FLOWSERVE

Flowserve Mechanical seal seminar

Presented By Flow Solutions Division

Experience In Motion

Flowserve at a glance

- Founded: In 1997 with the merger of two leading fluid motion and control companies – BW/IP and Durco International
- Stock symbol: FLS (NYSE)
- Total sales in fiscal year 2003: US $2.4 billion
- Core Business: Manufacture engineered and industrial pumps, industrial valves, control valves, nuclear valves, valve actuators and controls and precision mechanical seals, and provides a range of related flow management services, primarily for the process industry.
- More than 14,000 employees in 56 countries
- Customers in more than 70 countries

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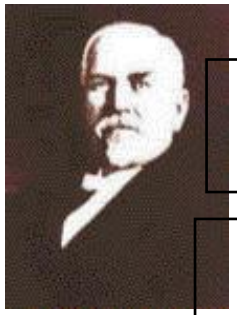
Flowserve FSD

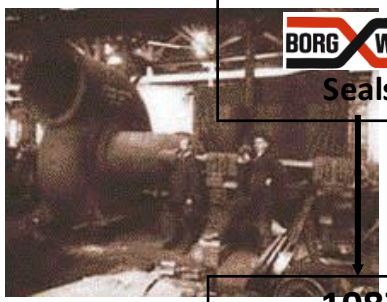
- History



1872
Byron Jackson founded

1923
1st centrifugal pipeline pump

1955
BORG WARNER Seals



1987
BW/IP International
BW Seals

1995
acquisition of
PACIFIC

1919
Pacific Wietz founded

1930
1st mech. seal

1970
new building and organisation
PACIFIC

1986
1st Gaspac development

1901
New Era Manufacturing Co

1923
DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

1930
1st Dura seal

1995
Pac-Seal acquired

1995 Oct.
Durco acquired
Durametallic

1997
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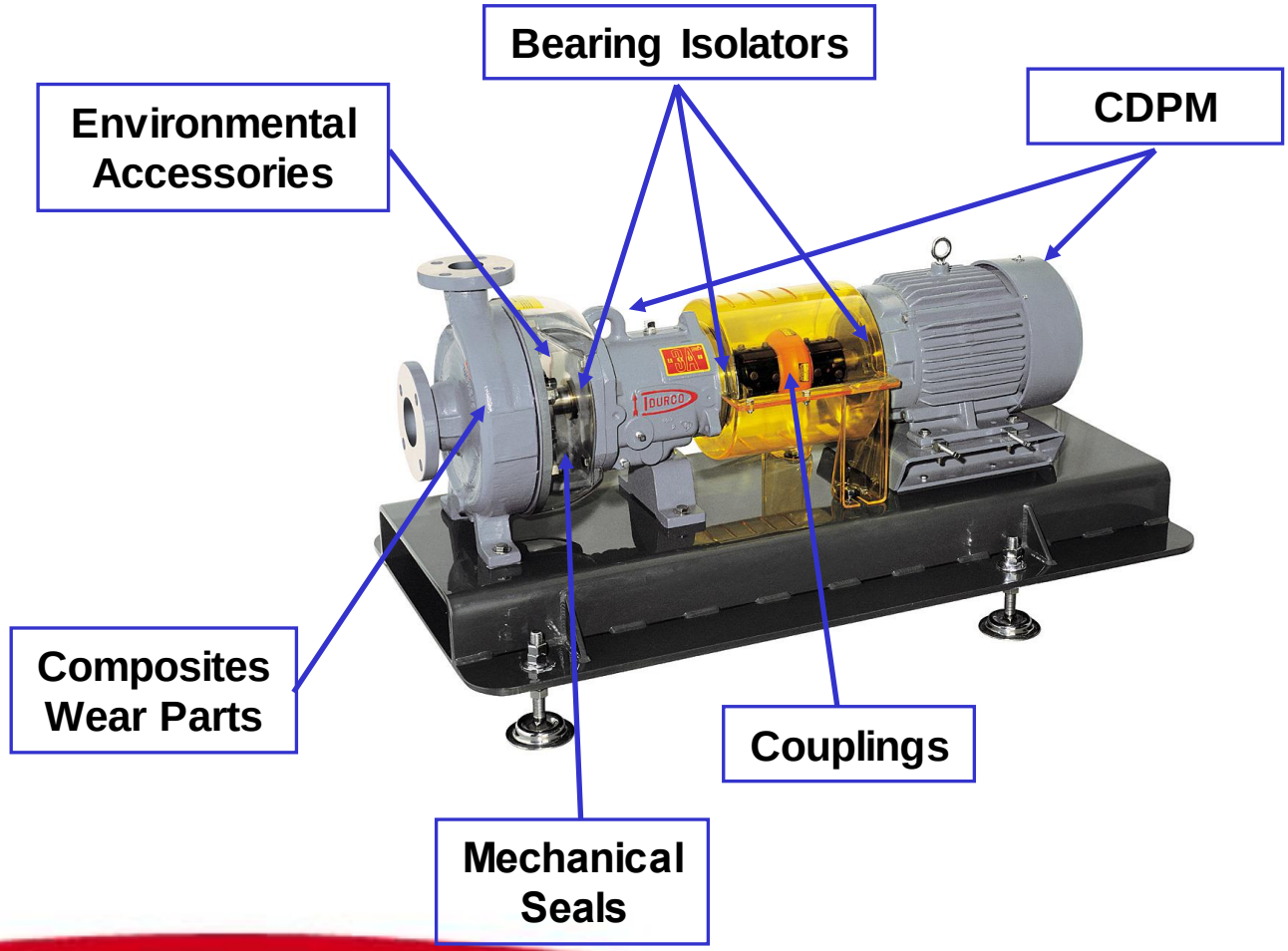
Flow Solutions Offer



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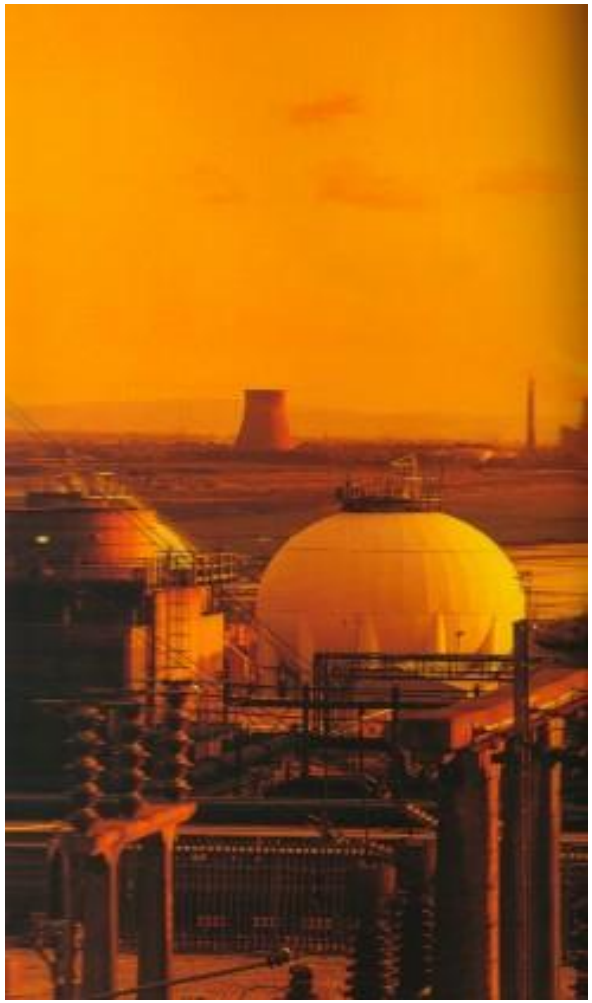
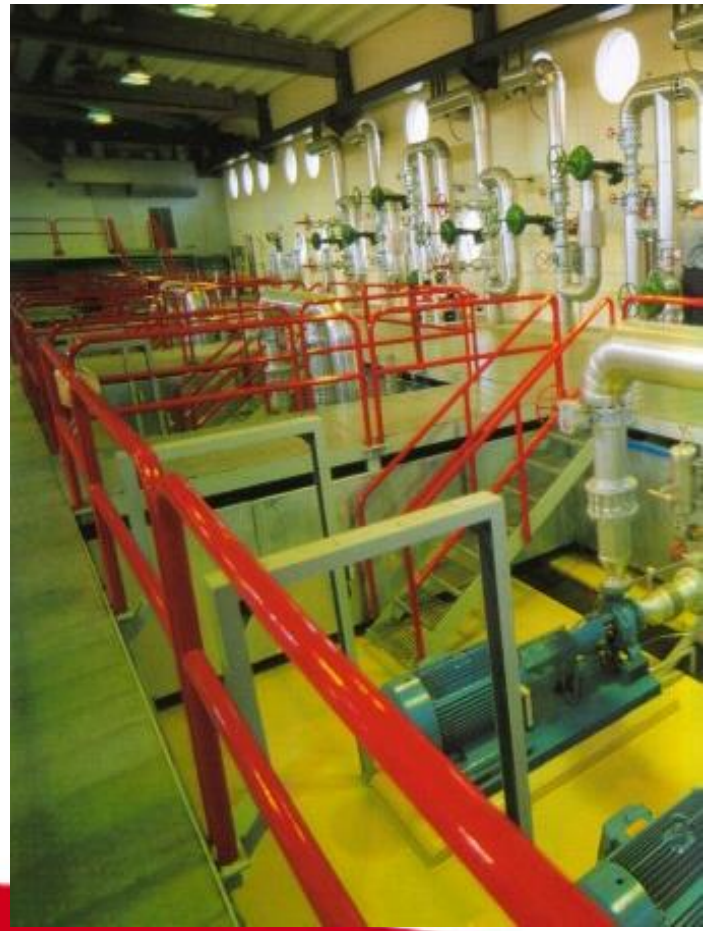
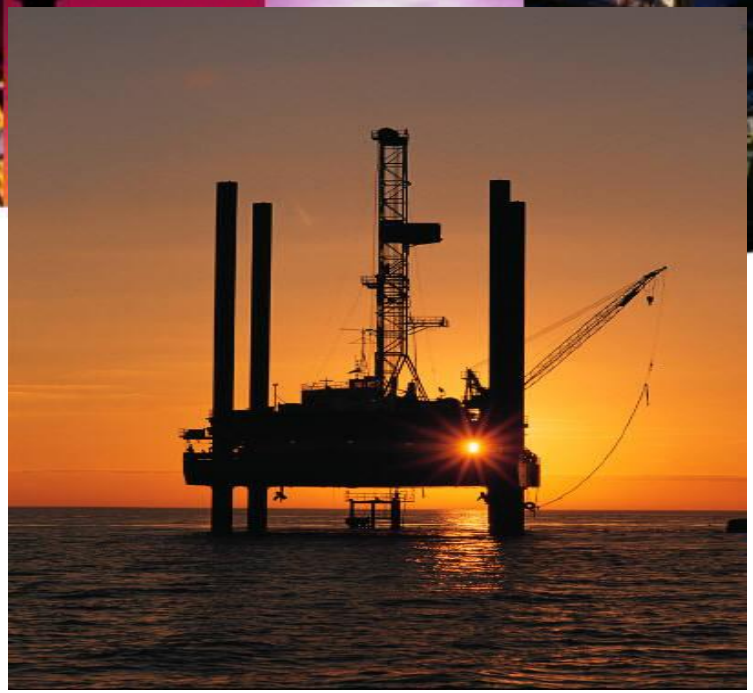
Leader of Industries







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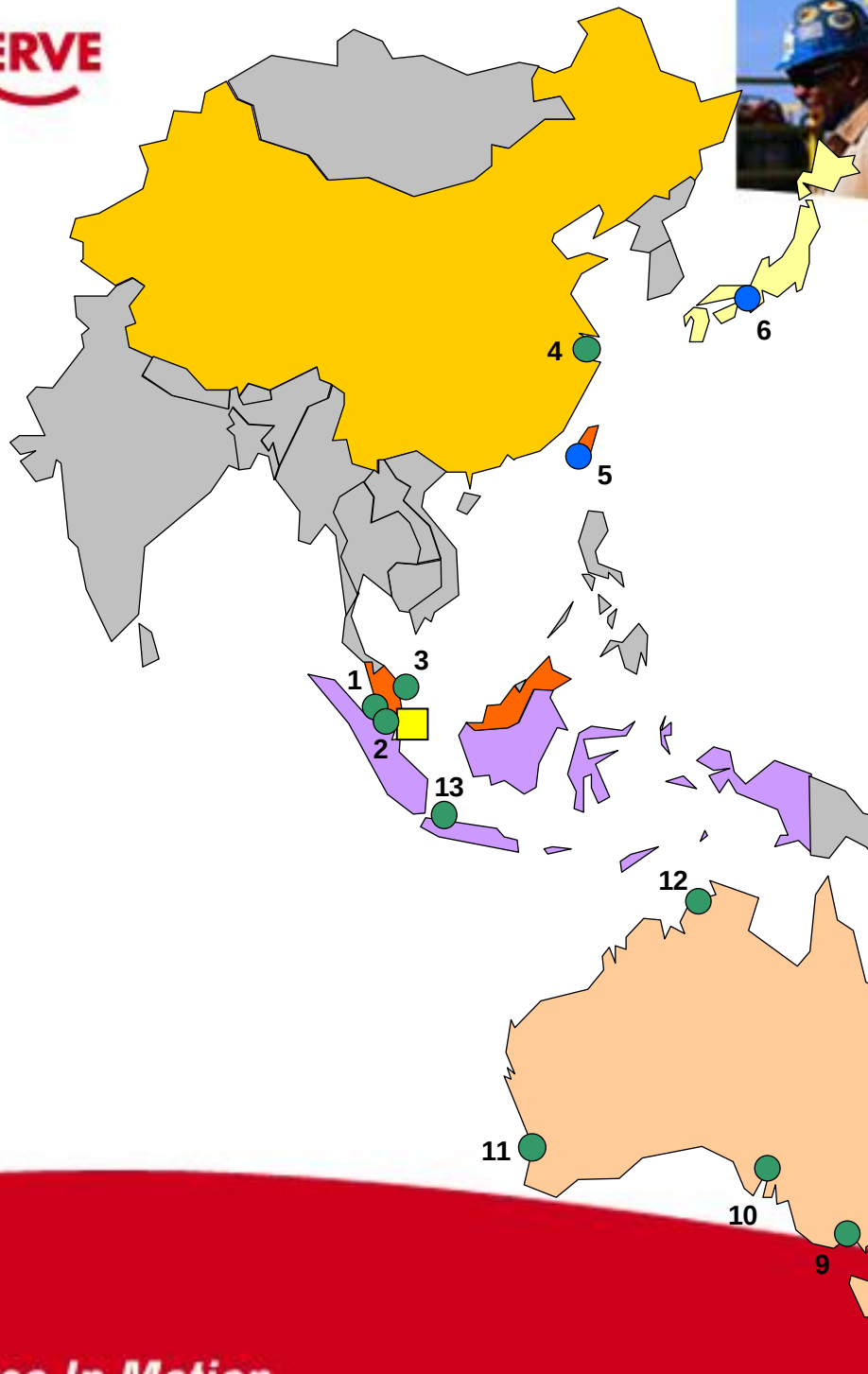

MALAYSIA

1: Kuala Lumpur [C]

2: Melaka [B]

3: Kemaman [B]

CHINA

4: Shanghai [C]

TAIWAN

5: Kao-Hsiung [B]

JAPAN

6: Osaka [B]

NEW ZEALAND

7: Auckland [B]

AUSTRALIA

8 Sydney [C]

9: Melbourne [B]

10: Whyalla [B]

11: Perth [B]

12: Darwin [B]

INDONESIA

13: Jakarta [C]

QRC Asia Pacific

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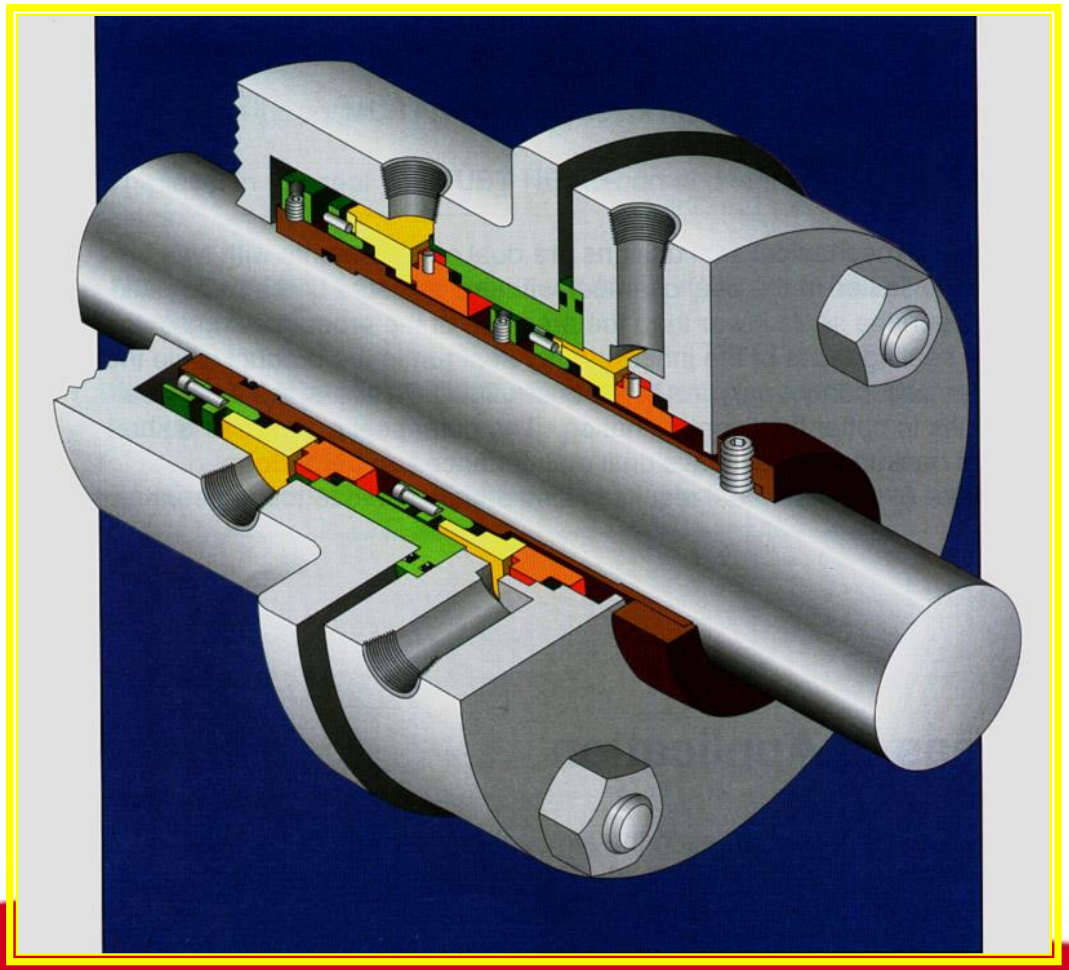
Mechanical Seals



1. Introduction

To allow a rotating shaft to emerge from a high pressure cavity to a low pressure cavity without significant leakage, a mechanical seal is required.

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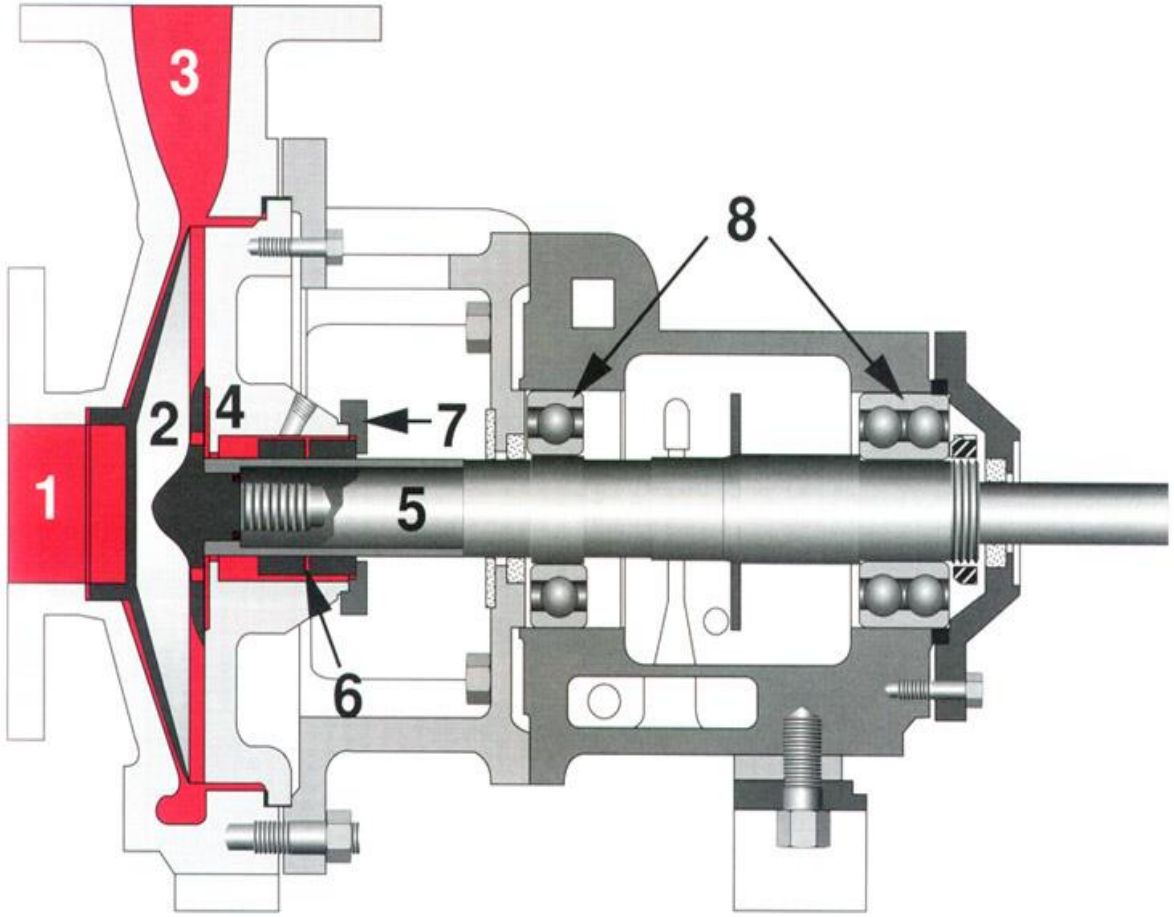
Mechanical Seals

The purpose of a mechanical seal is to stop the liquid in the pump (red) from leaking between the rotating shaft (**5**) and the stationary casing (**4**)



