

Parker Engineered Materials Group

Elastomers 101



**Valve
Repair
Council**

Nathan Sowder
Business Development Engineer
Parker O-Ring Division

“Rubber Compound”

Mixture of base polymer and other chemicals

- Polymer
- Cure System
- Reinforcing Agents
- Plasticizers & Process Aids
- Anti-oxidants & Anti-ozonants
- Miscellaneous (Pigments, Internal lubricants, etc)

Polymers

Base polymer determines chemical resistance, rough temperature limits, and rebound resilience

- In some materials, the high and low temp limits can be modified by other compounding ingredients.

Provides “baseline” for abrasion resistance, compression set resistance, permeation rates

- These can (and almost always are) modified – up or down – by other compounding ingredients.

Typical Polymers

EPDM / EPR

- Ethylene-Propylene-Diene Monomer

NBR – Nitrile

- Acrylonitrile-Butadiene

HNBR / HSN – Hydrogenated Nitrile

- Hydrogenated Acrylonitrile-Butadiene

FKM – Fluorocarbon

FEPM – AFLAS®

- Tetrafluoroethylene-Propylene

FFKM - Perfluoroelastomer

Cure Systems

“Glue” polymer chains together (cross-linking)

- Long-term resilience and elasticity
- Difference between rubber and rubber-like thermoplastics
- Prevent the material from “melting”
- Type and amount are strong drivers for compression set resistance
- Affects heat age resistance
- Affects flex life
- May affect chemical resistance (especially in FKM and FFKM)
- Different cure systems used with different polymers

Reinforcing Fillers

Mechanical Reinforcement

- Increase hardness
- Increase tensile and modulus, decrease elongation
- Improve abrasion resistance
- Improve compression set

Carbon Black

- Standard for black compounds
- Hundreds of grades available

Mineral Fillers

- Common in non-black compounds
- Several types available

Plasticizers and Process Aids

Typically liquid or wax-like ingredients

- Improves process flow
- May improve low temperature performance
- Offsets some volume swell
- Lowers the hardness
- May evaporate or extract into application fluid
- Makes compression set worse
- Limits the options for cure systems
 - Peroxides may react with plasticizer instead of the polymers

Anti-oxidants & Anti-ozonants

Chemicals that protect the rubber from ozone attack or oxidation at high temperatures

- May bloom to surface & act as a barrier film
 - More common is to stay within the rubber
- Once they are consumed, protection is gone
- Common in Nitrile and EPDM
 - Can provide better heat age properties
- Can extract into process fluids

Durometer/Hardness

- Resistance to penetration of an indenter
- Poor indication of properties
- Ranges
 - 30 to 95 Shore A Pts.



Tensile Strength

- Stress required to rupture specimen
- Maximum stress in application
- Abrasion resistance
- Small indication of extrusion resistance
- Typical Ranges
 - Poor, VMQ 1200 psi
 - Good, FKM, NBR 2500 psi
 - Excellent, HNBR, XNBR, XHNBR 4500 psi



Ultimate Elongation

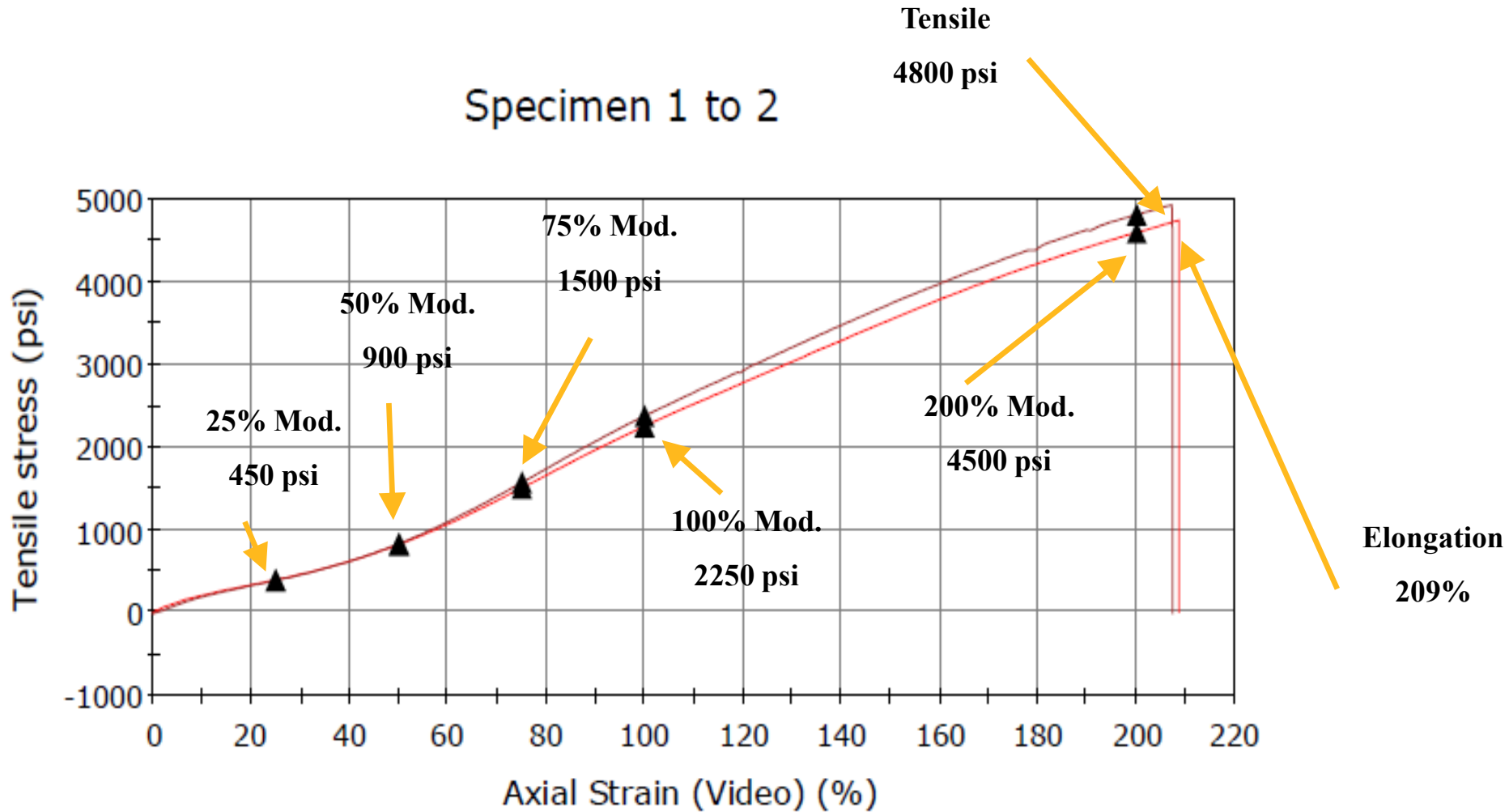
- Strain at which specimen ruptures, given as a %
- Maximum strain in application
- Splitting, cracking, fracturing
- Typical Ranges
 - Poor, 95 HNBR 50%
 - Good, 90 HNBR 100%
 - Excellent, 85 HNBR 200%

