Edge-Welded Metal Bellows

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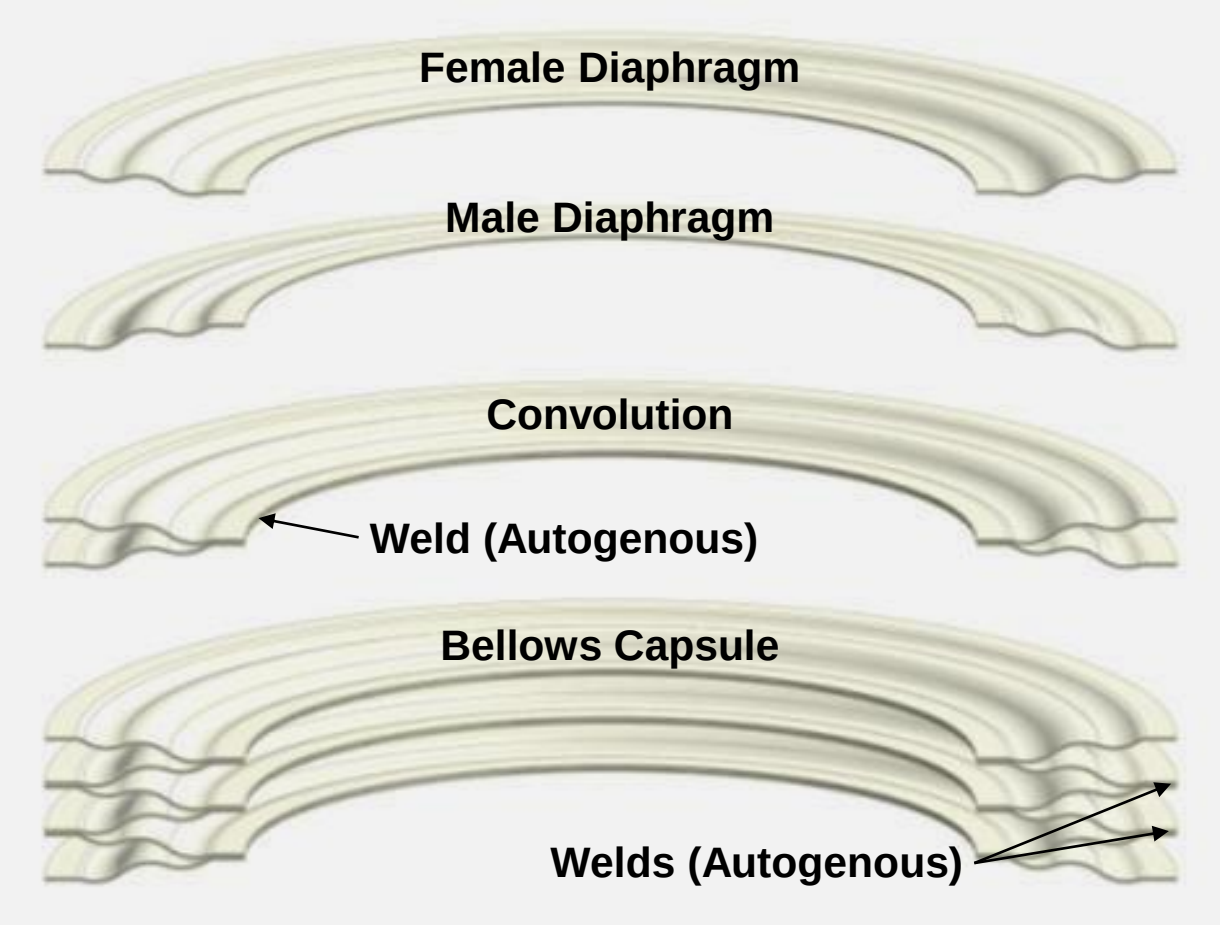
- Senior Aerospace Metal Bellows