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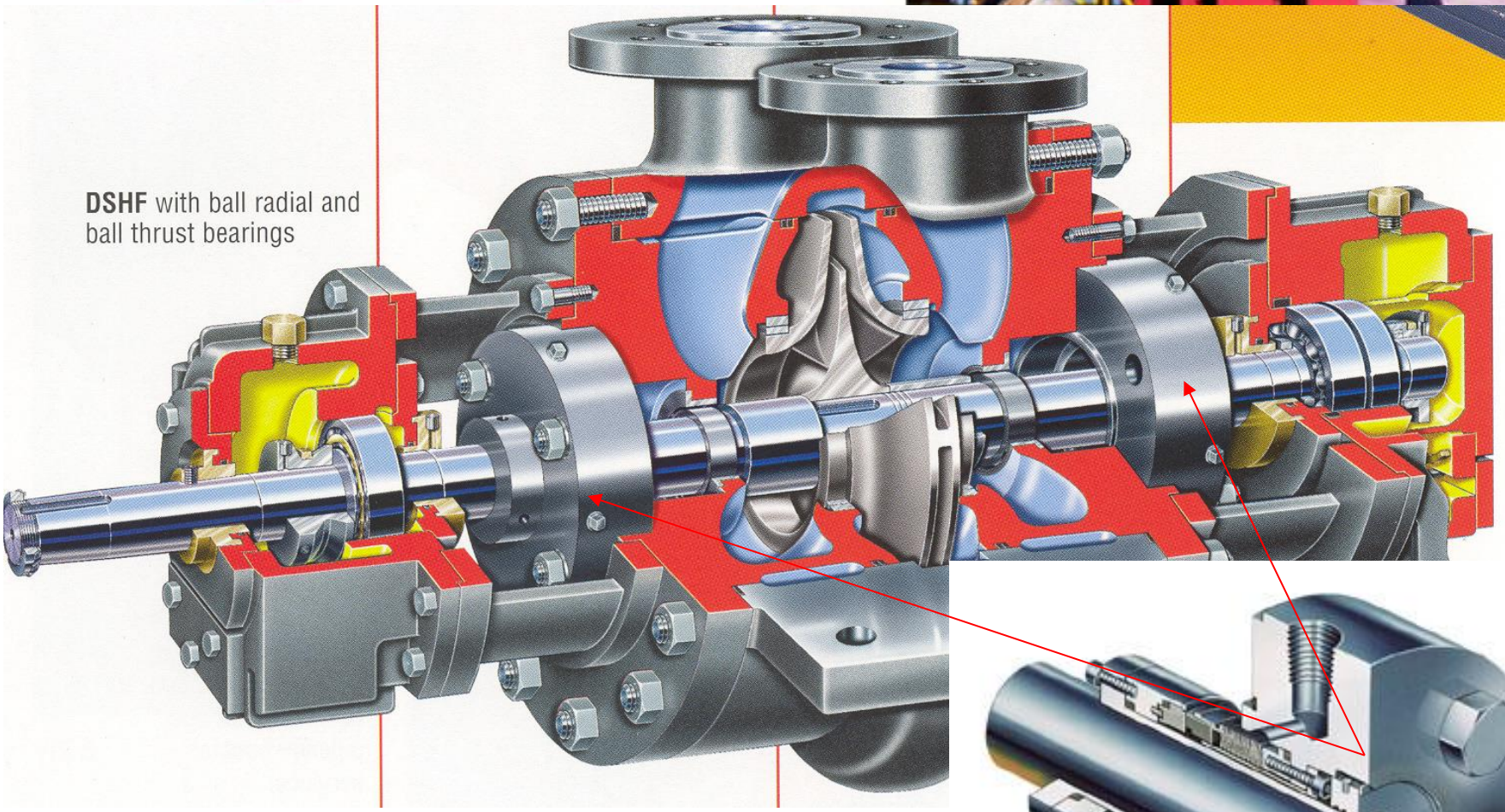
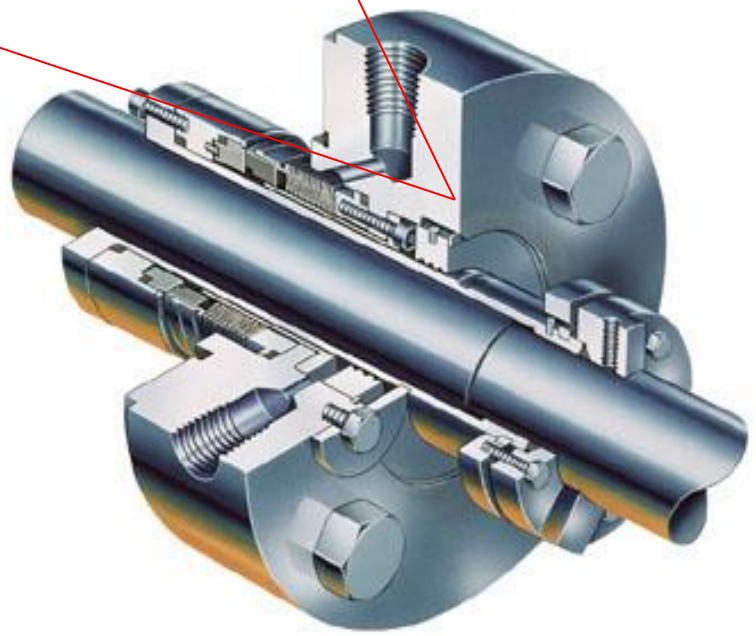
Seal for API pumps





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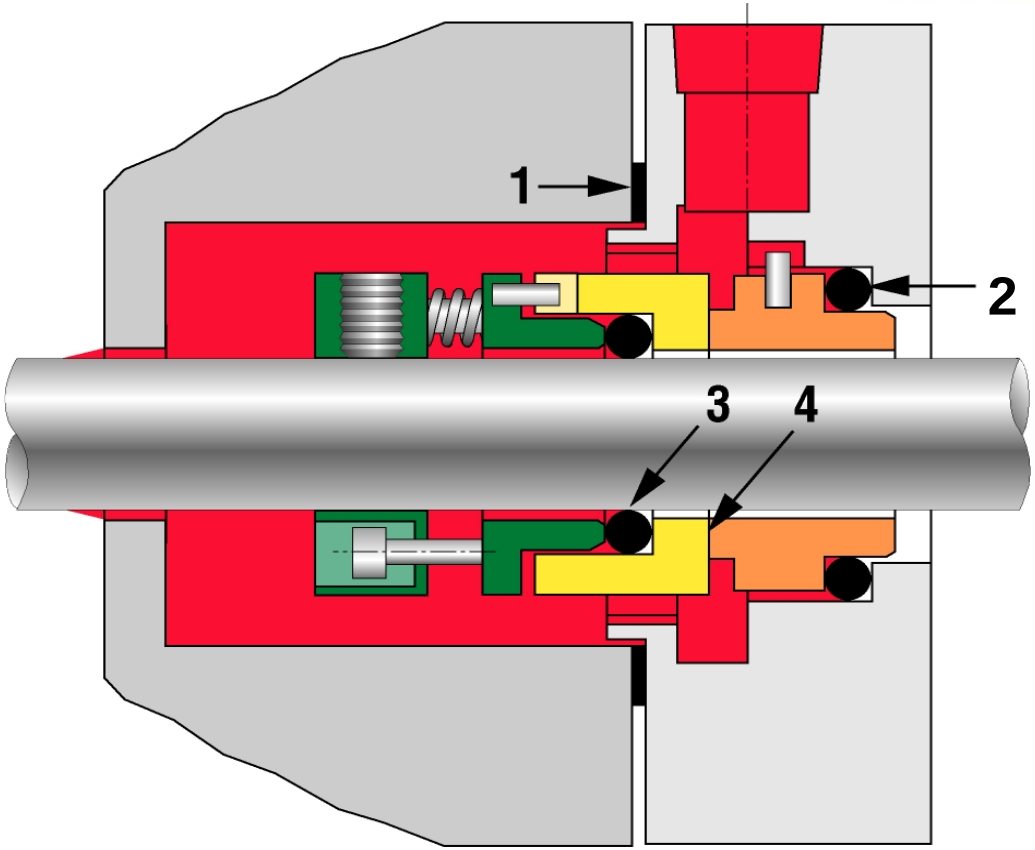
Potential Leak Paths

- **Path 1** – Between seal flange and pump face
- **Path 2 –** Behind stationary seal face
- **Path 3 –** Under rotating seal face
- **Path 4 –** Between mating seal faces

For dual seal design, paths **1, 2, 3 & 4** are duplicated.



What is necessary for a seal to work?

1. Face Contact

–Seal's flexible member must be free to wobble axially to compensate for misalignment and to move axially down the sleeve to make up for face wear.

2. Flatness

–Seal faces have flatness of 2 to 3 helium light bands. (1 LB equals 0.0000116" or 11.6 millionths of an inch).

3. Face Lubrication

–A stable lubricating film must be maintained between the faces at all times.

–Typical film thickness: 0.5μm(20μin), must be thick enough to prevent mechanical contact, thin enough to prevent high leakage. (Related to physical properties of the liquid: viscosity and specific gravity at pumping temperature)

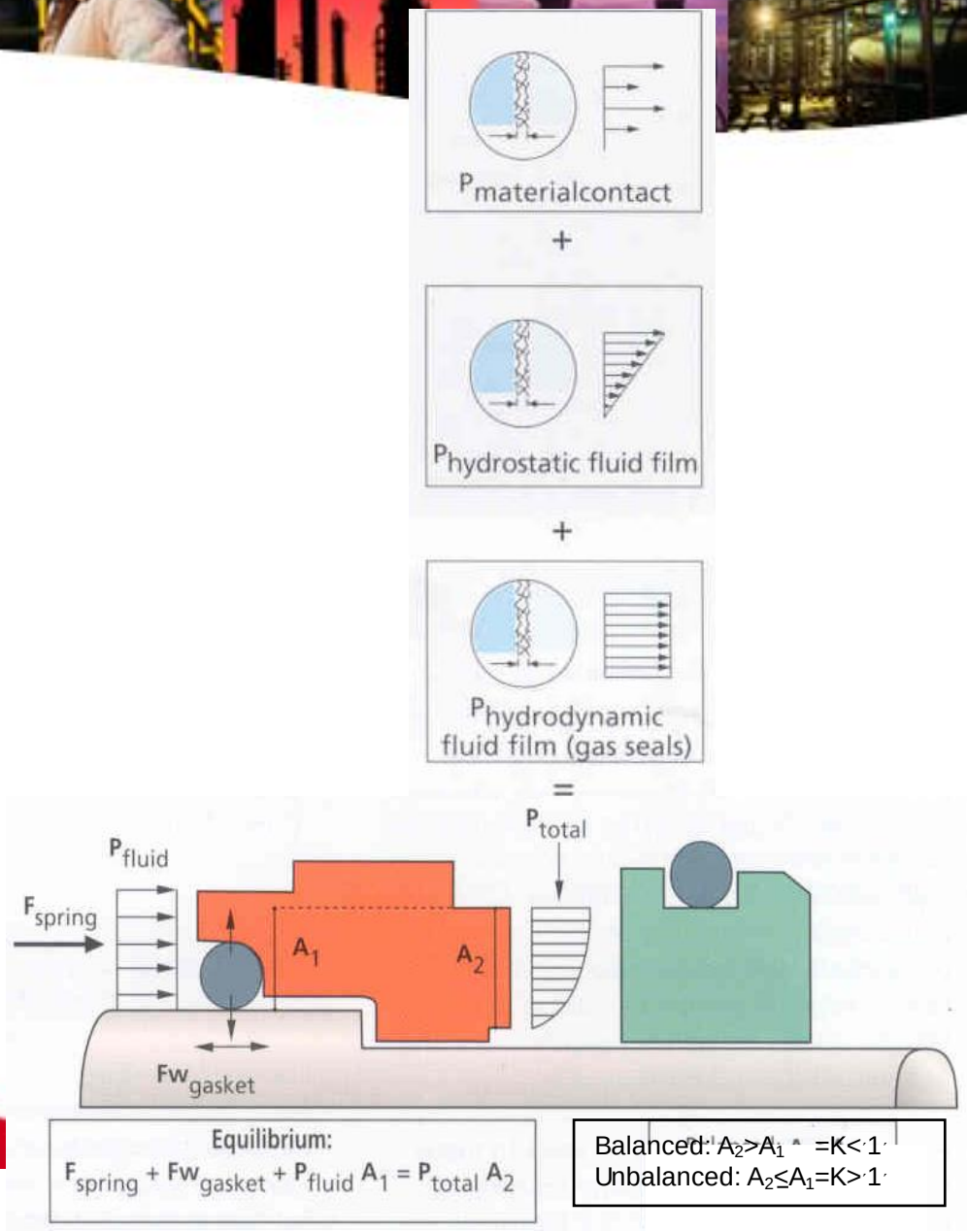
–Boundary layer of liquid in the seal chamber fills pores and imperfections of the seal faces.

–Dry running of a seal for only a few seconds may destroy it and result is premature seal failure.

From the sketch; figure **13** the red coloured ring is called ***the dynamic or spring loaded face.*** It can be seen as ***a free floating piston,*** where a number of forces are in balance:

- Hydrostatic pressures (closing and opening forces).
- Material contact at the contact zone of the two faces, the rotating and the stationary one (minimal during normal operation).
- Hydrodynamic pressure (minimal for a liquid seal, essential as aerodynamic pressure for a gas seal).
- Spring force
- Gasket friction force (O-ring drag)

Flowserve engineers have tuned all designs such that the axially moving, spring loaded face is ***in perfect equilibrium*** over the entire range of operating conditions. One method is changing the "balance ratio" "k" by changing the hydrostatic closing force, used for seals at higher pressures.

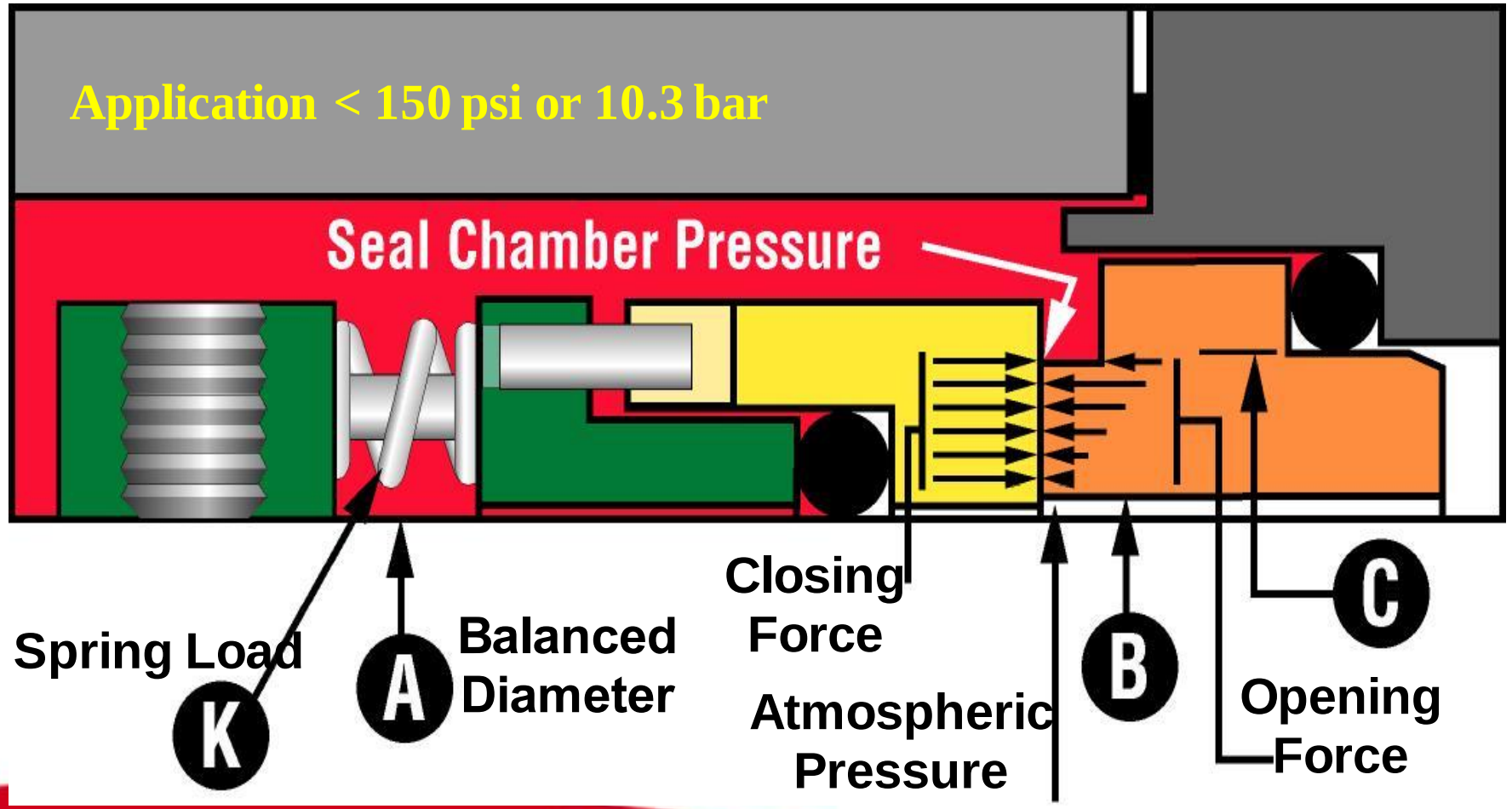


K= Balance Ratio; typically 0.6-0.7 for balanced seals

Figure **13** Equilibrium sketch

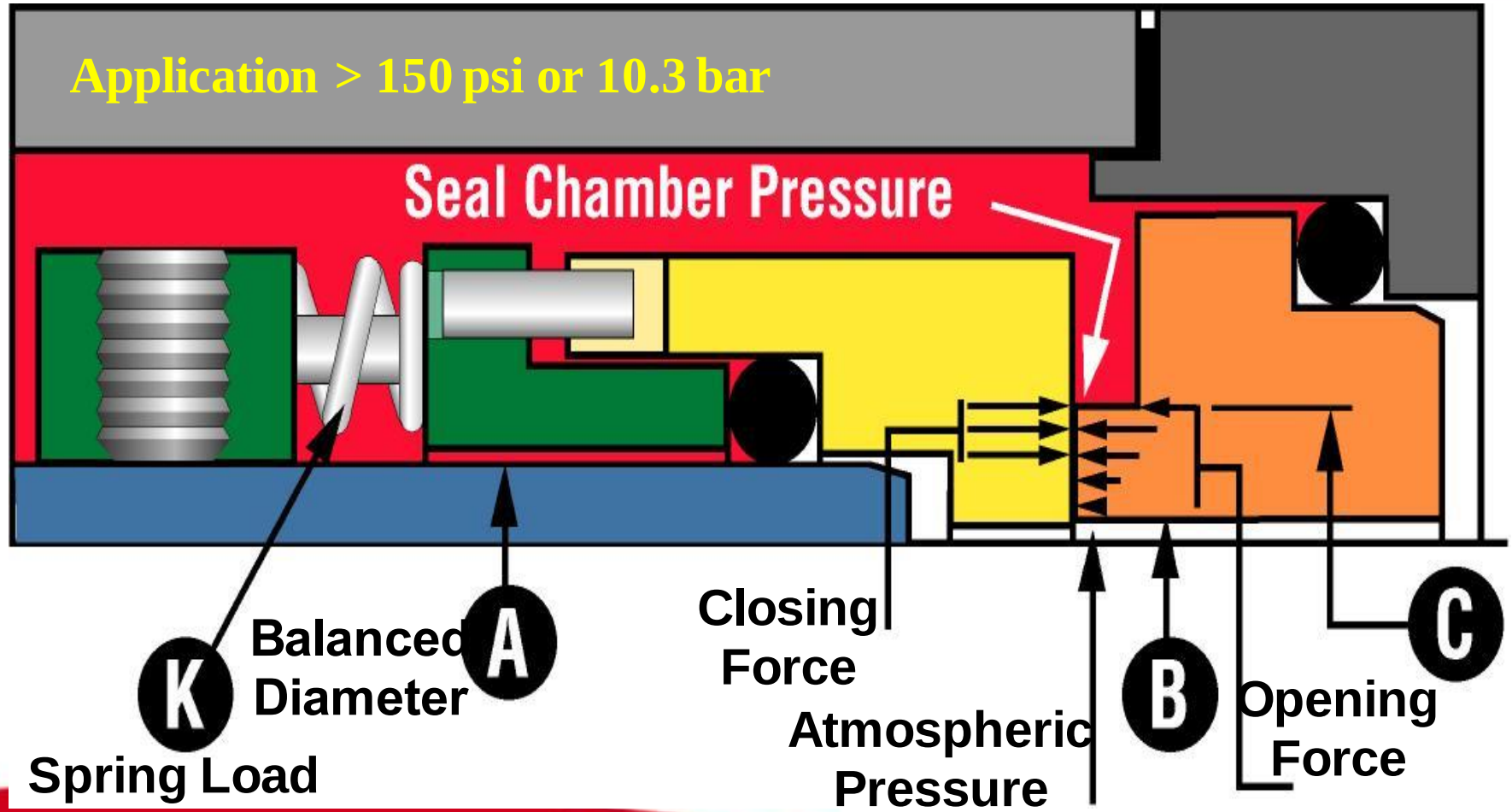
Unbalanced Seal

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



Balanced Seal

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



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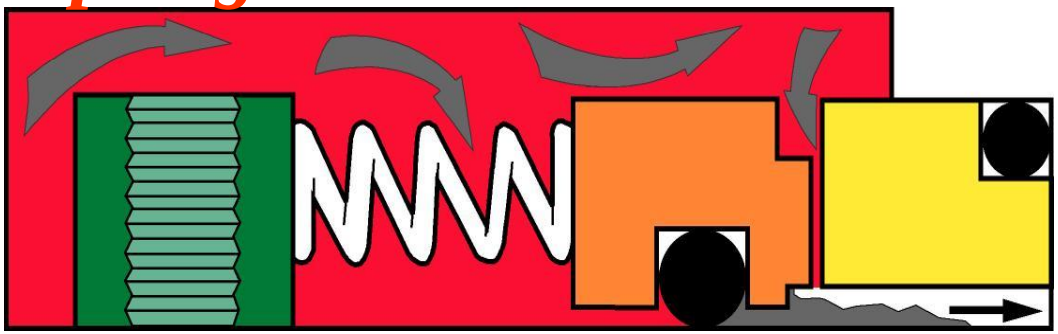
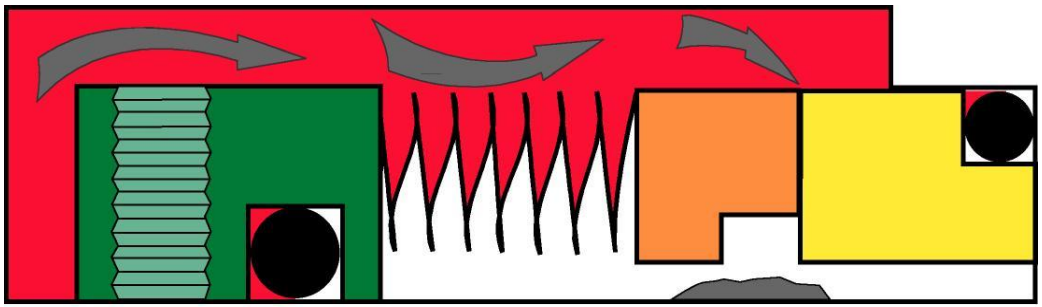
Spring Pusher Seal



Dynamic O-ring moves axially as seal faces wear, prone to hang-up.

Bellows Seal



O-ring does not have to move axially when faces wear, eliminates hang-up.