Modulus

- Stress observed for a given strain
- Installation force
- Best indication of extrusion resistance
- Typical Ranges (100% Modulus)
 - Low Extrusion Resistance 1000, psi
 - Moderate Extrusion Resistance, 2000 psi
 - High Extrusion Resistance, 3500 psi

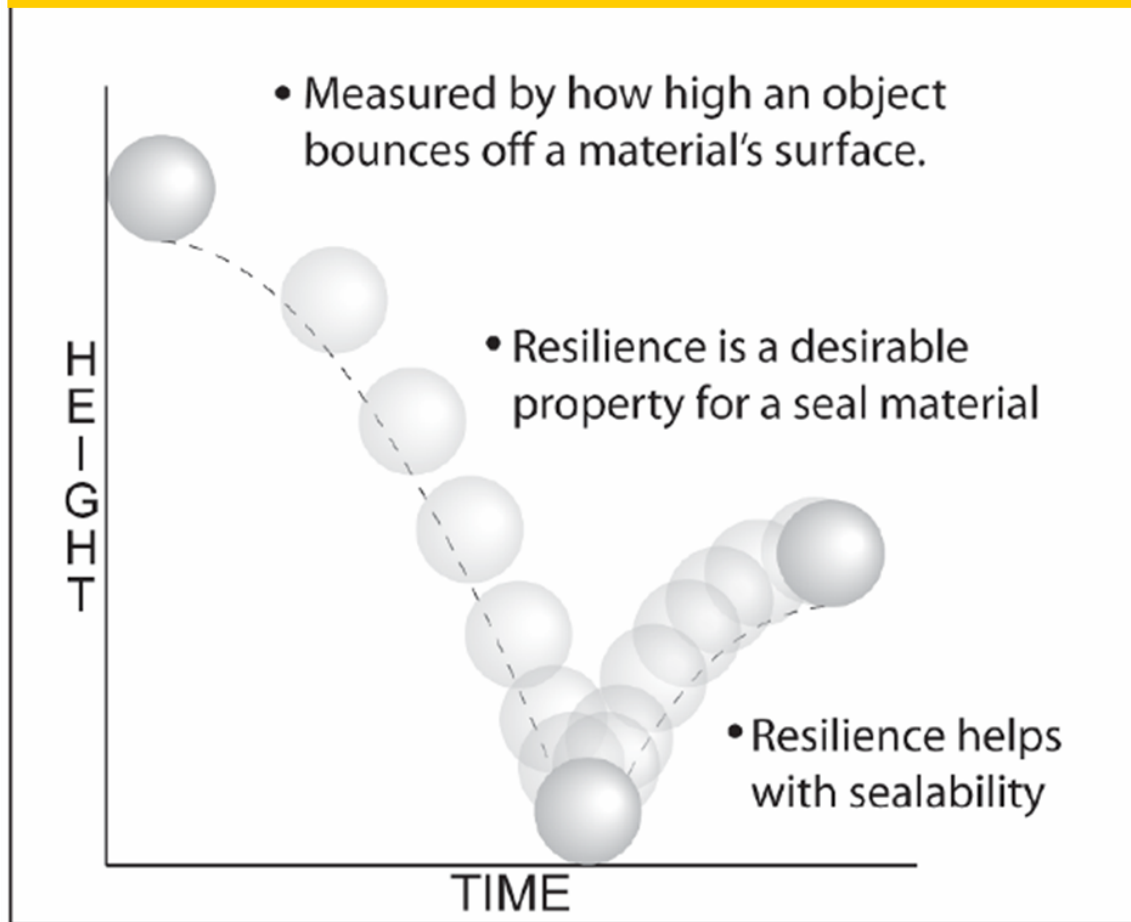


Mechanical Properties



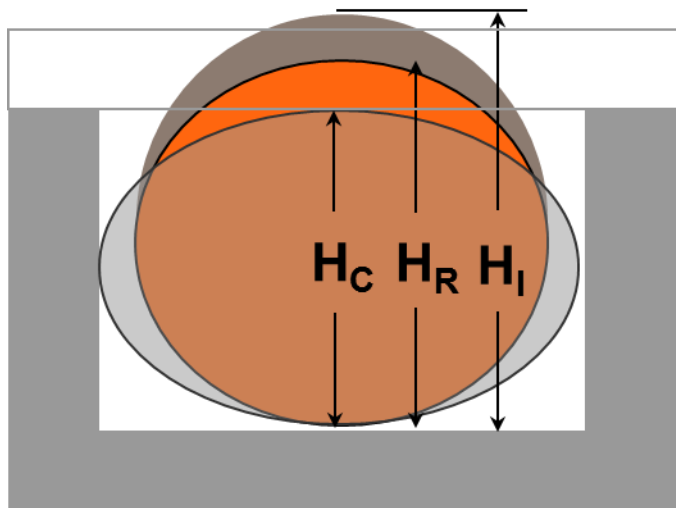
Rebound Resilience

Rebound Resilience = Bounce Back (short term)



Compression Set

- Permanent deformation under compressive load
- Maintained Resilience
- Long term seal ability