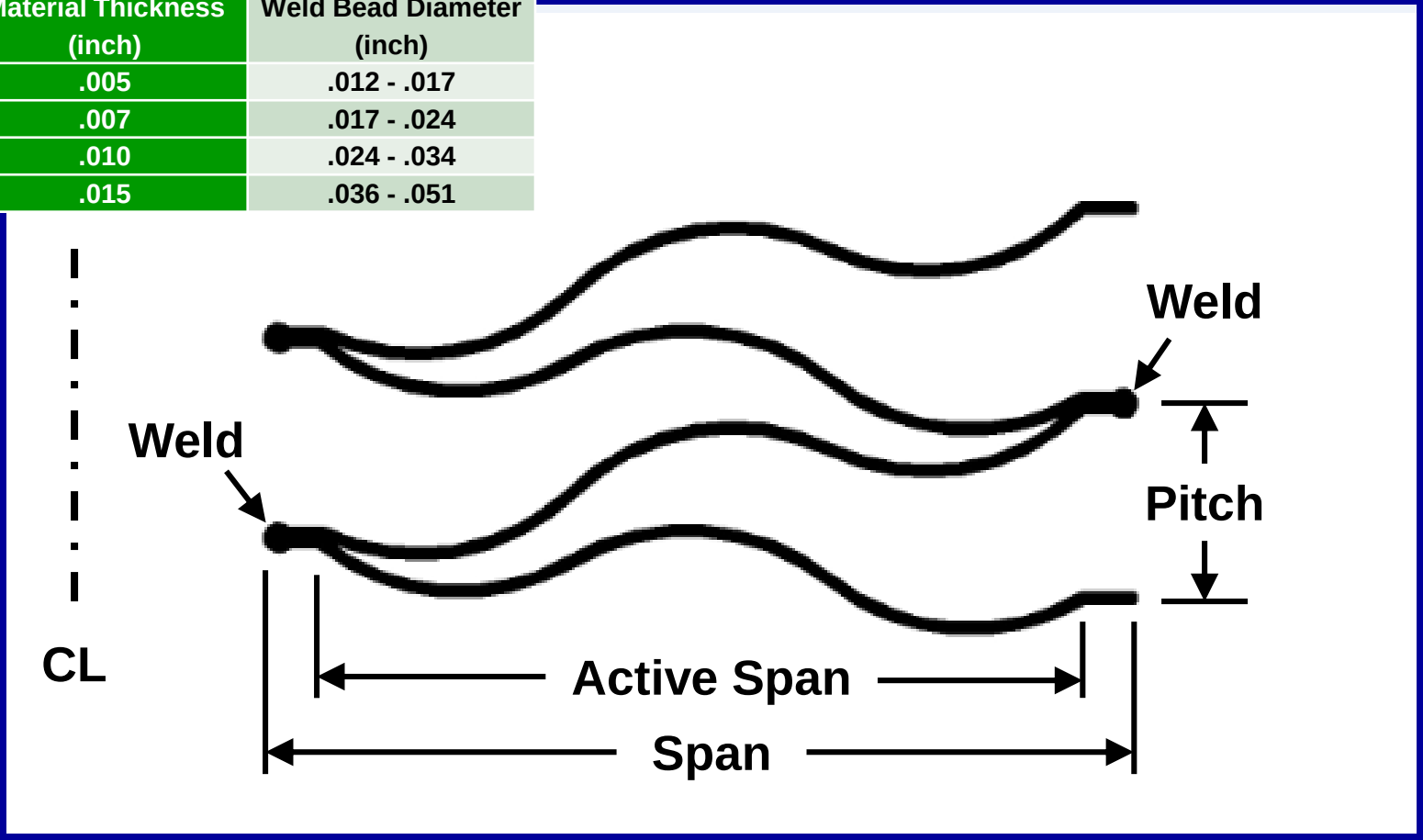
Senior Aerospace
Metal Bellows
Senior Operations LLC

What is an edge-welded metal bellows?