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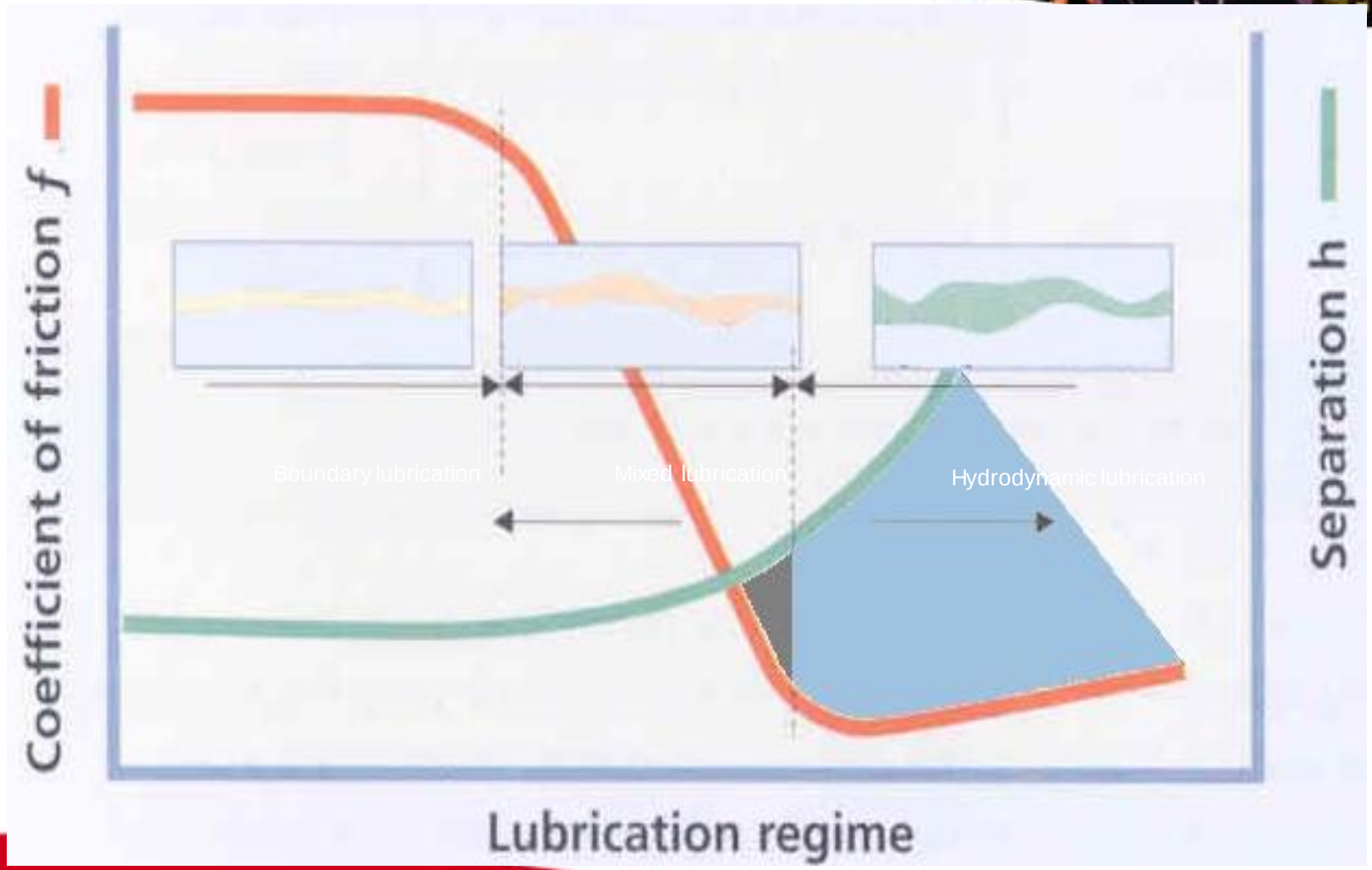
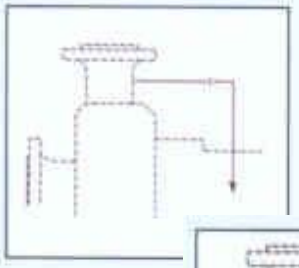
Lubrication Regimes



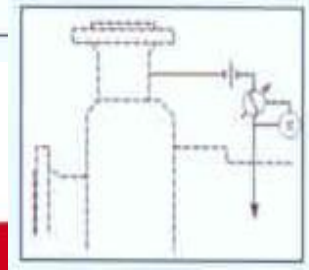
Material code family	Face materials: Silicon carbide SSiC	Silicon carbide SiC	Carbon resin impregnated	Carbon antimony impregnated	Carbon special grade	Tungsten Carbide	Aluminum Oxide (Ceramic)	Chrome steel casting	PTFE	Other	Elastomers: Fluoroelastomer	Ethylene Propylene (EPDM)	Neoprene	Nitrile Butadiene (Buna N)	Perfluoroelastomer	Fluoroelastomer/PTFE coated	Graphite	PTFE	PTFE elastomer	Other	Spring/bellows: 316	Alloy C-4	Alloy 20	Alloy 400	Alloy C 276	Alloy 718	AM-350	Other	Metal parts: 316 or CrNiMo	Alloy 20	Alloy 400	Alloy C-4	Alloy C276	CD4MCu	High chrome iron	Other
RO	B		●	●			○	○			●	○		○	○			○	○				●						●	○	○		○			○
Europac 600, 610, 615	C	●	●	●	●		○	○	●		●	○	○	○	○	○		○			●	○							●			○				
CRO	B		●	●			○	○			●	○		○	○				○		●								●	○			○			
QB, QBQ, QB-lub	A	○	●	●	○		○				●	○		○	○										○				●		○		○			
PSS II II	B	○	○	●				●			●	○													●				●				●			
UC, UOP	A	○	●	○	●		○				●	○		○				○			●				○		○		●	○	○		○			○
D, DP	A	○	●	○	●		○				●	○		○				○			●								●							
Allpac 480/487	C	●	●	●	●		○				●	○	○	○	○						●	○							●			○				
SL-5000/5200	B	●	●				○				●	○		○	○						●				●				●	○			○			○
BX, BXB, BXLS	A	○	●	●	●		○				●	○		○	○			○			●			○	○				●		○		○			
CBR	B	○	●	●			○	○			●	○		○	○					○			○	○		●			●	○	○		○			
BXR	A		●		●						●	○		○	○																					
BXRH	A		●	●	●													●																		
BXHH, BXHHB	A		●	●	●													●																		
ISC1PX, ISC2PP	B	●		●			○				●	○		○	○	○																				
ISC1BX , ISC2BB	B	●		●			○				●	○		○	○	○																				
ISC1EX	B	●		●							●	○		○																						
												○		○																						

Remark:

Extracts from Flowserve brochure „Products & Services“, pages 54+55.



Plan 11
Circulation from discharge through orifice



Plan 21
Circulation from discharge through orifice and cooler

Face materials	A BW Seals	B Duratallic	C PACAK
Silicon carbide SSiC	Z (YO)	2 (Silcar 2)	Q1 (Q69)
Silicon carbide SiC	X (SL)	4 (Silcar 1)	Q2 (Q57)
		Z (Silcar A2)	
		G (Silcar A)	
		J (Silcar M)	
		L (Silcar 3)	
Carbon resin impregnated	A (GE)	R (#5 carbon)	B (B04)
	P (KI) rot	5 (5# carbon)	
	Q (NA) rot		
	Q (KI) stat		
	R (NA) stat		
	V (OH)		
	H (LM)		
Carbon antimony impregnated	U (RY)	6 (#6 carbon)	A (A01)
Carbon special grade	D (AE)		
Tungsten Carbide Nickel	N (LV)	A (Tungcar A)	U2 (U49)
Tungsten Carbide Cobalt	W (RI) rot	8 (Tungcar 62-1)	U1 (U20)
	M (RI) stat		
Tungsten Carbide		M (Tungcar M)	
		B (Tungcar M1)	
		U (Tungcar 62-6)	
Aluminum Oxide (Ceramic)	C (JT)	7 (Peramic)	V (V21)
Chrome steel casting		D (Duramate)	S (S17)
PTFE, glass fibre reinforced	L (HD)	F (GF Duraflon)	Y1 (Y23)
PTFE, carbon reinforced		T (Duraflon)	Y2 (Y60)
316/sapphire overlay	J (LT)		
Kalamate		Y (Kalamate)	
Stellite overlay		S	
Durchrome facing			

Picture **14**

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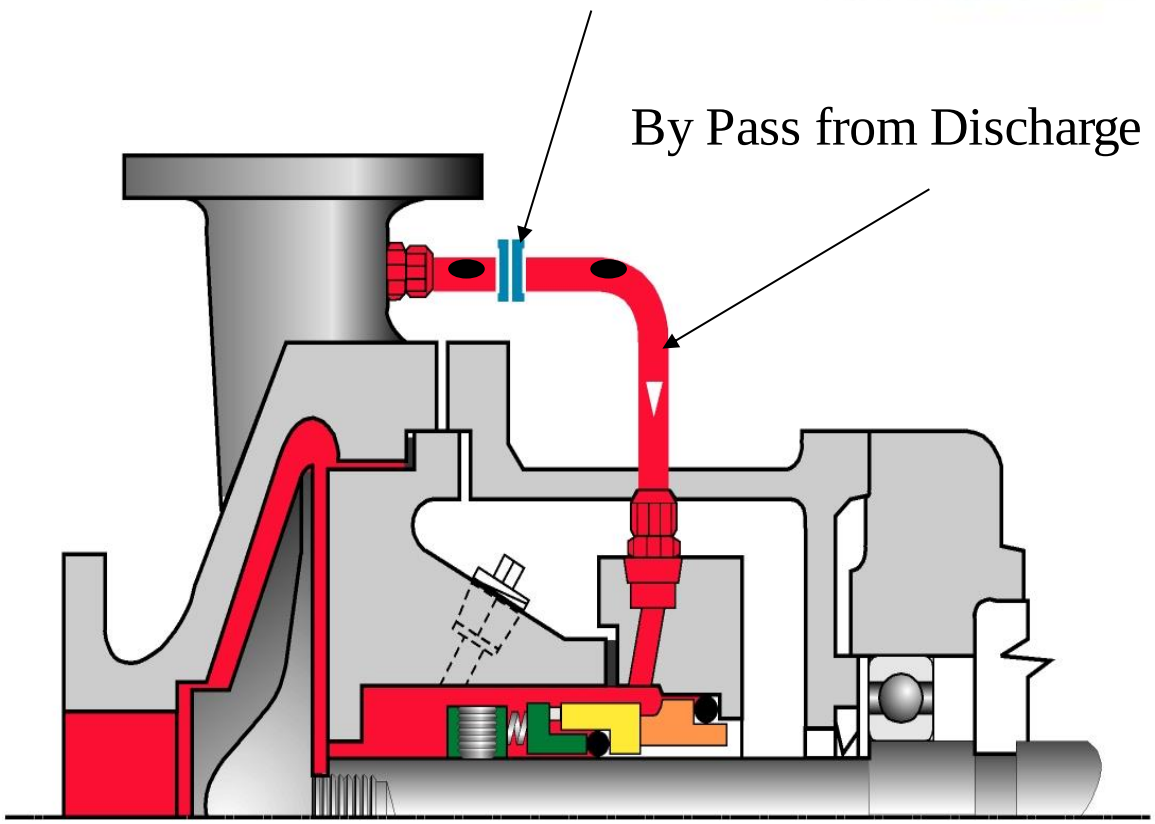
By Pass from Discharge

- Cools the seal and stuffing box
- Helps keep the seal chamber clean
- Can be used to prevent process vaporization by adding a close clearance bushing in the box causing the chamber pressure to increase.
- Keeps the chamber flooded and seal lubricated
- Normally use 1/8 or 3/16” orifice

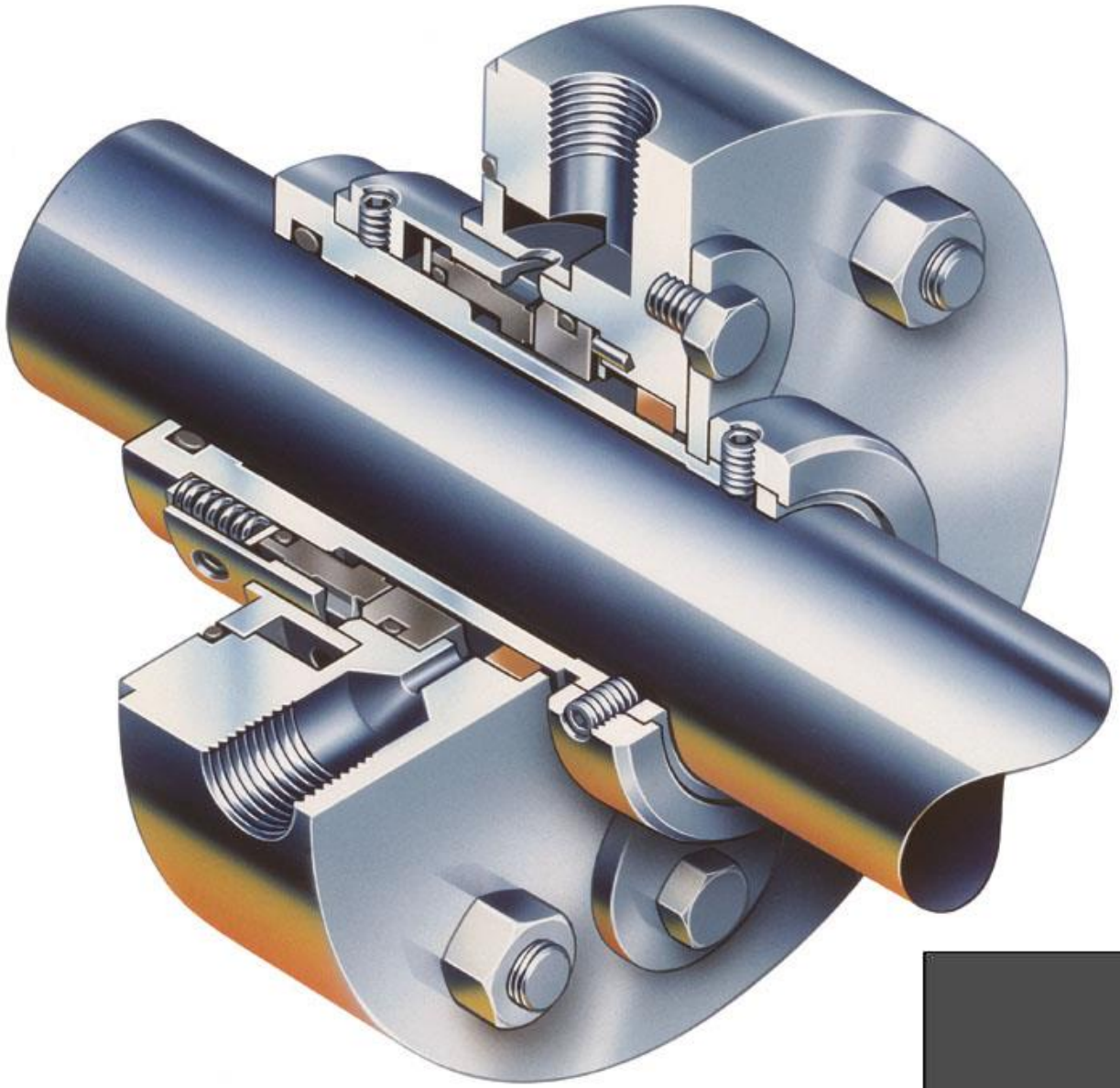


API Plan 11

FLOWSERVE

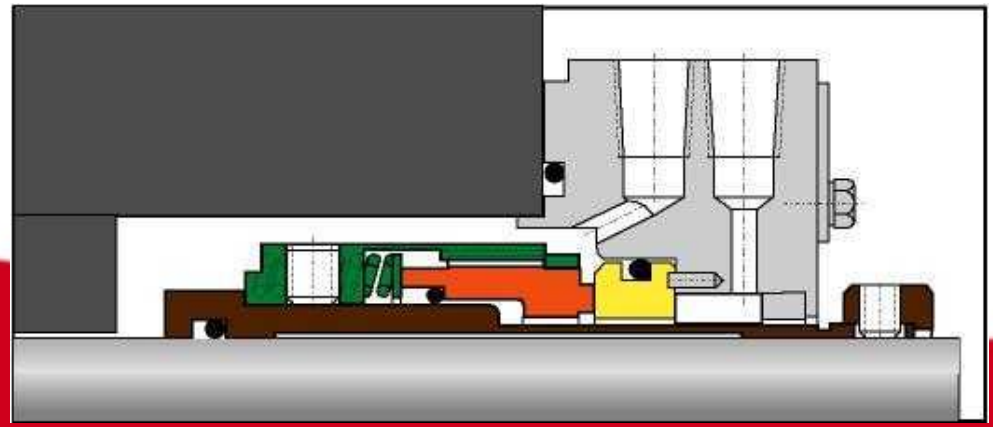
A Cool Seal is A Happy Seal

Experience In Motion



Single Cartridge Seal

- Balanced Pusher Desig

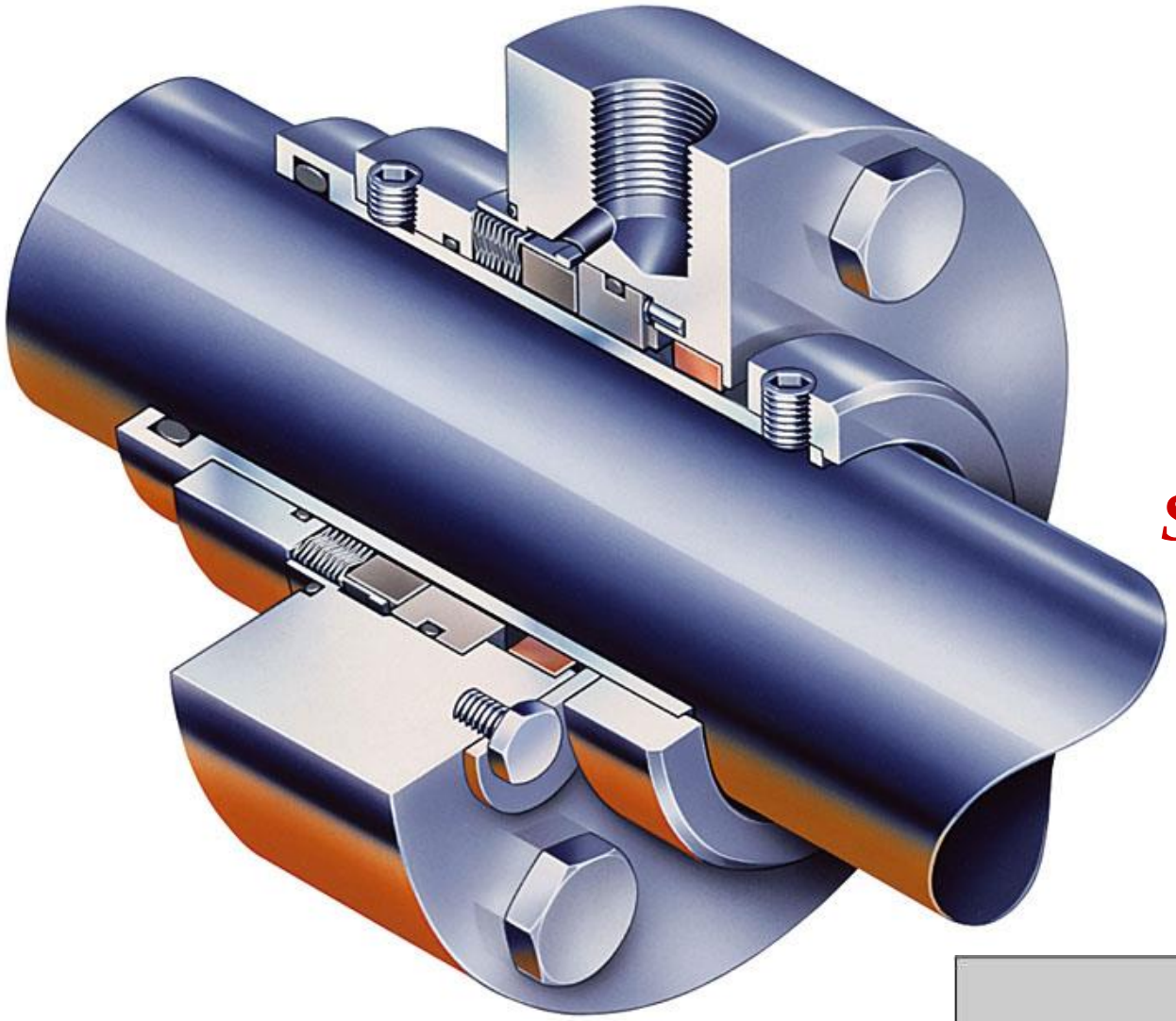


Experience In Motion

Seal Classifications

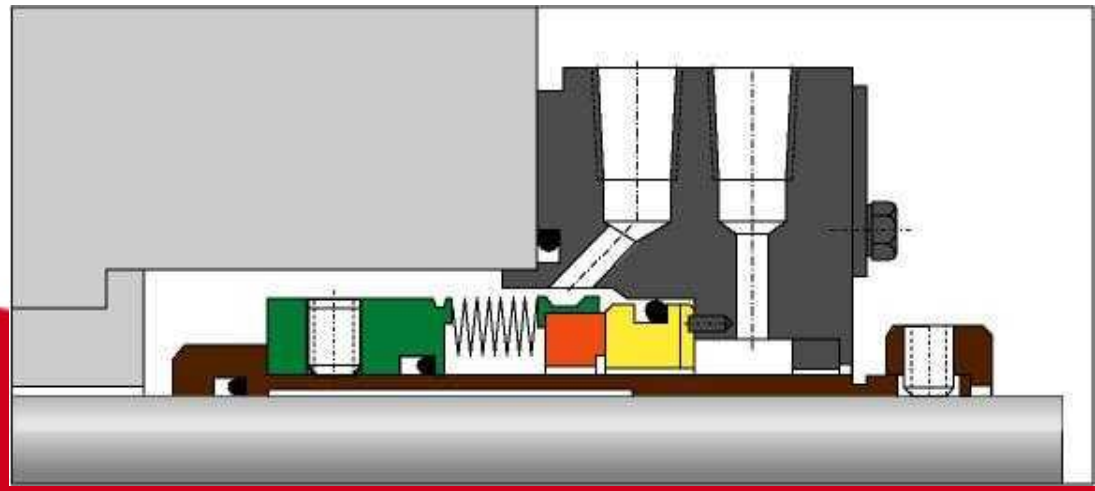
- Spring Pusher vs Bellows
- Balanced vs Unbalanced
- Component, Hook Sleeve & Cartridge Design

All Mechanical Seals fall into either of the above types. Neither design is inherently better than the other, but an understanding of the differences between them is necessary for selecting and maintaining it for it's specific purpose and application.



