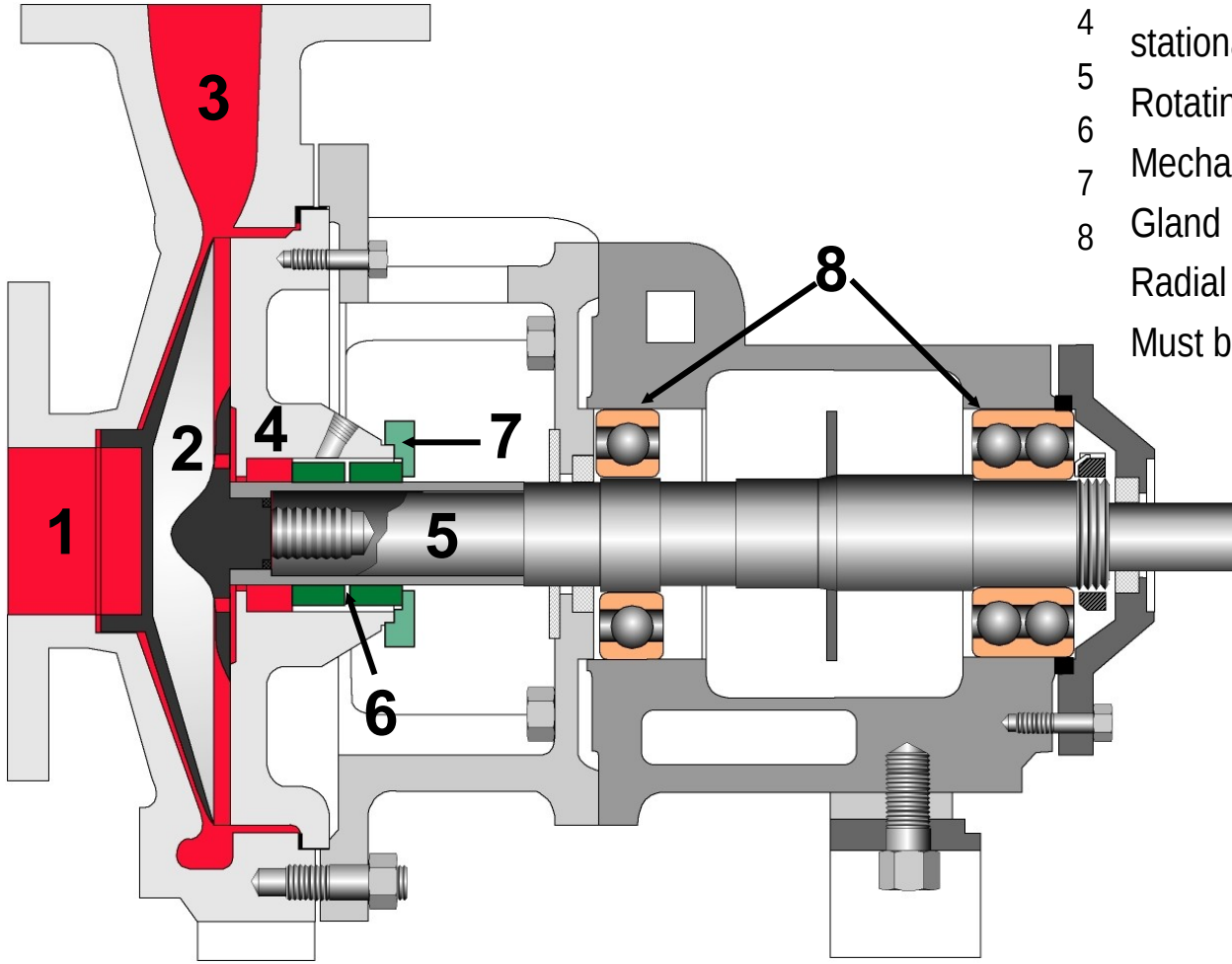
Typical Centrifugal Pump



1 Suction
2 Impeller
3 Discharge
4 stationary Casing
5 Rotating Shaft
6 Mechanical Seal in Stuffing Box
7 Gland
8 Radial & Thrust Bearings to Support the Shaft
Must be lubricated at all times.

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Seal Basics

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Pump Pressures

Suction Pressure

The actual pressure, positive or negative at the pump suction connection as measured on a gage.

Discharge Pressure

The actual pressure at the pump discharge connection as measured on a gage.

It is equal to the pump suction pressure plus total head developed by the pump.

Stuffing Box Pressure

The pressure acting on the stuffing box which must be sealed.

It is a function of pump impeller design and the presence or condition of wear rings.

Stuffing Box Pressure

- The pressure acting on the stuffing box which must be sealed.
- It is a function of pump impeller design and the presence or condition of wear rings.

Impeller design and Stuffing box pressure

Back vanes - Open impeller

Suction + 25% of differential = Stuffing box pressure

Balance Holes - Closed impeller

Suction + 10% of differential = Stuffing box pressure

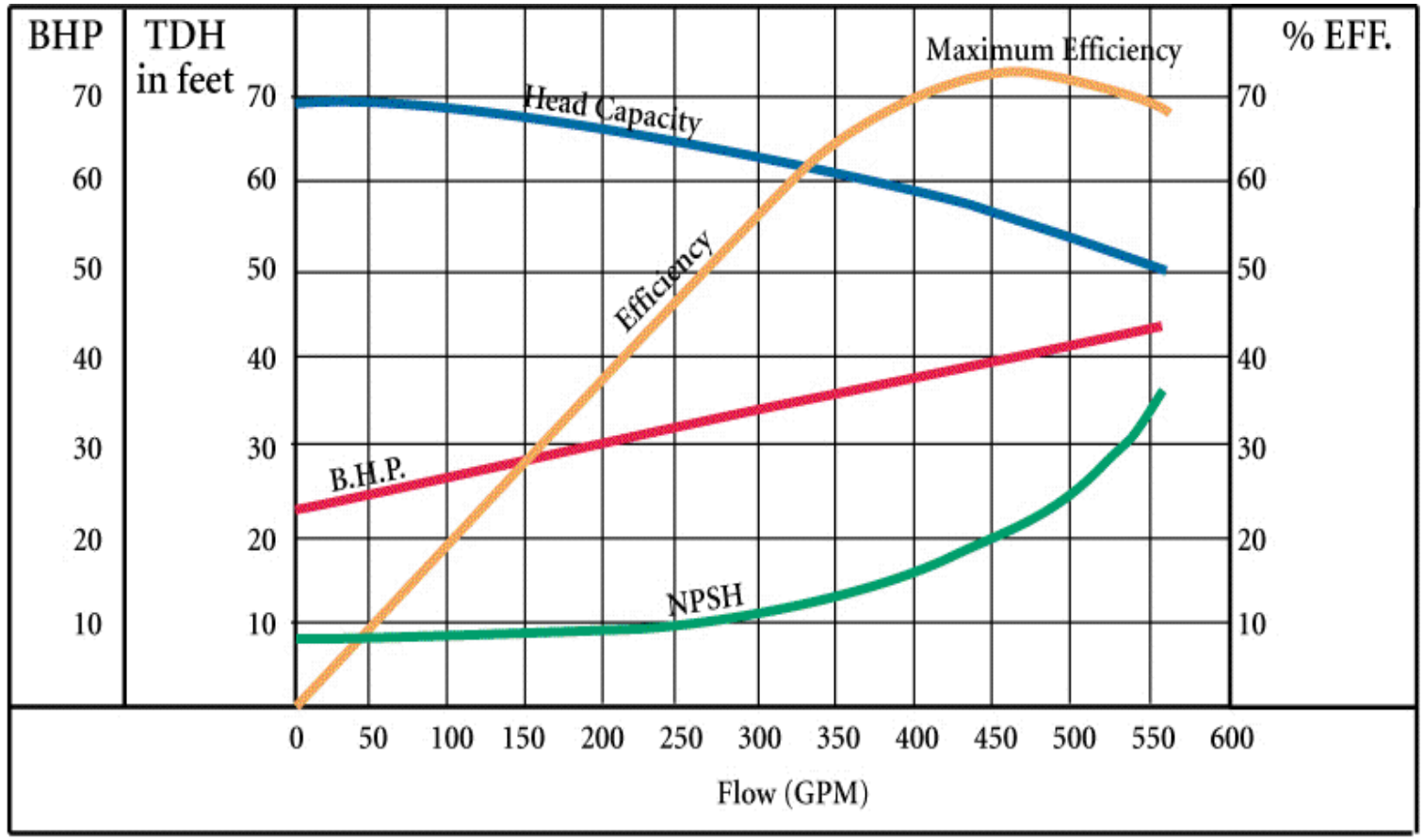
Double Suction

Suction pressure = stuffing box pressure

Viscosity

- Generally the higher the viscosity, the better the lubricating characteristics
- A product with a viscosity of 20,000 SSU (5000 cp) can be sealed with standard seals
- Beyond 5000 cp, the drive unit has to be beefed up to compensate for the increased shear occurring at the sealing faces.
- For high viscous applications:
  - Single seal with external flush
  - Double seal with external flush
- The viscosity & lubricity of water decrease with increased temperature. Above 82°C (viscosity 0.35 cp) seal faces can contact each other and wear rapidly, unless specially designed

Centrifugal Pump Performance Curve



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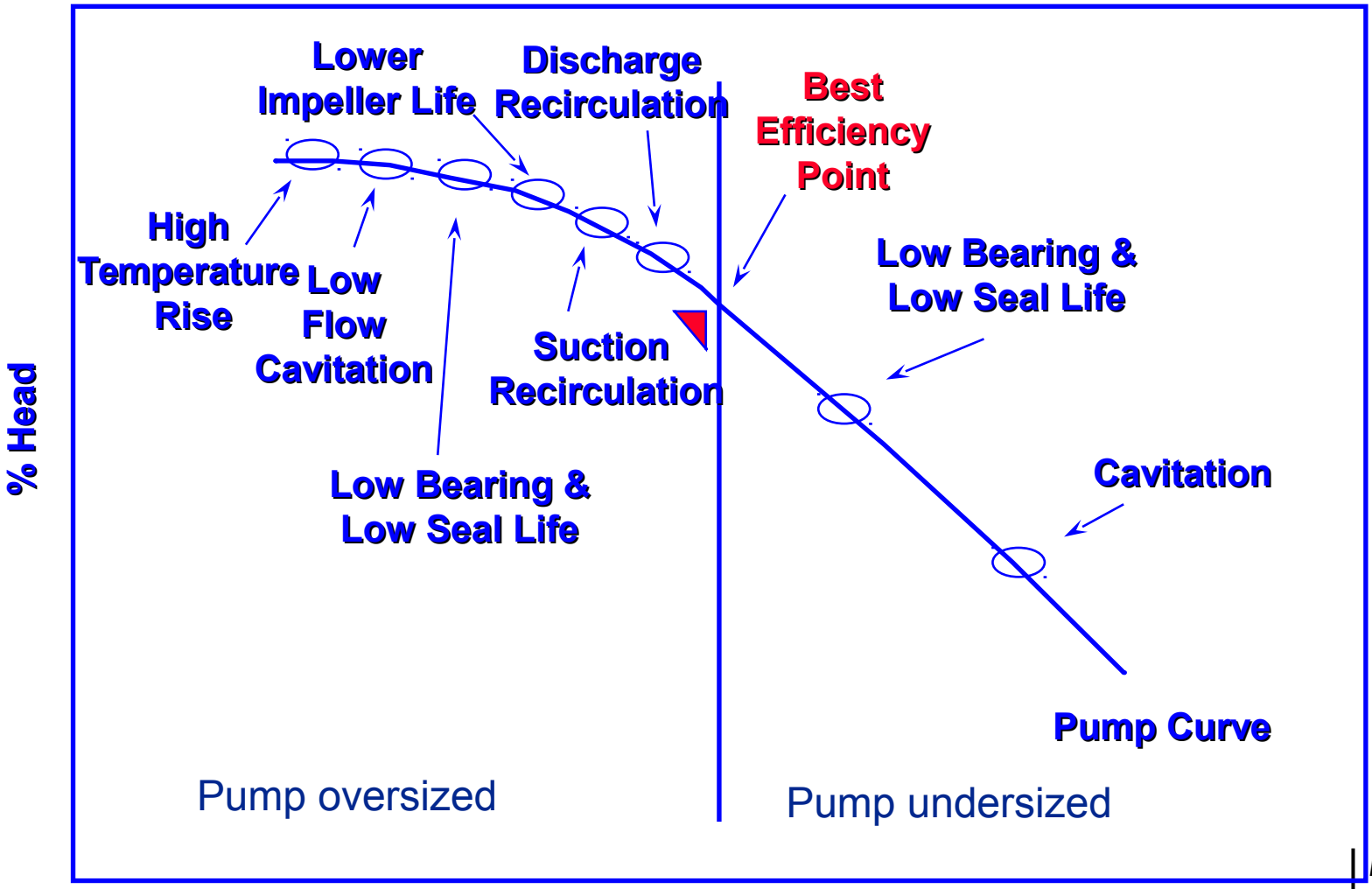
Equipment Reliability - Best Practices



