

Observation:

During disassembly and inspection of the mechanical seal, the **secondary sealing element** (e.g., O-ring, or wedge) exhibits visible signs of material displacement into the extrusion gap (*Fig. 1a*).

Extrusion may occur with O-rings, wedges, and other secondary seals; however, the most common form is O-ring extrusion, where a portion of the O-ring is forced into the clearance between mating components (extrusion gap) under differential pressure.

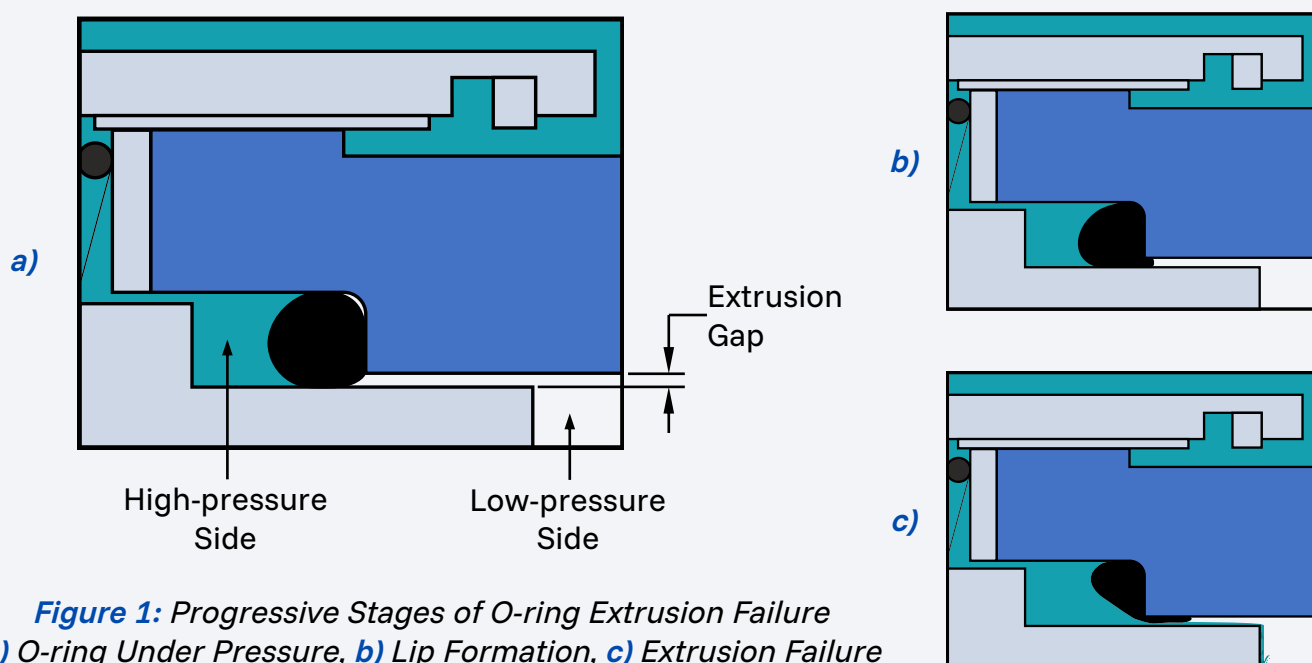


Figure 1: Progressive Stages of O-ring Extrusion Failure
a) O-ring Under Pressure, b) Lip Formation, c) Extrusion Failure

Typical visual indicators include:

- A distinct lip formation on the low-pressure side of the O-ring, indicating material being forced into the extrusion gap under differential pressure.
- The formed lip may subsequently be cut, peeled, or sheared off, sometimes resembling removal of a thin outer layer.
- Localized nibbling, tearing, flaying, or shredding along the extrusion gap region.
- Thermoplastic materials (e.g., PTFE) typically exhibit pronounced lip formation and plastic flow, whereas thermoset elastomers (e.g., FKM, NBR, EPDM) more commonly show nibbling, tearing, or flaying damage.

- In severe cases, partial material loss or detached elastomer fragments may be found within the adjacent cavity (e.g., seal chamber or gland area), depending on pressure direction and seal configuration.

These indicators confirm that the secondary seal has been forced into the extrusion gap due to excessive differential pressure, commonly referred to as **Extrusion Failure**.

Symptom:

- Leakage increases with rising differential pressure.
- Leakage may reduce when system pressure is lowered but does not completely disappear.
- Sudden onset of leakage following pressure spikes, transient conditions, or pulsation events.
- Leakage may reduce or temporarily stabilize when the shaft stops rotating.

Root Cause:

Extrusion of the elastomer occurs when differential pressure acting across the elastomer **exceeds** its ability to resist deformation relative to the available clearance (extrusion gap).

Under differential pressure, the elastomer deforms toward the low-pressure side. When the applied differential pressure exceeds the material's extrusion resistance for the available clearance (extrusion gap) — such as at shaft-sleeve, or seal ring-gland/retainer interfaces — a portion of the elastomer is **forced into the clearance**, initiating lip formation (*Fig. 1b*). Continued or cyclic pressure loading may then result in progressive nibbling and eventual tearing or material loss (*Fig. 1c*).

Primary contributing factors include:

- Excessive radial or axial clearance beyond design limits.
- Inappropriate elastomer material selection, including inadequate hardness for the applied pressure and reduced extrusion resistance at elevated temperature.
- Absence of back-up rings in high-pressure applications.

Corrective Actions for Possible Root Causes:

Sr	Possible Cause	Corrective Action
1	Excessive Extrusion Gap	<ol style="list-style-type: none"> 1) Measure extrusion gap and compare with seal design limits. <ol style="list-style-type: none"> a) If the gap is within the seal design but unsuitable for the operating pressure and temperature, review and modify the seal design for an appropriate allowable gap. b) If the gap exceeds design limits, repair, replace, or re-machine the mating components to restore the specified clearance.
2	Inappropriate Elastomer Material Selection	<ol style="list-style-type: none"> 1) Verify elastomer material suitability for the operating differential pressure and temperature. <ol style="list-style-type: none"> a) If elastomer hardness (Shore A) is inadequate for the applied pressure and extrusion gap, select an elastomer with higher hardness (<i>e.g., 70 Shore A → 80/90 Shore A</i>). b) Where both pressure and temperature are elevated, evaluate material performance considering their combined effect, as increased temperature reduces elastomer modulus and significantly lowers extrusion resistance under pressure.
3	Absence of Back-up Ring in High-Pressure Applications	<ol style="list-style-type: none"> 1) For high-pressure applications where increasing elastomer hardness alone is insufficient to prevent extrusion, incorporate a suitable back-up ring. <ol style="list-style-type: none"> a) Install a <i>PTFE</i> or <i>PEEK</i> back-up ring on the low-pressure side of the O-ring to restrict material flow into the extrusion gap. b) Verify correct orientation and placement of the back-up ring relative to the pressure direction. c) Where bidirectional pressure is possible, consider back-up rings on both sides.