Single Cartridge Seal

- Balanced Non-Pusher

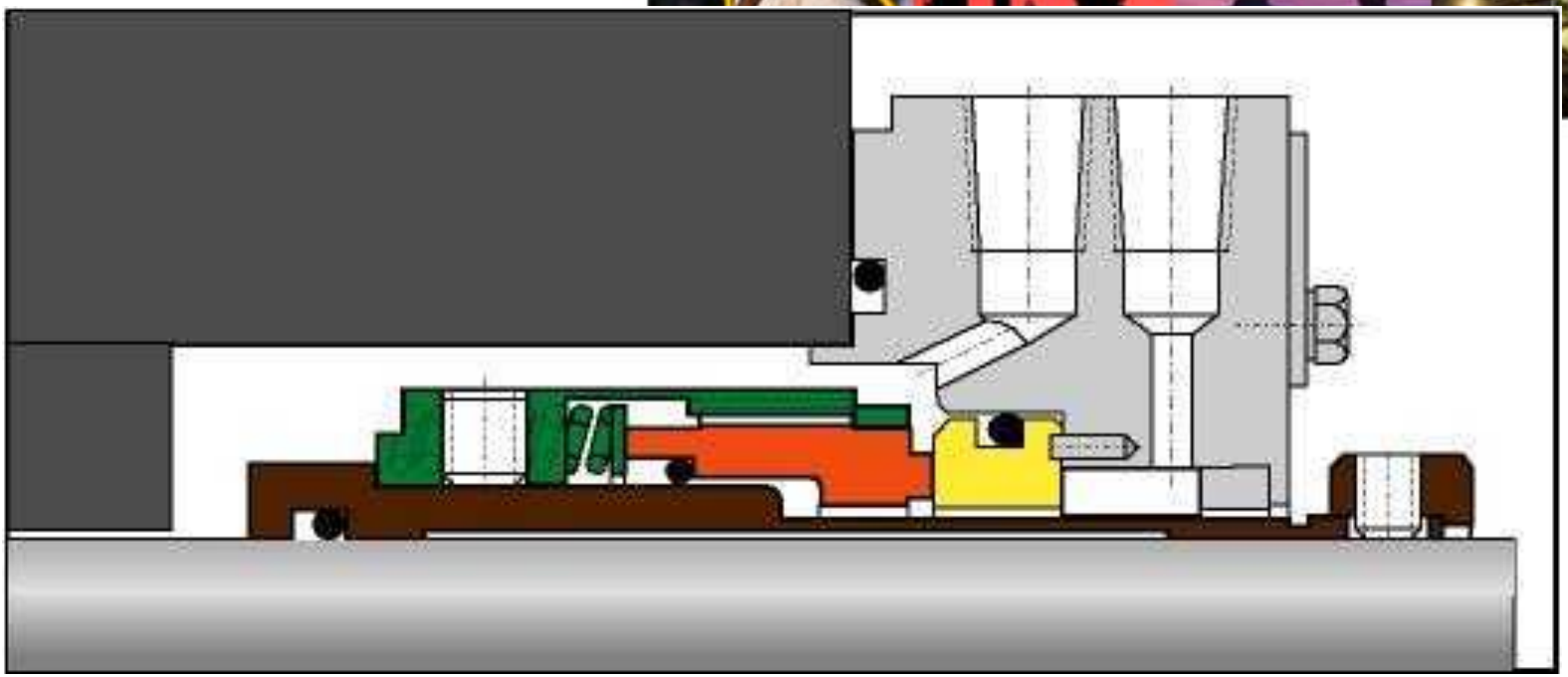


Experience In Motion

Mechanical Seal Classifications

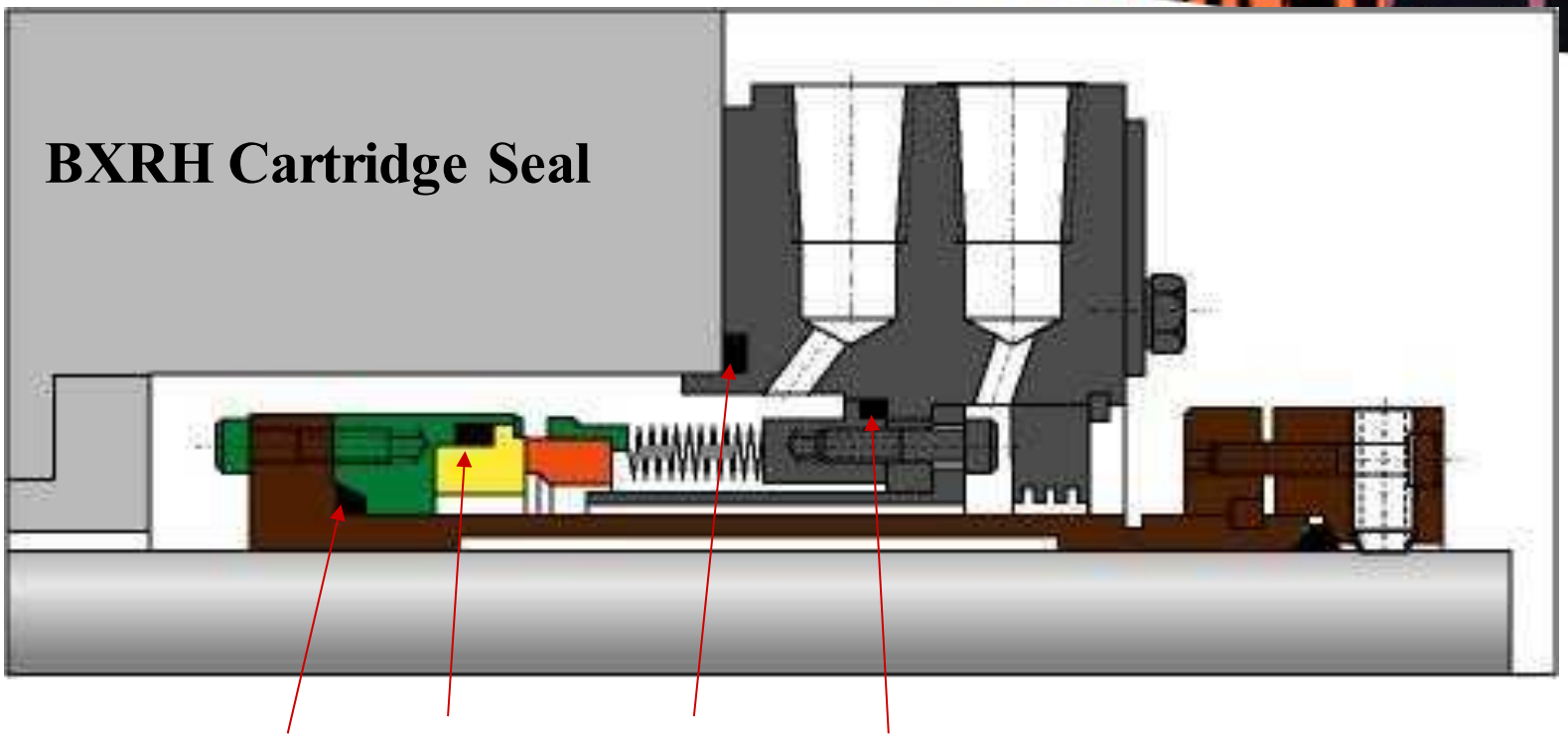
Single Seals

Pusher



- ***Single seals are the most common type of seal and the most economical to operate and maintain.***
- ***Seal Faces are lubricated by the process fluid.***
- ***Working envelope from vacuum to over 1000 psi and Temperatures from -40 to 550 F***
- ***Typically less expensive compared to Tand/Dbl seals.***
- ***Generally limited to temperatues below 500 F***
- ***Has potential for Dynamic oring handup in dirty services.***

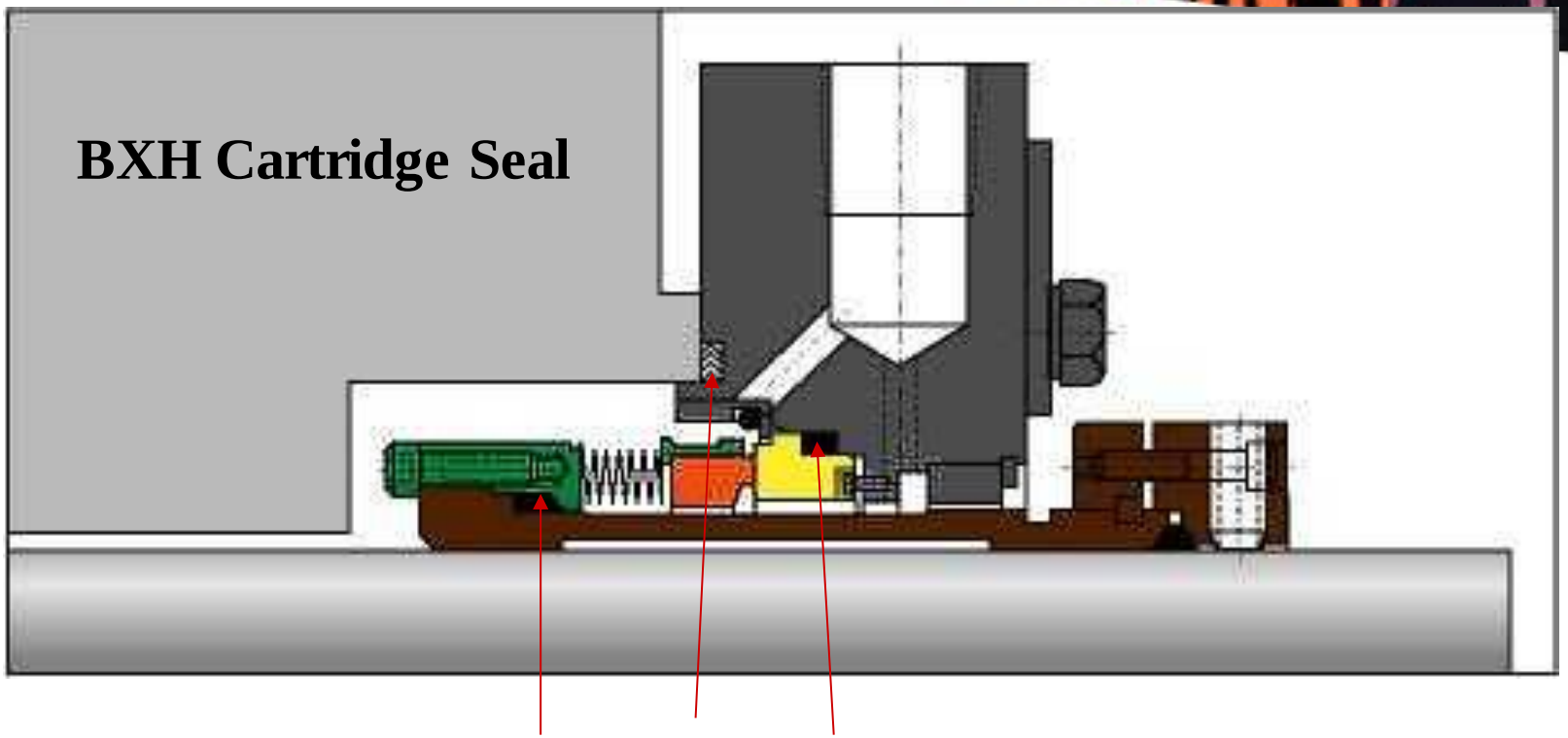
Mechanical Seal Classifications



O'rings are now replaced with Hi-Temp. Grafoil gaskets.

High Temperature Single Cartridge Seal

Mechanical Seal Classifications



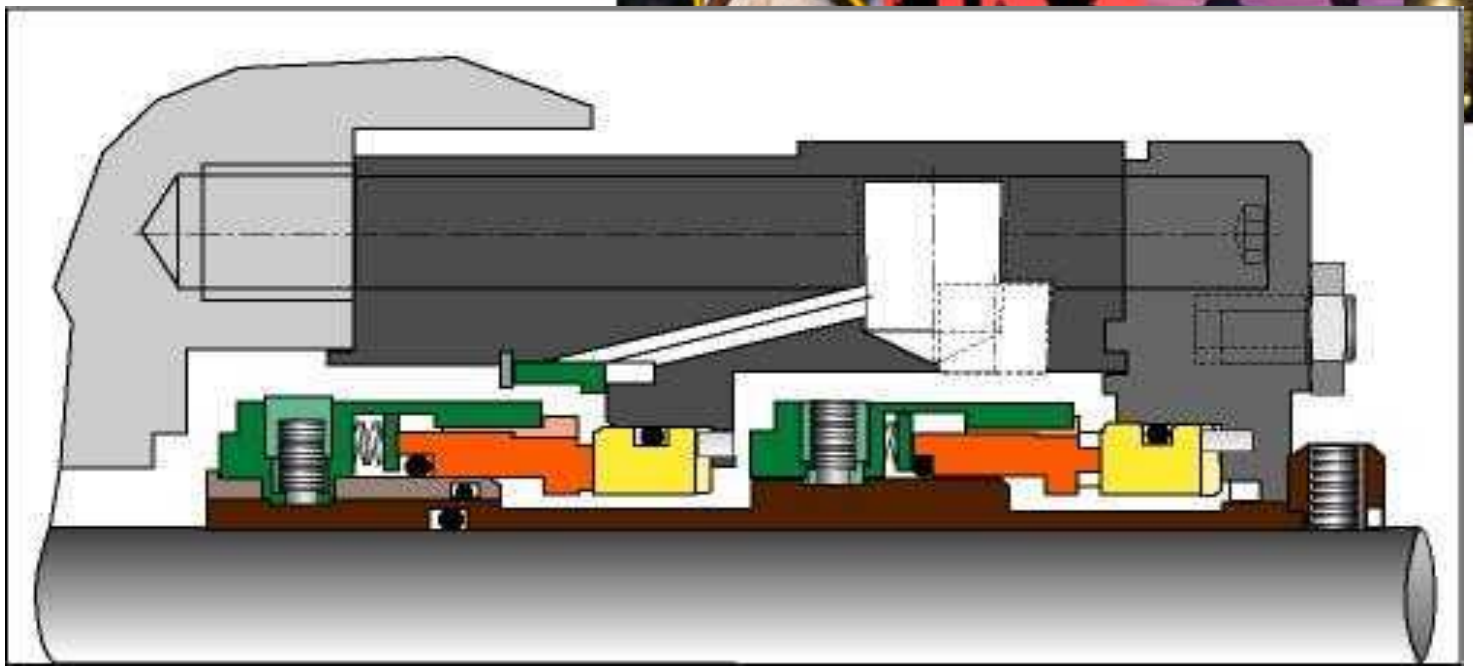
O'rings are now replaced with Hi-Temp. Grafoil gaskets.

High Temperature Single Cartridge Seal

Mechanical Seal Classifications

Tandem Seals

Non-pressurized



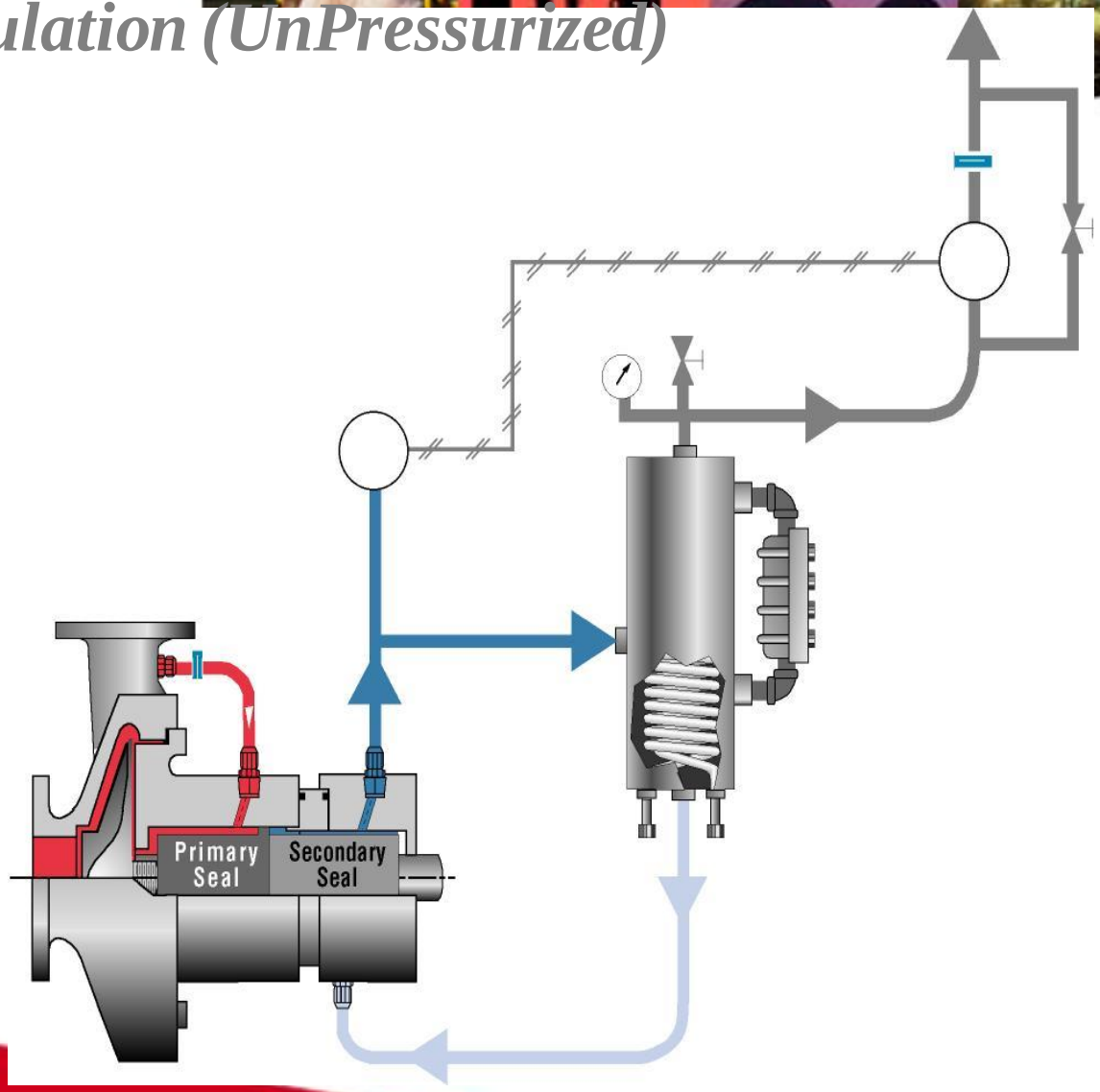
- *Tandem seals generally used where leakage of process to atmosphere is unacceptable.*
- *Two seals work independent of each other.*
- *Primary seal in Process fluid and secondary seal operates in the buffer fluid.*
- *Dual seal will require an auxillary support system. Eg. Reservoir.*
- *Typically more expensive than single seals.*
- *Requires higher level of monitoring*

API Plan 52

Internal Buffer Fluid Circulation (UnPressurized)

- To Provide a protective buffer media between product and atmosphere to prevent environmental contact in the event of a primary seal failure

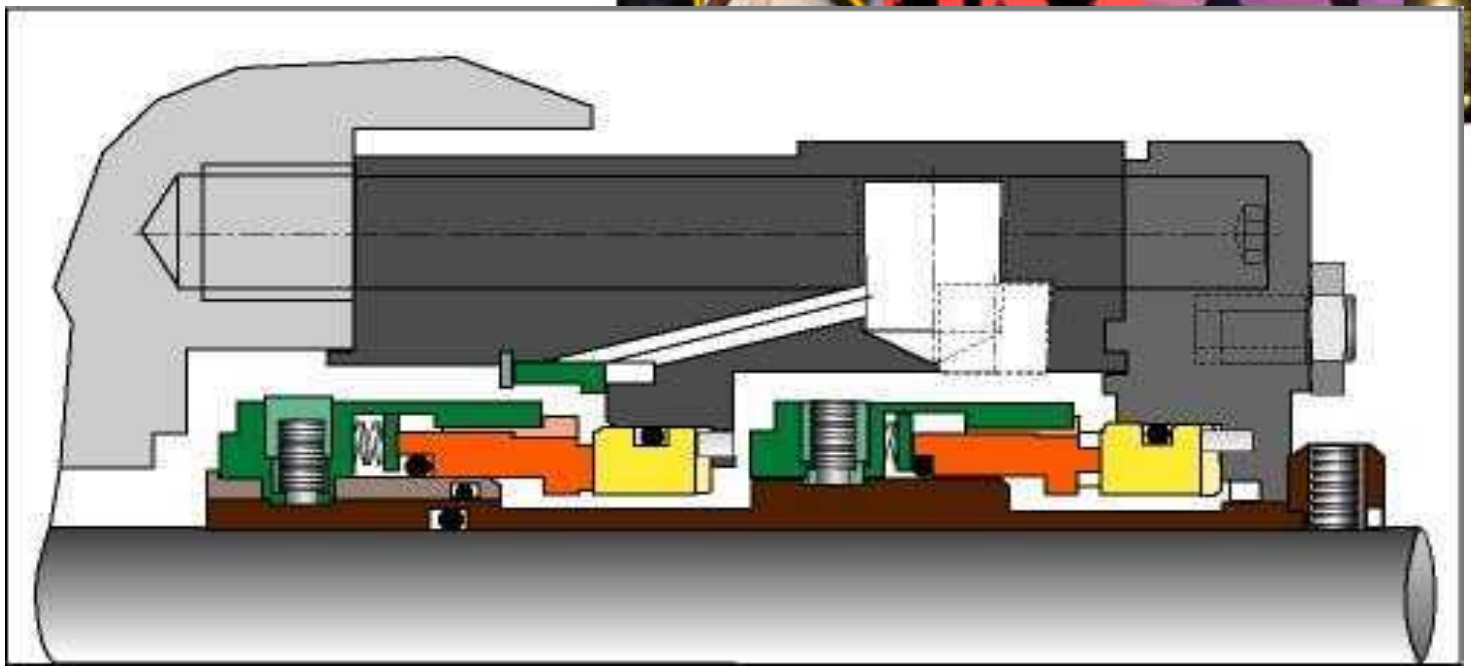
- Normally the reservoir is vented to a flare or low pressure point to dispose of vapors that have leaked across the primary seal.



