Metal Seal Technologies in Valve Applications

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INDUSTRIALVALVESUMMIT

Agenda

- Introduction
- Basic Principles
  - Static Sealing
  - Dynamic Sealing
  - Semi-Dynamic Sealing
- How metallic sealing solutions can work
- Types of metal seals
- Some example applications

Introduction: Engineered sealing & sub-systems solutions for critical applications focused on optimizing performance and safety while reducing environmental impact

Metal Seals

Mechanical Seals

Carbon Face Seals

PTFE/PEEK Components & Seals

Elastomer Seals

Inflatable Seals

Edge-Welded Metal Bellows

The Valve Industry

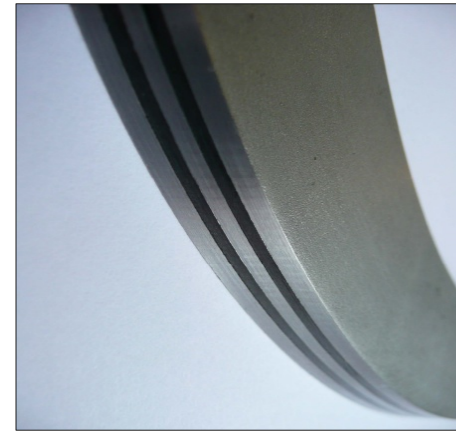
- **Industry Evolution**
  - From conventional resources to very difficult recoverable fields
  - Higher temperature & pressure
  - Reliability & environmental concerns

- **Industry Requirements**
  - Extreme temperature and pressure
  - Corrosion resistance & extended seal life
  - Fluctuating pressure directions
  - Thermal & pressure cycles
  - Axial pressure / radial compression

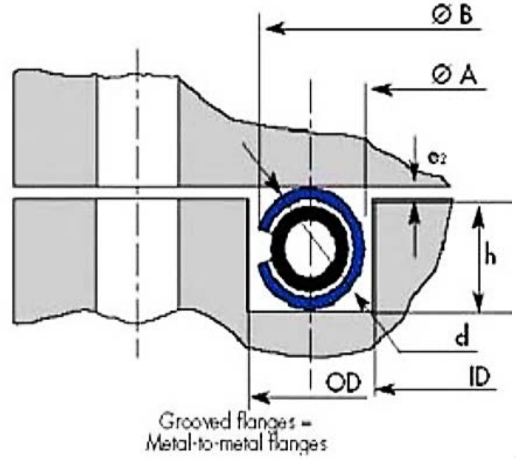
The Basics of Metal Seals

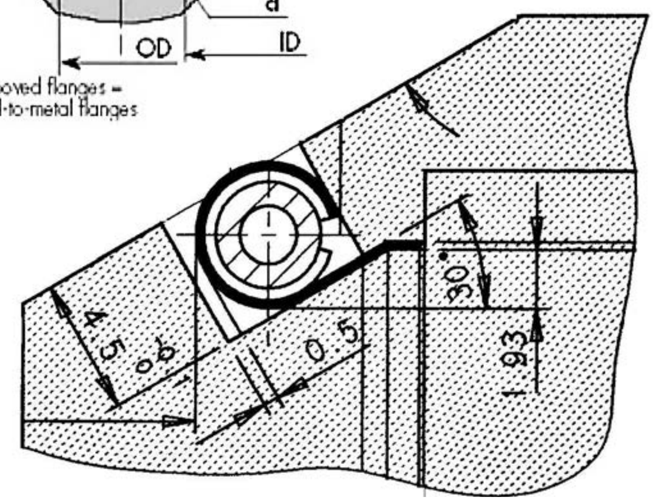
- The contact stress applied to the sealing surface
- The amount of resiliency inherent to the specific design for that metal seal
- The required leak rate and the media to be sealed
- Plastic deformation from an outer coating or jacket material designed to fill the imperfections on the sealing area
- The metal-to-metal contact (controlled compression)
- The surface finish - Metal seals do not always require a very smooth surface finish. They can even accommodate standard ANSI flange finishes
- Metal seal type, cross section, material & thickness

Dynamic vs Semi-Dynamic Sealing

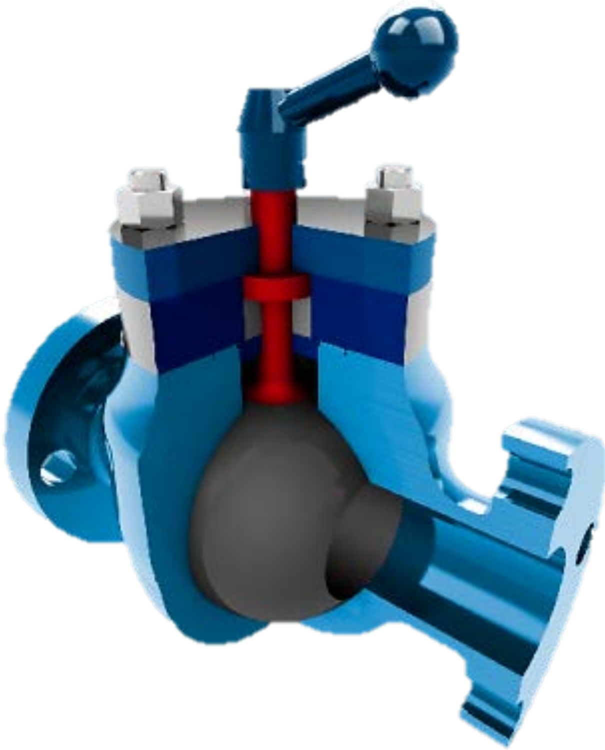


- Semi-Dynamic rather than Semi-Static
- Perfectly Static does not exist
- Thresholds of micro-movements
- Potential leak paths created; to avoid require
  - Perfectly mated surfaces
  - Minimum friction coefficient at the interface