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Equipment Reliability - Best Practices

- Operate pump -10% to +5% of B.E.P.
- Use 8-10 L/D in suction line
- Operate pump with minimum 25 psi over vapor pressure
- Eliminate pipe strain
- Properly apply selected piping plan (“a cool seal is a happy seal”)
- Properly align shaft

Specific Gravity

$$\text{Specific Gravity} = \frac{\text{Density of a substance}}{\text{Density of Water at 4°C}}$$

Specific gravity is used to estimate the lubricity of light hydrocarbons

Specific gravity below 0.68 (Heptane), require one face as carbon and special seal face design with higher balance to contain fugitive emissions

Vapour Pressure

The pressure at which a liquid will flash into vapor at given temperature

IF seal generated heat causes the sealing liquid to boil in seal chamber pressure, the liquid film between the seal faces will vaporize.

Solution :

- Increase seal chamber pressure with proper bypass flush line and throat restriction device.
- Cooling the seal chamber. Seal chamber should be kept at least 15°C below the boiling point of the product at the seal chamber pressure

Cavitation

Operated under cavitating conditions for sufficient length of time:

- Pitting of impeller vanes and pump volute
- Short bearing life and heavy loading
- Shaft breakage and other fatigue failures in the pump
- Short seal life

Damages to mechanical seals can be :

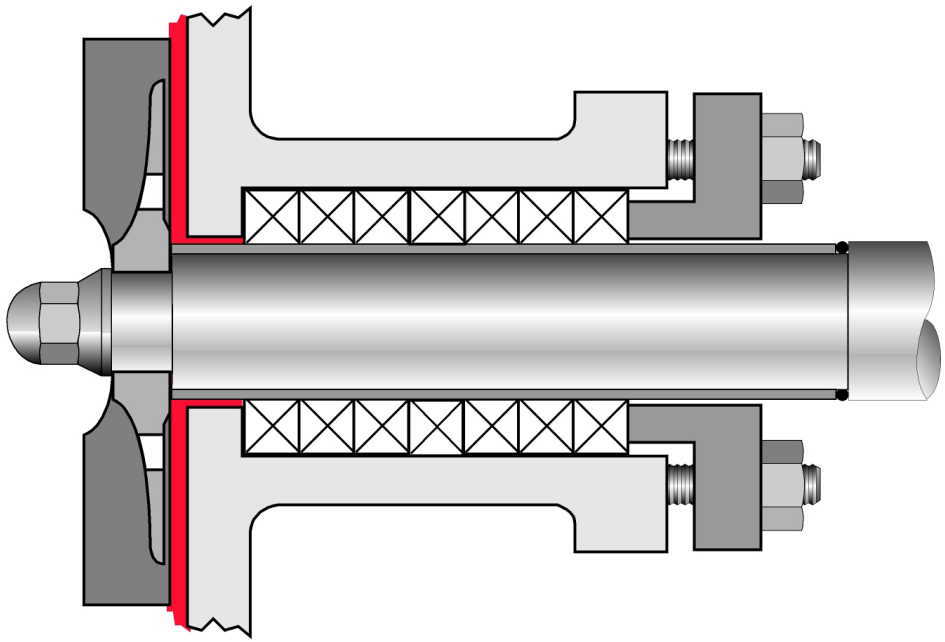
- worn pins and pin slots
- Broken springs
- shaft fretting
- Chipping of carbon faces

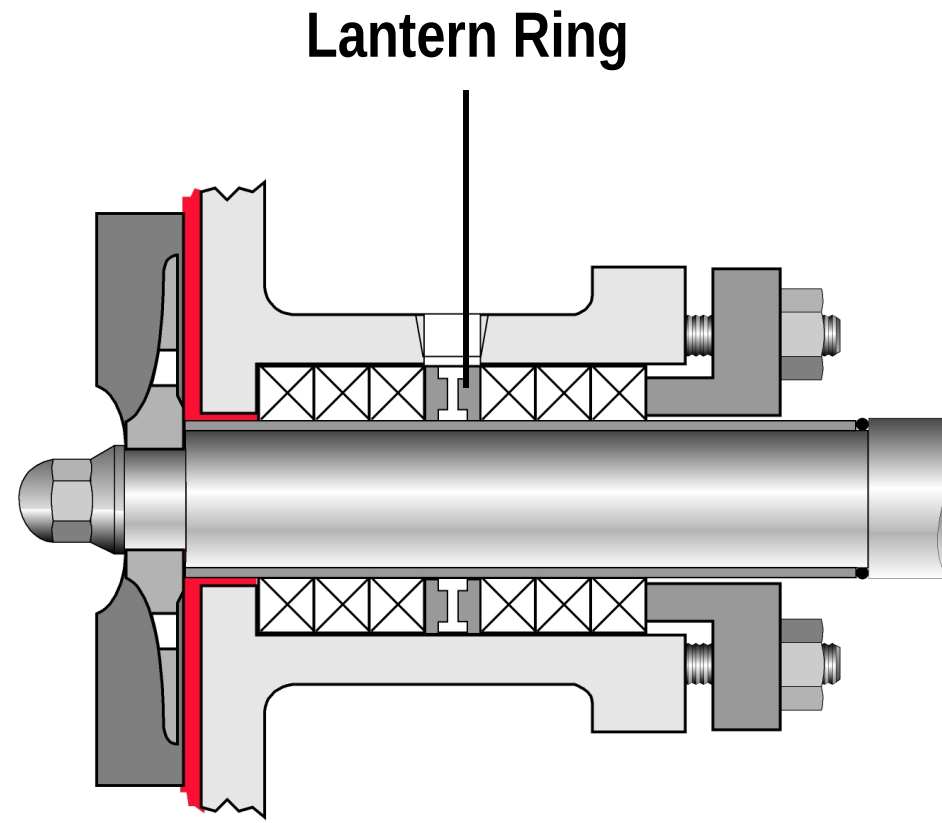
Cavitation

High Speed video shows that seal face temperature excursions occurred when gases were drawn across the seal faces and by the formation of gas bubbles in the seal chamber near the seal faces during pump cavitation.

Seal performance during cavitation :

Zones	Normal Pump Operation	Pump Cavitation Mode
Seal chamber temperature (C)	65	65
Shaft sleeve vibration, mils p-p	1.9	2 to 8.4
Seal face vibration, mils p-p	< 2.0	13 to 35
Seal face temperature (C)	67 to 74	166 to 427





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Disadvantages of Compression packings

- **Power consumption is HIGH.**
  The ratio of power consumption of Mechanical Seal to compression packing is 1:8

- **Leakage is very high and unpredictable.**
  Varies with compression on the packings. The ratio of Leakage of mechanical seal to compression packing is 1:600

- **No automatic wear compensation**

- **Fretting on sleeve or shaft**

Compression Packing – Leakage rates

Pressure	Leakage	
lb/in^2 (kPa)	drops / min	cc/min
0 - 60 (0 - 400)	60	4
61 - 100 (401 - 700)		190
101 - 250 (701 - 1700)		470

Heat Generation of Gland Packing

The heat generation at the packing can be estimated as :

$$Q = \frac{f \pi^2 P N D^2 L}{C J}$$

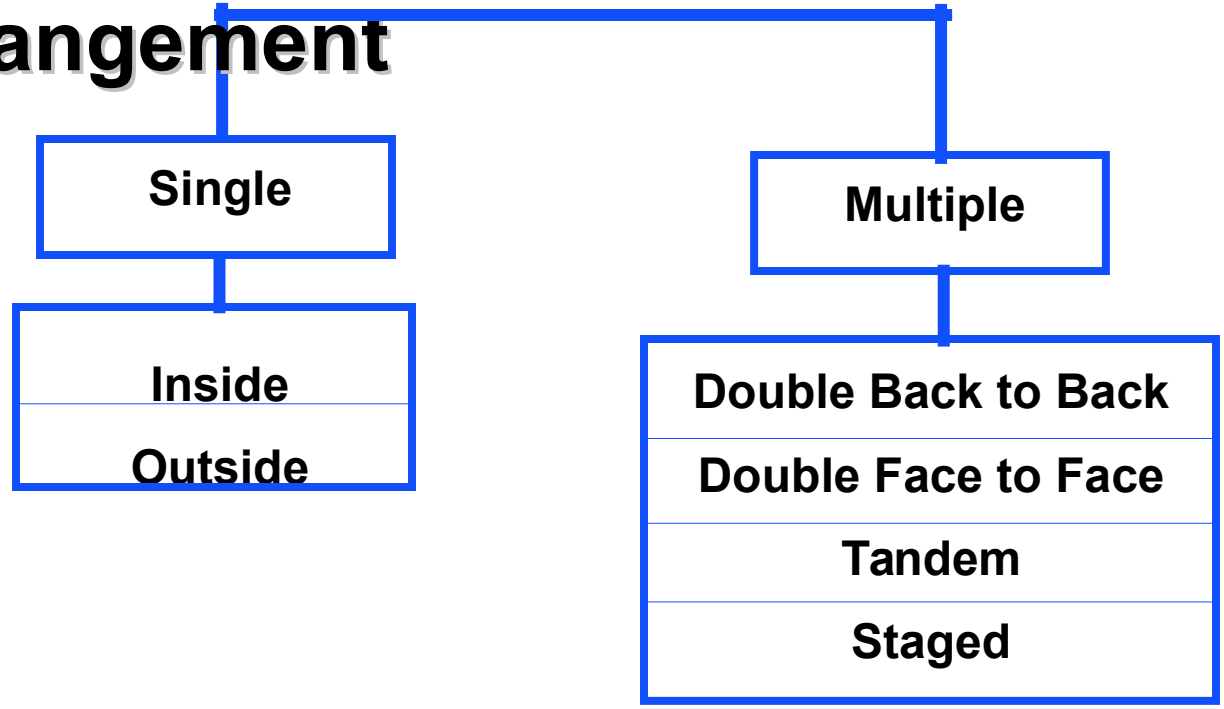
where
Q = heat generated , Btu/min (W)
f = co-efficient of friction
P = liquid pressure at packing, lb/in^2 gage (Pa)
N = Shaft speed, rpm
D = Sleeve OD or packing ID , in (m)
L = Sleeve length covered by packing, in (m)
C = 12 (60 for SI unit)
J = mechanical equivalent of heat = 778 ft . lb / Btu (1 N.m/s.W)

The co-efficient of various packings at a pressure of 100 lb/in^2 (689 kPa) is given below.