Mechanical Seal Classifications

Double Seals

Pressurized

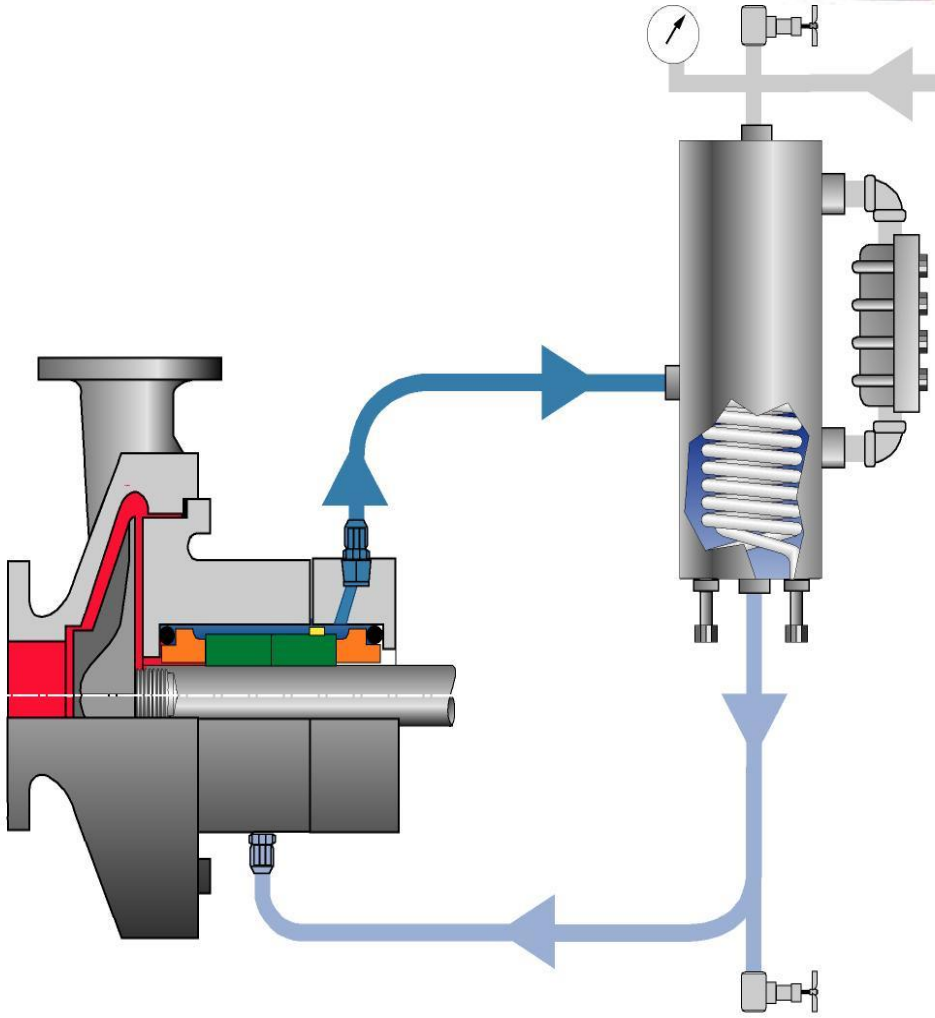


- *Double seals are used when zero leakage to atmosphere can be tolerated.*
- *Used in toxic, lethal, carcinogenic, dirty, viscous, abrasive fluids. Pump cavitation ??*
- *Barrier Fluid is now at higher pressure than process. Generally recommend 25 psi differential*
- *Barrier must be compatible with process and the enviroment.*
- *Requires auxillary support system and reliable Nitrogen pressure*
- *Requires higher level of monitoring and detailed startup and shut down procedures.*

API Plan 53

Internal Barrier Fluid Circulation (Pressurized)

- Circulates barrier liquid through the seal chamber.
- Requires a circulation device (flow inducer, pumping ring)
- Pressurize barrier fluid 15 to 25 psig above seal chamber pressure
- Never let the barrier fluid level go below the return line to the supply tank. Flow will be lost, the seal will over heat and nitrogen will be released from the barrier fluid causing gas to migrate to the seal faces



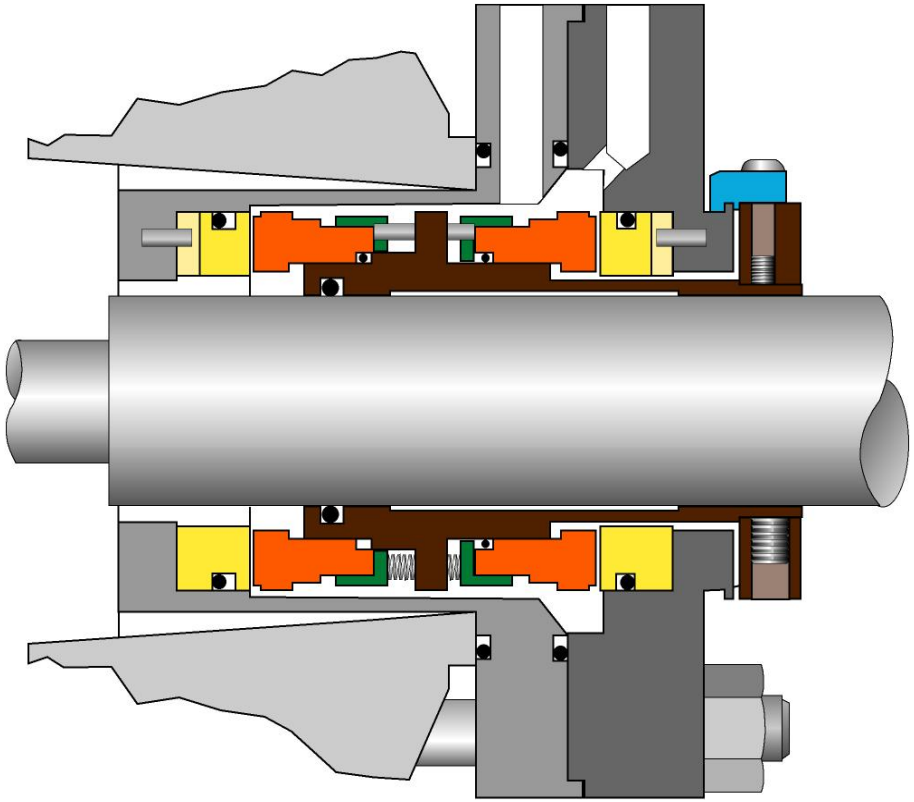
API Plan 53

Experience In Motion

Mechanical Seal Classifications

Gas Seals

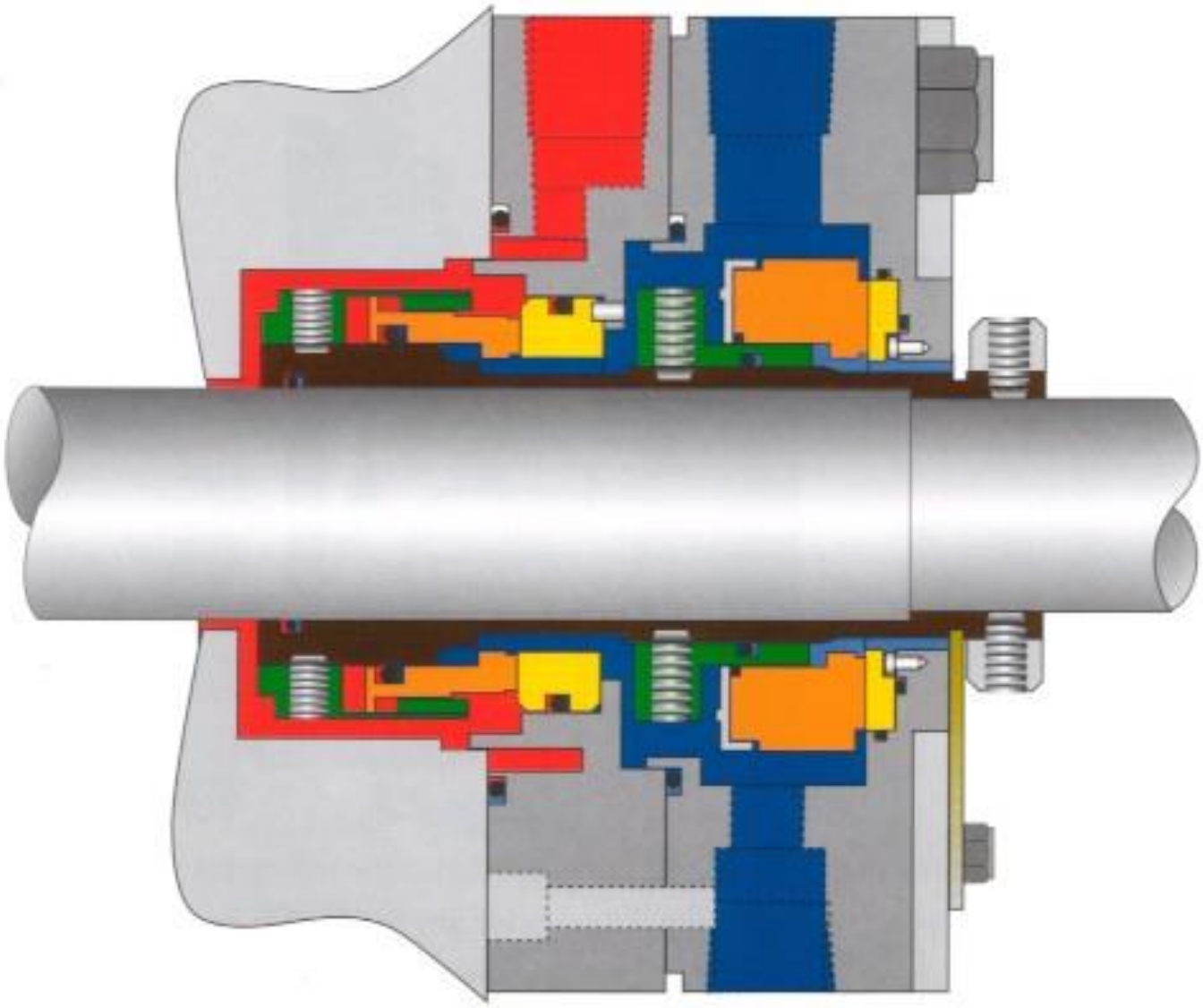
- Two sets of seal faces, inner (process side) and outer (atmospheric side).
- Gas (nitrogen, instrument air, mixed gas) is pressurized between the two sets of seal faces at a higher pressure than is acting on the stuffing box.
- A small amount goes to process and atmosphere (usually between .05 and 3 SCFH (standard cubic feet per hour). This is measured on the flow meter in the gas barrier control panel
- Never turn off the gas while the pump is in service. Gas can be turned off if the pump has been cleared and suction and discharge valves have been closed.



FLOWSERVE

Dry Gas Back-Up Seal

- Conventional primary seal
- Dry gas seal at outboard
- No seal pot
- Use with vapor recovery system
- Good for flashing application,LPG



Reliability

All the efforts put into designing, constructing and maintaining for high reliability can be negated in an instant by improper operation of the equipment.

In order for any Mechanical seal to be successful, we must first have a reliable pump. ***We cannot solve a pump problem by simply changing the mechanical seal.***

FLOWSERVE

Rear Cover

Discharge

Shaft

Wear Rings

Impeller

Flow Modifier

Thrust & Radial Bearings

Suction

Mechanical Seal

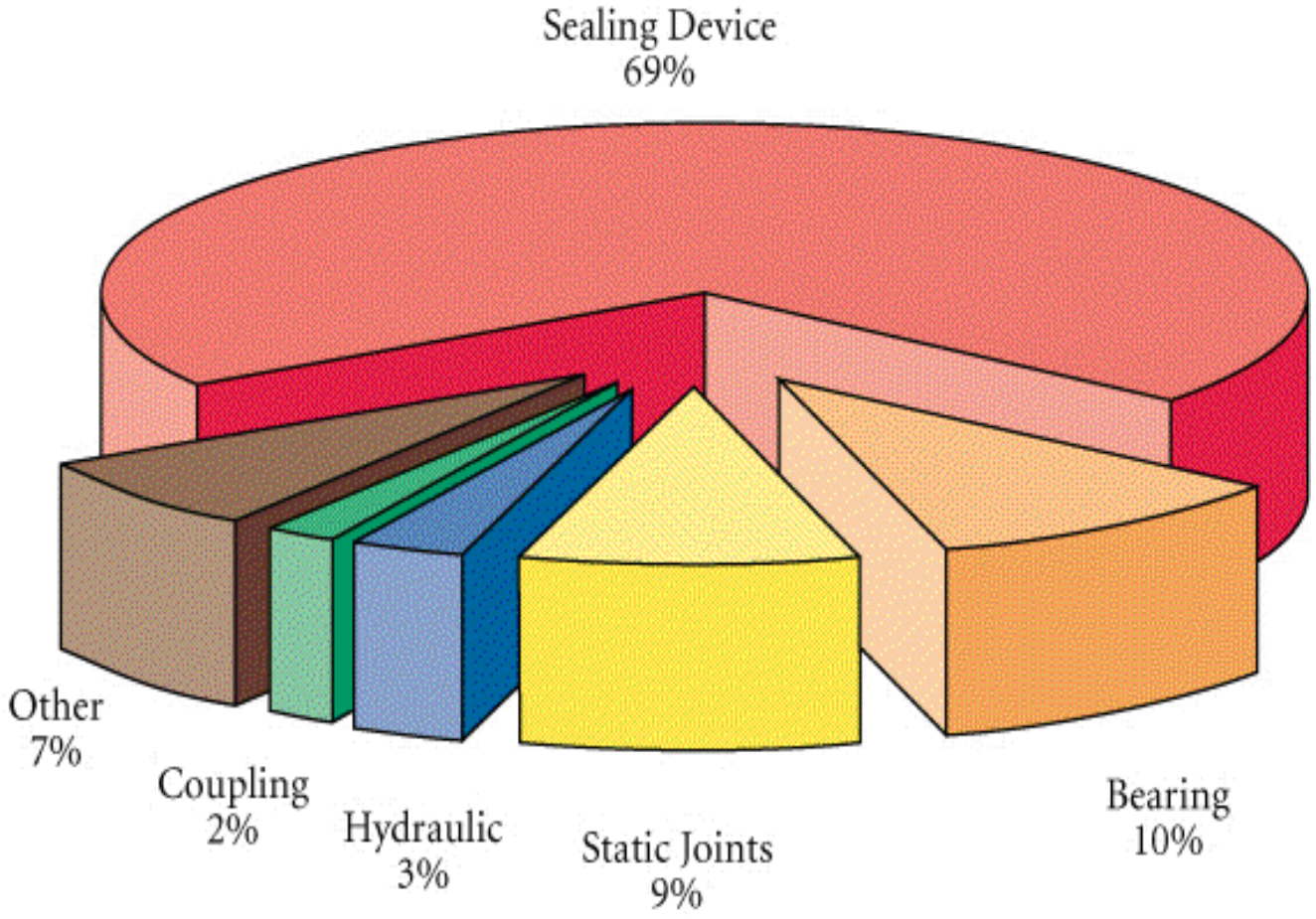
Gland

Experience In Motion

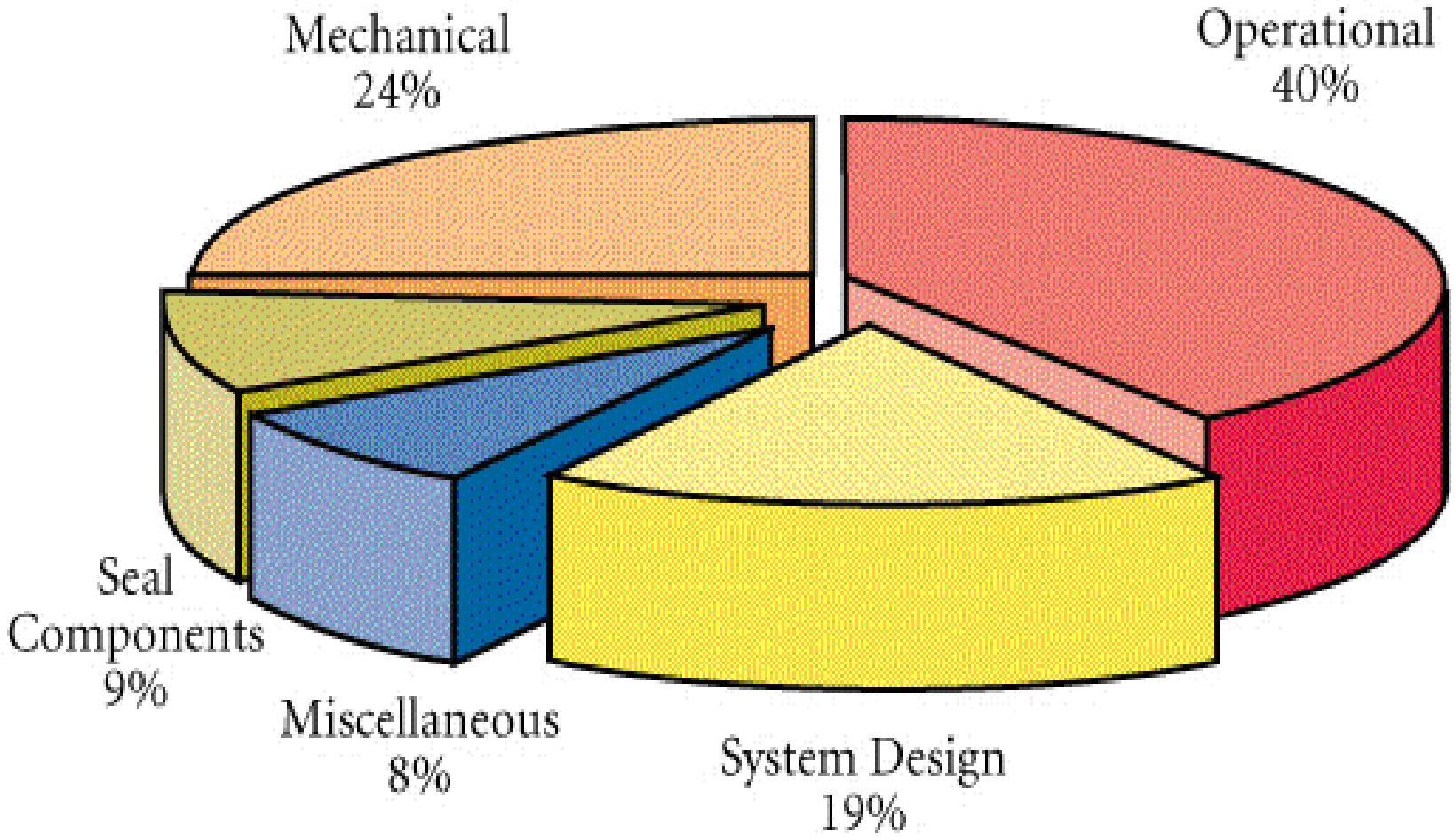
FLOWSERVE

Reliability

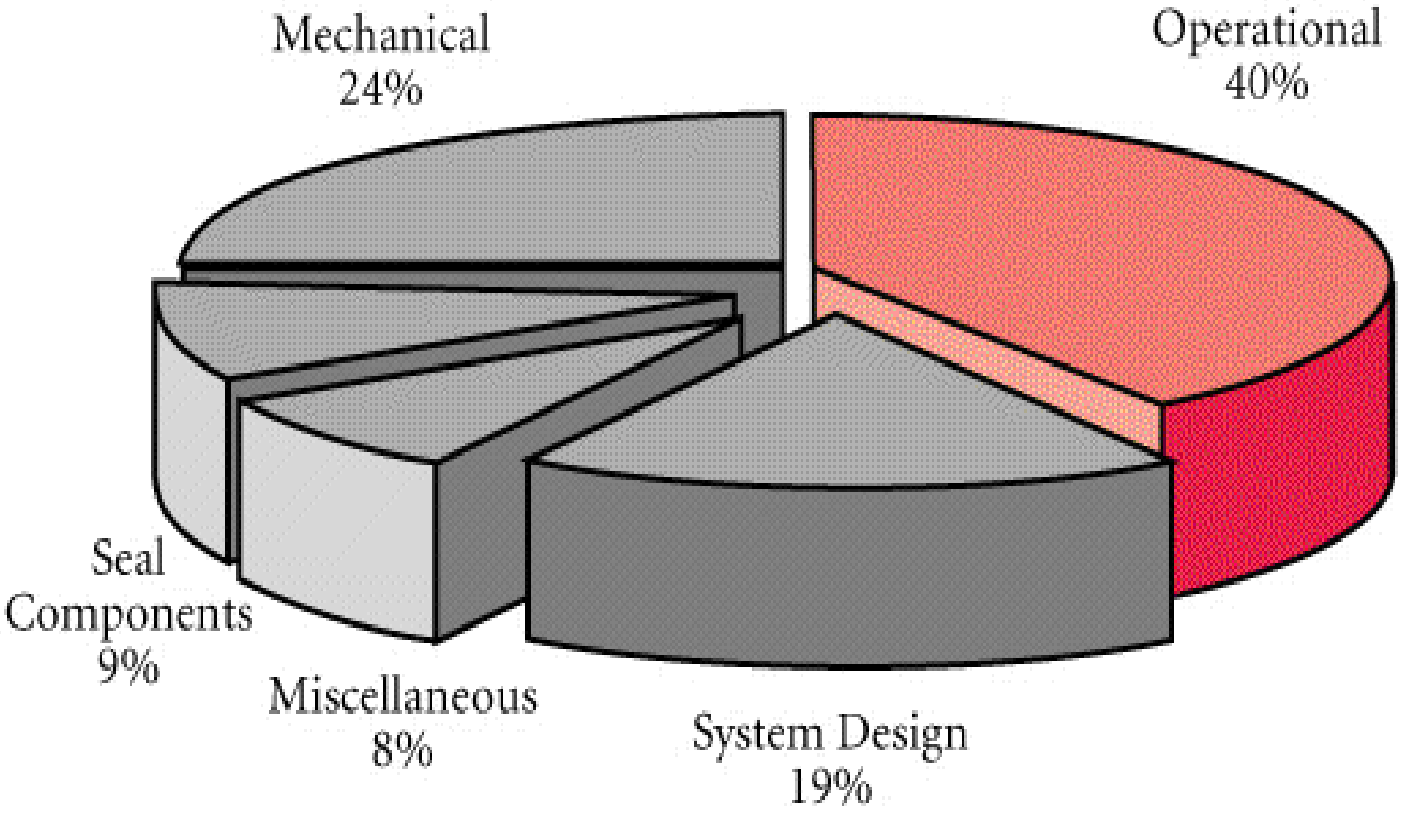
Causes of Rotating Equipment Failures



Causes of Mechanical Seal Failure



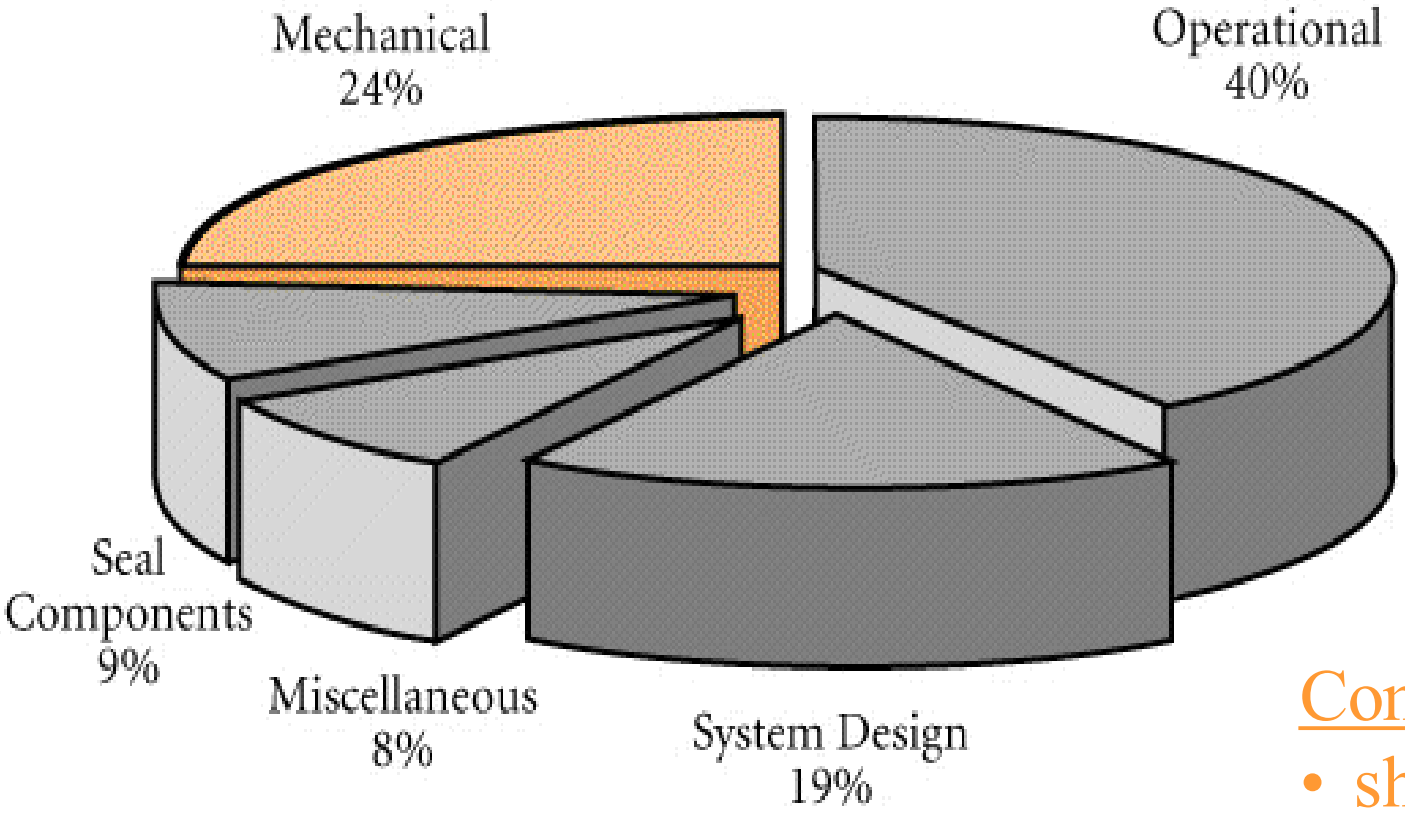
Causes of Mechanical Seal Failure- OPERATIONAL



Common causes:

- not at BEP
- insufficient NPSH
- operating dead-headed
- dry-running
- improper venting
- etc.