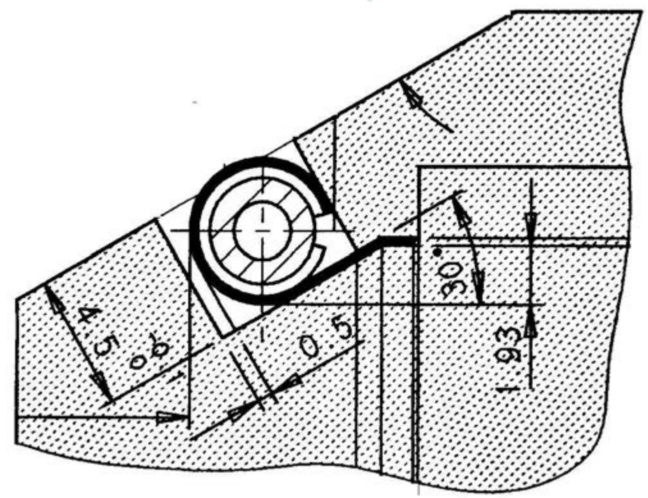




Static vs Semi-Dynamic



- Potential interference with the seal resulting in deformation
- Potential interaction with the seal unevenly around the circumference,
- Interacting with the seal differently depending on direction of flow
- Having to be in its optimum position in every direction relatively to the seal, cycle after cycle
- Designed to be a potential threat for the seal in terms of abrasion and wear



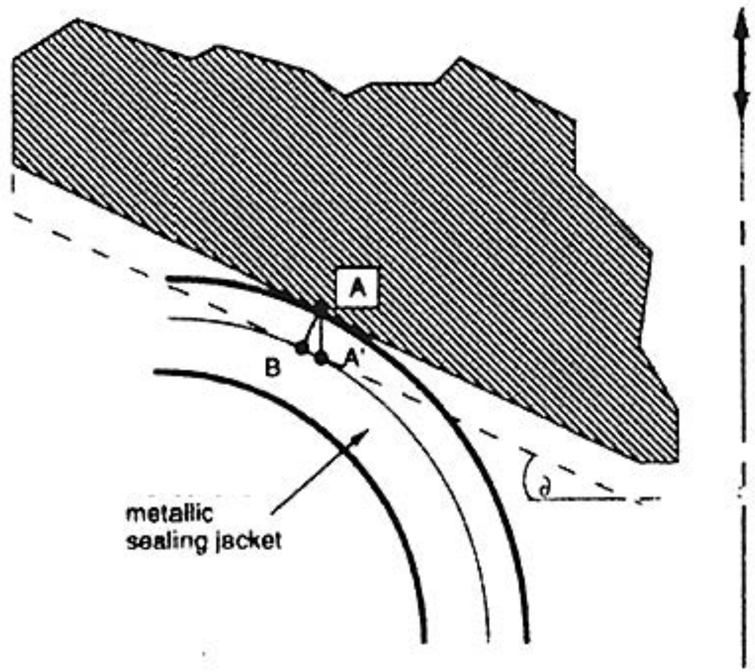
How Can Metallic Sealing Solutions Works

From the Valve Manufacturers Standpoint:

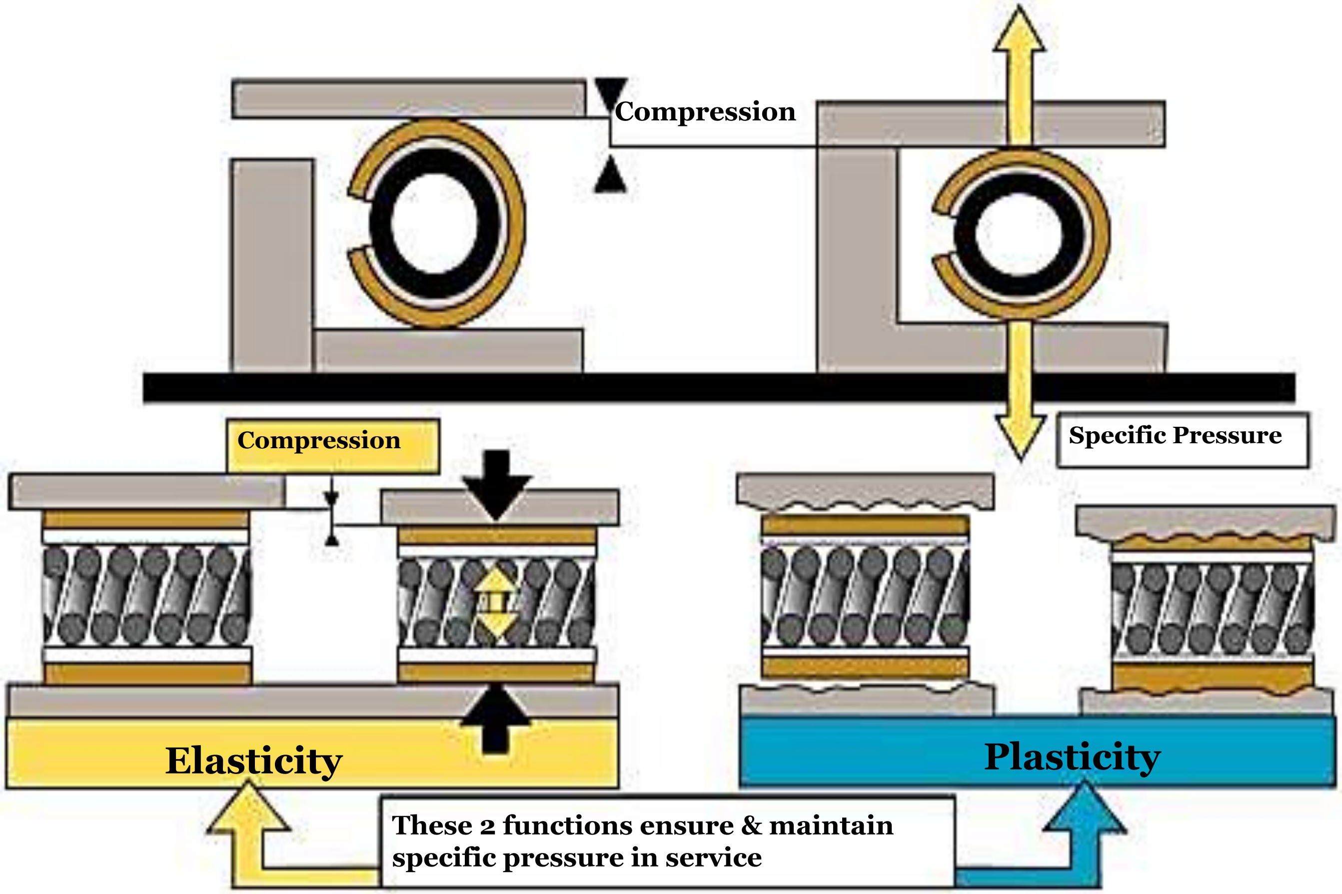
- Disk Geometry
- Relative Positioning between seal and disk in closed position
- Performance versus direction of flow
- Acceptable Torque