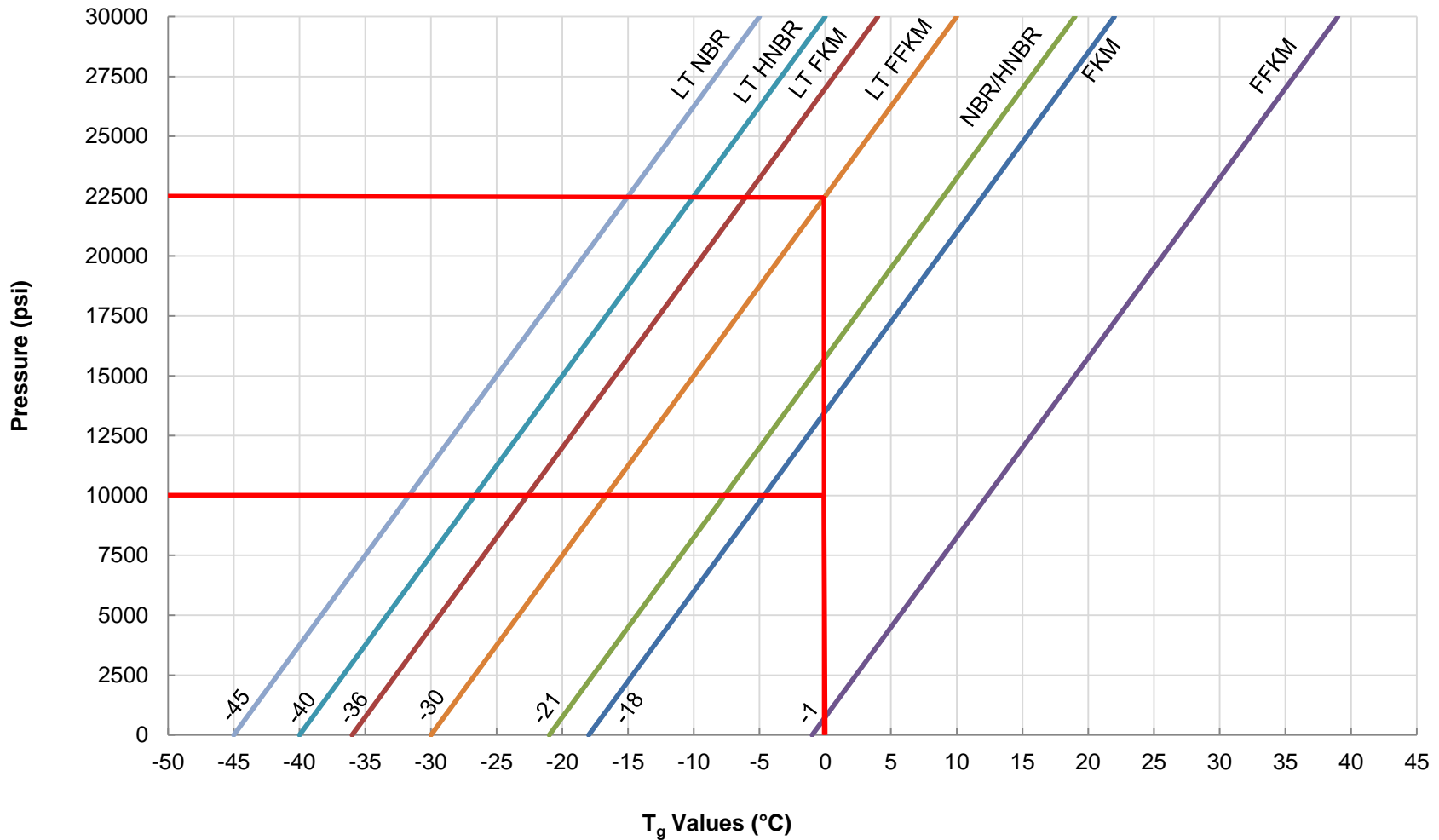
H_I = Initial Height

H_C = Compressed Height

H_R = Recovered Height

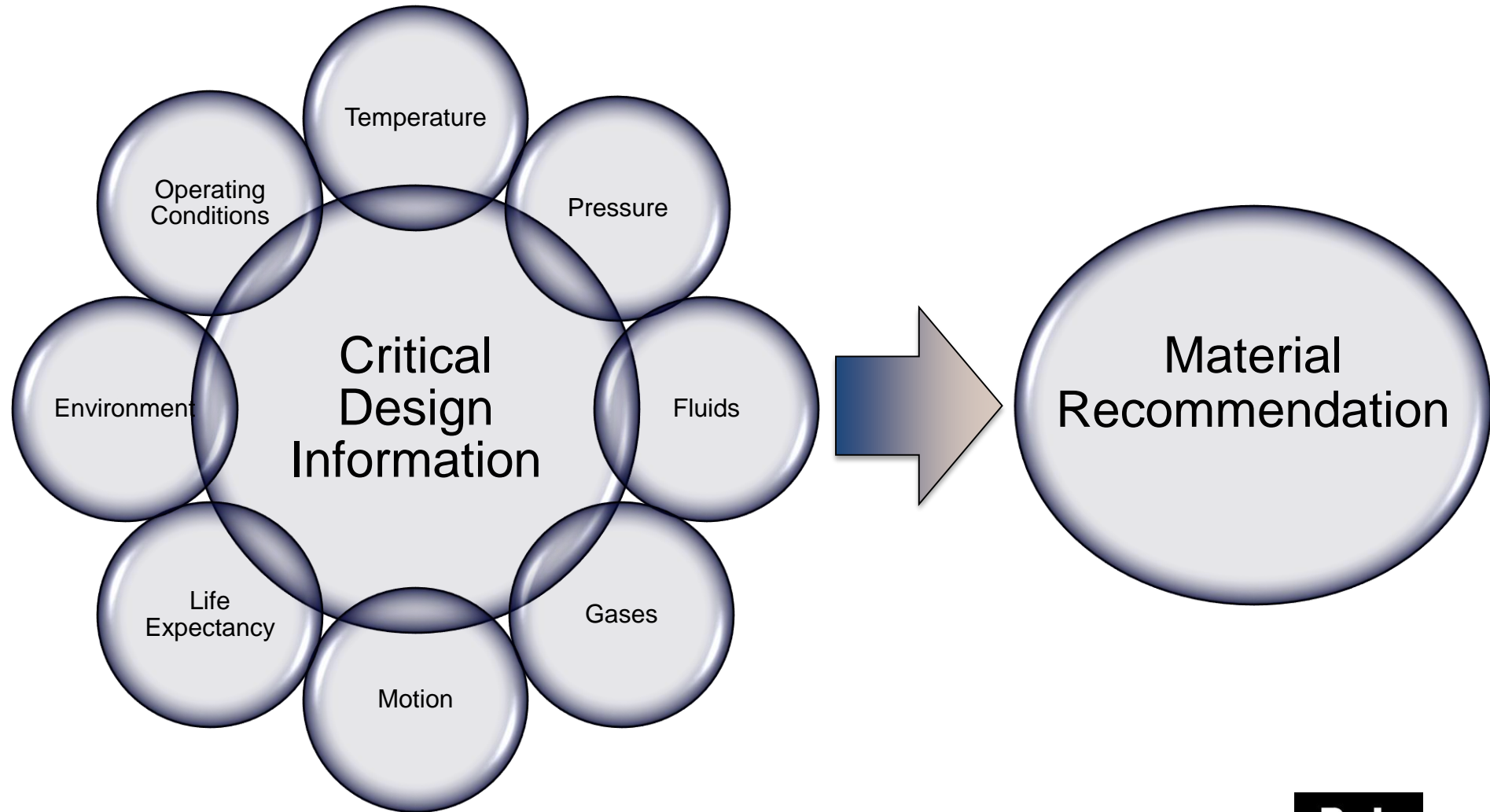
$$CS(\%) = \frac{H_I - H_R}{H_I - H_C} = \frac{\text{amount_of_loss}}{\text{initial_deformation}}$$

Thermal Glass Transition Temp (T_g)