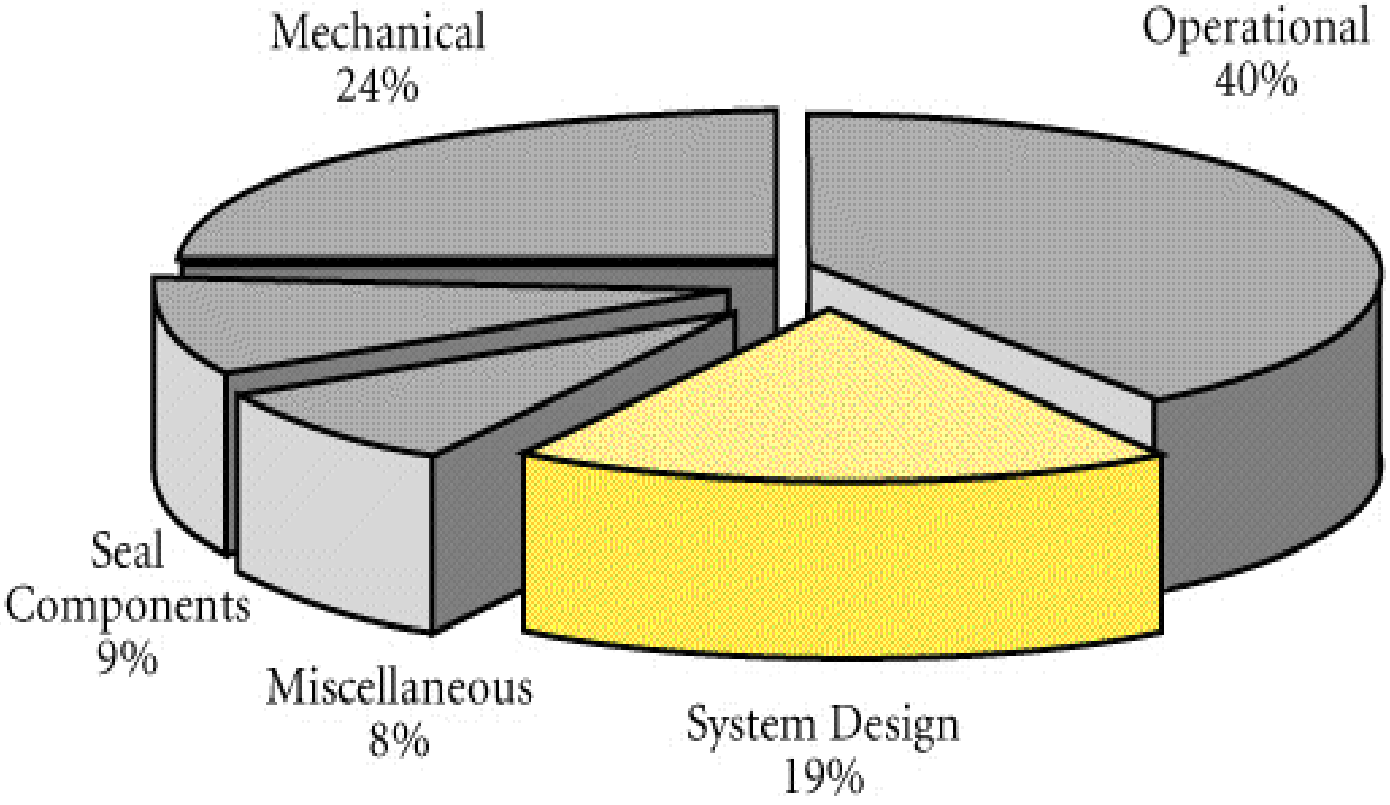
Causes of Mechanical Seal Failure- MECHANICAL



Common causes:

- shaft alignment
- coupling balance
- pipe strain
- etc.

Causes of Mechanical Seal Failure- SYSTEM DESIGN

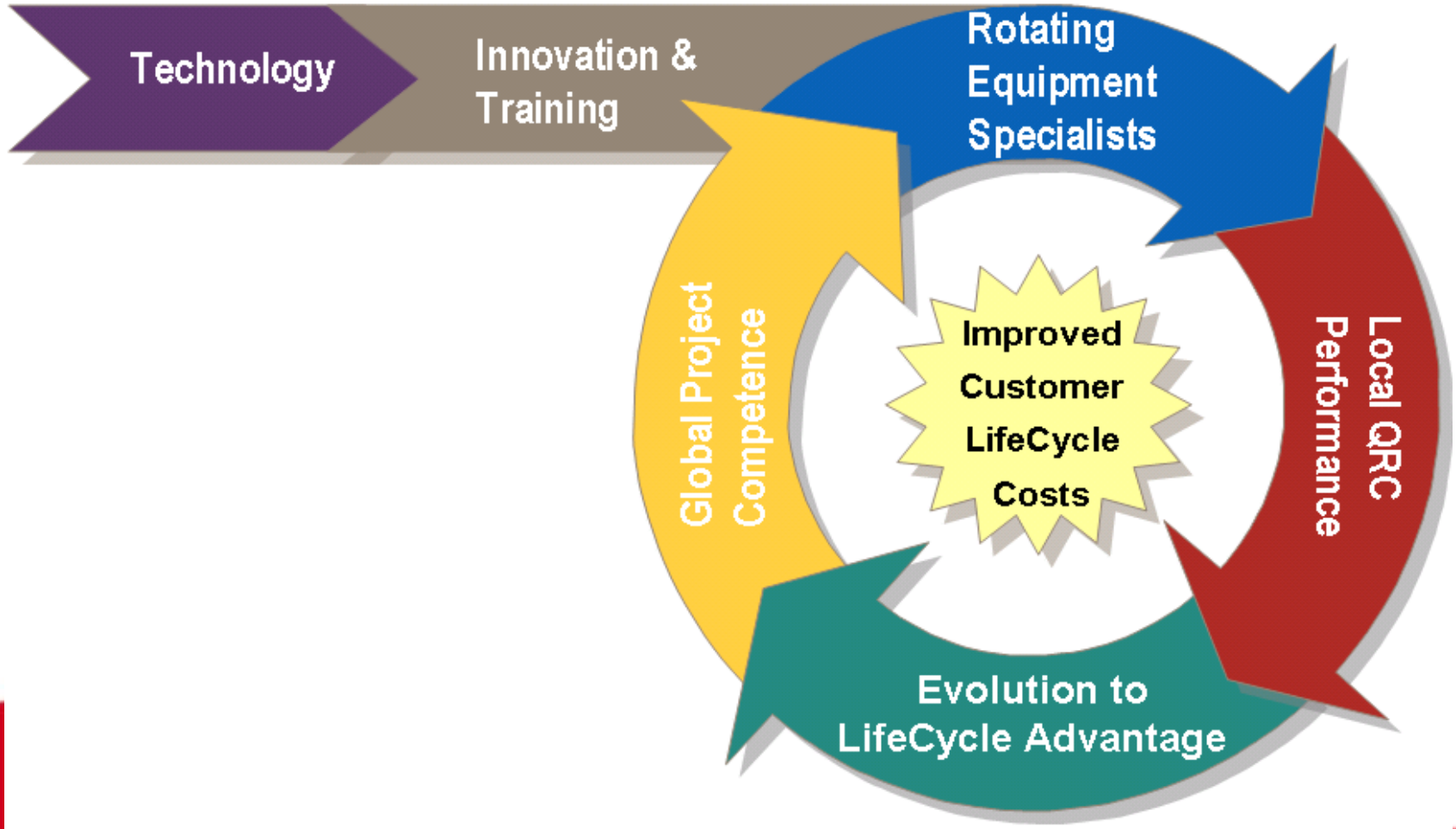


Common causes:

- flush arrangement
- insufficient cooling
- dual seal auxiliaries
- etc.

