EXPERT KNOWLEDGE

FAILURE ANALYSIS

OF ELASTOMER COMPONENTS

SHORT VERSION

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TESTING CONSULTING DEVELOPING

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Ozone Cracks –

A Common, but Preventable Cause of Failure

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It has been known for over 150 years that natural rubbers can be severely damaged by ozone from the ambient air, and some synthetic rubbers are also affected by this phenomenon. Despite this knowledge, however, seals damaged by ozone are still often found in the practice. This damage occurs particularly when seals are under tension. Almost all unsaturated diene rubbers (e.g. NBR, SBR, NR, BR, ...) that have double bonds in the main chain are susceptible to ozone cracking. This double bond - recognizable by the "R" in the abbreviation - can be damaged by ozone. An exception is a fully hydrogenated HNBR, which has a relatively good resistance to ozone cracking. M, Q and O rubbers (e.g. FPM, VMQ, ECO), on the other hand, are considered to be good to very good ozone resistant.

Damage Pattern

Ozone cracks always appear perpendicular to the direction of the stress (**Fig. 1**). The cracks are deep and can lead to the tearing of the seal. The damage is irreversible and can only be repaired by replacing the seal. In practice, the damage pattern can easily be confused with other damage patterns: the damage pattern of ozone cracks is similar to the damage pattern of fatigue cracks caused by cyclic dynamic loading (**Fig. 2**). For a damage assessment, the type of stress must be known. Then, a clear differentiation is possible. It is easier to determine seal damage caused by chemical erosion. It can be seen in the greater depth of the cracks and in a stress-dependent, which is normally parallel, orientation of the cracks.

Problematic Areas

Ozone cracks often appear on pre-assembled components if they are directly exposed to ambient air during intermediate storage (see **Fig. 3**). The sealing damage can occur here already after a few days. The consequences are leakages up to a total seal failure (tearing of the seal), which can lead to a failure of the entire system.

Fig. 1: Cracks in statically pre-stretched bellows made of BR/IR elastomer

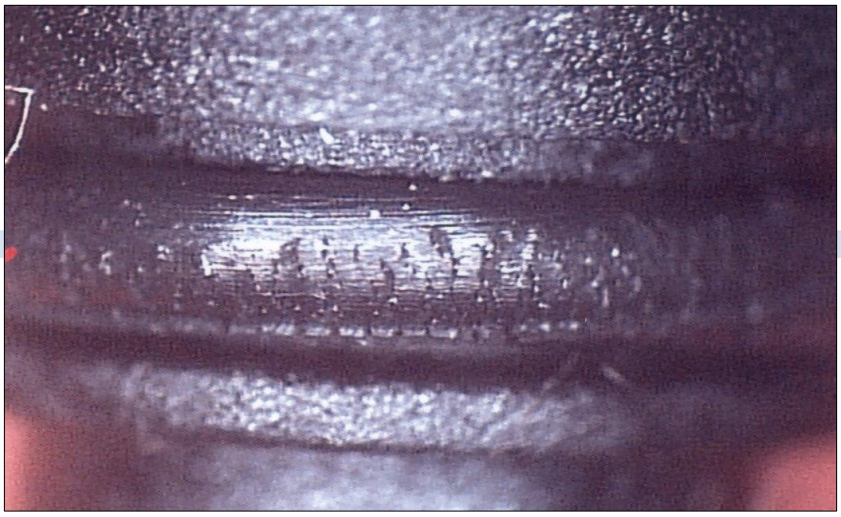

Fig. 2: The ozone cracks resemble fatigue cracks - here ozone cracks using the example of an NBR O-ring

Fig. 3: Pre-assembled NBR O-ring, which after a few weeks of storage became very severely cracked

Prevention

In practice, a number of measures have been proven to be effective which need to be examined on a case-by-case basis:

- Seals with modified rubber formulation (e.g. use of ozone protection agents or ozone protection waxes).
- Seal coatings that reduce ozone susceptibility.
- Blending the damaged rubber with ozone-resistant rubbers or PVC.
- Use of a higher quality and ozone-resistant M, Q or O rubber. The often higher costs usually quickly pay off over longer service lives and system availability.
- Design measures (e.g. reduction of the ambient air inlet to the damaged seal or minimization of the gas inlet by flow of fluids).
- Logistical measures: seals susceptible to ozone cracking should never be stored under tension.

Practical Tips

When using unsaturated elastomers, which are exposed to ambient air in their deformed state over a longer period of time, a resistance test against ozone (ISO 1431) is generally recommended. If possible, the test should be carried out directly on the finished part in order to check the effectiveness of the ozone protection used in the compound.