How Can Metallic Sealing Solutions Works

- **From the Seal Manufacturers Standpoint:**
  - The Interface



Elastic –vs- Plastic Deformation



Elastic Deformation

- Spring Force & Spring Back from
- Metal Substrate/Elastic Core: Spring/Tubing/C-E-Profile)
- Spring Rate varies based on Seal Type and Jacket/Plating

Plastic Deformation

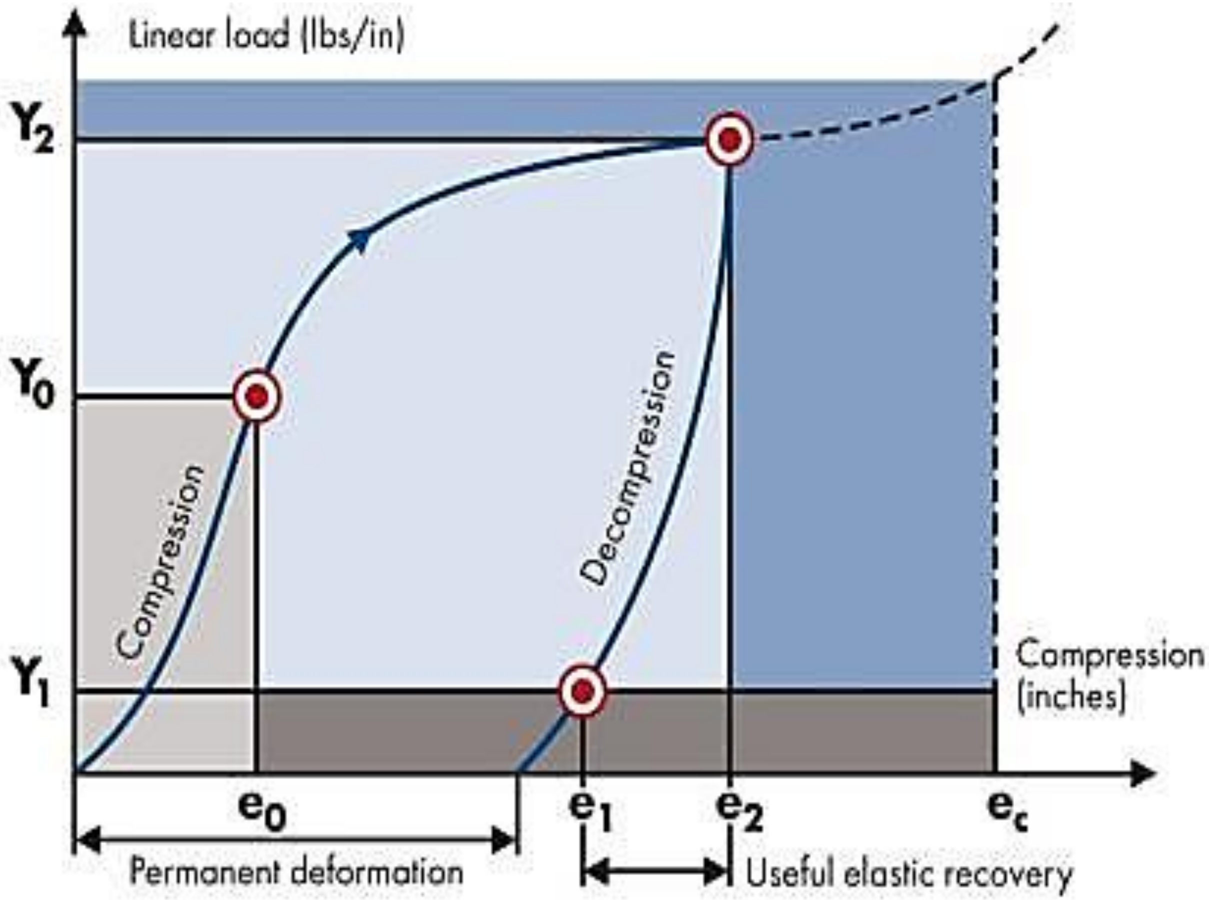
- Jacket or Plating/ Coating

Surface Finish

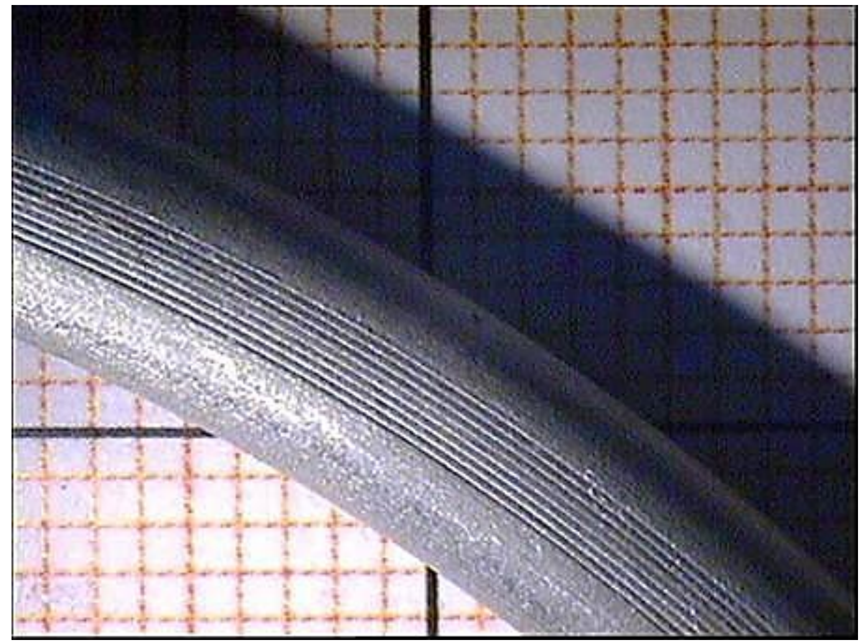
- Lathe Turned
- Varies by Jacket/Plating

Spring Energized Metal Seals

Sealing Concept of Spring Energized Metal Seals



Plastic Deformation Examples



Silver Plating: O-Ring
Poor Flange Finish: Radial Marks

Silver Jacket: Spring-Energized
Good Flange Finish: Concentric Marks

Materials

Spring Energized

Name/ Type	Description	MAX Temperature Service
Aluminum	Has good formability and high resistance to corrosion.	680F
Silver	Good corrosion resistance, Electrically conductive, High thermal conductivity, Requires low load to plastically deform	950F
Nickel	Good corrosion resistance, Low-Carbon, Easily machined, Makes a great coating	1200F
Stainless Steels	Offer enhanced resistance to creep, high tensile, non-magnetic, strength, Commercially available	800F
Inconel	Good corrosion resistance, Age-Hardenable Super Alloy, Great high temperature tensile strength, High fatigue resistance	1200F