FLOWSERVE

Flow Solutions Core Value



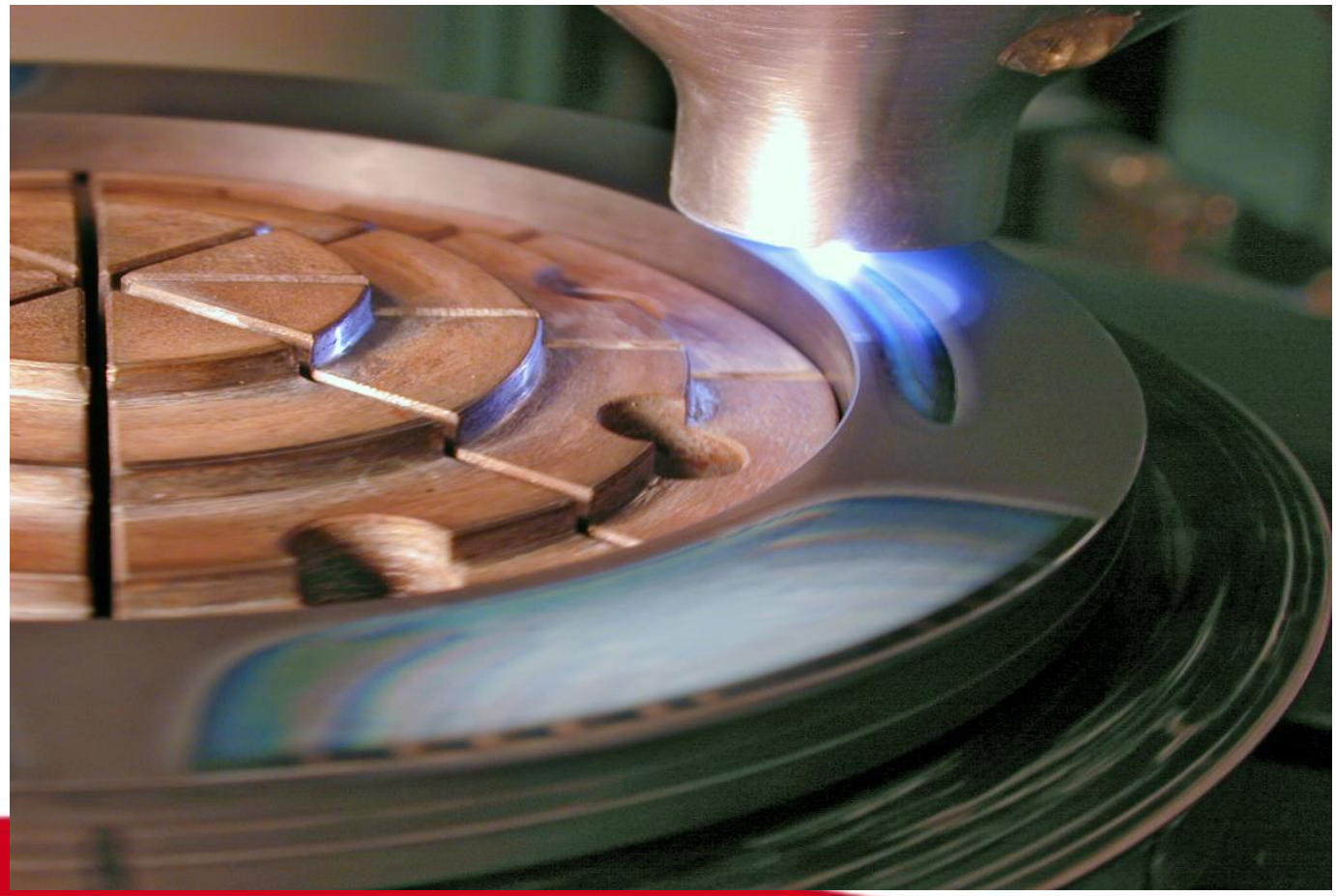
FLOWSERVE

Advance Face Technology

Experience In Motion

FLOWSERVE

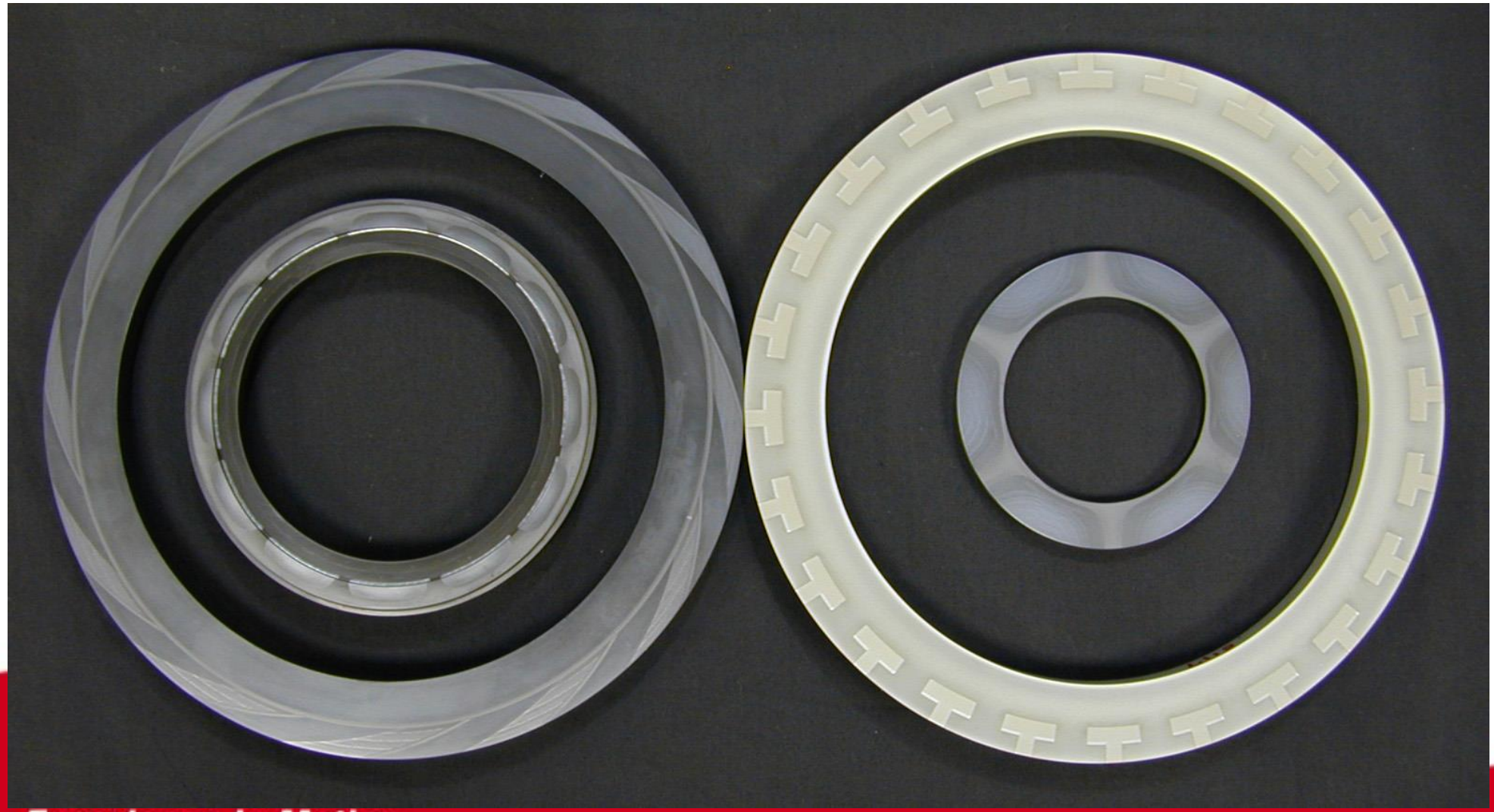
Laser Machining



Experience In Motion

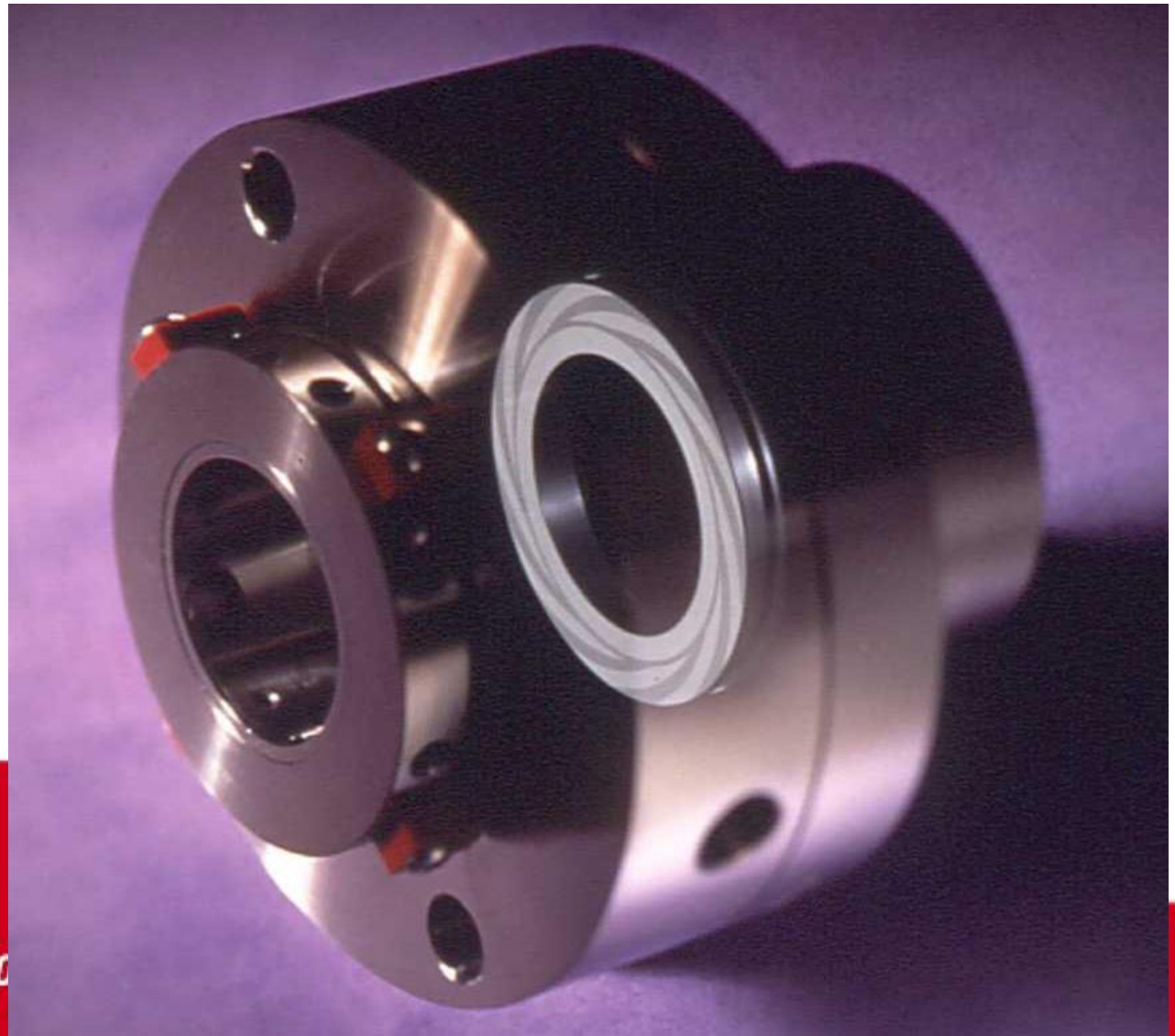
FLOWSERVE

Laser Face Technolgy



FLOWSERVE

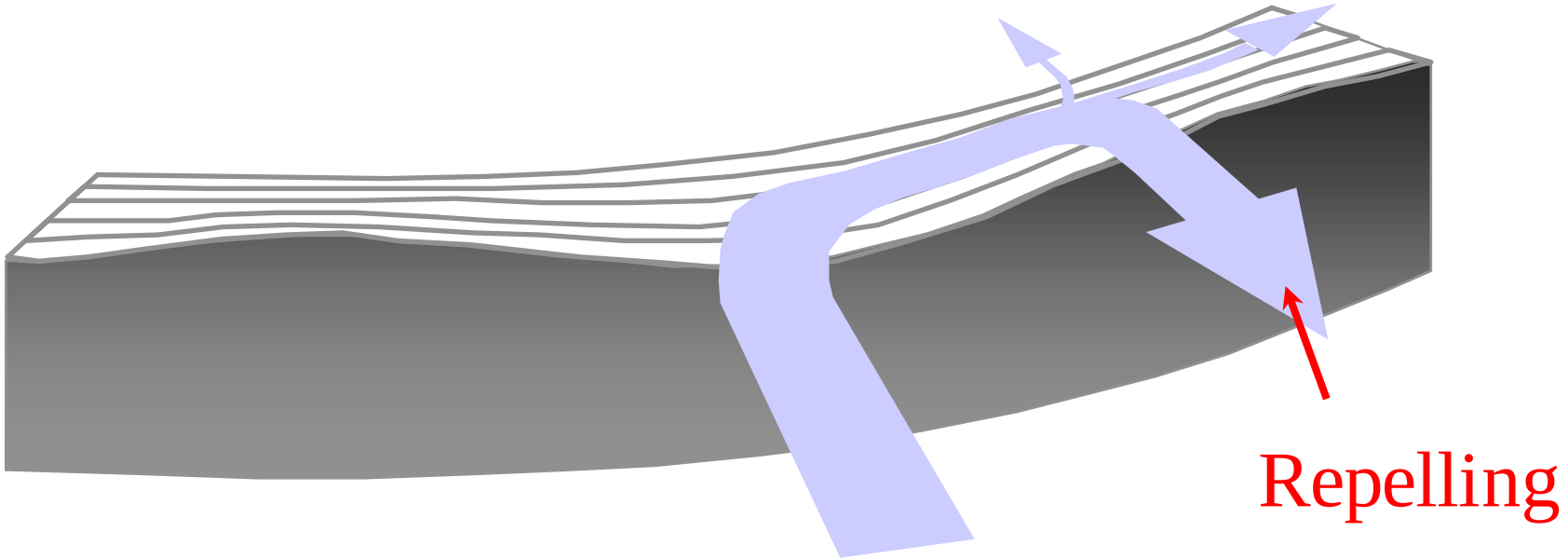
Gas Barrier Seal



Experience In Mo

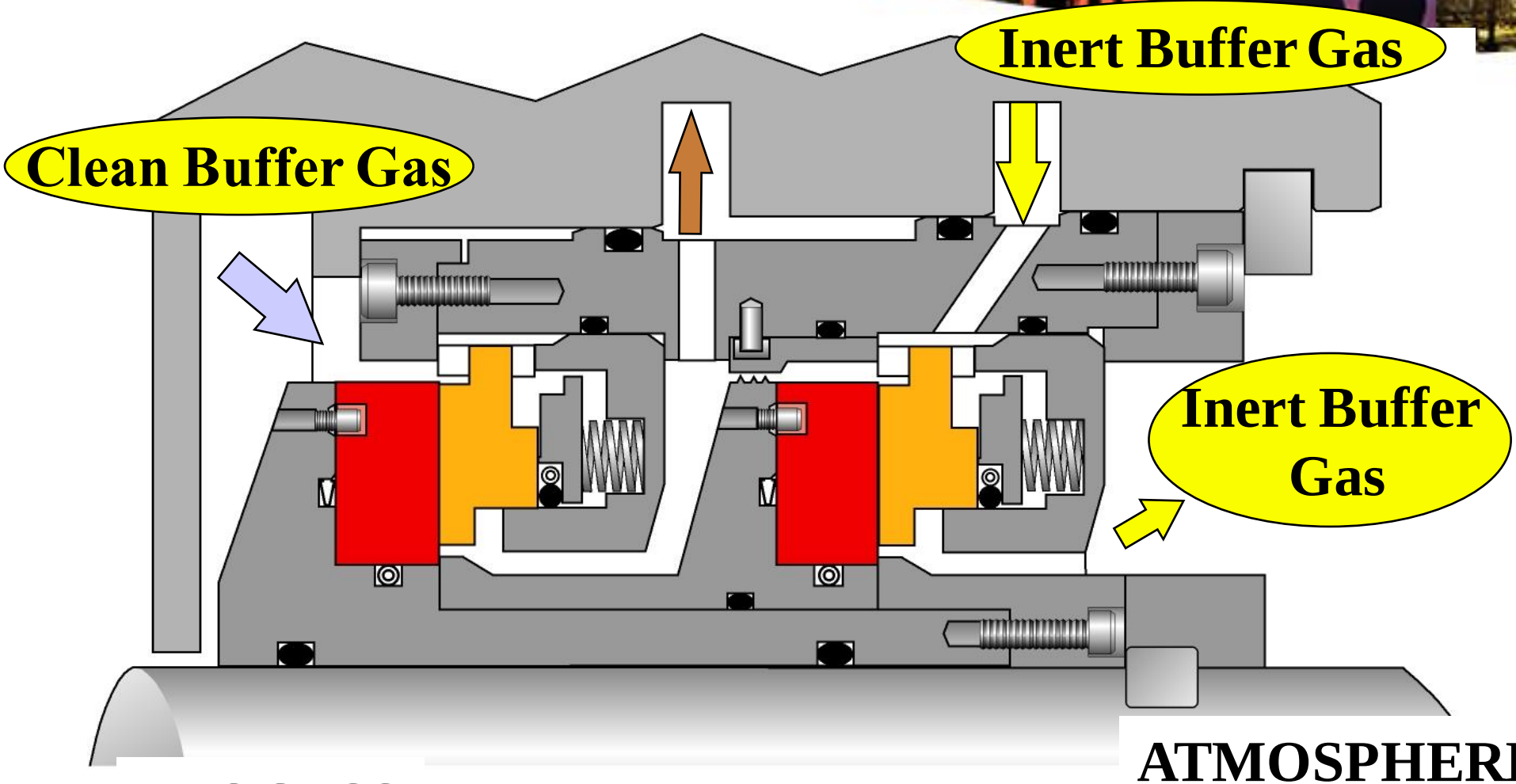
FLOWSERVE

Circulation Effect of Waves



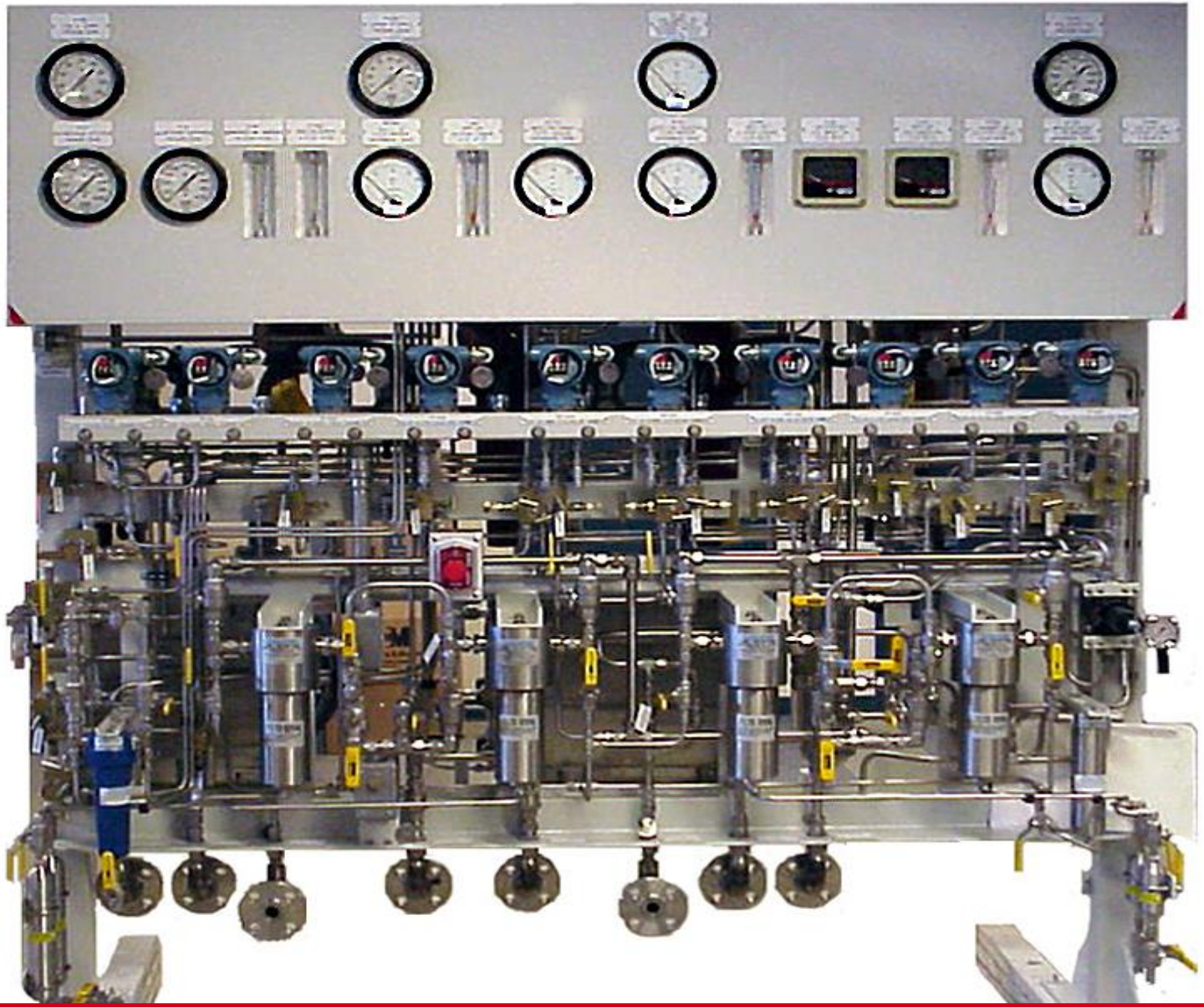
FLOWSERVE

GASPAC L



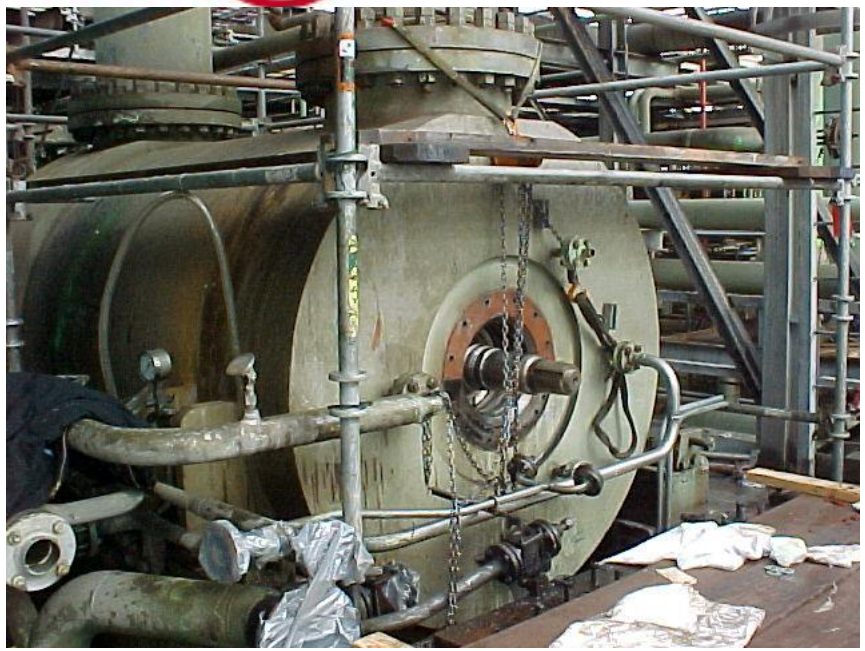
Experience In Motion

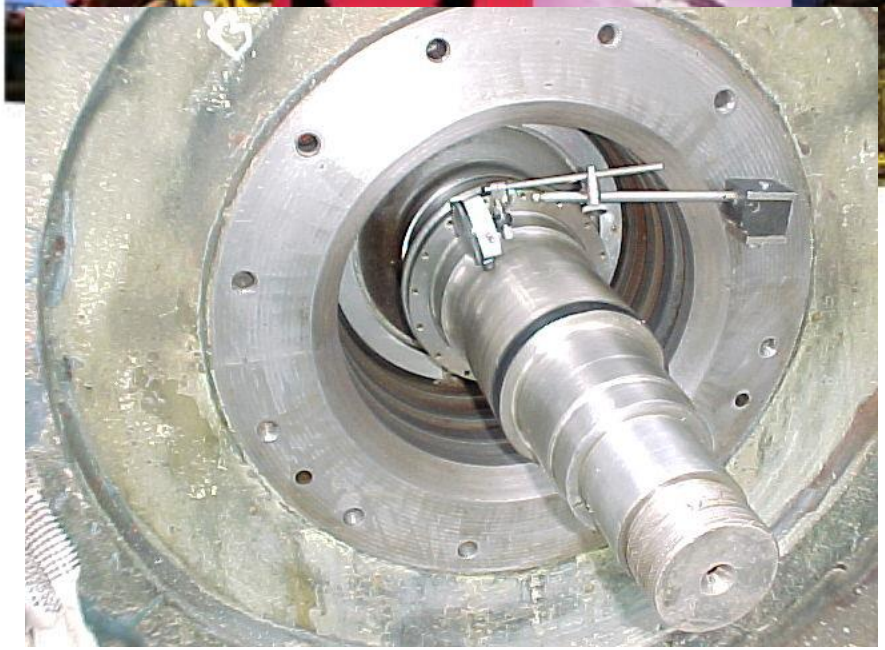
FLOWSERVE



Experience In Motion

FLOWSERVE





On Site Compressor Service

Experience In Motion

FLOWSERVE

Indoor Gas Seal Tester 0-86 bar; 6000-34000 rpm

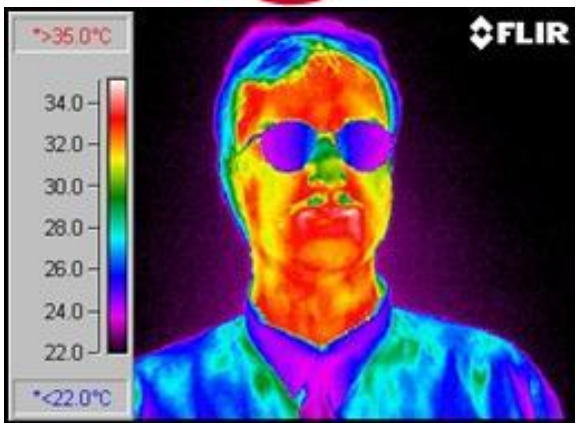
Experience In Motion

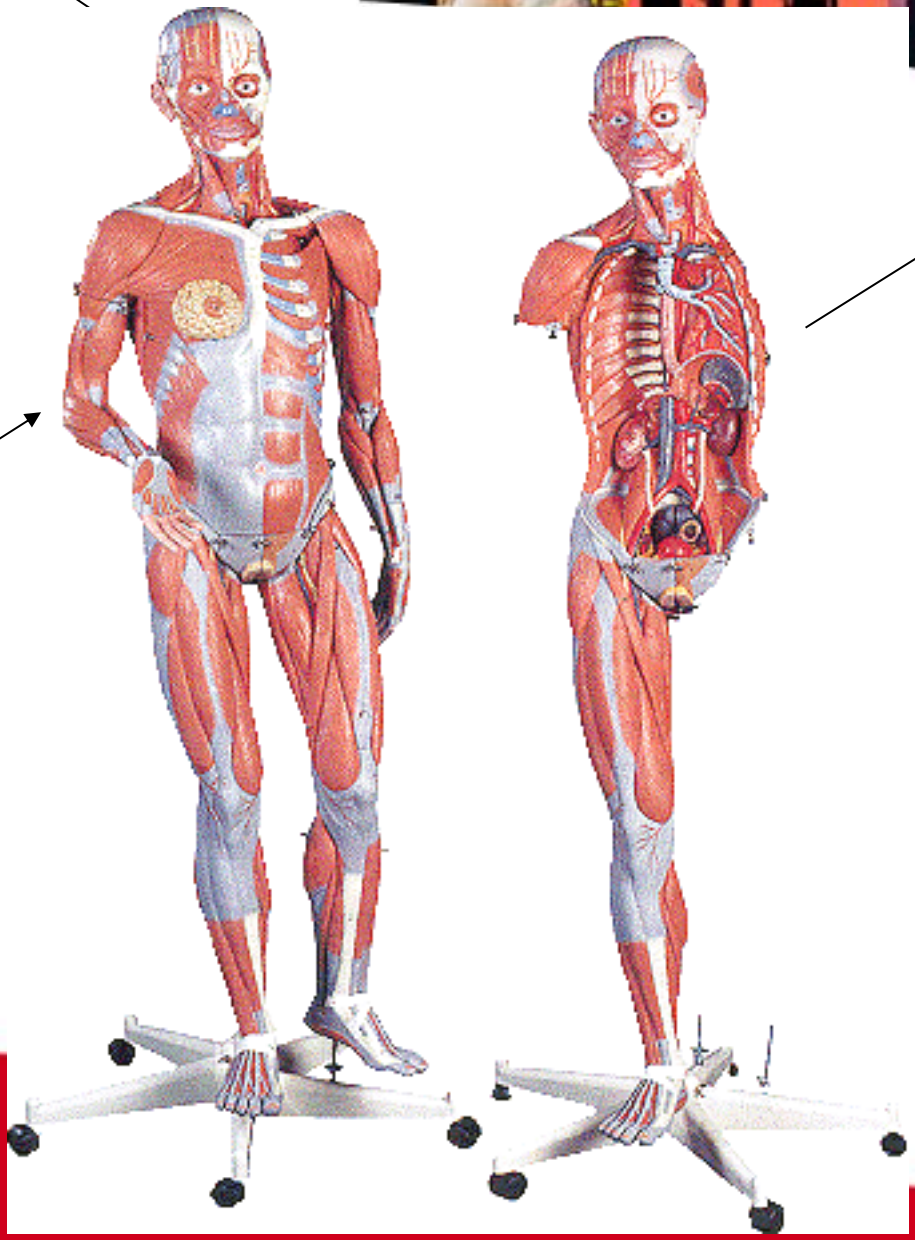
FLOWSERVE

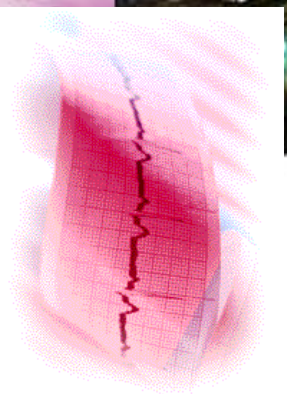
Condition Point Monitoring (CDPM)