~ Every 750 psi = T_g of material > +1°C

Application Engineering



Parker O-Ring Division

O-Ring Design Basics



ENGINEERING YOUR SUCCESS.

O-Ring Gland Design

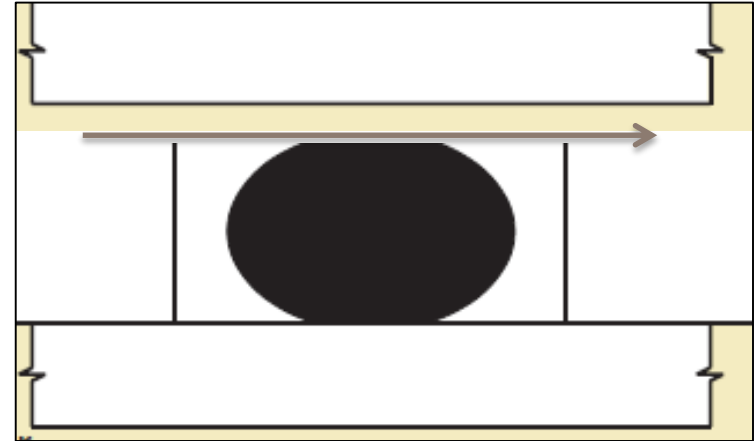
The best O-rings in the world won't work if the gland they're in isn't designed correctly.