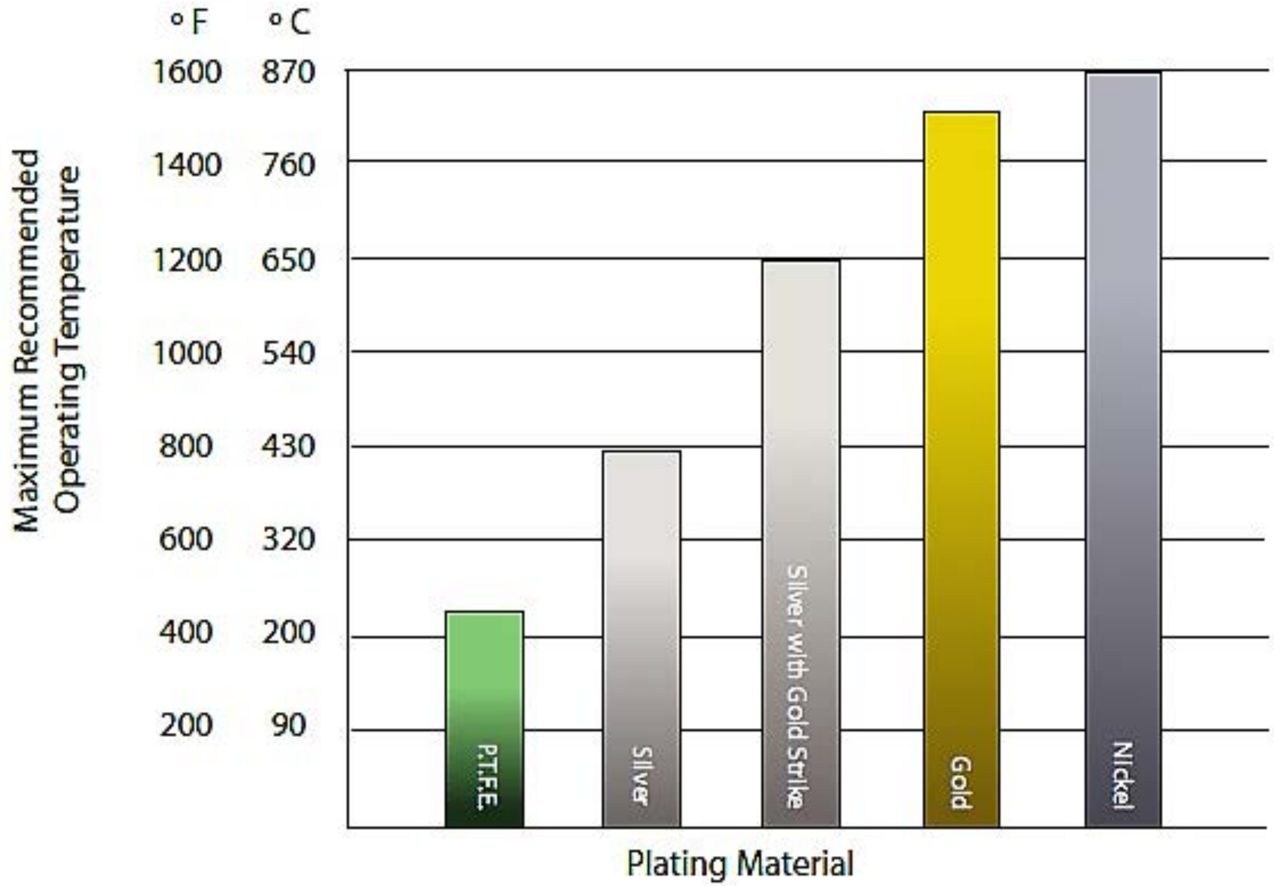
C-Ring

Name/ Type	Description	MAX Temperature Service
Alloy X750	Age hardenable, high temperature alloy.	1100F
Alloy 718	An austenitic nickel-base super-alloy which is used in applications requiring high strength to approximately 1400°F (760°C) and oxidation resistance to approximately 1800°F (980°C).	1200F
Waspalloy	Age-hardenable alloy with excellent strength in the 1000°F-1800°F (540°C-980°C) temperature range. Used for critical gas alloy turbine engine components. The alloy exhibits good resistance to gas turbine combustion gas environments at temperatures of use up to about 1600°F (870°C)	1300F

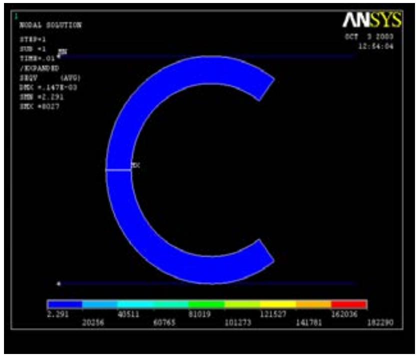
Note: guideline only – pressure dependent

