Technetics GROUP

FAILURE IS NOT AN OPTION

STATIC METAL SEALS FOR SPACE APPLICATIONS

PRESENTATION NOTES

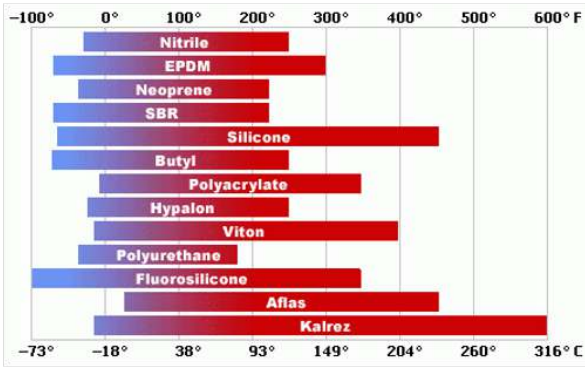
AGENDA

- Why you need a metal seal
- How metal seals work
- What is a metal seal
- Groove design considerations
- Application conditions
- Leak Rate discussion
- Question & Answer Session

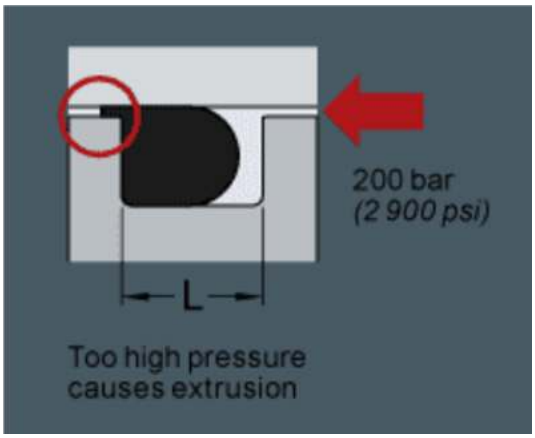
WHY METAL SEALS

Three main elements affecting elastomers

- Temperature
- Pressure
- Environment



https://websealinc.com/technical-info/o-ring-temperature-guide/



https://www.skf.com/group/products/industrial-seals/hydraulic-seals/o-rings-and-back-up-rings

ELASTOMER/METAL COMPARISON

Temperature			Pressure		
Condition	Elastomer	Metal	Condition	Elastomer	Metal
Cryogenic [<-100°F]	✗	✓	UHV	✗	✓
High Temperature [>600°F]	✗	✓	High Pressure [2900 PSI+]	✗	✓

ENVIRONMENT CONSIDERATIONS

Radiation

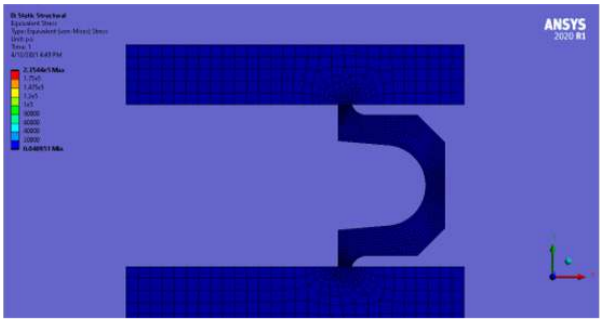
Media

Gas

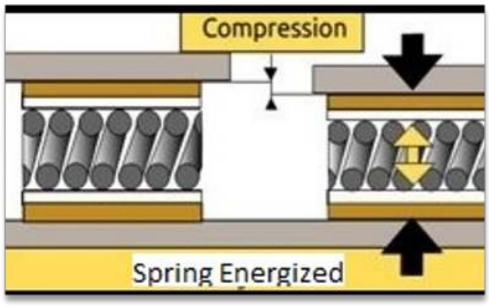
- Permeation
  - Butyl O-Ring - ~4E-5 scc/s
  - SS 304 Metallic Seal - ~5E-10 scc/s

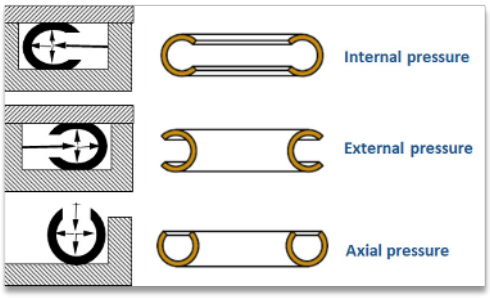
HOW A METAL SEAL WORKS

- Contact Pressure
  - Contact area - “seal track”
  - Seating load of seal
  - Surface finish
- Plastic Deformation of Sealing Material
  - Plating
  - Coatings
  - Jackets