Material	f
Plain cotton	0.22
TFE-impregnated asbestos	0.17
Grease-lube asbestos	0.1

Classification of End Face Mechanical Seals

By Arrangement



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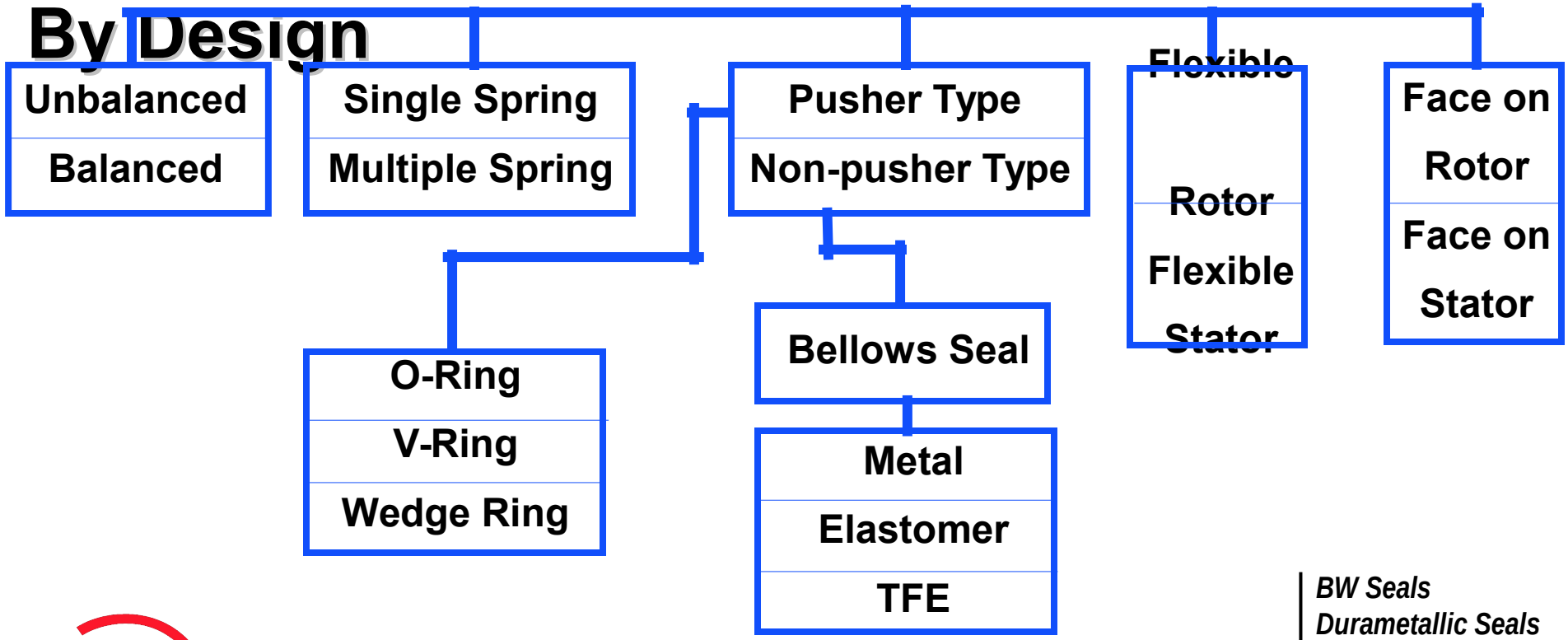
Classification of End Face Mechanical Seals

By Design



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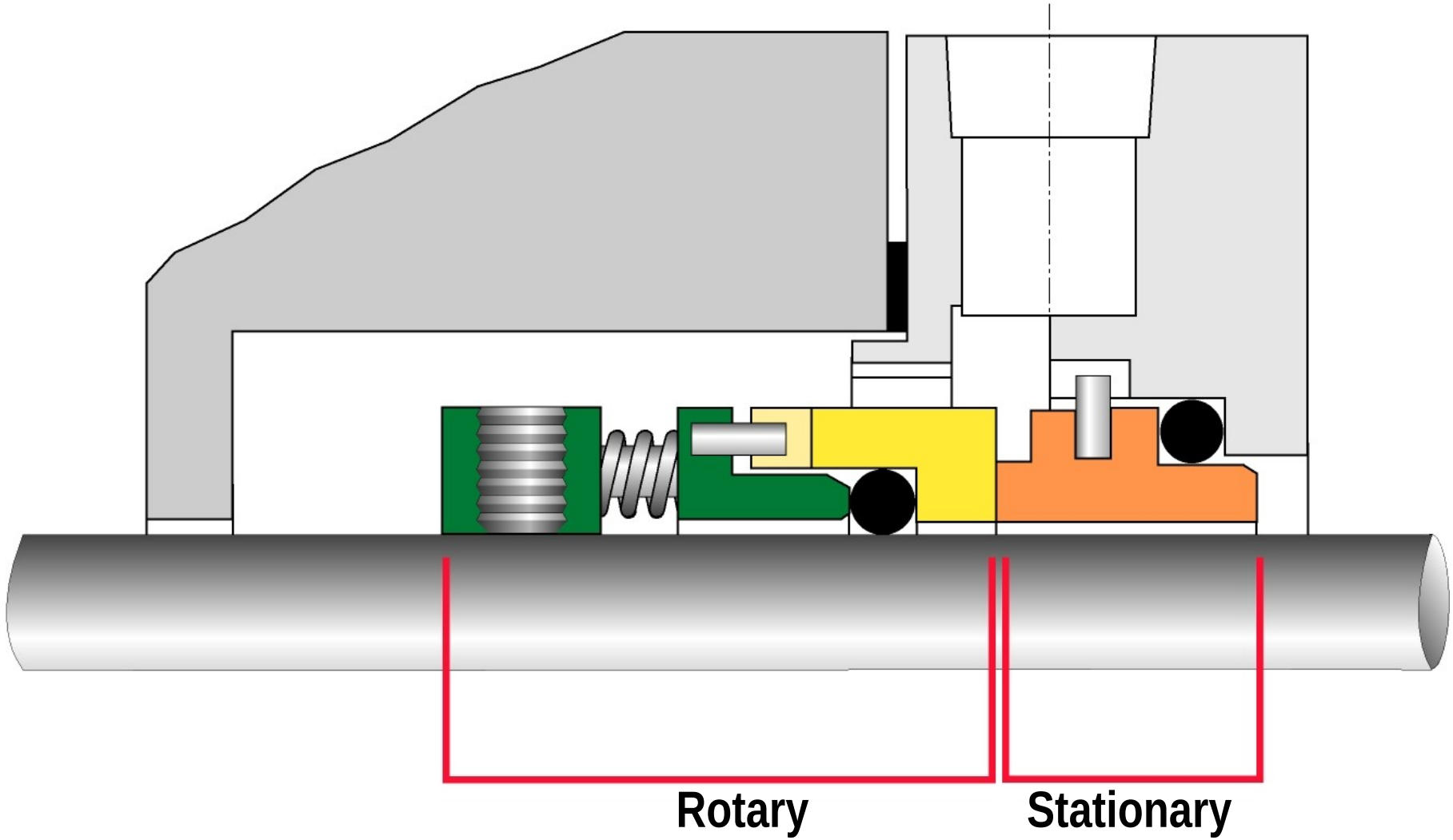

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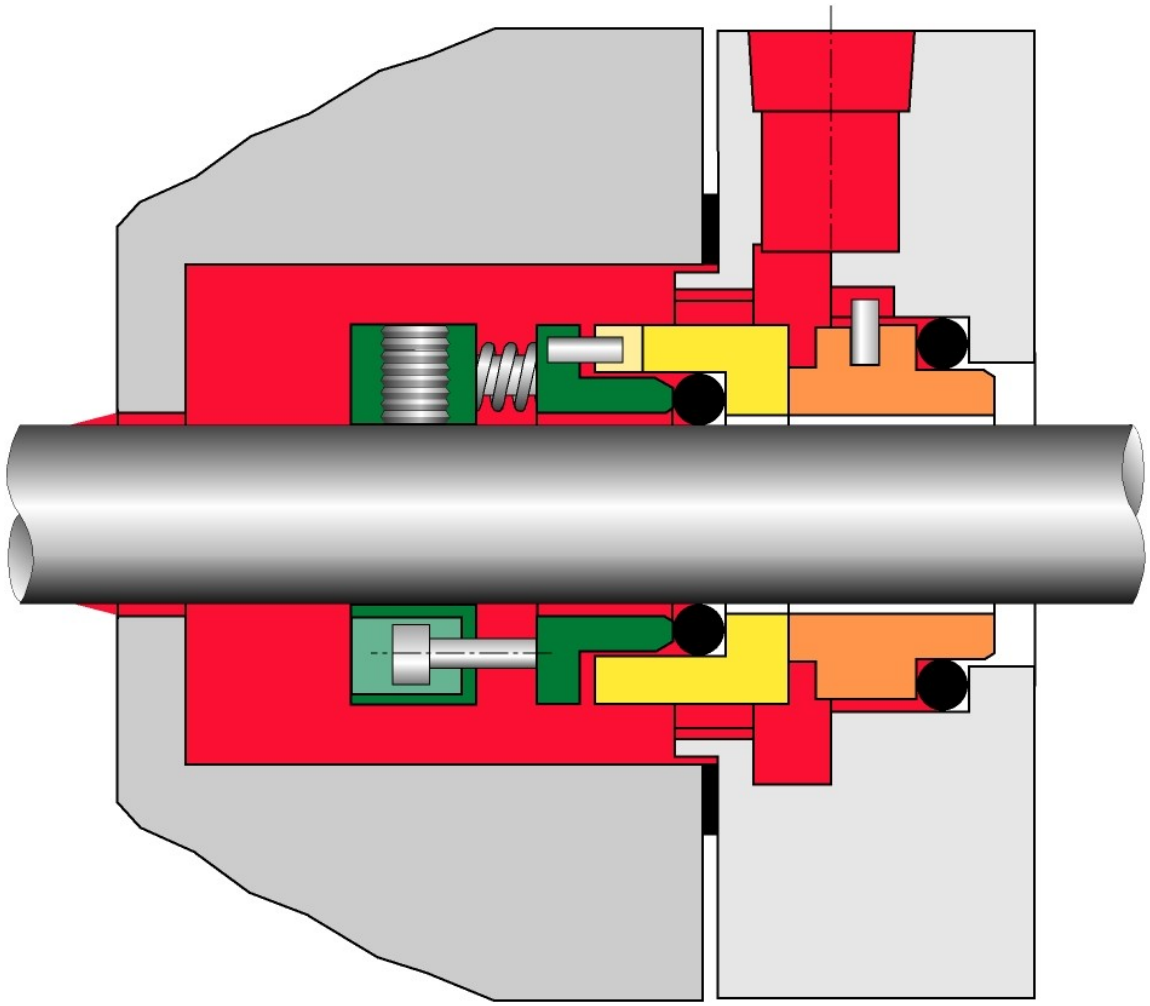
Typical Single Inside Pusher Seal