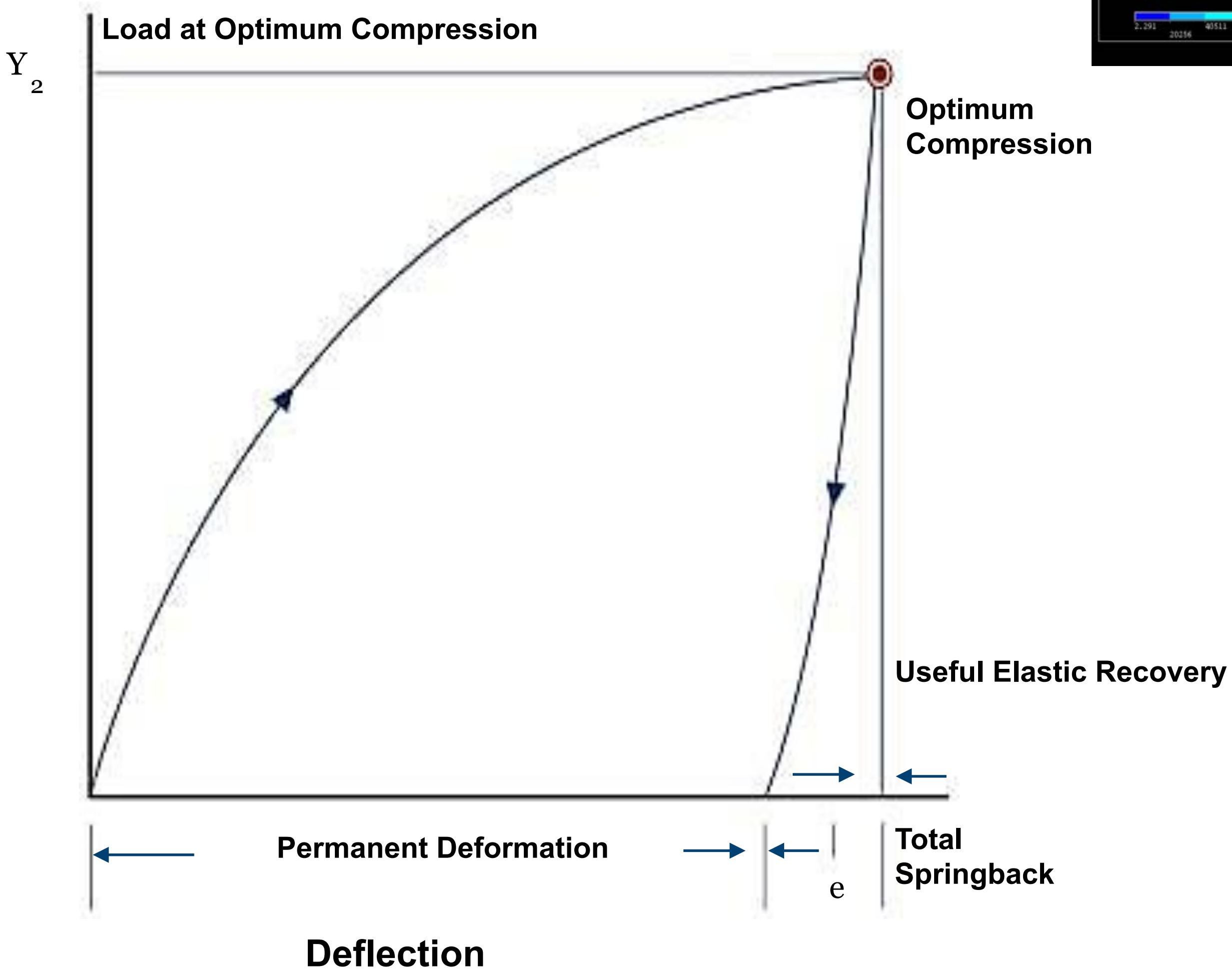
Platings & Coatings

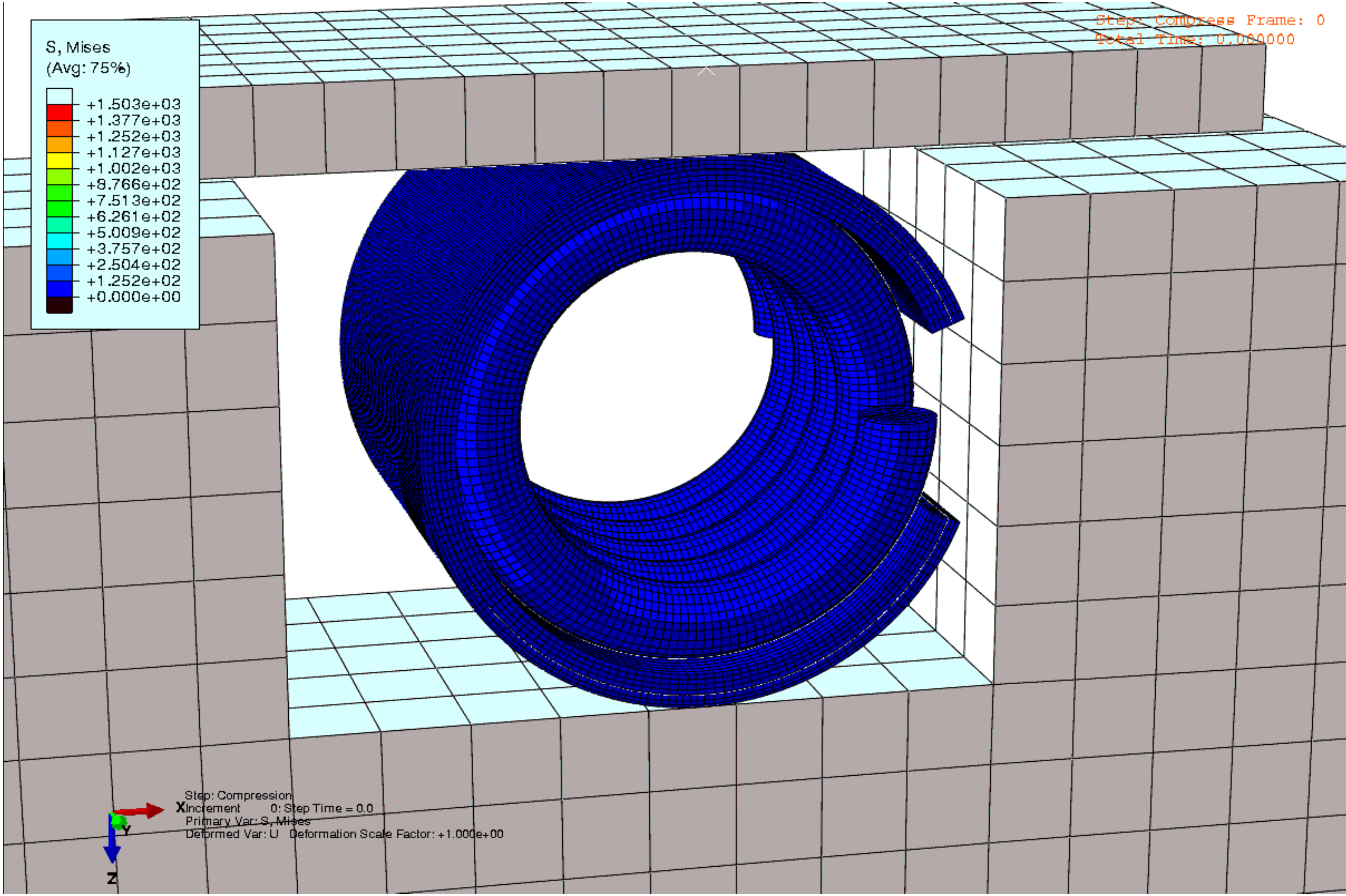
Maximum Recommended Operating Temperatures for Platings & Coatings