- Probably 25 - 50% of all leakage problems are a problem with gland design.
 - The remainder are caused by poor seal material selection, seal damage, and / or reaching the end of the seal's service life (they just wear out.)
- Gland Design / Analysis = Number Crunching
- Mobile inPhorm does most of the work:
 - Material Selection
 - Stretch, Squeeze, & Fill
 - Tolerance Stack-ups

O-Ring Design

Tangential Leaks

- Leakage around the seal



Permeation

- Leakage through the seal



O-Ring Design

Primary Considerations

- **Material Selection**
 - Hardness, Permeability, Media Compatibility
- **Squeeze**
 - Amount of Compression on the Seal
- **Gland Fill**
 - Amount of void space filled by the seal
- **Stretch**
 - Amount the seal is stretched in the installed state

Squeeze

Compression expressed as a percentage of the free-state cross-sectional thickness.

$$\frac{(\text{O-Ring C/S}) - \text{Gland Depth}}{(\text{O-Ring C/S})}$$

- Too little shortens seal life
- Too much overstresses material
- 25% optimum nominal design squeeze
- Recommended squeeze different for different gland configurations and different sizes

Gland Fill

Gland volume vs. O-ring volume

$$\frac{\text{O-ring Volume}}{\text{Gland Volume}}$$

- Recommend 75% nominal fill
- 95% maximum gland fill
- Allow for volume swell, thermal expansion, and increasing width due to squeeze
- Overfill can damage o-ring by causing extrusion into clearance gap.

Stretch

% inside diameter stretch installed in groove

$$\frac{(\text{Groove Diameter} - \text{O-ring ID})}{\text{O-ring ID}}$$

- General rule is 0-5%
- Excessive stretch can overstress material
- Thins cross section and reduces % squeeze
- % CS reduction approx. 1/2 of the % ID stretch
(10% Stretch = 5% CS Reduction)

Static O-Ring Sealing

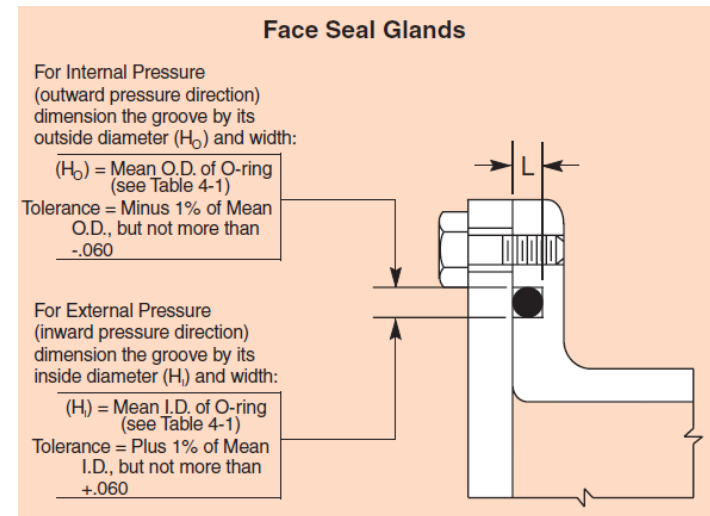
- **Face Seal**
 - Design Chart 4-3
- **Radial (Male and Female)**
 - Design Chart 4-2
- **Dovetail/Half Dovetail**
 - Design Charts 4-4 and 4-5
- **Crush (Triangular)**
 - Design Chart 4-6

Static O-Ring Sealing

Face Seal

- NO STRETCH
- INTERNAL PRESSURE: DESIGN TO GROOVE OD
- EXTERNAL PRESSURE: DESIGN TO GROOVE ID
- “0” CLEARANCE: HIGH PRESSURE
- 20-32% SQUEEZE
- SURFACE FINISH

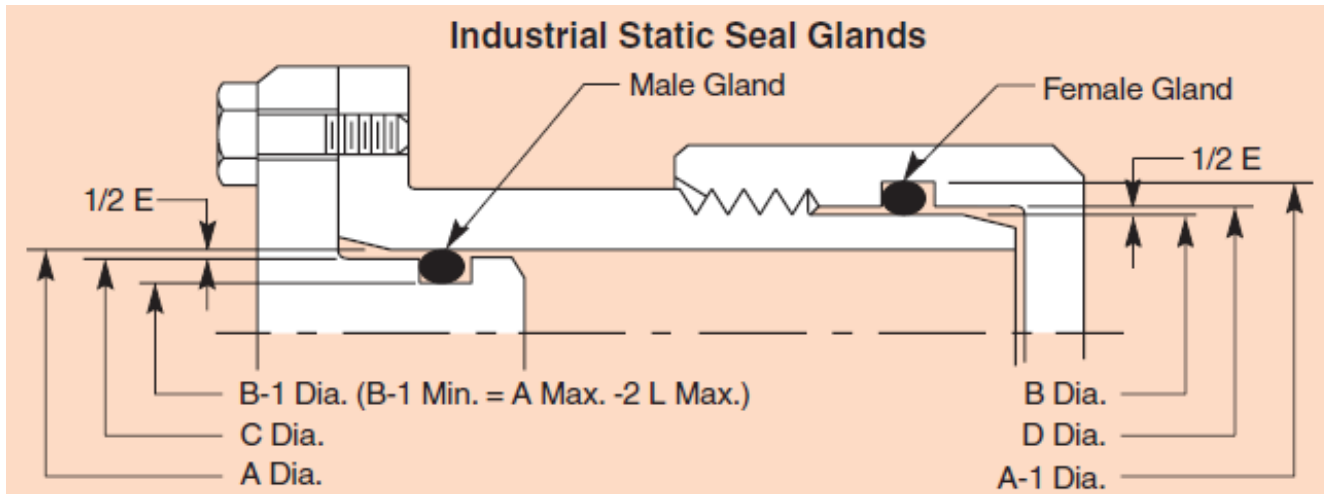
LIQUIDS – 32 micro-inches RMS
GASES – 16 micro-inches RMS