- Faces must be in contact
- Faces must be flat to within 3 light bands (34.8 millionth of an inch) Most are 1 light band (11.6 millionths)
- Faces must be lubricated by the liquid in the stuffing box

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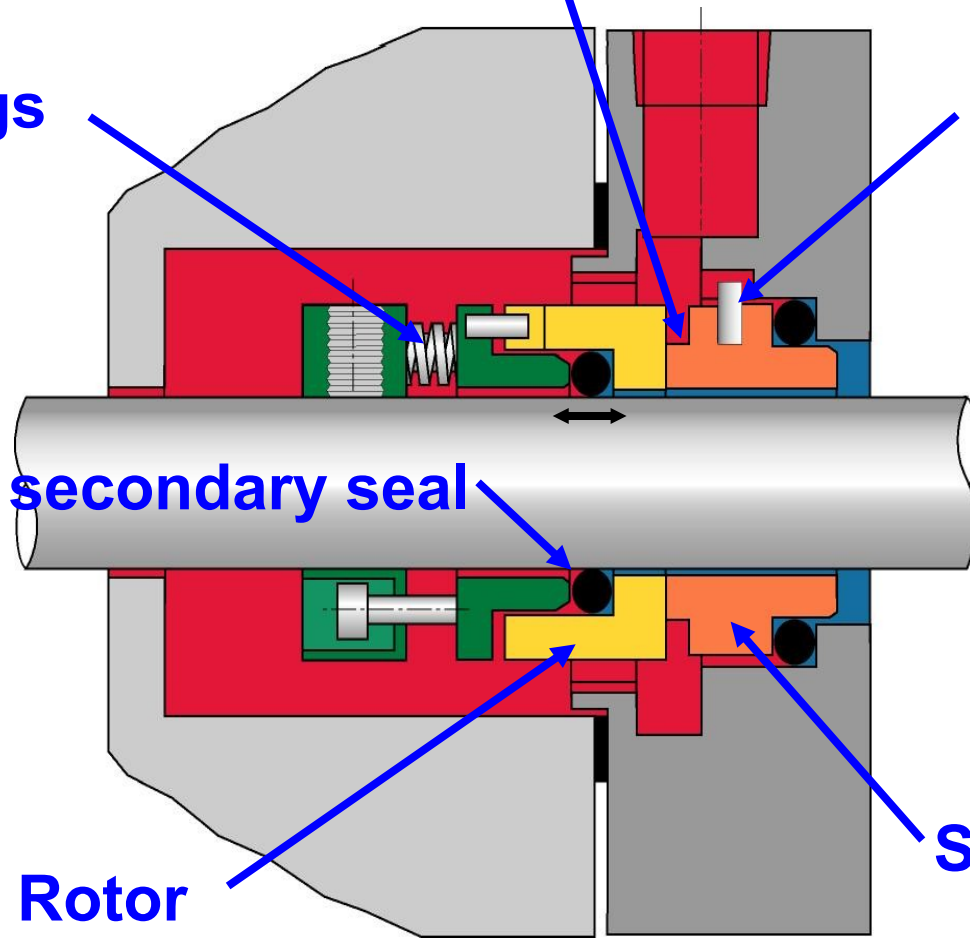
Mechanical Seal Terminology



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Hardware

316 /316 L / 316 Ti…..	Inconel 600
Alloy 20	17-4 PH
Hast C-276	Zirconium
Monel 400	Nickel
Titanium Gr 2, 7	AM-350 – For bellows
Duplex	Inconel 718
High Chrome Iron	

Seal Faces

Silicon carbide – Reaction bonded	Ceramic - Peramic
Silicon Carbide – Alpha Sintered	
Tungsten Cabide – Ni binder	
Tungsten Carbide – Co binder	
Tungsten Carbide - Binderless	
Stellite	
Chrome oxide - Durchrome	

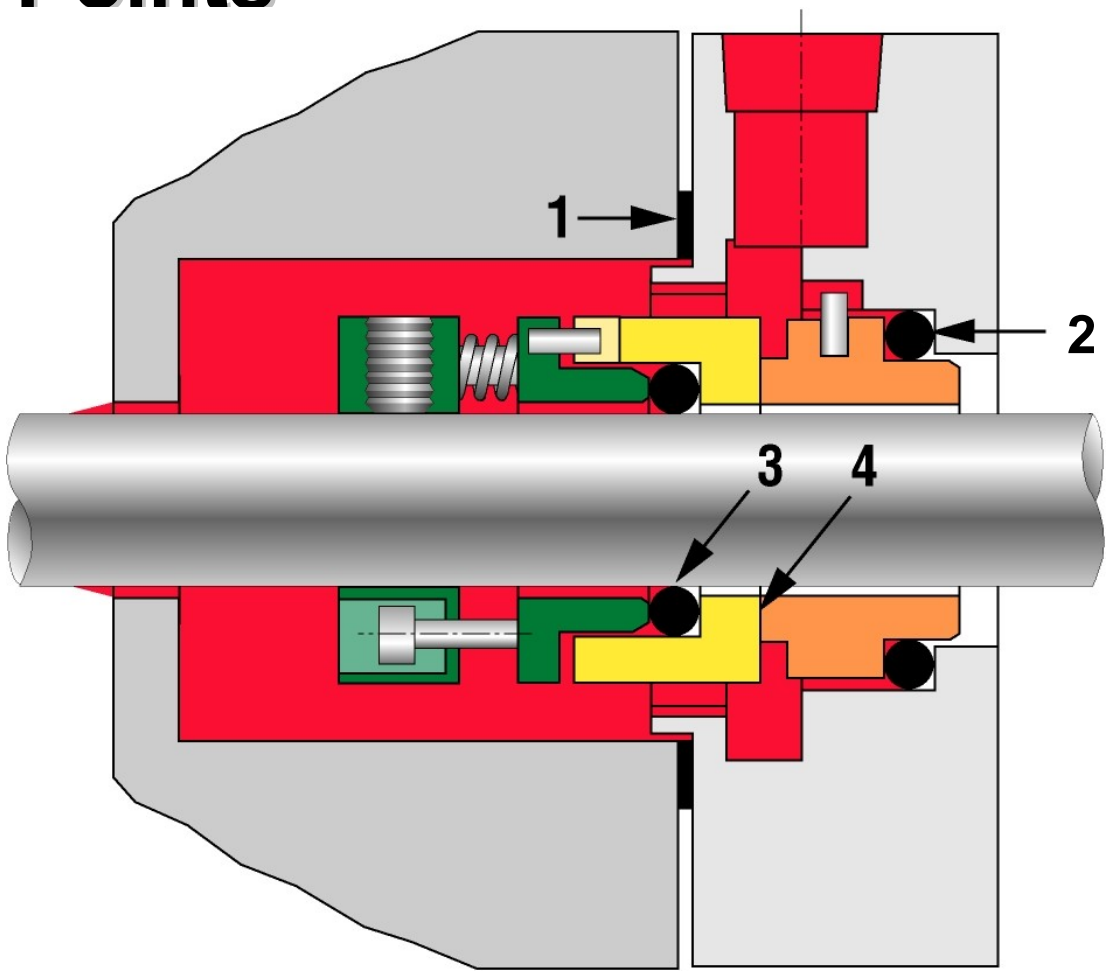
Seal Faces

# 5 Carbon	GF Carbon (Ammonia Resistant Grade)
# 6 Carbon	NA Carbon (Acid Resistant – HF)
# 17 Carbon	
# 19 Carbon	
GE / KI Carbon (Resin Impregnated)	
RY Carbon (Antimony Impregnated)	
AE Carbon (Dry Running grade)	

Secondary Packings

Viton (Flurocarbon)	Glass Filled Teflon
Nitrile (Buna – N)	Graphite filled Teflon
Neoprene	Grafoil (Durafite)
EPR / EPT	
Kalrez (Perfluro carbon)	
Chemraz (Perfluro carbon)	
Pure Teflon	

Mechanical Seal Leak Points



1 Gland to pump face -
2 sealed with a gasket
3 Over the top of the seal -
4 O-ring
Under the seal - O-ring
Between the faces

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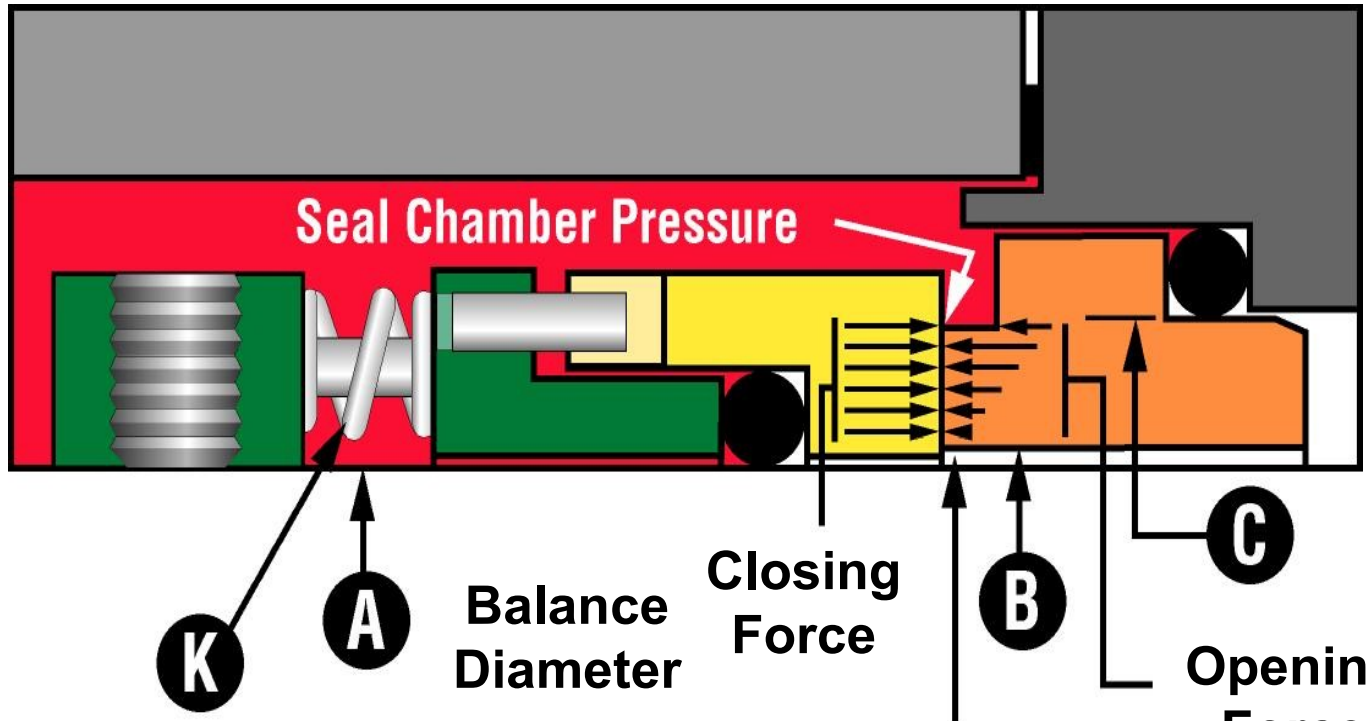
Unbalanced Seals
- Forces Acting on Seal Faces