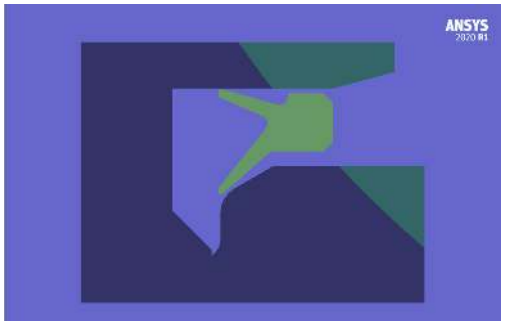


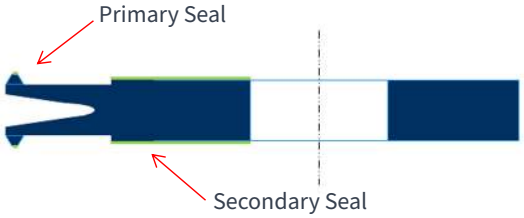
ENERGIZATION OF SEALS

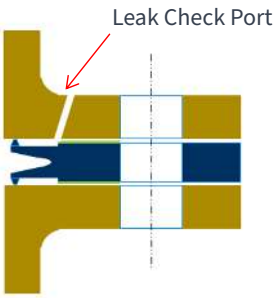




REDUNDANT SEALING





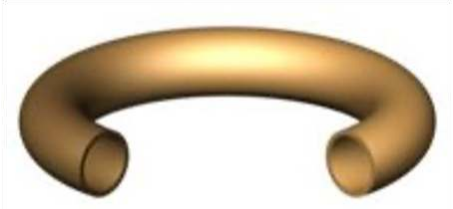


TYPES OF METAL SEALS

- Formed
- Machined

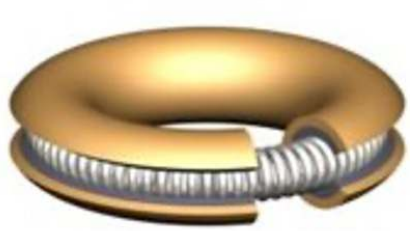
FORMED METAL SEALS

Delta Seals



O-Rings

E-Rings



Helicoflex

C-Rings

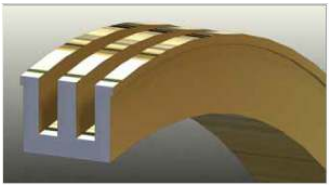
MACHINED METAL SEALS

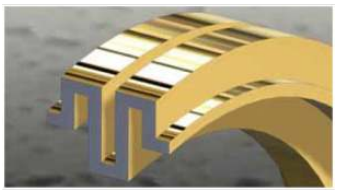
Sizes from .250” to over 48” Inner Diameter

K-Port Seals

Naflex Seals

Seal Saver



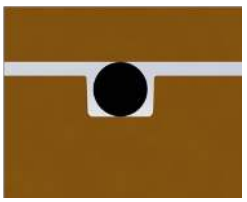


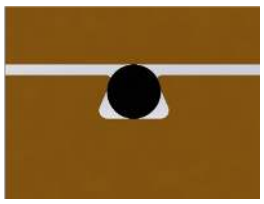
Ultratech Seals

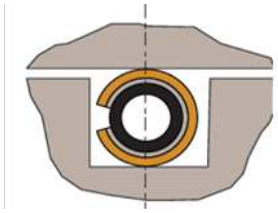
Custom Seals

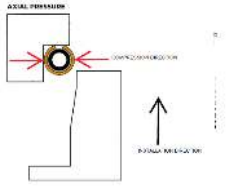
STANDARD GLAND GEOMETRIES

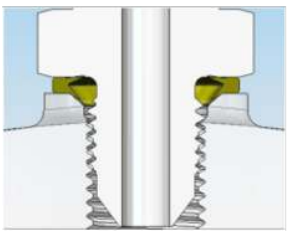
- Face Seal (Flange/Face Groove)
- Axial Seal (Shaft Seal Gland)
- Dovetail Groove
- Threaded Port (AS5202)
- Fluid Fitting