Edge-Welded Metal Bellows Terminology

Weld Bead Size vs. Material Thickness	
Material Thickness (inch)	Weld Bead Diameter (inch)
.005	.012 - .017
.007	.017 - .024
.010	.024 - .034
.015	.036 - .051



Effective Area

The area that pressure acts upon to produce a force output

- **Similar to the piston in a air cylinder**
- **Force (lbs) = Pressure (psi) x Area (sq.in.)**

$$A_E = \frac{(OD + ID)^2 \pi}{16} = \frac{(2 + 1.4)^2 \pi}{16} = 2.27$$

Spring Rate

Convolution Spring Rate (Kc)
(lb./in/convolution)

$$K_c = \frac{10.3x10^6 t^2}{S}$$

Capsule Spring Rate (K)
(lb/in)

$$K = \frac{K_C}{N}$$

t = Diaphragm Thickness
S = Span
N = Number of Convolutions

Spring Rate

Convolution Spring Rate (Kc)
(lb./in/convolution)

Thickness = .002"
Span = (OD - ID)/2
Span = (2 - 1.4)/2 = 0.3"

$$K_c = \frac{10.3x10^6(.002)^2}{0.3} = 137$$

Capsule Spring Rate (K)
(lb/in)

Convolution K-rate = 137
Number of Convolutions = 56

$$K = \frac{137}{56} = 2.4$$

Force/Pressure Balance

$$\Delta P \cdot A_E = k \cdot \Delta L$$

Example:

$\Delta P = differetial\ pressure\ (psid)$

$A_E = effective\ area\ (in^2)$

$K = spring\ rate\ (lb/in)$

$\Delta L = change\ in\ length\ (in)$

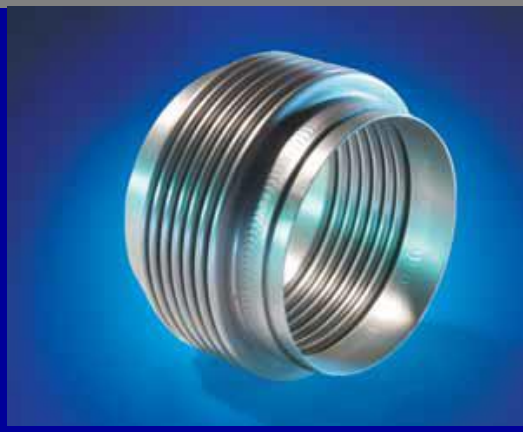
$\Delta P = 1\ psid$

$A_E = 2.27\ in^2$

$K = 2.4\ lb/in$

$$\Delta L = \frac{(1\ psid)(2.27\ in^2)}{2.4\ lb/in} = 0.946\ in$$

Edge-Welded versus Formed



Stroke

- Edge-welded bellows can be compressed up to 90% and extended up to 30%
- Formed bellows are limited to about 10%

Flexibility

- Edge-welded bellows are relatively soft in the axial, angular, and radial directions

Cost

- In general, edge-welded bellows are more expensive due to the extensive welding

Materials of Construction

Heat Treatable:

- AM-350 Stainless Steel
- Inconel 718
- Haynes 242

Non-Heat Treatable:

- 300 Series Stainless Steels
- Inconel 625
- Titanium
- Hastelloy C276

Mate bellows with compatible fittings including Incoloy® 945/945X

Methods of Manufacture

Micro-welding

- GTAW (TIG)
- Laser
- Electron Beam

Cleaning

- Aqueous
- Electropolish
- Pickle

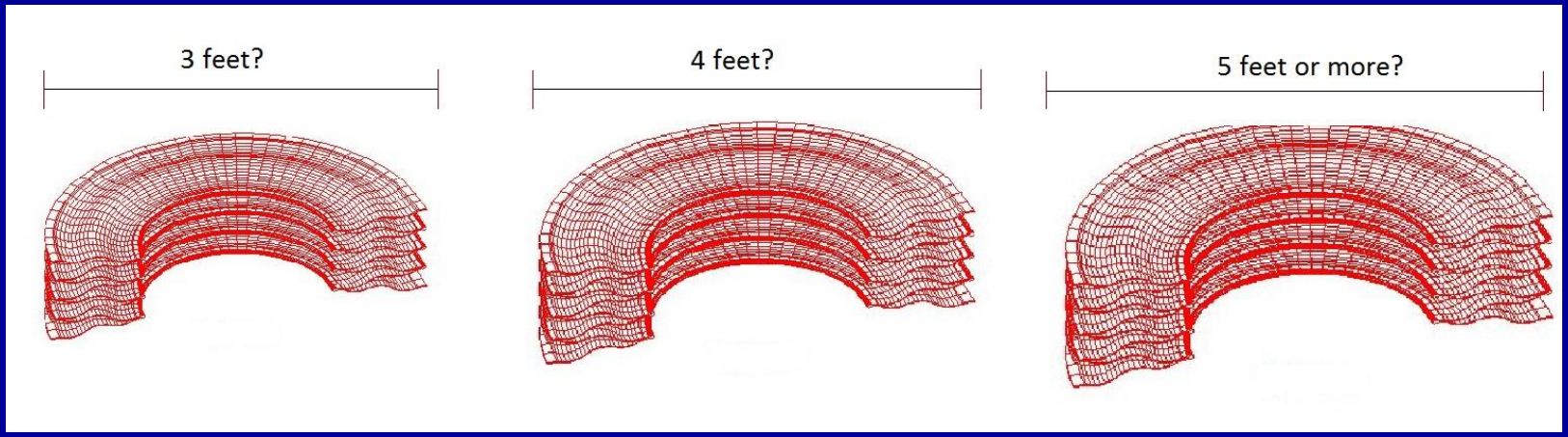
Sizes and Thicknesses

Outside Diameters

- < 0.125"
- Up to 6 feet

Thickness

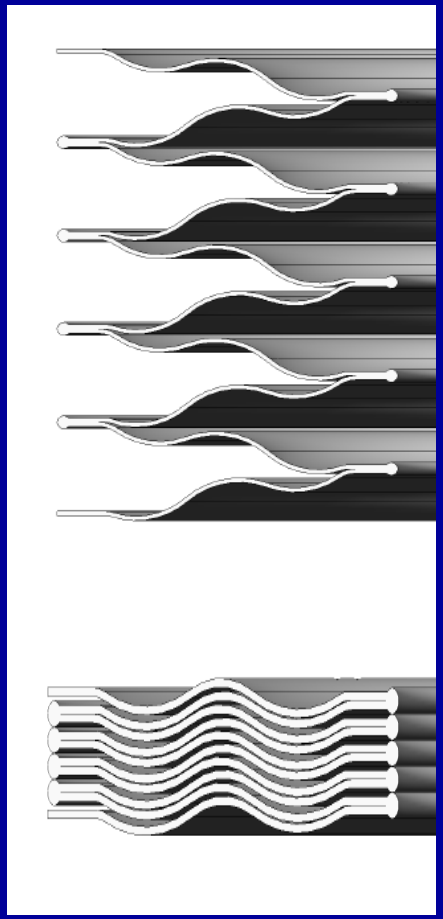
- 0.001" - .050"