$$F_{spring} + F_{closing} - F_{opening} = F_{net}$$



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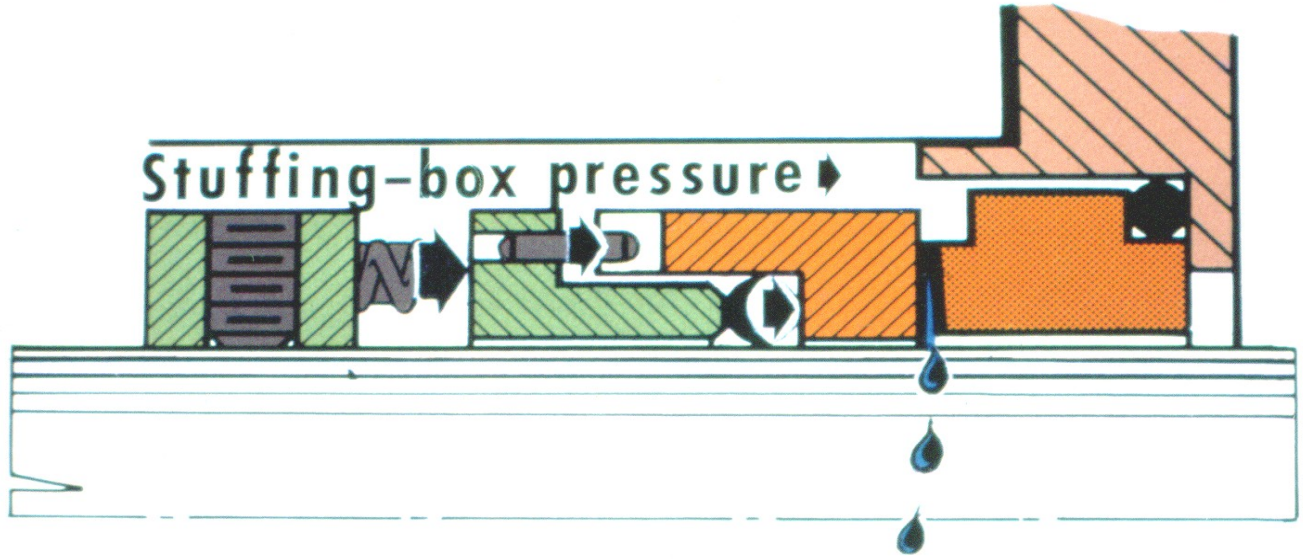
Effect of High Pressure



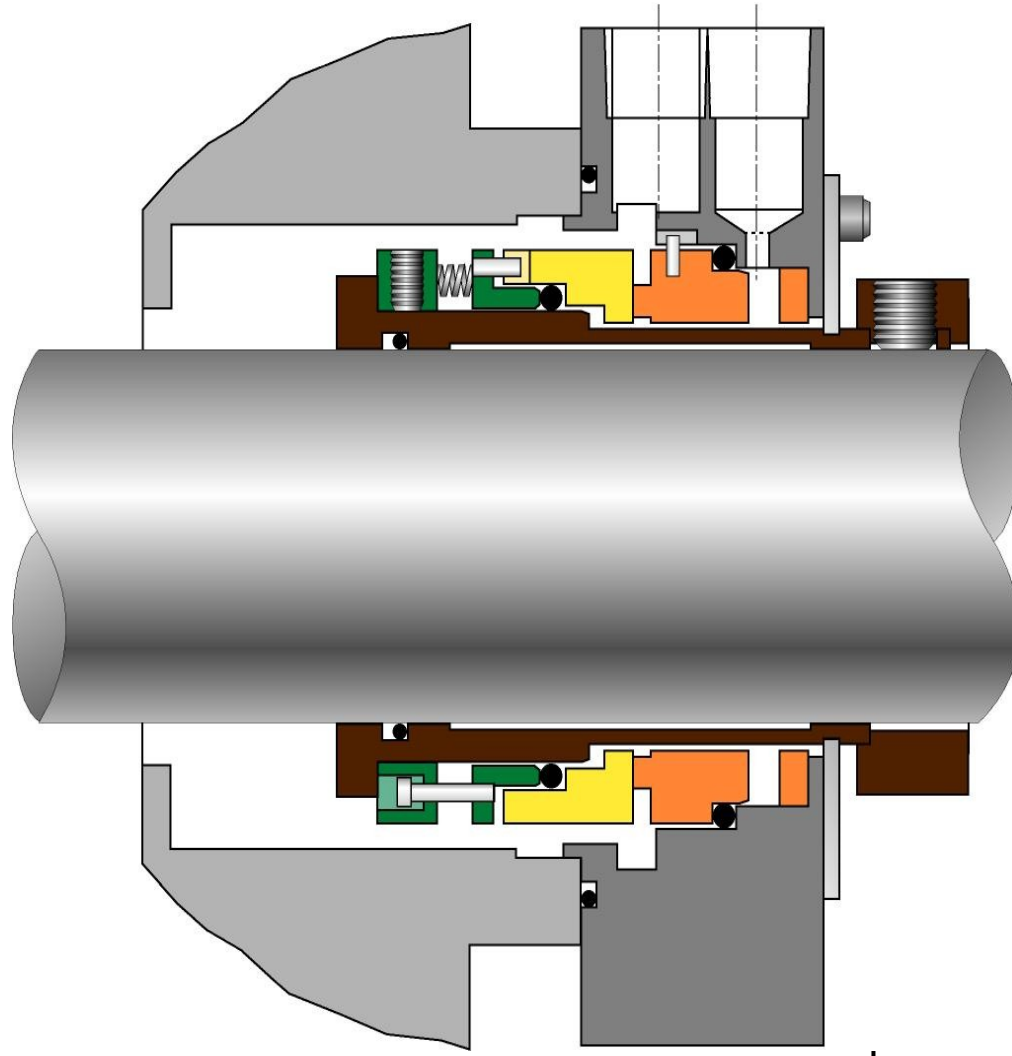
EXTREME PRESSURE DESTROYS LIQUID FILM

TYPE RO

G-I-6

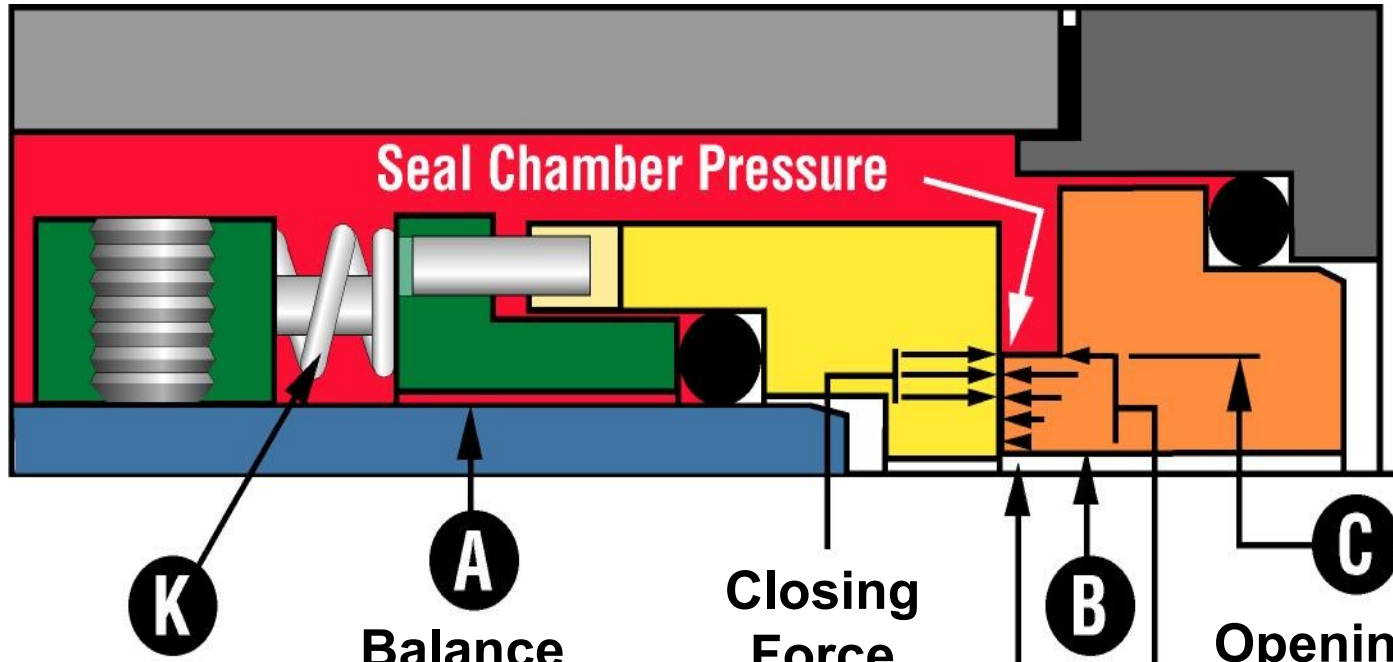
Balanced Seals

- Balances out portion of hydraulic loads for process fluid pressure to reduce closing forces on seal faces
- Has increased pressure capabilities



