UNDERSTANDING

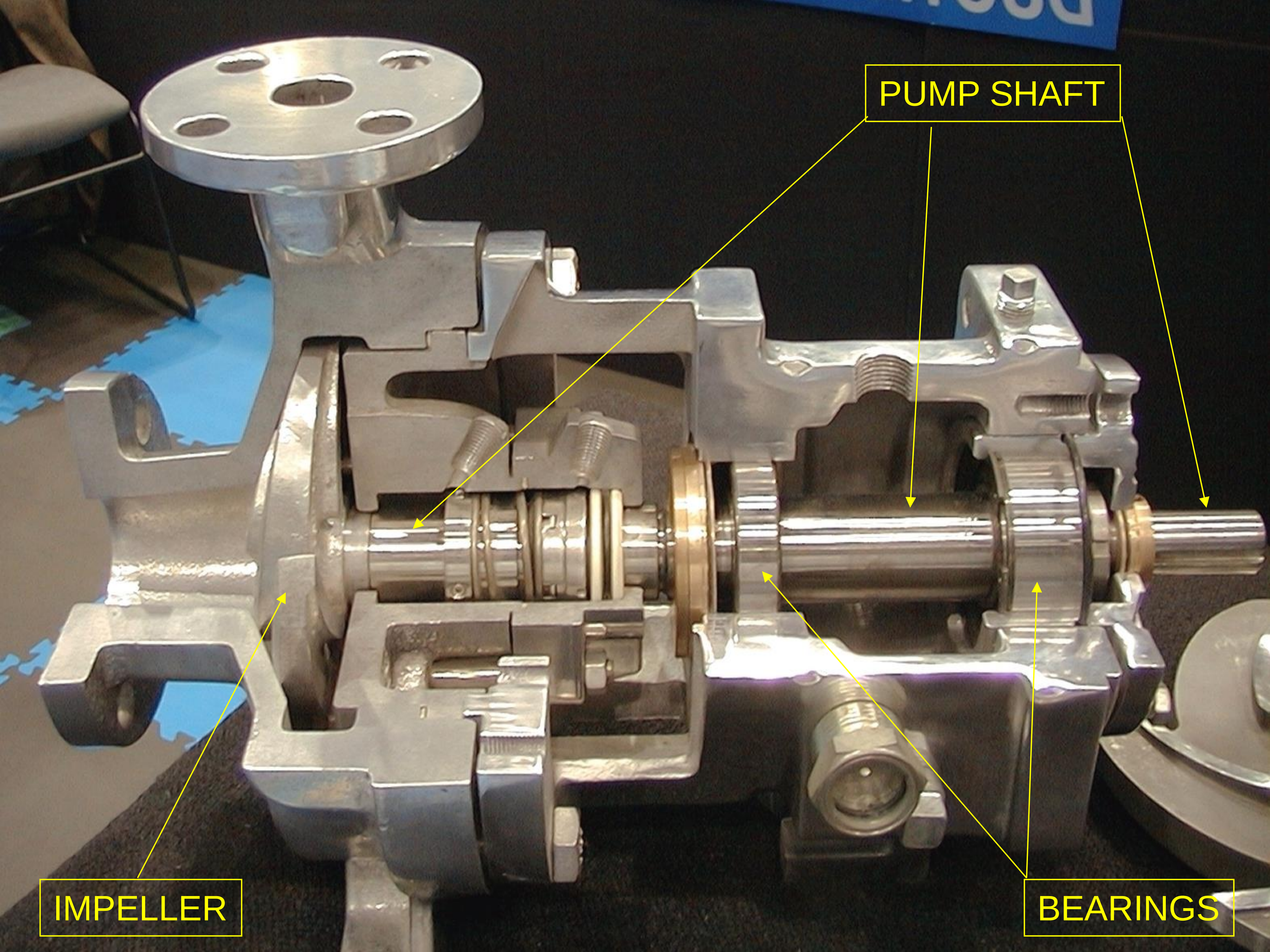
MECHANICAL SEALS

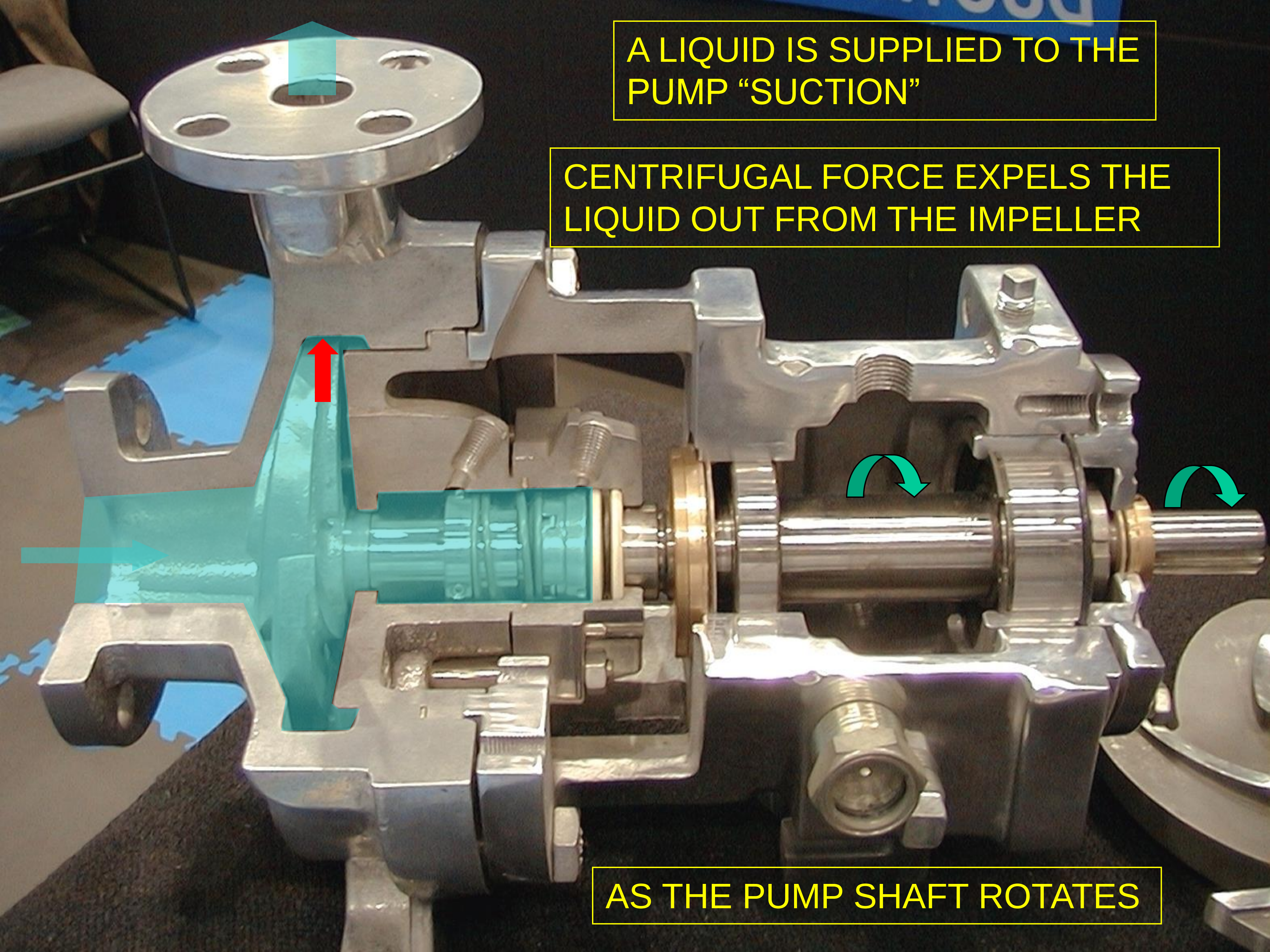
INTRODUCTION

- Since their inception, mechanical seals have carried with them a mystique of “Gee Whiz”, bizarre, physics defying properties that have baffled the untrained observer. But that impression is really misplaced. Mechanical seals are not magic by any means and actually perform well within the realm of easy to understand principles of physics and hydraulics.
- Mechanical seals are simply another means of controlling leakage of a process where other means are deemed to be less capable of performing the task adequately. For the purposes of this discussion, consider that a mechanical seal will out-perform common types of packing.
- As mechanical seals can be used to seal a myriad of different products on an equally vast array of equipment, we will be primarily focusing on the use of mechanical seals on rotating shaft pumps. Since our subject is dealing with pumps, let’s first explore a basic understanding of the need to seal a process liquid in a centrifugal pump.