C-Ring Load/Deflection

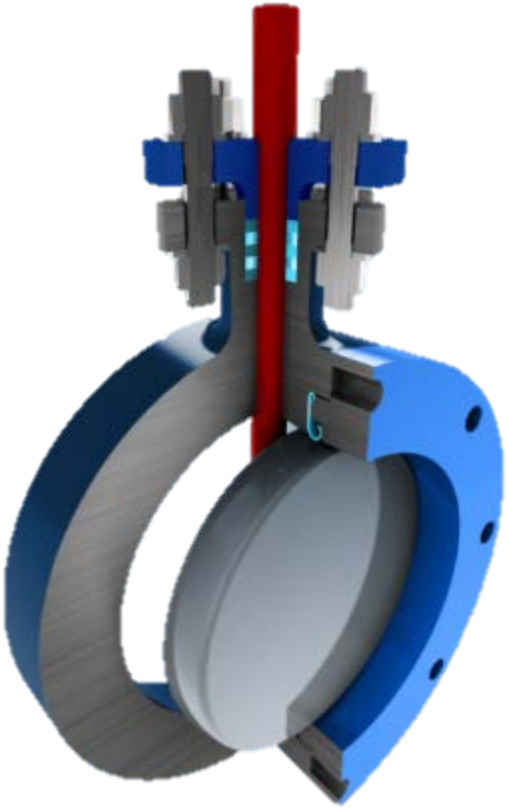


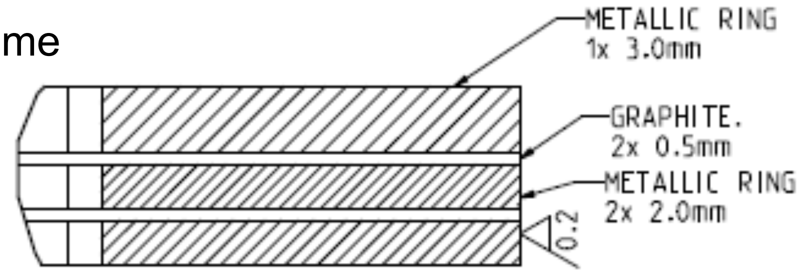



S, Mises
(Avg: 75%)
+1.503e+03
+1.377e+03
+1.252e+03
+1.127e+03
+1.002e+03
+8.766e+02
+7.513e+02
+6.261e+02
+5.009e+02
+3.757e+02
+2.504e+02
+1.252e+02
+0.000e+00
Step: Compress Frame: 0
Total Time: 0.000000
Step: Compression
Increment 0: Step Time = 0.0
Primary Var: S, Mises
Deformed Var: U Deformation Scale Factor: +1.000e+00
X
Y
Z

Example Applications

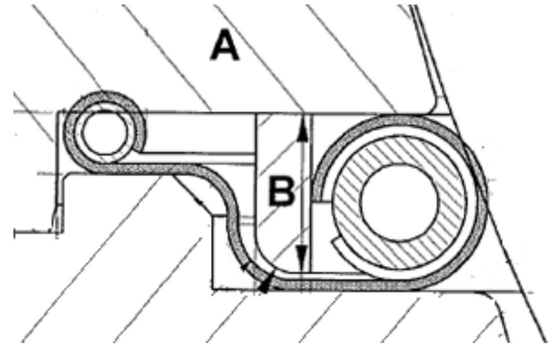
- **Laminated Graphite Seal**
  - Metallic and graphite
  - High precision and complex geometry
  - Control of graphite flow
  - Up to 150 bar pressure
  - Triple-offset valves
  - LNG, Steam …
  - High leak tightness
  - High resistance over time

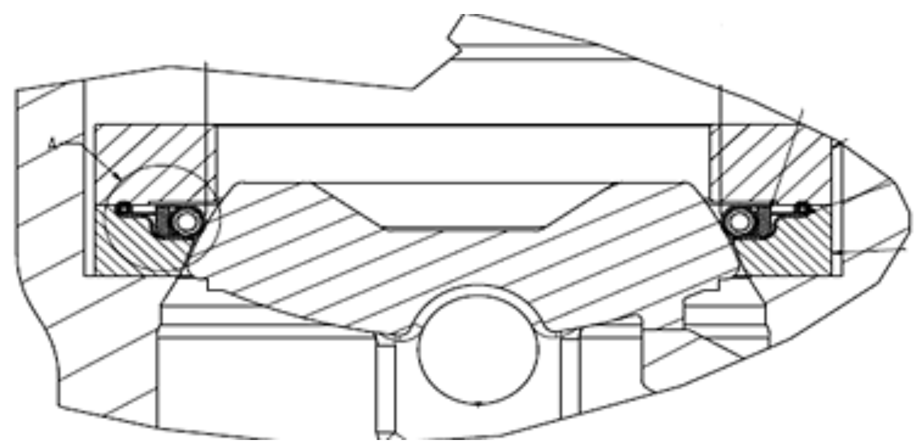




Example Applications

- **Double torus spring energized metallic seal**
  - 100% metallic
  - High precision and complex geometry
  - Control of compression
  - Up to 50 bar pressure
  - Triple-offset valves
  - LNG, Steam …
  - High leak tightness
  - High resistance over time





Cautions

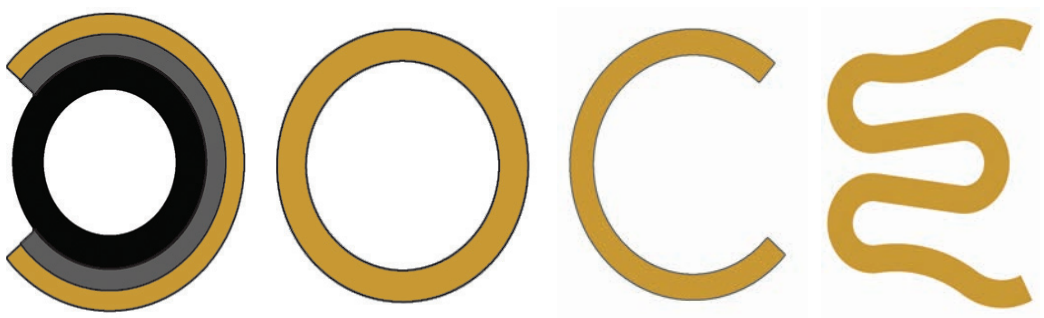
- **Proper Installation**
  - Proper bolting practices
  - Seal orientation for axial pressure sealing
  - Avoid damage to seal or hardware during seal removal
- **Seal design criteria should be considered during hardware design**
- **Bi-Directional Pressure**
- **Finish: Specific to seal type and material**

Example of improperly installed Spring Energized Seal
(Jacket stripped from spring)

Conclusions

Metal Sealing in the Valve Industry

- ***Resilient metal seal technologies improve leak rates, safety & reliability***



- **Controlled compression load**
- **Can suit standard AINSI surface roughness**
- **High resiliency**
- **Flexible design**
- **Helium leak rate**