Static O-Ring Sealing

Radial Seal

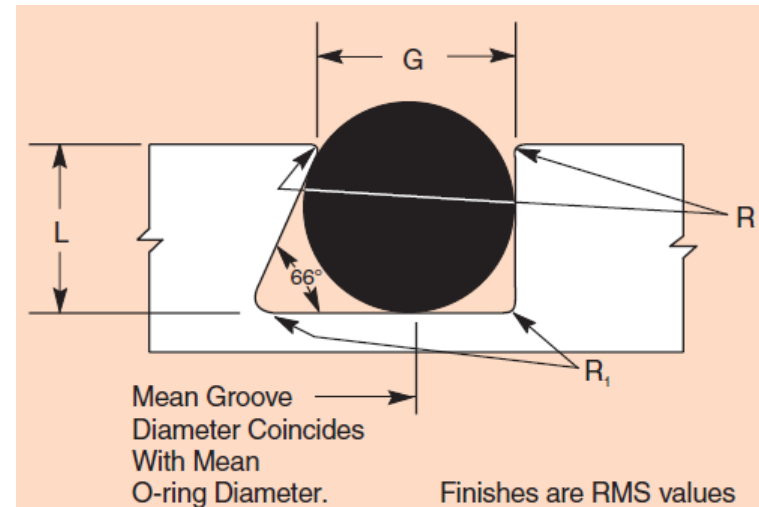
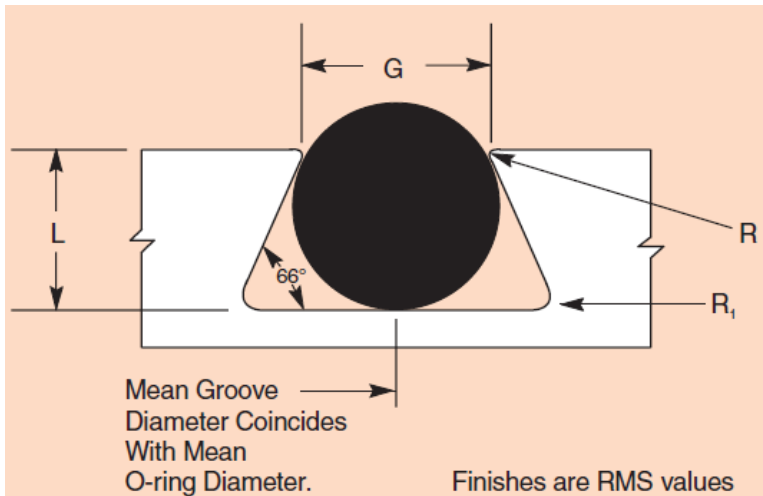
- 0-5% STRETCH
- 15-30% SQUEEZE
- CLEARANCE GAP
- SURFACE FINISH LIQUIDS – 32 micro-inches RMS
 GASES – 16 micro-inches RMS



Static O-Ring Sealing

Dovetail/Half Dovetail

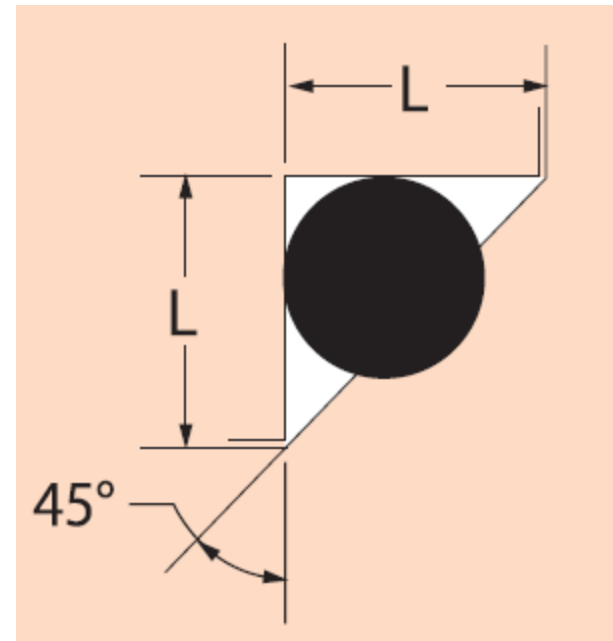
- PRE-DESIGNED CUTTING TOOLS
- HOLD O-RING IN GROOVE
- MORE DIFFICULT/EXPENSIVE TO MACHINE



Static O-Ring Sealing

Crush Seal

- 45 DEGREE ANGLE
- $L = 1.321 \times CS$
- Following this yields:
- 85%-95% Volume Fill