Balanced Seals
- Forces Acting on Seal Faces

$$F_{spring} + F_{closing} - F_{opening} = F_{net}$$



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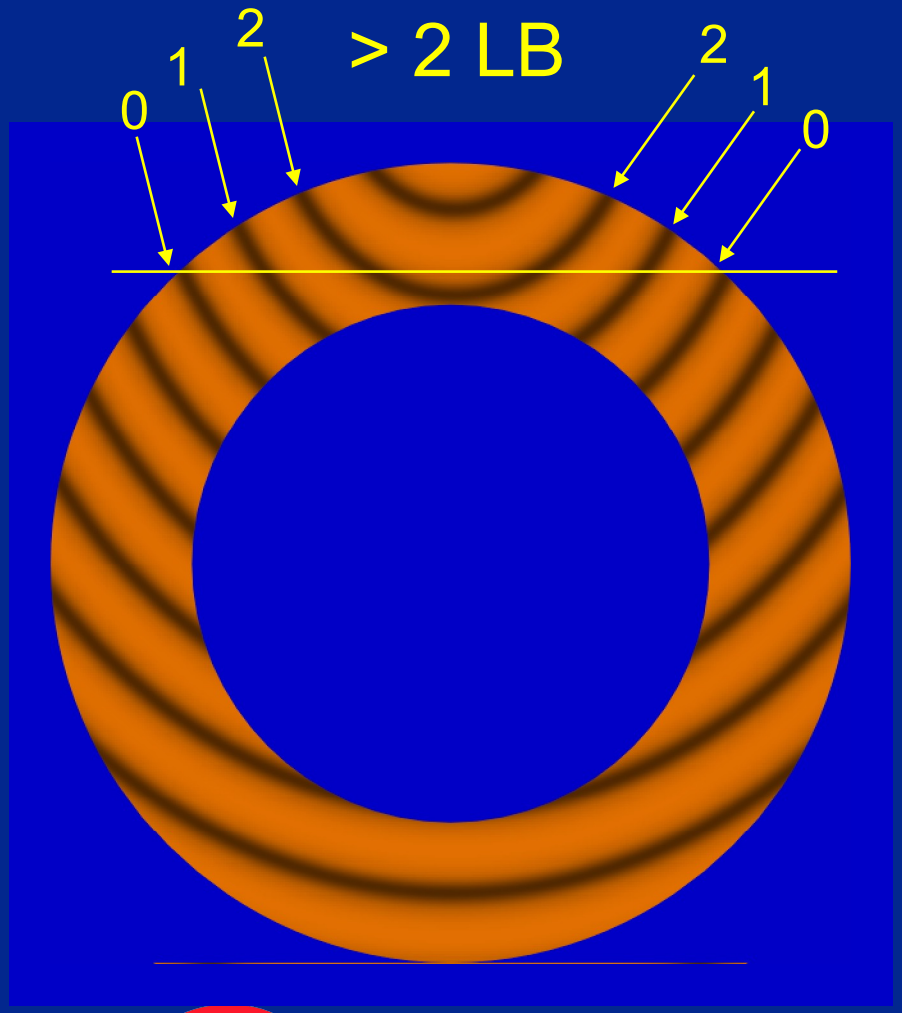
What is a light band?

It is a unit of measure.

- One light band = .0000116”
- Two light bands = .000023”
- Three light bands = .000035”

Reading Seal Face Flatness



To determine flatness, draw a straight line from the band on one edge to the same band on the other edge.

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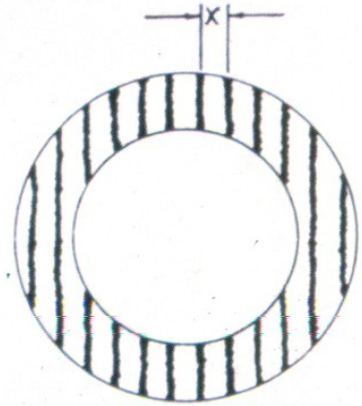
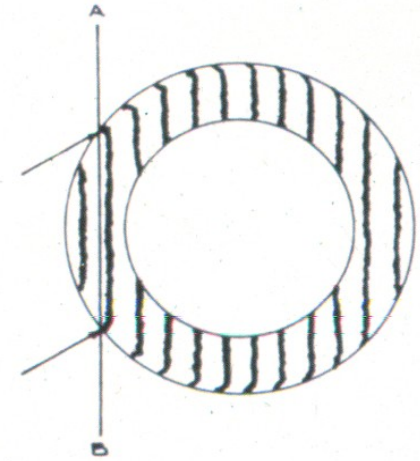
ACCEPTABLE LIGHTBAND READINGS



FLAT—The most prominent seal face band pattern produced at DMC and is flat to within one light band. Distance "X" is dependent on the amount of air between the optical flat and the face, and has nothing to do with flatness.

(a)

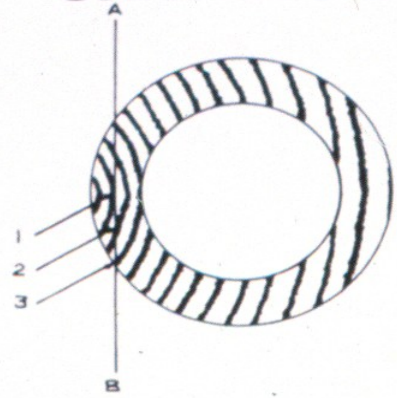


Bands bend at outer edges and indicate wash out of the periphery due to the polishing process. This is a normal pattern and **is** related to flatness. Line AB intersects **one** black band. The areas contacted by AB show the face out **1** light band.

(b)

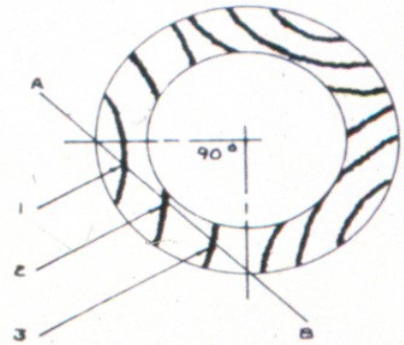
G-6-151

UNACCEPTABLE LIGHTBAND PATTERNS



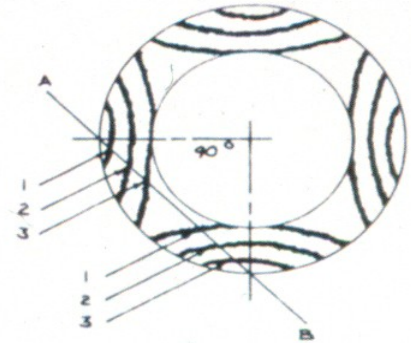
Bands bend on one side and show an out of flat condition of 3 light bands. Since line AB intersects 3 bands as illustrated by arrows, this pattern is out of flat beyond the acceptable quality level imposed on Dura Seal Seal Faces.

(c)



Bands show a saddle shape out of flat condition of 3 light bands.

(e)



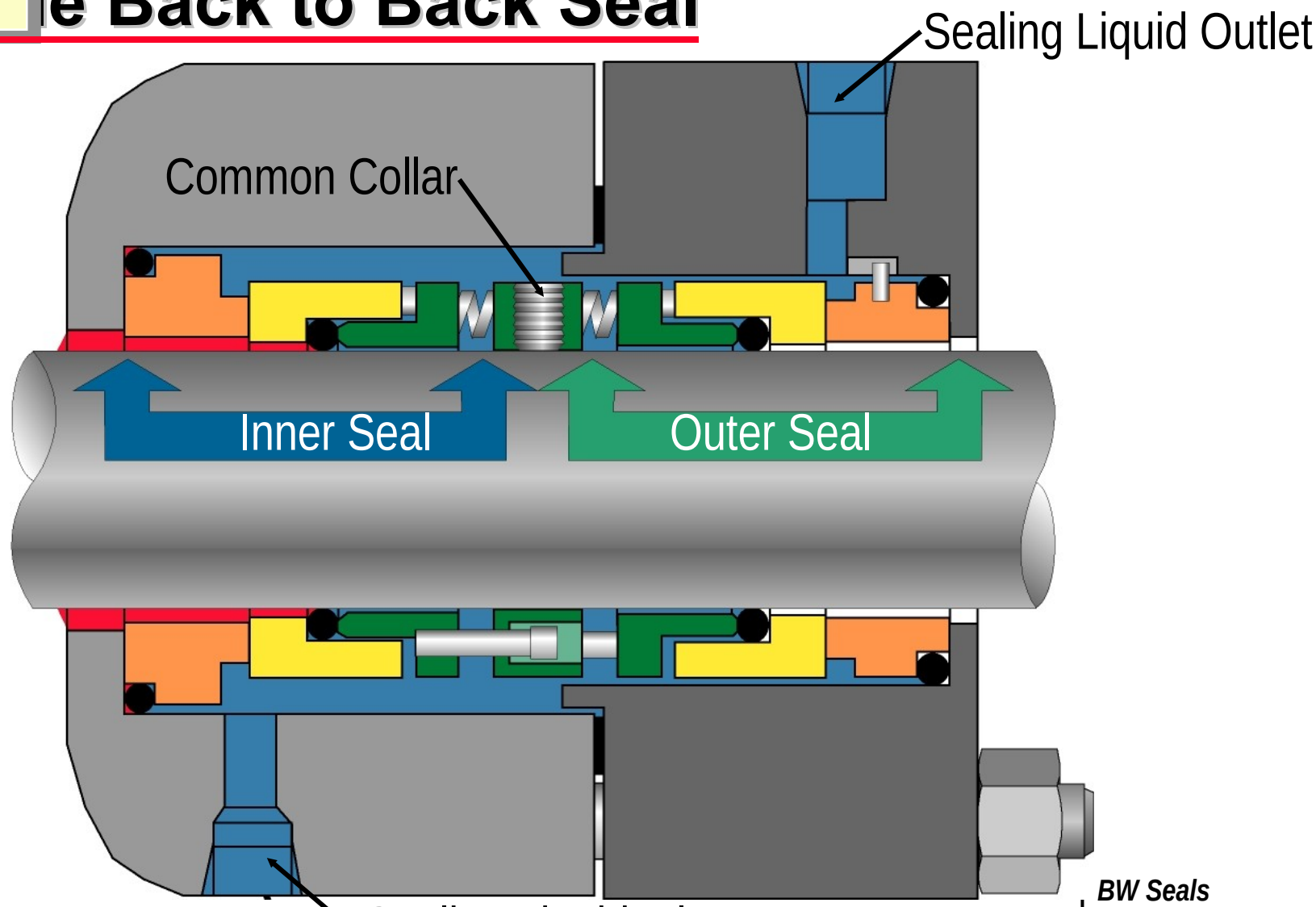
Bands again show a saddle shape out of flat condition. However, in this illustration, we have 6 bands intersected or 6 light bands out of flatness.