Types of Edge-Welded Bellows

Nesting Ripple Bellows

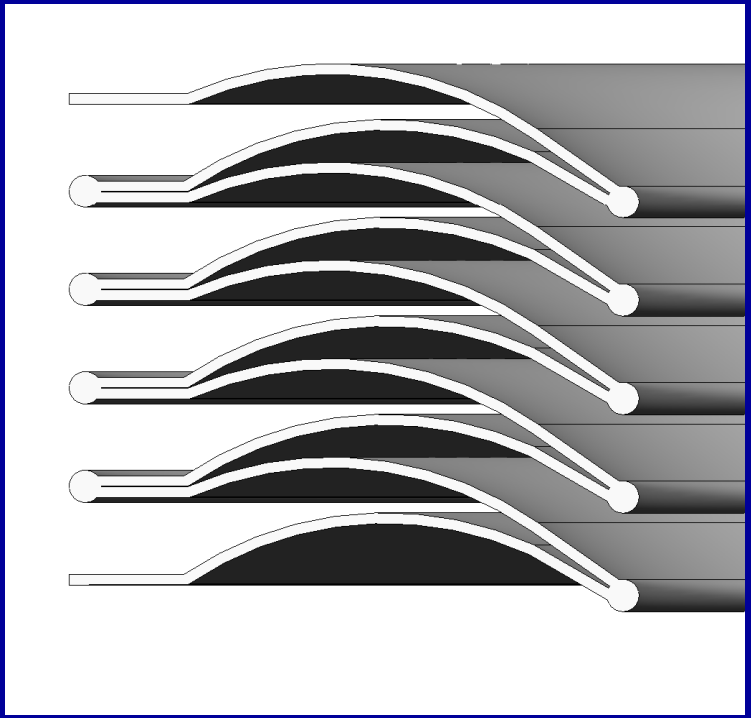
- Long Stroke Capability
- Compact Nested Length
- Good Linearity
- Moderate Pressure Capability



Types of Edge-Welded Bellows

Single Sweep Bellows

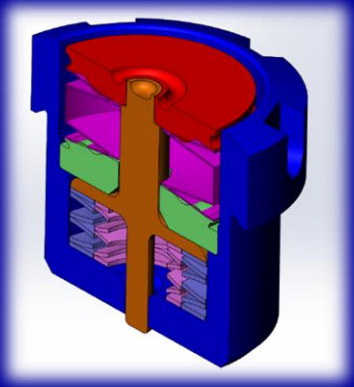
- Good Pressure Capability
- Good Stroke Capability
- Compact Nested Length
- Good Linearity