O-Ring Design

Other Considerations

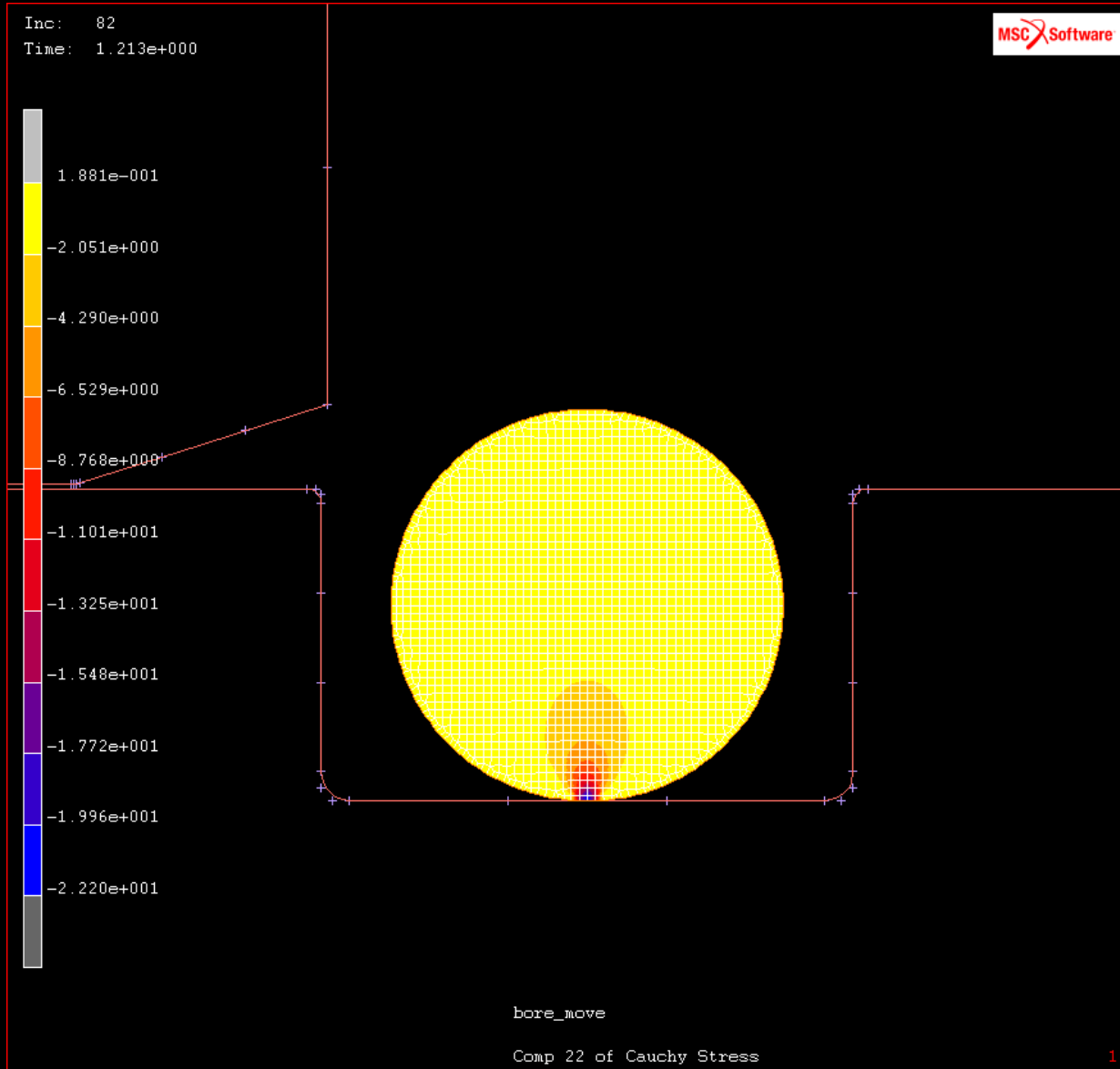
- Sharp Corners
 - Installation difficulties, Pinching/Cutting
- Surface Finish
- Tolerance Stack-ups
 - Min, Nominal and Max
- Eccentricity & Side Loading
- Pressure vs. Clearance
 - Extrusion, Back-up rings

Installation Damage

- **Sharp Corners**
- **Sheared, torn, nicked**
- **Cut appearance**
- **Causes**
 - Sliding over threads
 - Insufficient lead-in chamfer
 - Improperly sized O-ring
 - No lubrication used