(f)

G-6-152

Diann Stender:

le Back to Back Seal



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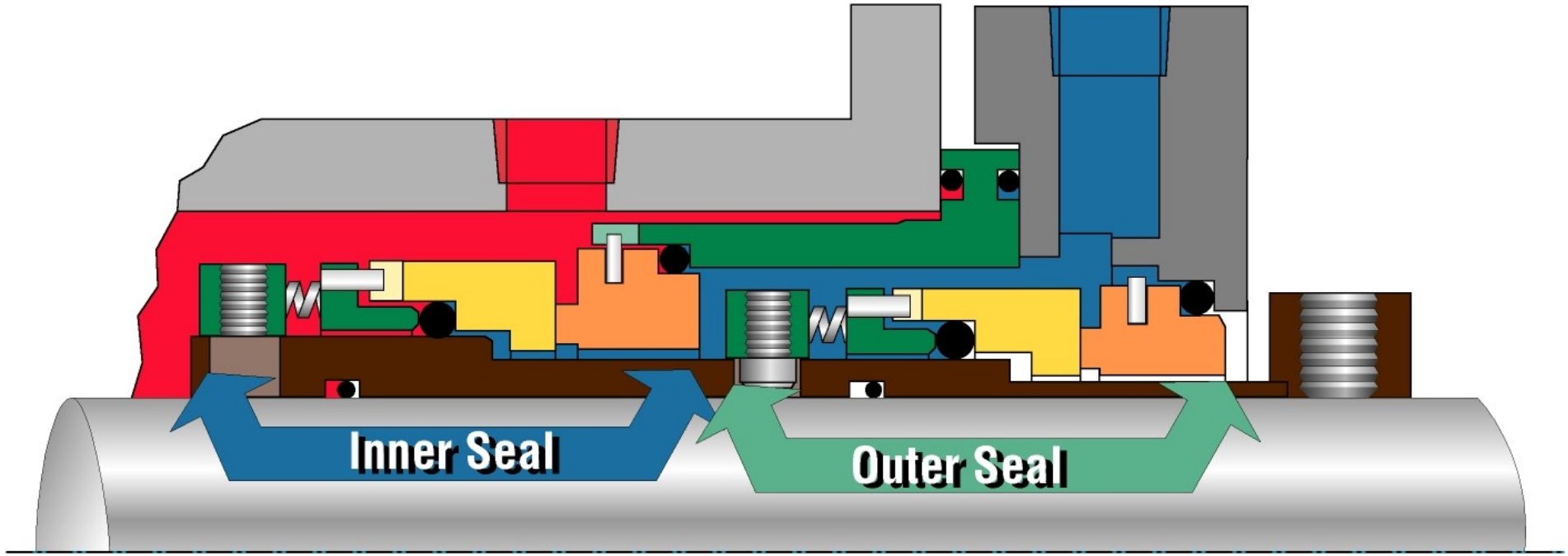
Tandem Seal



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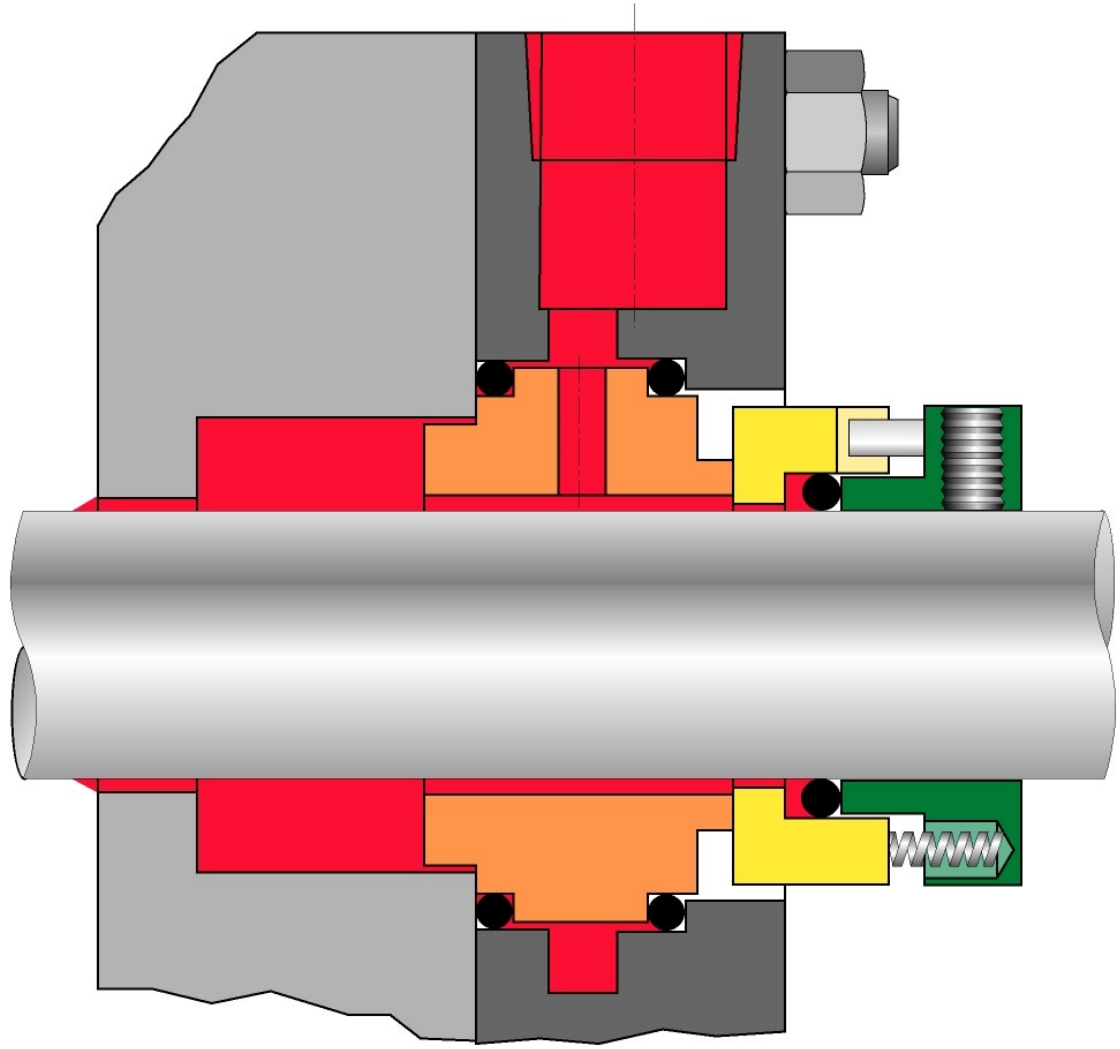
Single Outside Seal



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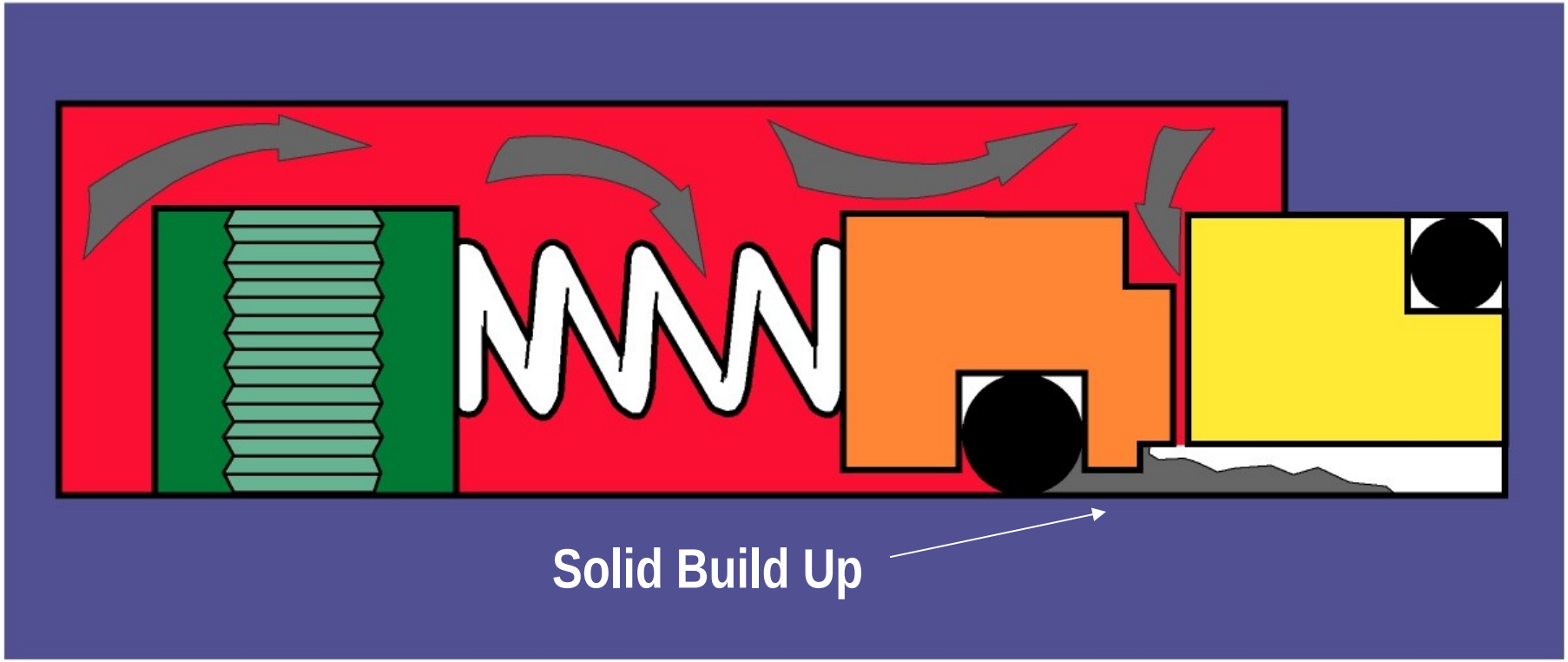
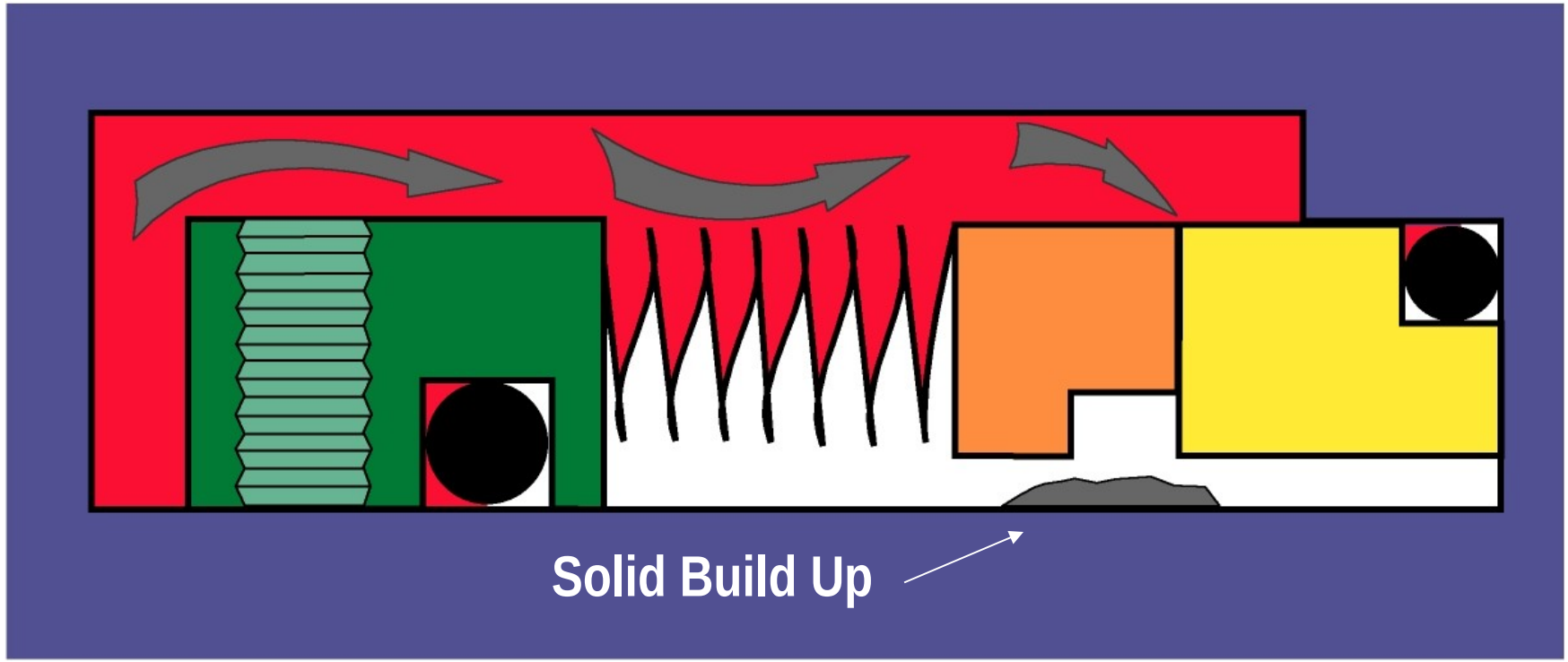
~~Basic Pusher Seal~~