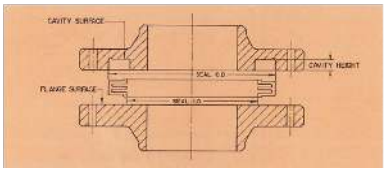


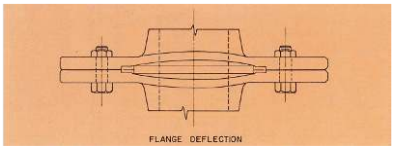


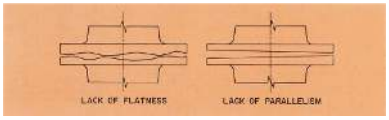


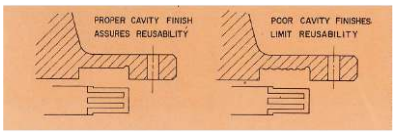
FLANGE/CAVITY DESIGN

- Pressure Direction
  - Groove Walls
- Joint Connection
  - Higher load to compress with a metallic seal
- Surface Finish
  - Most important item to ensure a good seal
- Flatness and Parallelism
- Flange Deflection









SURFACE FINISH

- Sealing Material Dependent
  - General surface finish callout
  - PTFE coated seals can tolerate a rougher surface than metal plated
- Circular Lay

APPLICATION DETAILS

Application Data Sheet

- Temperature (Operating and Max/Proof)
- Pressure (Operating and Max/Proof)
- Leak-Rate Performance
- Media
- Life Expectancy
- Hardware Geometry

LEAK RATE DISCUSSION

EQUIVALENT LEAKAGE RATES

Std cc/sec*	mbar-l/sec	Torr Liters/sec	Time to leak one cubic centimeter	Time to leak one bubble**
10^{-1}	1.01×10^{-1}	7.6×10^{-2}	10 seconds	.25 seconds
10^{-2}	1.01×10^{-2}	7.6×10^{-3}	100 seconds	2.5 seconds
10^{-3}	1.01×10^{-3}	7.6×10^{-4}	16.7 minutes	25 seconds
10^{-4}	1.01×10^{-4}	7.6×10^{-5}	2.8 hours	4 minutes
10^{-5}	1.01×10^{-5}	7.6×10^{-6}	28 hours	40 minutes
10^{-6}	1.01×10^{-6}	7.6×10^{-7}	11.5 days	7 hours
10^{-7}	1.01×10^{-7}	7.6×10^{-8}	3.8 months	3 days
10^{-8}	1.01×10^{-8}	7.6×10^{-9}	3.2 years	1 month
10^{-9}	1.01×10^{-9}	7.6×10^{-10}	32 years	9 months
10^{-10}	1.01×10^{-10}	7.6×10^{-11}	320 years	8 years
10^{-11}	1.01×10^{-11}	7.6×10^{-12}	3200 years	80 years

* **Std cc/sec = One cubic centimeter of gas flow per second at 14.7 psi of pressure and a temperature of 77°F**

** **Bubble diameter is 3mm**

LEAK RATE EXAMPLE

A fluid system with a total volume of 5 ft^3 and 15 joints is pressurized with Methane to 500 psia at room temperature. It must remain above 390 psia after 24 months in space with a nominal operating temperature of -40°F.

- Determine Acceptable Mass loss (Δm)
- Determine equivalent Standard Volume loss (ΔVs)
- Acceptable System Leak Rate Q_{System}
- Acceptable Joint Leak Rate Q_{Joint}
- Equivalent Helium Leak Rate Q_{Test}
- Apply MOS as required

$$\Delta m = \frac{P_1 \cdot V}{R_s \cdot T_1} - \frac{P_2 \cdot V}{R_s \cdot T_2} = \frac{.142\ m^3}{518.279 \frac{J}{kgK}} \left(\frac{3.45}{293} - \frac{2.69}{233}\right) \frac{MPa}{K} = .06\ kg = .14\ lbm$$

$$\Delta V_S = \frac{\Delta m \cdot R_s \cdot T_{STP}}{P_{STP}} = \frac{.06kg \cdot 518.277 \frac{J}{kgK} * 273K}{.10\ MPa} = .088scm\ = 3.10scf$$

$$Q_{System} = \frac{\Delta V_S}{Life} = \frac{.088scm}{24\ Months} = 1.39x10^{-3} sccs\ C_2H_4$$

$$Q_{Joint} = \frac{Q_{System}}{\#\ Joints} = \frac{1.39x10^{-3} sccs}{15} = 9.26x10^{-5} sccs\ C_2H_4$$

$$Q_{Test} = \frac{Q_{Joint}}{MOS} \cdot \left(\frac{\nu_{Methane}}{\nu_{Helium}}\right) = \frac{9.26x10^{-5} sccs\ C_2H_4}{2} \cdot \left(\frac{.0109}{.198}\right) = 5.10x10^{-6}\ sccs\ GHe$$