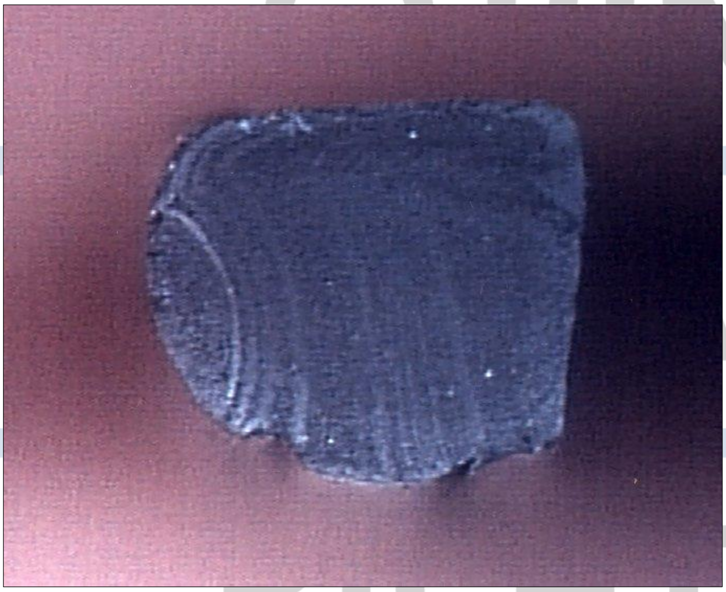

Fig. 2: Cross-section of a heavily overheated O-ring (short operating time) due to dry start-up of a mechanical seal, permanent deformation and only local embrittlement are noticeable, the core is still fully elastic.

Fig. 3: This brittle NBR O-ring shows cracks during bending (circumferential grooves are an impression of the contact surface), differentiation from ozone cracks: Hardening of cracked zones. In the case of ozone or fatigue cracks, there are cracks in the elastomer matrix, which is still elastic here.

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