For further information please contact one of the offices below, or visit our website at www.dupontelastomers.com

Global Headquarters—Wilmington, DE USA
Tel. +1-800-853-5515
+1-302-792-4000
Fax +1-302-792-4450

European Headquarters—Geneva
Tel. +41-22-717-4000
Fax +41-22-717-4001

South & Central America Headquarters—Brazil
Tel. +55-11-4166-8978
Fax +55-11-4166-8989

Asia Pacific Headquarters—Singapore
Tel. +65-6275-9383
Fax +65-6275-9395

Japan Headquarters—Tokyo
Tel. +81-3-5521-2990
Fax +81-3-5521-2991

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DuPont
Performance Elastomers

O-ring troubleshooting guide

Developed by the Kalrez® division of DuPont Performance Elastomers

Kalrez®
From DuPont Performance Elastomers

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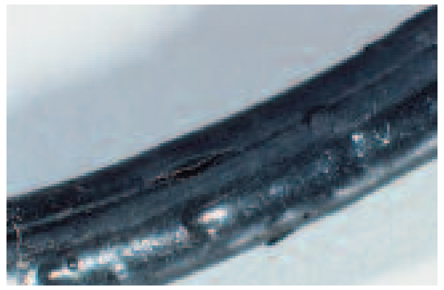
How to assess seal failure

Successful seal performance requires careful consideration of process conditions, elastomer properties and seal design. A deficiency in any one of these areas will result in a reduction of seal service life. If a seal failure does occur, a systematic approach should be taken to determine the root cause of the failure.

The following O-ring samples were submitted to DuPont Performance Elastomers for evaluation. They illustrate the many reasons possible for seal failure. Corrective action as well as suggestions to improve seal performance were provided. Before an in-depth analysis of O-ring failure can be provided, application data, such as process chemicals, temperatures, etc. must be supplied.

Causes of seal failure
- Chemical attack
- Thermal attack
- Process pressure
- Mechanical failure
- Seal design:
  - Groove dimensions
  - O-ring size
  - Elastomer compound.

No. 1 Chemical attack

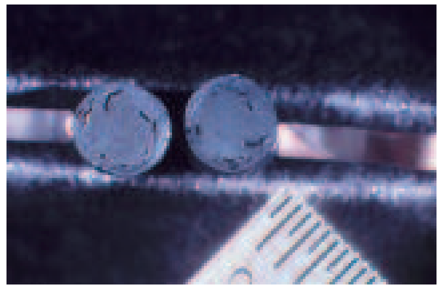


Description
- Numerous small blisters and fissures (cracks and splits), high gloss surface.
- Entire O-ring surface is damaged because sample was completely immersed.

Key factors
- Very aggressive chemicals attacked the basic polymer structure.

Corrective action
- Select a different elastomer compound that is compatible with the process chemicals.

No. 2 Chemical attack



Description
- O-ring surface has blisters and cracks with numerous internal fissures.
- O-ring is dimensionally elongated.

Key factors
- Very aggressive chemicals attacked the basic polymer structure.

Corrective action
- Select a different elastomer compound that is compatible with the process chemicals.

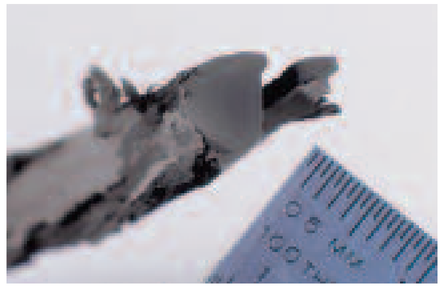
No. 3 Chemical attack

Description
- O-ring softened and swelled resulting in extrusion.
- O-ring filled the entire groove and extruded in two directions, even against the fluid pressure!

Key factors
- Very aggressive chemicals attacked the basic polymer structure.

Corrective action
- Select a different elastomer compound that is compatible with the process chemicals.

No. 4 Chemical attack

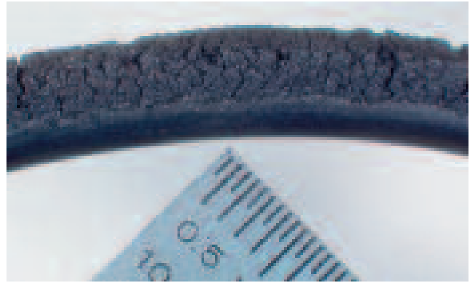


Description
- O-ring is discolored and cracked. Surface is corroded.
- Small cracks extend into the cross section and O-ring surface.
- Excessive compression set and some extrusion are present.

Key factors
- Primary failure mode is oxidation of the carbon black. Some examples of oxidizing chemicals are nitrous oxide, chlorine dioxide, etc.

Corrective action
- Switch to non-carbon black filled compound to prevent oxidation of the filler.
- Review groove design to optimize O-ring compression.

No. 5 Chemical attack

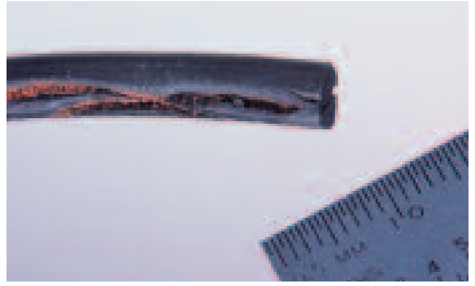


Description
- O-ring shows signs of swell with embrittled particles on outer edge.
- Radial-oriented cracks are present along the outer diameter.
- Surface area exposed to the chemical has damage.

Key factors
- Chemicals permeated into the O-ring and polymerized inside the elastomer; this is often accelerated with heat. Some examples of these types of chemicals are styrene, butadiene, methyl methacrylate, methacrylic acid, etc.