Experience In Motion

Human Health Monitoring

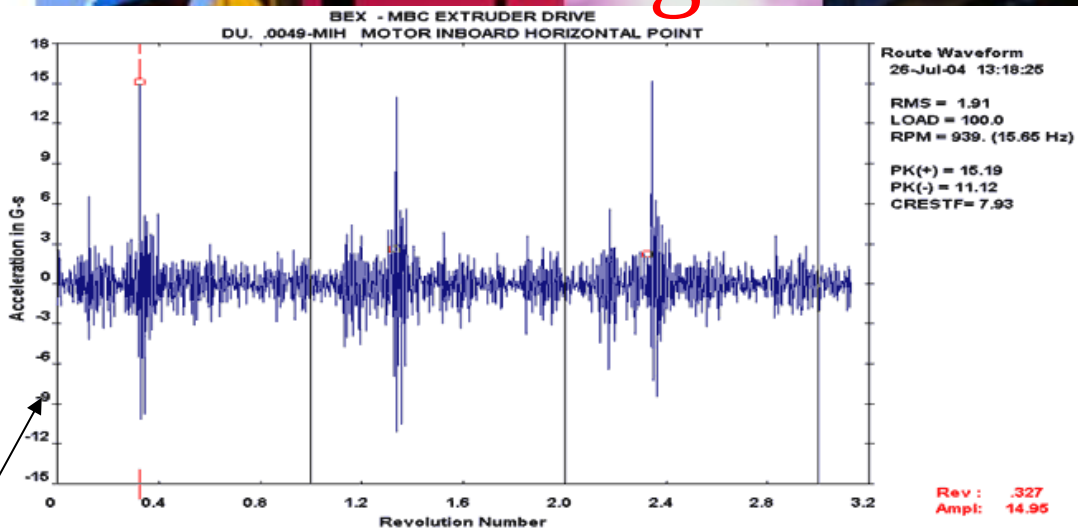


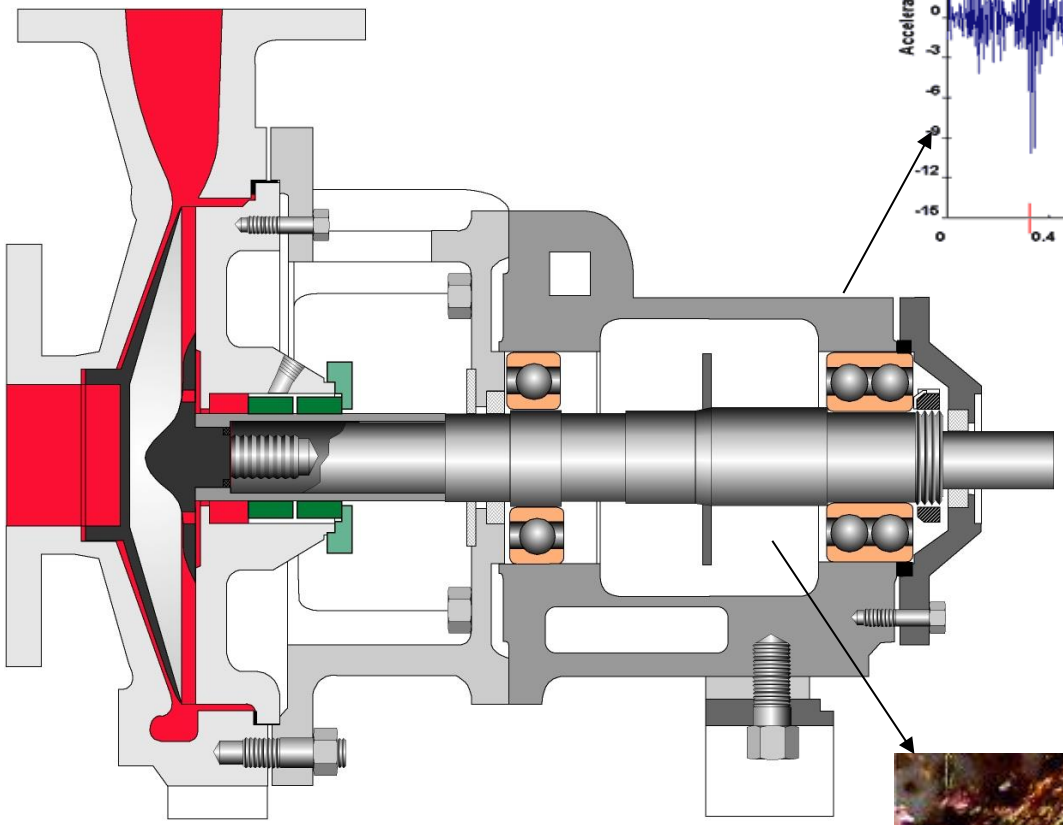


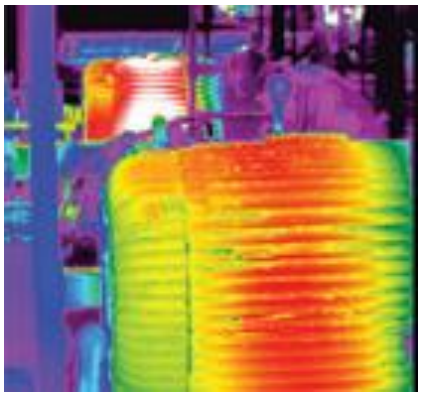


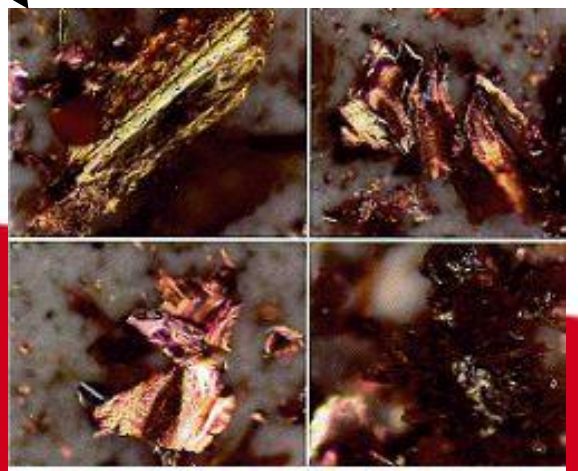
Experience In Motion

Machinery Health Monitoring



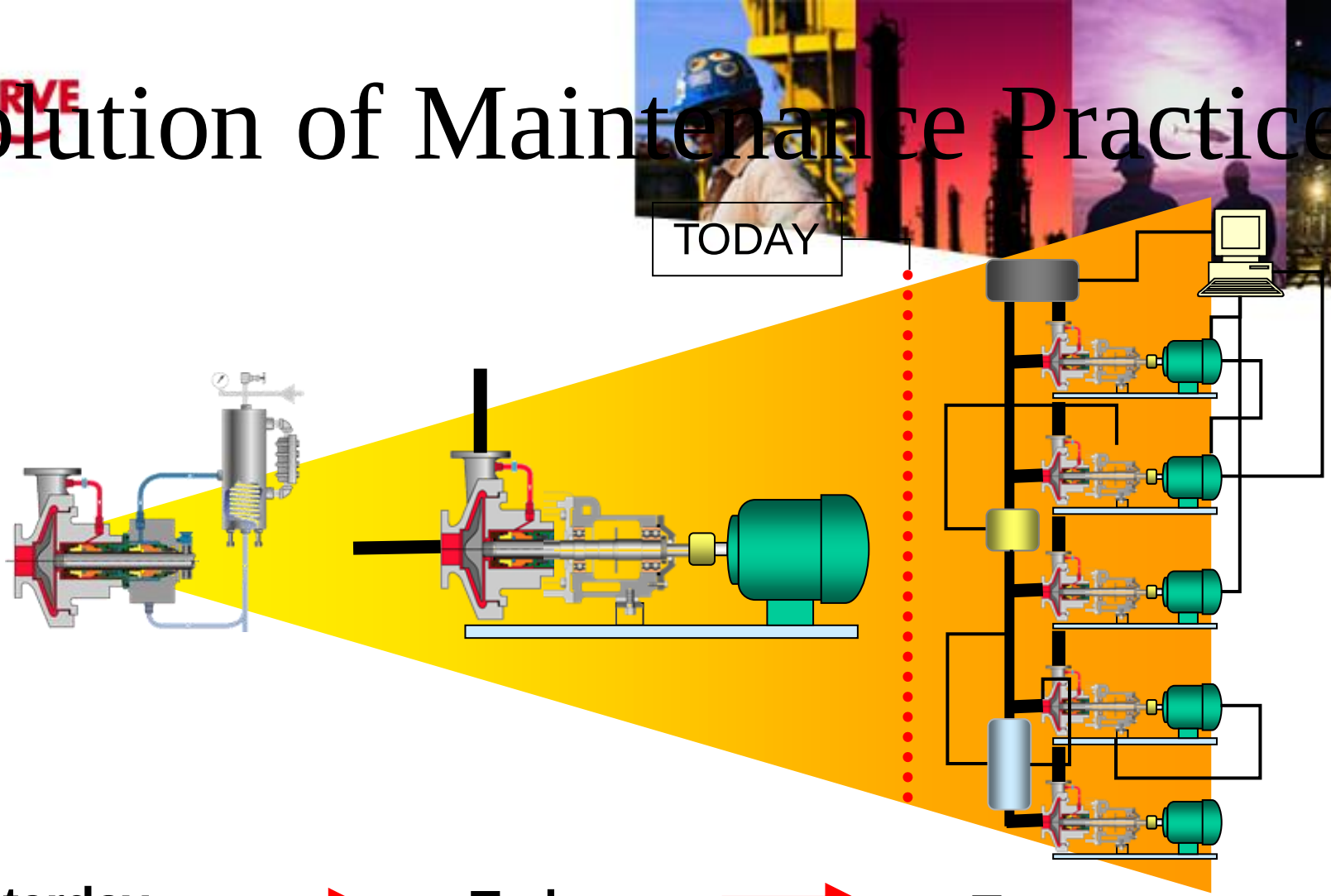






Experience In Motion

Evolution of Maintenance Practices



Yesterday → **Today** → **Tomorrow**

Component Focus — ***System Focus***

Keep it running — **Increase MTBF** — ***Optimize Asset Utilization***
Financial Management

Data Collection Process Flow Diagram

Customer Facility
Flowserve

Entek ROL Control Center

LAN Modem

Phone line

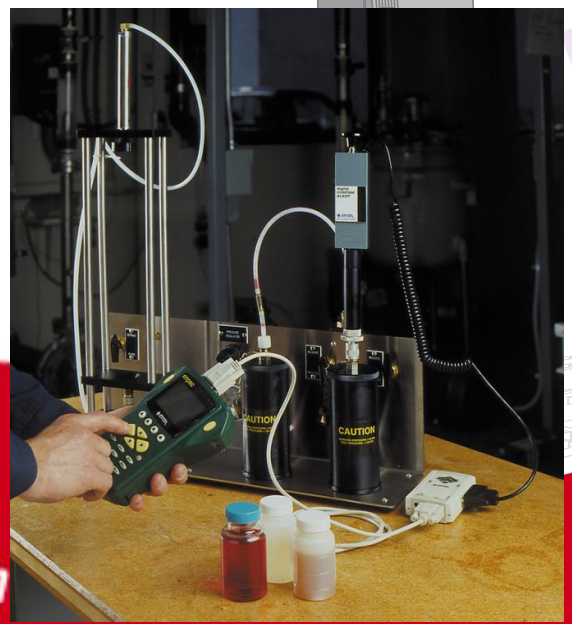
LAN Modem

Data

Data

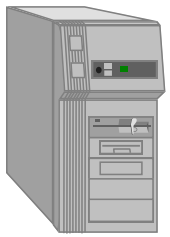
Unload Station

Data Collection



Secure Customer Web Site

Reports



RA-Entek Server
Customer Database

Experience In Motion

Lucite International

Reports

Date	Summary	Report
November 2002	November Summary	November Report
December 2002	December Summary	December Report
January 2003	January Summary	January Report
February 2003	February Summary	February Report
March 2003	March Summary	March Report
April 2003	April Summary	April Report
May 2003	May Summary	May Report
June 2003	June Summary	June Report
July 2003	July Summary	July Report
August 2003	August Summary	August Report
September 2003	September Summary	September Report
October 2003	October Summary	October Report
November 2003	November Summary	November Report

FLOWSERVE

Alliance (Partnership)

Experience In Motion

FLOWSERVE

Global Alliance Leader…..

- ✓Started in mid 1980's
- ✓ 280 alliance sites globally
- ✓ Documented results
- ✓ Customer references

Marathon Oil Corporation

ارامكو السعودية
Saudi Aramco

Celanese

DUPONT

BR PETROBRAS

ChevronTexaco

bp

BASF

MERCK

AIR LIQUIDE

PEMEX

PDVSA

Pfizer

ConocoPhillips

DOW

Bayer

DSM

EASTMAN

LYONDELL

ExxonMobil

Cargill

Experience In Motion

Benefits of an Alliance

- Business Alignment - Mutually compatible goals between Flowserve and client
- Creates a long term performance oriented relationship between companies
- Delivers long term sustainable results for both companies

Value to Client

Maintenance & Engineering

- Ease of Maintaining Production (Flow)
- Improved Response Times
- Improved Resource Productivity
- Minimized Maintenance Cost
- Ensures Equipment MTBR Is Maximized
- Root Cause Analysis
- Mitigates Loss of Intellectual Capital (Retirement)

Operations

- Ensures Regulatory and Environmental Compliance
- Increases Asset Utilization & Manufacturing Productivity
- Assures Equipment Availability
- Improves Safety and Reliability
- Mitigates Risk of "Downtime" Losses

Supply Chain Management

- Leveraged Savings Across Multiple BU's
- Minimized Maintenance Cost
- Leverages Standardization Programs
- Reduction of Inventory & Associated Costs
- Quantifies Sustainable Cost Savings
- Single set of T's and C's

Senior Management

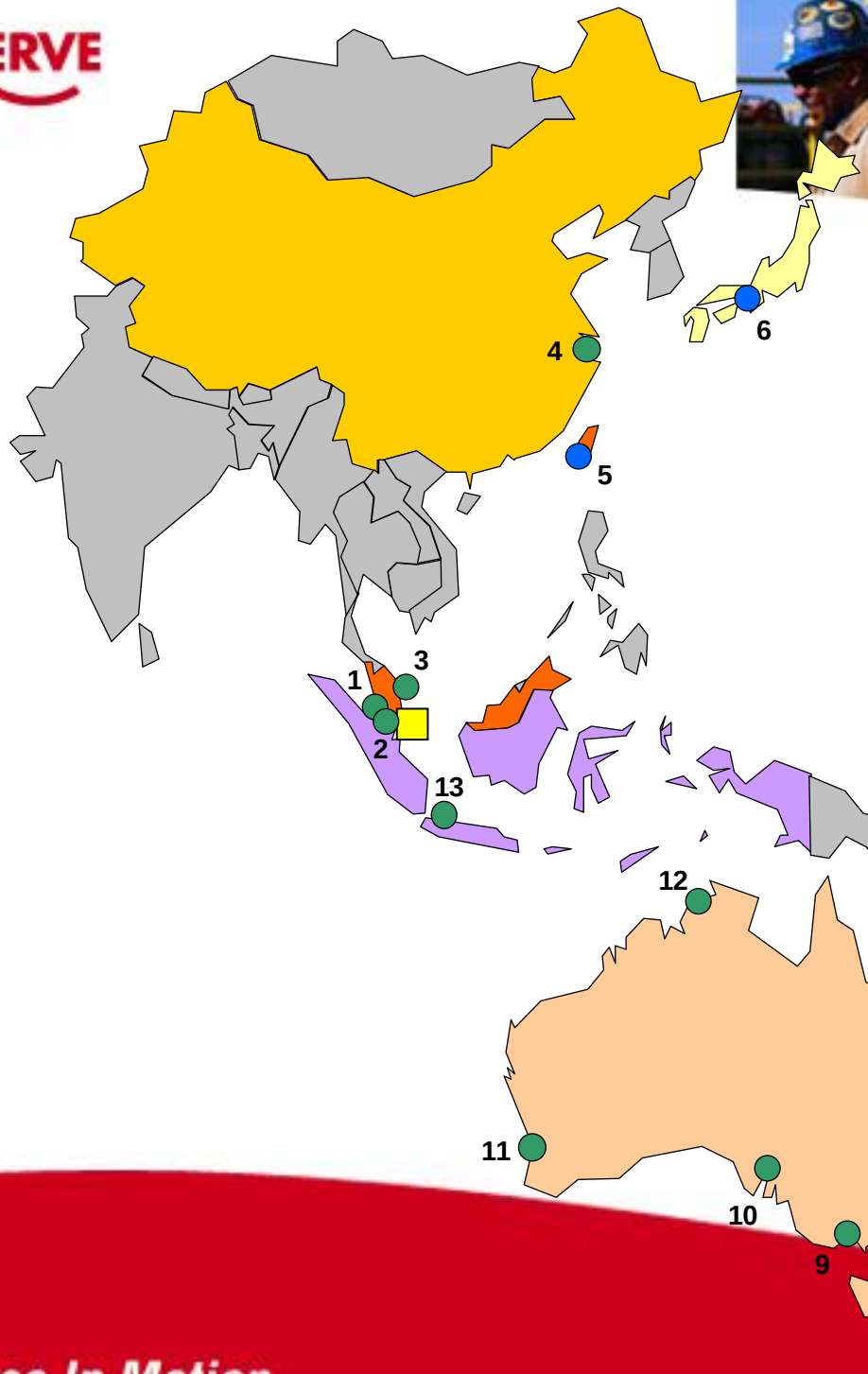
- Improves Revenue and Operating Income
- Mitigates Risk of "Downtime" Losses
- Improved RONA
- Improved Revenue/employee
- Leveraged Savings Across Multiple BU's

FLOWSERVE

Quick response centre

Experience In Motion

FLOWSERVE



MALAYSIA

1: Kuala Lumpur [C]

2: Melaka [B]

3: Kemaman [B]

CHINA

4: Shanghai [C]

TAIWAN

5: Kao-Hsiung [B]

JAPAN

6: Osaka [B]

NEW ZEALAND

7: Auckland [B]

AUSTRALIA

8 Sydney [C]

9: Melbourne [B]

10: Whyalla [B]

11: Perth [B]

12: Darwin [B]

INDONESIA

13: Jakarta [C]

QRC Asia Pacific

Experience In Motion

Inspection

Bellow Leakage Tester & Parallel Hydraulic Press

Bellow Spring Load Tester & 'O'-ring Gauge

Spring Load Tester & Monochromatic Light

Cartridge Seal Tester

Experience In Motion

Inventory

Inventory Store

Repair

Water Jet Blasting Machine & Solvent Cleaner

Downdraft Table For Seal Dis-assembly Work

Lapping Machines

Induction Heater For Bellow Seal Face Replacement

Quality Manufacturing

CNC High Tolerance Machining

Cell Manufacturing

Quality Control

Surface Visual Check

Bellow QC

Dimensional contol

Experience In Motion

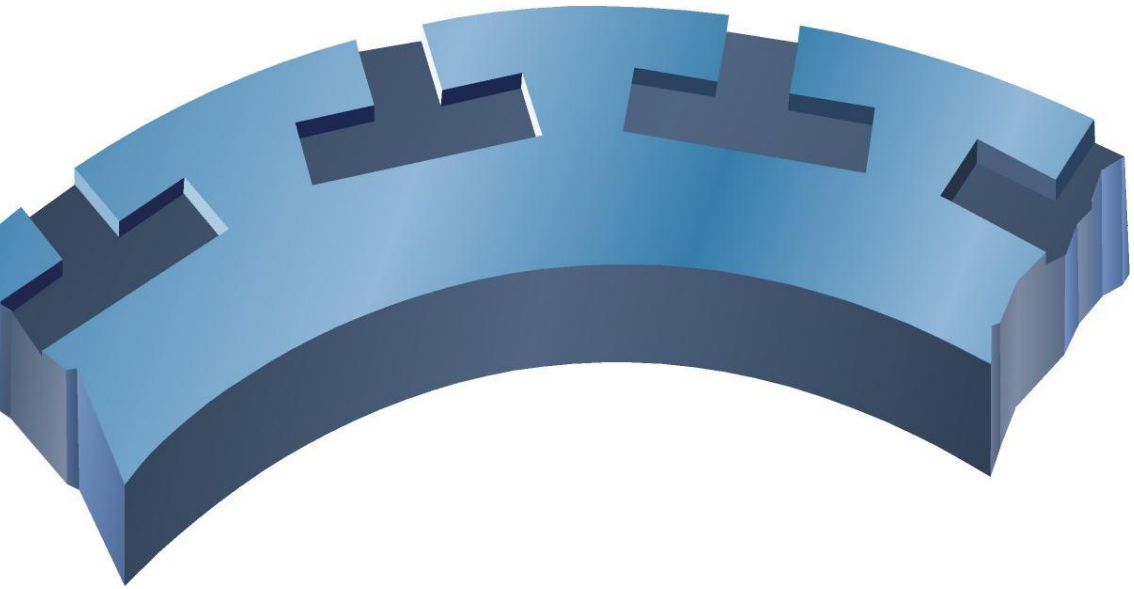
Leader in market

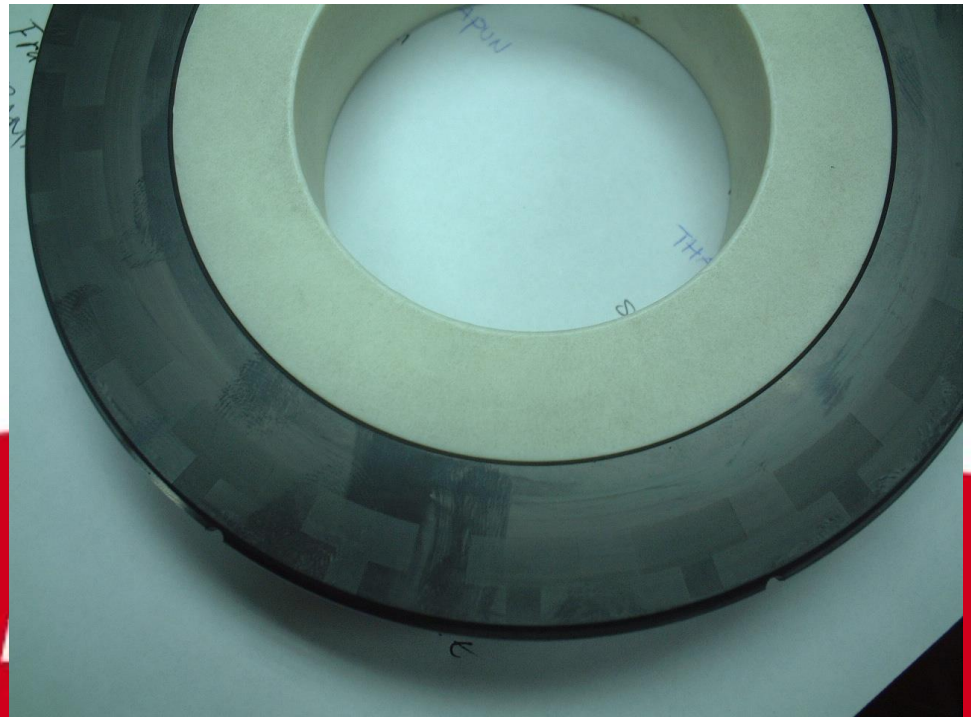
- Only company that offers Pumps, Mechanical Seals and Valve.
- Number 1 in Global alliance with 280 + sites – World class plants trust us in after sale service.
- Number 1 mechanical seal used in refinery application in Asia Pacific with population of 20,000 + pumps.
- Number 1 Quick Repair Centre strategically support customer in the region of 13 sites.
-

Leader in Product

- For compressor, high pressure bi-directional gas seal (T groove bi-directional gas seal)
- For bellow seal, API 682 bellow seal with 6 or 8 mils of diaphragm thickness for corrosion and vibration resistance.
- For pusher seal, API 682 pusher seal that achieve strict emission control of less than 500 ppm with single seal (QBQ)

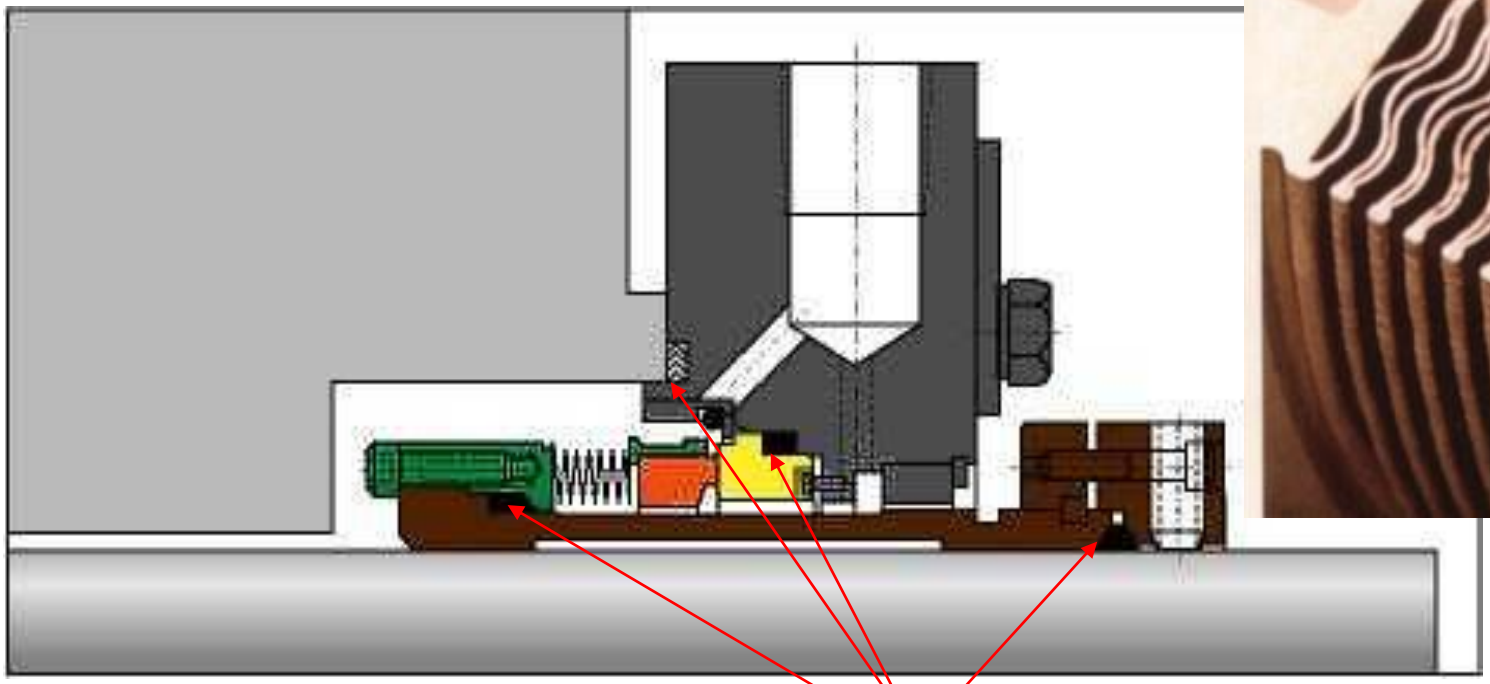
Bi-direction prevent reverse rotation damage

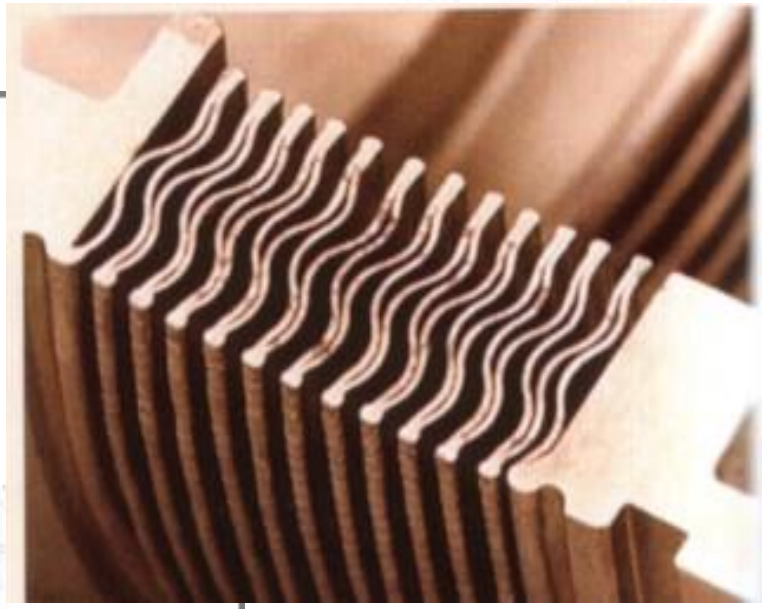




Bellows Seal

High Temperature Rotating Bellows Seal





BXH Cartridge Seal

High Temperature Graphite gaskets are used here.