H2S, and other Gases

Extreme Temperatures

Extreme Pressure Conditions

Environmental Challenges

Wellhead Drilling

- Globe Valves
- Choke Valves

Hydraulic Fracturing

- Globe Valves
- Plug Valves
- Butterfly Valves

Flow Back and Well Test

- Pressure relief valves
- Ball Valves
- Choke Valves
- Plug Valves
- Butterfly Valves

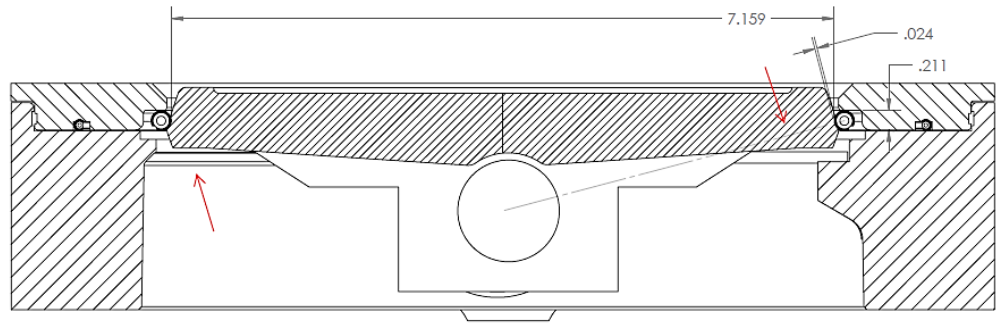
Production

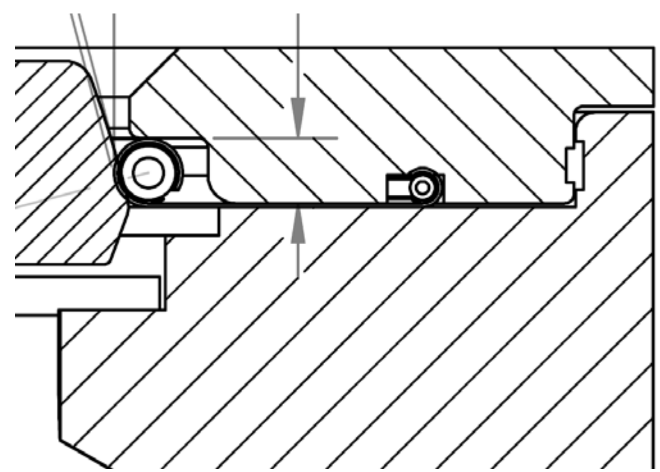
- Choke Valves
- Ball Valves
- Check Valves
- PRV
- Butterfly etc

API 6A → API 5D

Conclusions: Best Practice Design & Selection

- This industry demands the widest variety of materials
- Virtually all valve types
- Materials from steel to super alloys
- Sizes from ½” to 48”
- Operating conditions from cryogenic to 1204°C
- Low pressure classes through 4500 class
- Water to hydrofluoric acid





Thank You!

Any Questions?

EXPLICIT DEFINITION OF SEALING LEVELS IN THE CASE OF GASES

(for Delta P = 1 bar)

(In easy terms, a given leak rate corresponds to a volume or weight of product wich escapes from a chamber in a given time)

HELIUM				EQUIVALENT			
Leakage rate (measured with a mass spectrometer) Pa.m3/s	Sealing level	PVRC Classification (USA)	Leakage rate (measured with a mass spectrometer) atm. cc/s	*Capacity of reference*	*Time*	*He weight (gaseous)*	*volume*
10^{-13} Pa.m3/s		T8	10^{-12} atm.cc/s	**Pin-head**	**2 200 years**	0,01 mg	0,1 cc
10^{-12} Pa.m3/s			10^{-11} atm.cc/s	**Pin-head**	**200 years**	0,01 mg	0,1 cc
10^{-11} Pa.m3/s		T7	10^{-10} atm.cc/s	**Pin-head**	**20 years**	0,01 mg	0,1 cc
10^{-10} Pa.m3/s	Helium		10^{-9} atm.cc/s	**Thimble**	**50 years**	0,27 mg	1,5 cc
10^{-9} Pa.m3/s		T6	10^{-8} atm.cc/s	**Thimble**	**5 years**	0,27 mg	1,5 cc
10^{-8} Pa.m3/s			10^{-7} atm.cc/s	**Thimble**	**6 months**	0,27 mg	1,5 cc
10^{-7} Pa.m3/s		T5	10^{-6} atm.cc/s	**Thimble**	**2 weeks**	0,27 mg	1,5 cc
10^{-6} Pa.m3/s			10^{-5} atm.cc/s	**Thimble**	**2 days**	0,27 mg	1,5 cc
10^{-5} Pa.m3/s	Bulloscopy	T4	10^{-4} atm.cc/s	**Magnum of champagne**	**6 months**	0,27 g	1,5 dm3
10^{-4} Pa.m3/s			10^{-3} atm.cc/s	**Magnum of champagne**	**2 weeks**	0,27 g	1,5 dm3
10^{-3} Pa.m3/s		T3	10^{-2} atm.cc/s	**Bucket**	**2 weeks**	2,7 g	15 dm3
10^{-2} Pa.m3/s			10^{-1} atm.cc/s	**Bucket**	**2 days**	2,7 g	15 dm3
10^{-1} Pa.m3/s		T2	1 atm.cc/s	**Tanker**	**20 weeks**	2 100 g	12 000 dm3
1 Pa.m3/s			10 atm.cc/s	**Tanker**	**2 weeks**	2 100 g	12 000 dm3
10 Pa.m3/s		T1	100 atm.cc/s	**Tanker**	**1 day**	2 100 g	12 000 dm3