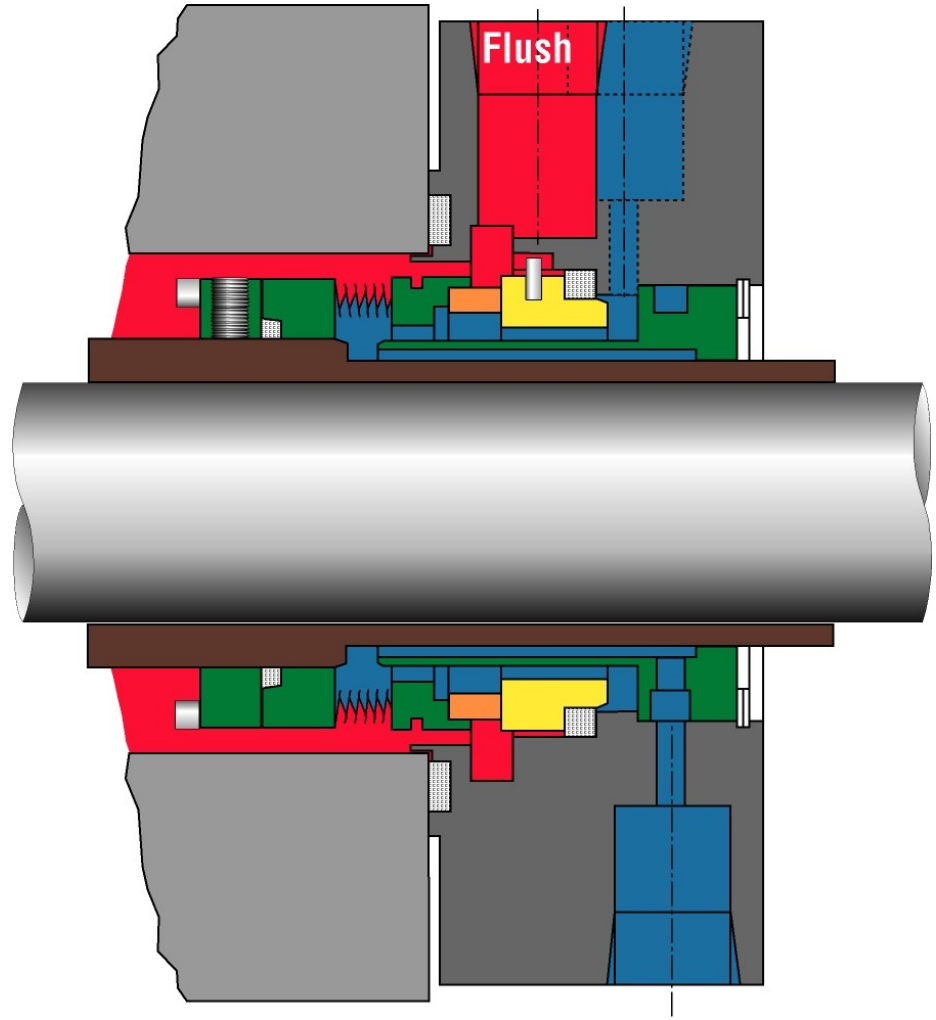
Gasket hang-up occurs when solids build-up sufficiently to impede gasket movement. The spring's closing force is disrupted and heavy leakage soon develops.

~~Non Pusher Seal~~



The secondary seal does not have to move along the shaft or sleeve to maintain face contact

~~PBR Seal~~



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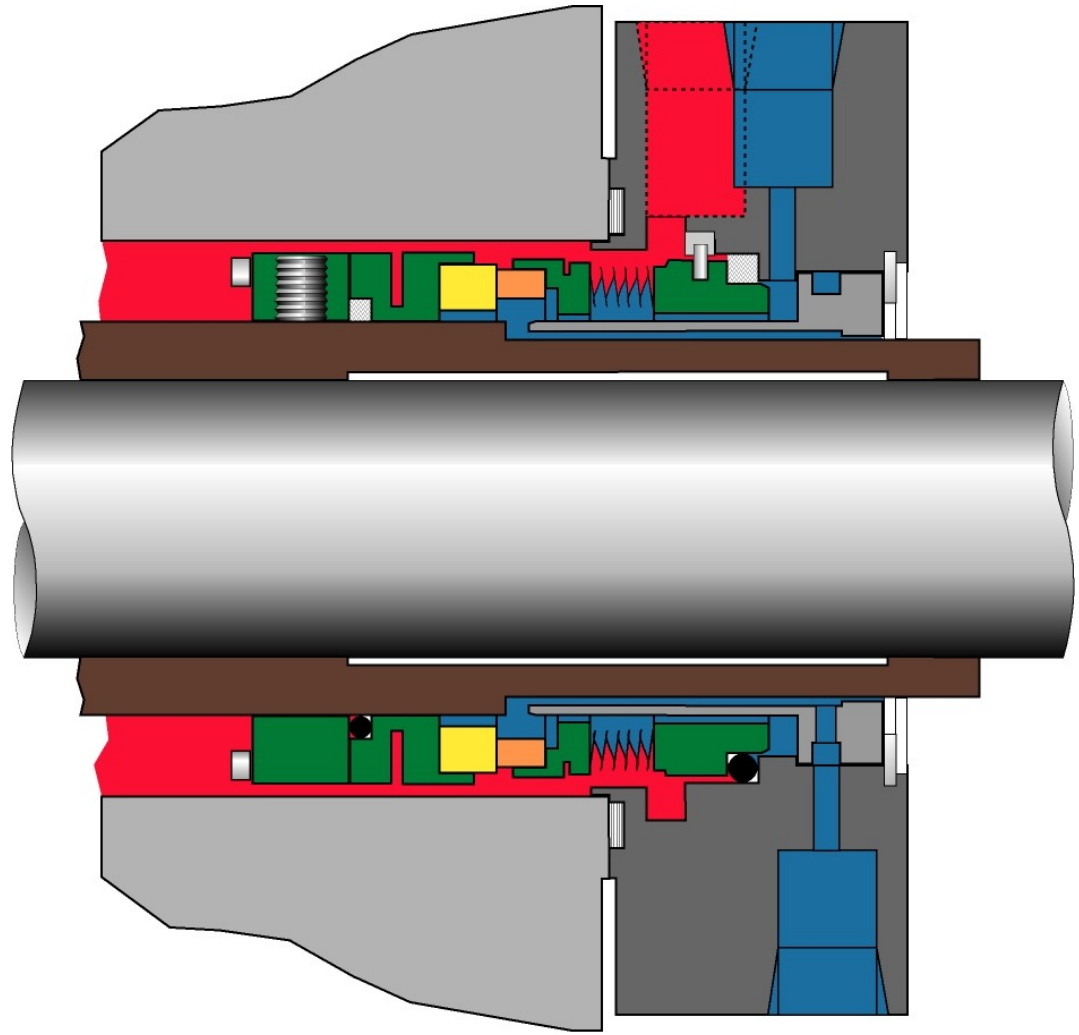
PBS Seal



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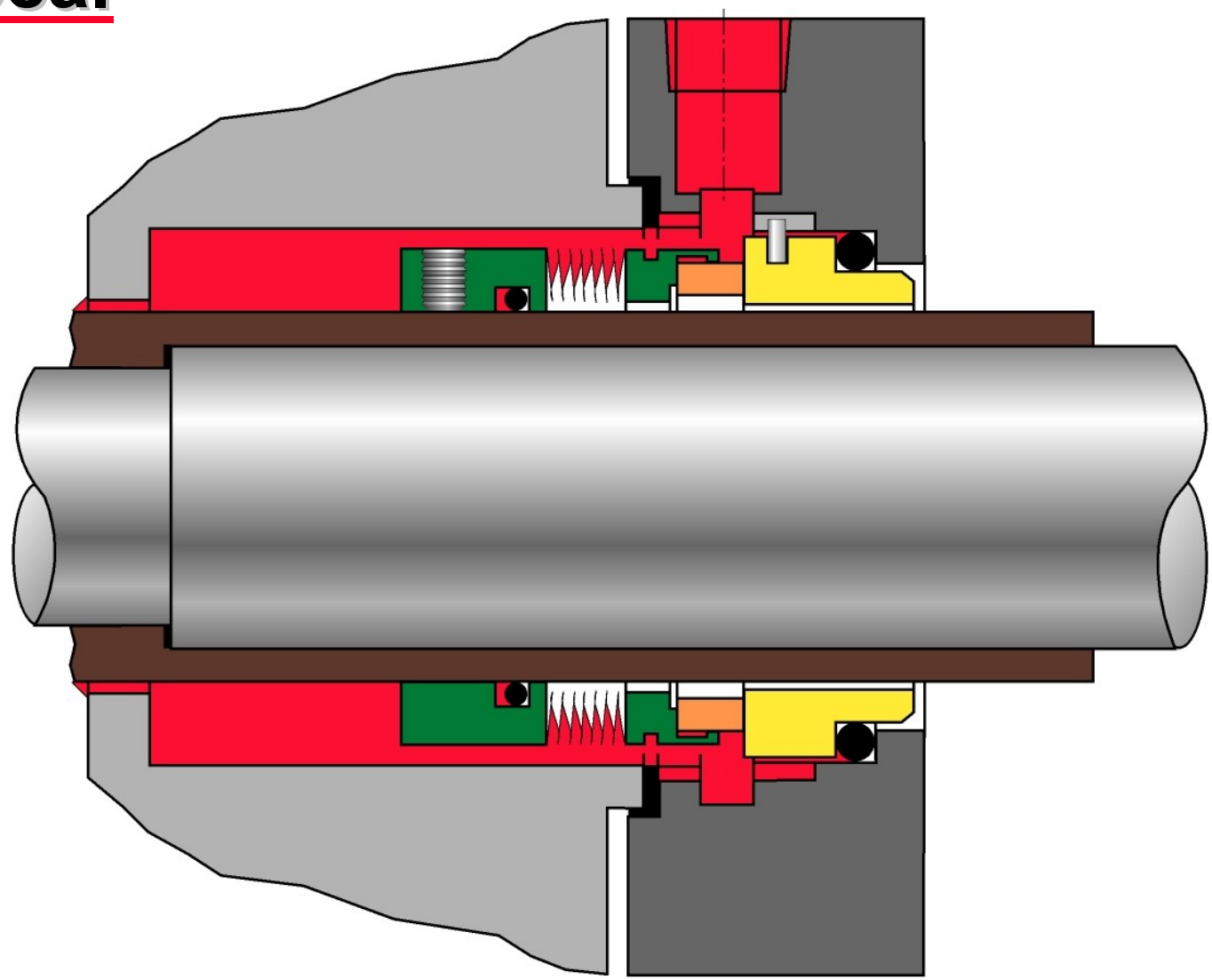
CBR Seal



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