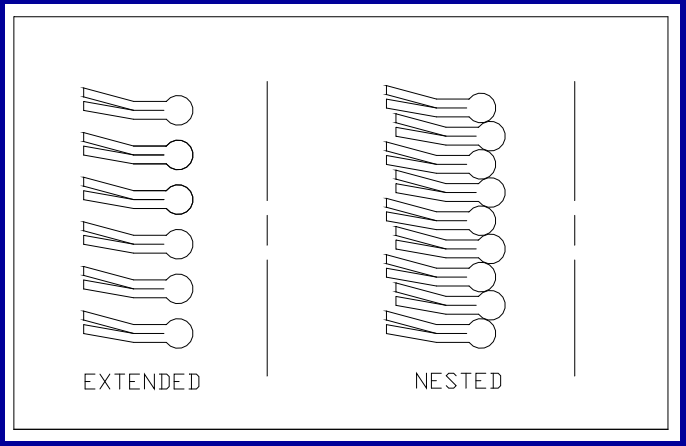


Types of Edge-Welded Bellows

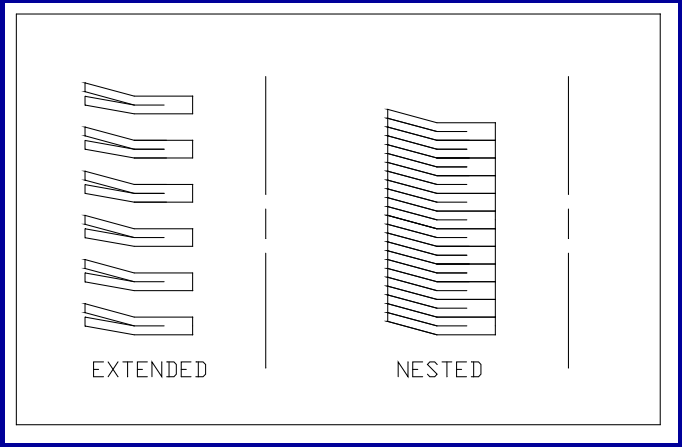
HIPRES® Bellows

- **Withstands tremendous pressure in the nested position**





Conventional Bellows



HIPRES® Bellows

Types of Edge-Welded Bellows

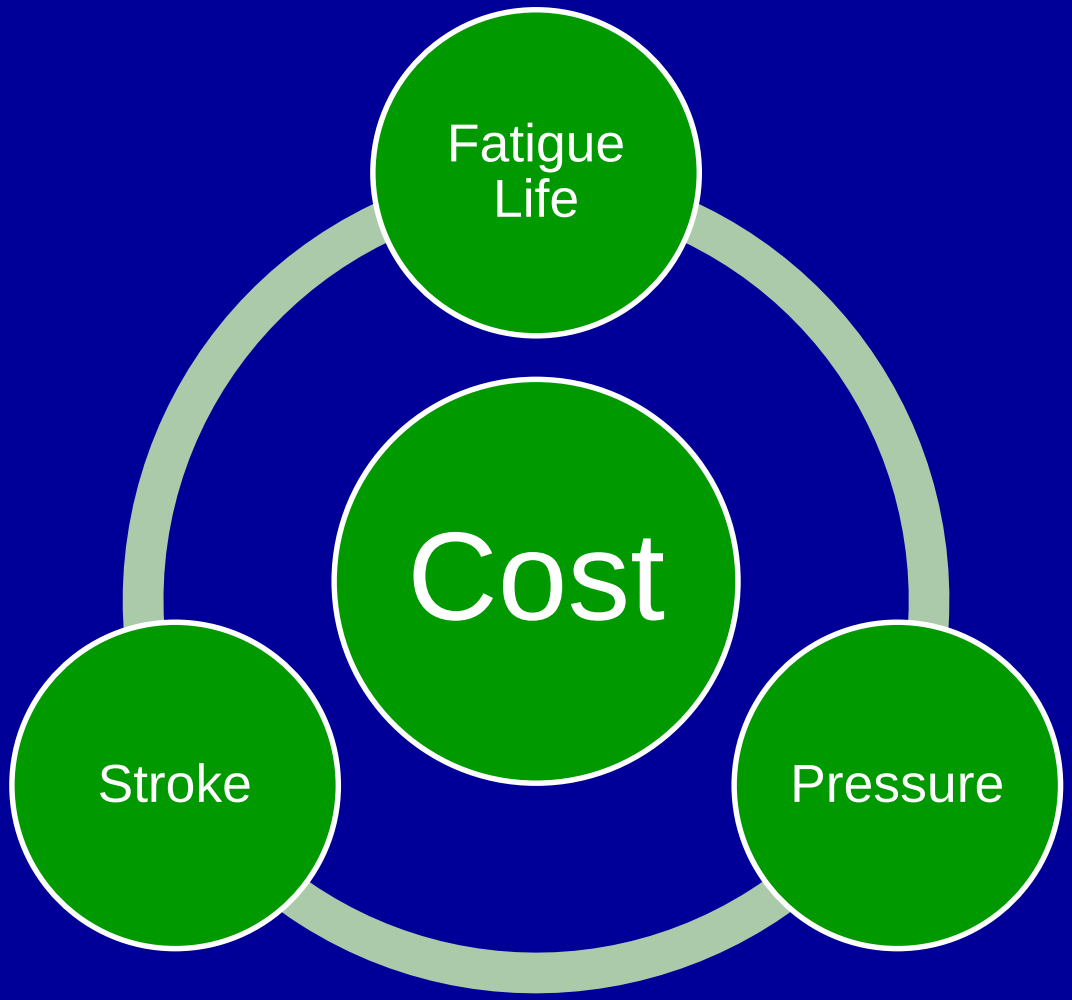
HIFORCE Bellows

- Transmits tremendous force in the nested position
- Excellent for holding and locking

Other Bellows Configurations

- Coned OD & ID, flat plate, crescent, torus, multi-ply bellows

Design Considerations



Extreme Temperatures

- Temperatures up to 1400°F (760°C) and higher
  - Flexible exhaust ducts
  - Thermal switches
  - Thermal valves
  - Thermal actuators
  - Firewall penetrations

Bellows!!