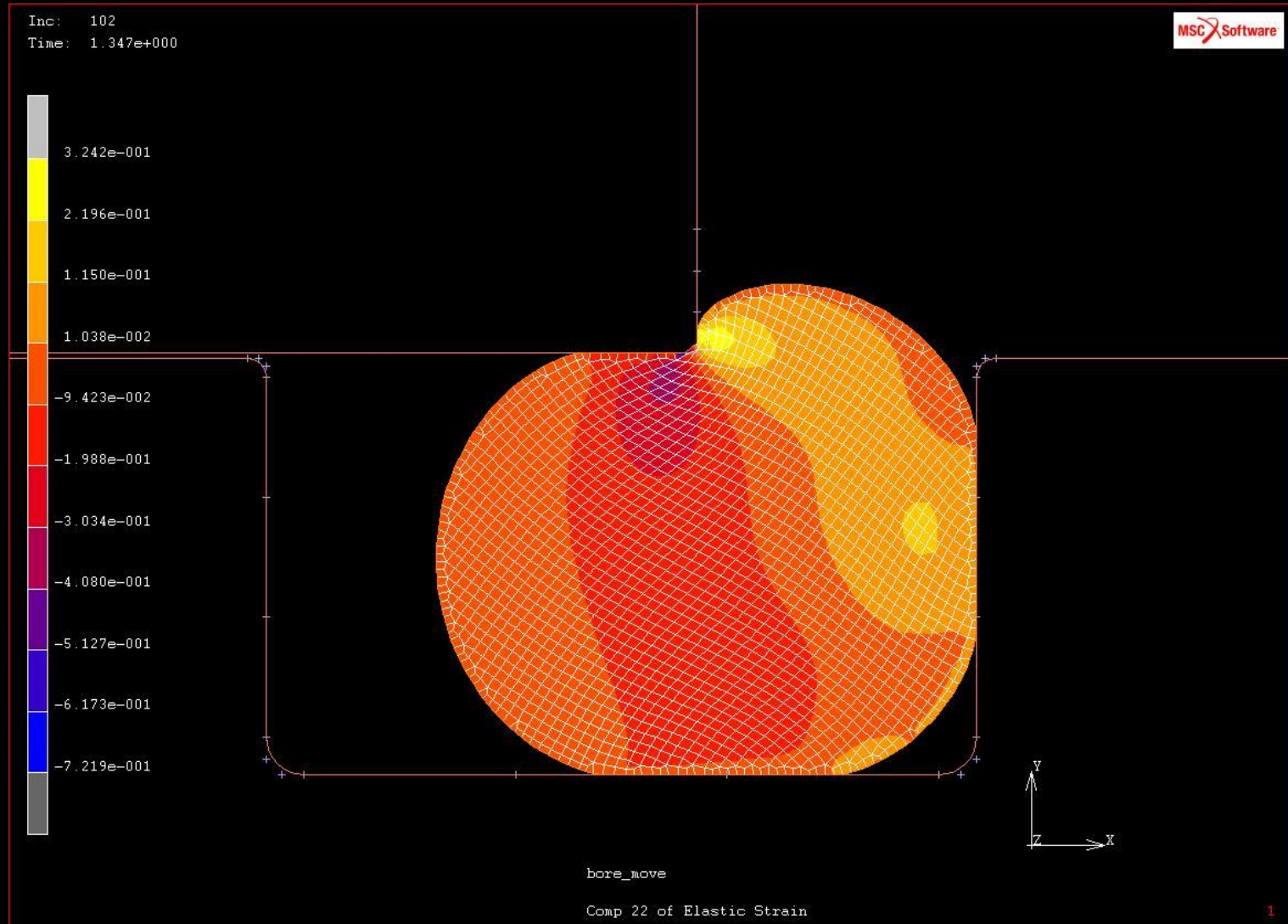
Installation Damage



Installation Damage



Installation Damage



Installation Damage

Solutions

- Cover threads during installation.
- Recommend using lubrication, when possible.
- Proper Lead-in chamfers and smooth edges.
- Make sure the correct O-ring size is being utilized.

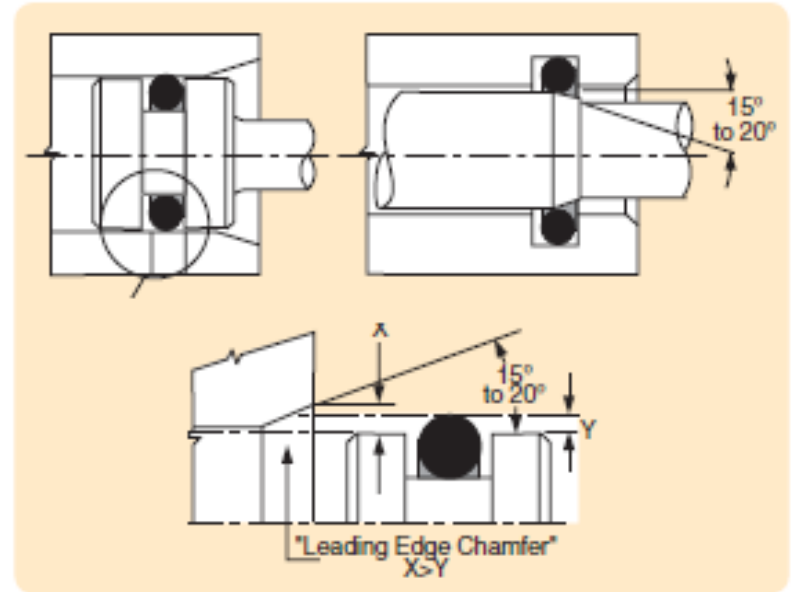


Figure 10-6: Chamfers



O-Ring Division

Together, we can provide sealing solutions to maintain resilience at the highest pressures.

The Global Leader in Cutting Edge Elastomeric Technology

Parker O-Ring Division offers a unique combination of experience, innovation, and support, working with customers to engineer your success.

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O-Ring Handbook

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5/4/2015 - [Parker O-Ring Division Leads Elastomeric Technology with New, Innovative Rubber Materials that Extend Seal Life in the Harsh Environments of the Oil and Gas Industry](#)

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What is an O-Ring? An O-ring is a torus, or doughnut-shaped ring, generally molded from an elastomer with a circular cross-section. Rubber O-rings are used primarily for sealing. They are also used as light-duty, mechanical drive belts. So what is an O-ring seal? An O-ring seal is used to prevent the loss of a fluid or gas. The combination of an O-ring and gland constitute the classic O-ring seal assembly.

Parker O-Ring Division is committed to every aspect of customer service—from product development and research to our mobile apps and teaching tools. Our goal is to provide quality products, premier customer service, and product tools to exceed our customers' purchase experience expectations.

Any Questions?

Applications Engineering

- ORDmailbox@parker.com
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 - Applications Hotline
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- Material Recommendations
- Gland Design
- Failure Analysis
- FEA Capabilities
- Proper Assembly
- Leakage Troubleshooting

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Thank you