Corrective action
- Select higher modulus (tougher) compounds to improve mechanical strength.

No. 6 Thermal failure

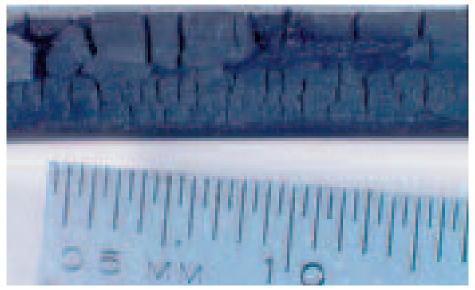


Description
- Extreme damage to O-ring including compression set, cracking, and splitting.
- No indication of elastomer extrusion.

Key factors
- High temperature excursions beyond the capability of the elastomer. Temperature caused elastomer to swell and created insufficient room in the groove. The resulting compressive forces exceeded the modulus at the highest stress location (the cross section) and split the O-ring.

Corrective action
- Reduce application temperature, minimize high temperature excursions or select an elastomer with a higher temperature capability.
- Confirm proper groove design after reducing process temperature or changing the elastomer.

No. 7 Thermal failure



Description
- Inner diameter of O-ring has fine, regular cracks with some particles of O-ring broken away.
- O-ring has taken the shape of the groove.

Key factors
- High temperature broke performance of the elastomer structure.
- Gland compression and fluid pressure caused compression set and cross section to take the groove's shape.

Corrective action
- Reduce application temperature, minimize high temperature excursions or select an elastomer with a higher temperature capability.

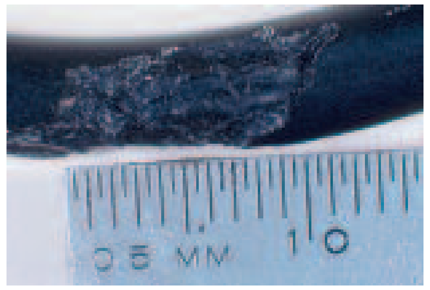
No. 8 Mechanical failure

Description
- O-ring flattened out and split.

Key factors
- Overcompression. PTFE O-ring replaced by an elastomer O-ring. PTFE O-rings are designed to be crushed unlike elastomer O-rings. Elastomer O-ring compression in service was greater than 30%, almost twice the suggested value.

Corrective action
- Redesign groove and/or reduce O-ring cross section to reduce compression as appropriate for the elastomer.
- If redesign or reduced cross section is not possible, consider a higher modulus (tougher) compound for improved mechanical properties at high compression.
- Be cautious when substituting different O-ring materials for existing materials.

No. 9 Mechanical failure

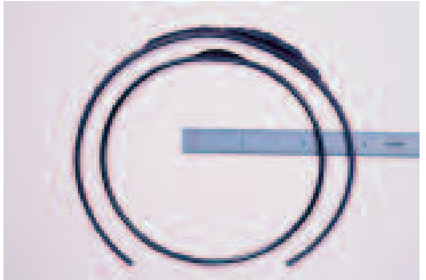


Description
- Mechanical abrasion on O-ring in a slightly spiraled orientation along the outer diameter.
- "Moonscape" surface appearance indicates chemical attack, however damage is not uniform along the surface exposed to the fluid.

Key factors
- O-ring was pinched or rolled during installation or while in service (dynamic applications).

Corrective action
- Insure installation procedures do not cause twisting of O-ring.
- Proper groove design ensures that the O-ring will not twist, roll or get pinched in dynamic applications.
- Use anti-extrusion ring and reduce clearance gaps to minimize pinching.

No. 10 Mechanical failure

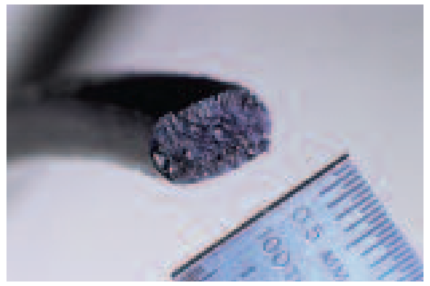


Description
- Extrusion evident at one specific sealing location along the O-ring.
- Compression set and minor extrusion evident along low-pressure side of rings.

Key factors
- O-ring used to seal reciprocating piston at high temperature and high pressure beyond the capability of the elastomer (lower modulus elastomers are more susceptible to extrusion at high temperatures).
- Localized extrusion indicates piston was not properly centered.

Corrective action
- Select higher modulus compound to resist extrusion due to the high pressure.
- Use anti-extrusion rings to minimize extrusion due to high pressure.
- Piston applications require the piston to be centered.

No. 11 Mechanical failure



Description
- Numerous cracks and fissures are visible throughout O-ring cross section.
- O-ring feels soft to the touch due to the numerous fractures inside the ring.
- Severe cracks and fissures along the length of the O-ring, where fluid contacted the O-ring.

Key factors
- Fluids under high pressure permeated the O-ring. When rapid depressurization occurred, expansion of the fluid occurred too rapidly for the fluid to permeate out of the O-ring. The result is that the fluid literally blows its way out of the O-ring causing cracks and possibly large parts of the O-ring to be missing.
- Carbon dioxide is often associated with explosive decompression.

Corrective action
- Eliminate rapid system depressurization.
- Select higher hardness/modulus compounds with better internal strength.
- Design system with minimal free volume at operating conditions to minimize damage due to explosive decompression.

For help in evaluating your sealing performance, the DuPont Performance Elastomers – Kalrez® division offers assistance in compound selection and seal design for Kalrez® parts.
For elastomer compatibility information visit our web site's Chemical Resistance Guide at www.dupontelastomers.com or call DuPont Performance Elastomers.