Extreme Pressures

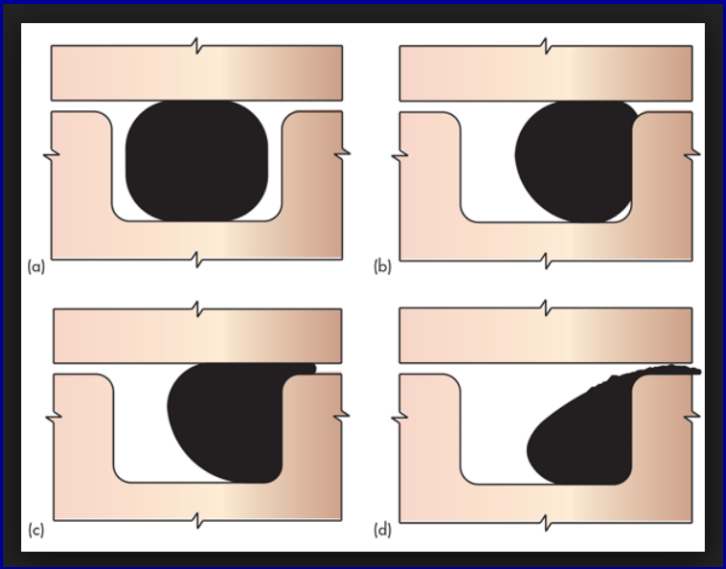
- Pressures up to 25,000 psi
  - Gas-lift valves
  - Pressure/temperature compensators (e.g. for ESP's)
  - Pressure switches
  - Sub-sea junction boxes
  - Accumulators (e.g. for aircraft hydraulic systems)

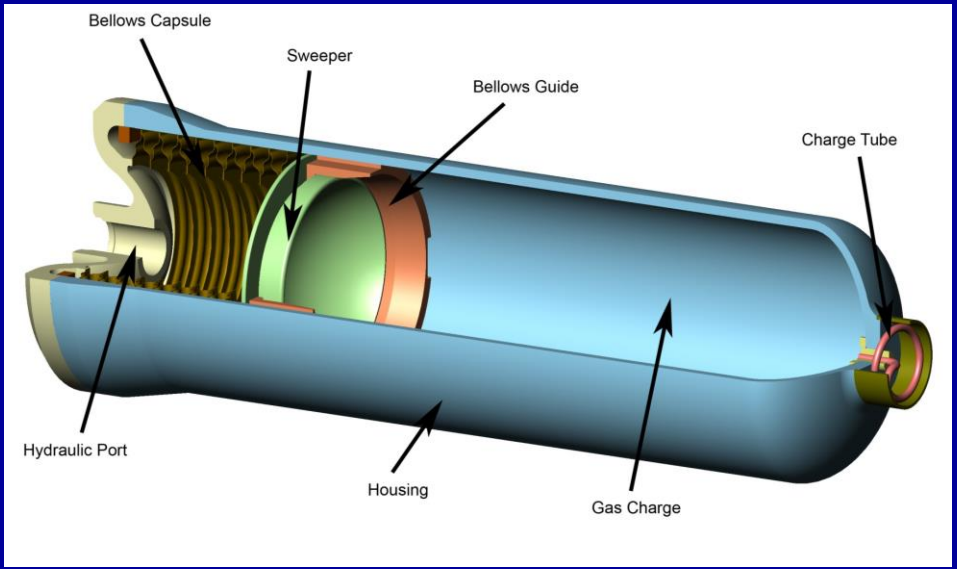
Reliability/Zero Maintenance

- 1,000,000,000 cycle bellows
- Gas-lift valves to 13,000 psi
- Medical implants
- Maintenance free accumulators
  - Fully welded and hermetically sealed for life
  - Space shuttle and space station applications

Leakage

- Helium mass spectrometer leak tight up to $1x10^{-10}$ scc/sec helium (1 cc in 320 years)
- Elastomeric seal replacements
  - Dynamic seals in the desert





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