CENTRIFUGAL PUMPS

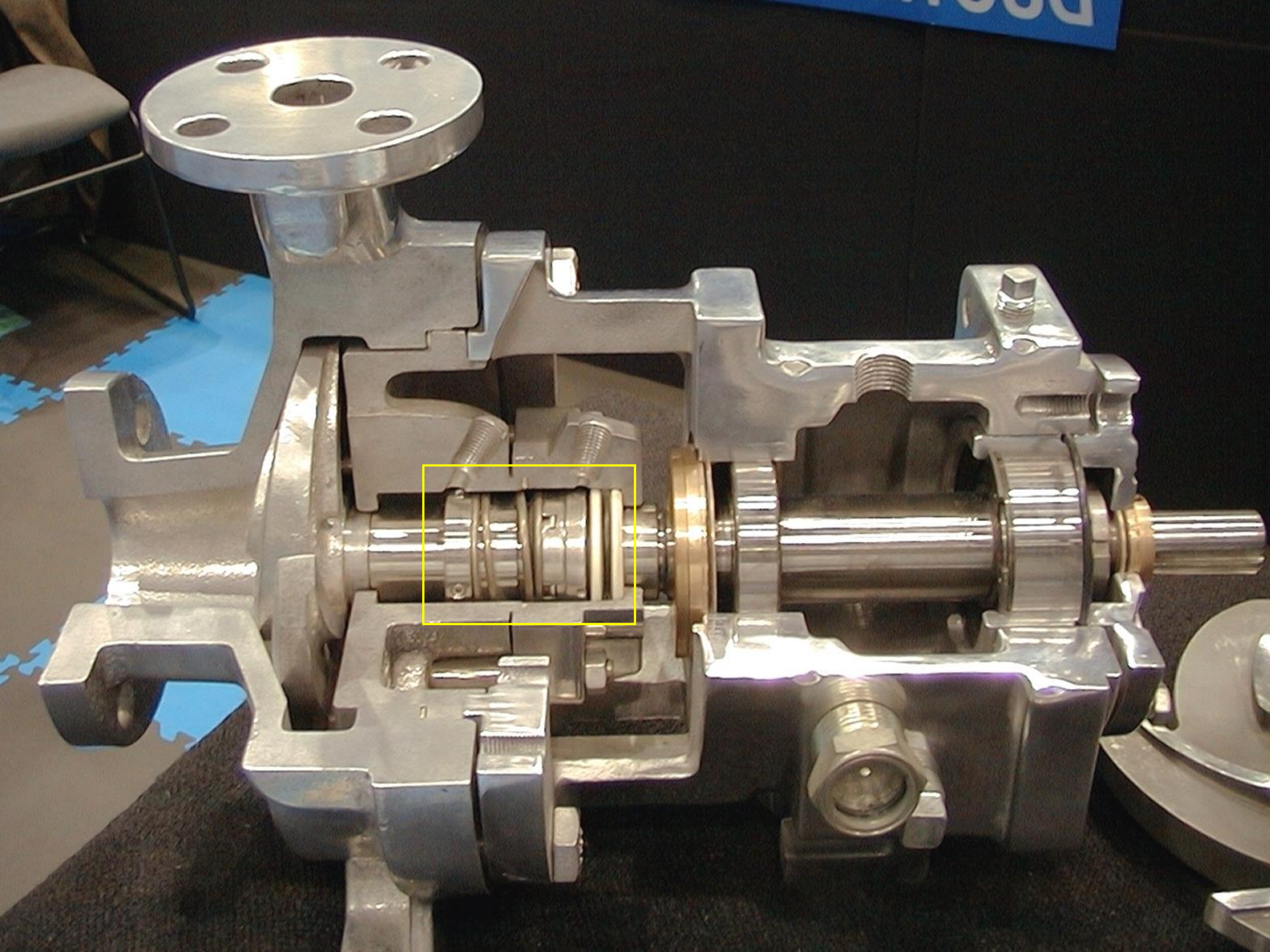
- A centrifugal pump is simply a shaft, suspended on bearings with an impeller attached to one end. The impeller is encased in a housing that is filled with a liquid. As the shaft is rotated, centrifugal force expels the liquid out through an orifice, where it is typically piped into a process or another collection point. As the expelled liquid exits the case, additional liquid is added to the case so that a flow develops. That is basically how a centrifugal pump works.
- The next slide shows a photograph of a typical “End Suction Centrifugal Pump”.


PUMP SHAFT
IMPELLER
BEARINGS


A LIQUID IS SUPPLIED TO THE PUMP "SUCTION"
CENTRIFUGAL FORCE EXPELS THE LIQUID OUT FROM THE IMPELLER
AS THE PUMP SHAFT ROTATES

CENTRIFUGAL PUMPS

- The force of the expelled liquid creates pressure. This liquid under pressure will seek areas of lower pressure. This is a known physical principle of hydraulics. Some form of seal must be applied to keep liquid from leaking around the shaft at the point where it enters the case to drive the impeller. This is where our mechanical seal comes into play.
- Take a look at the same pump again. Can you see the mechanical seal behind the impeller?

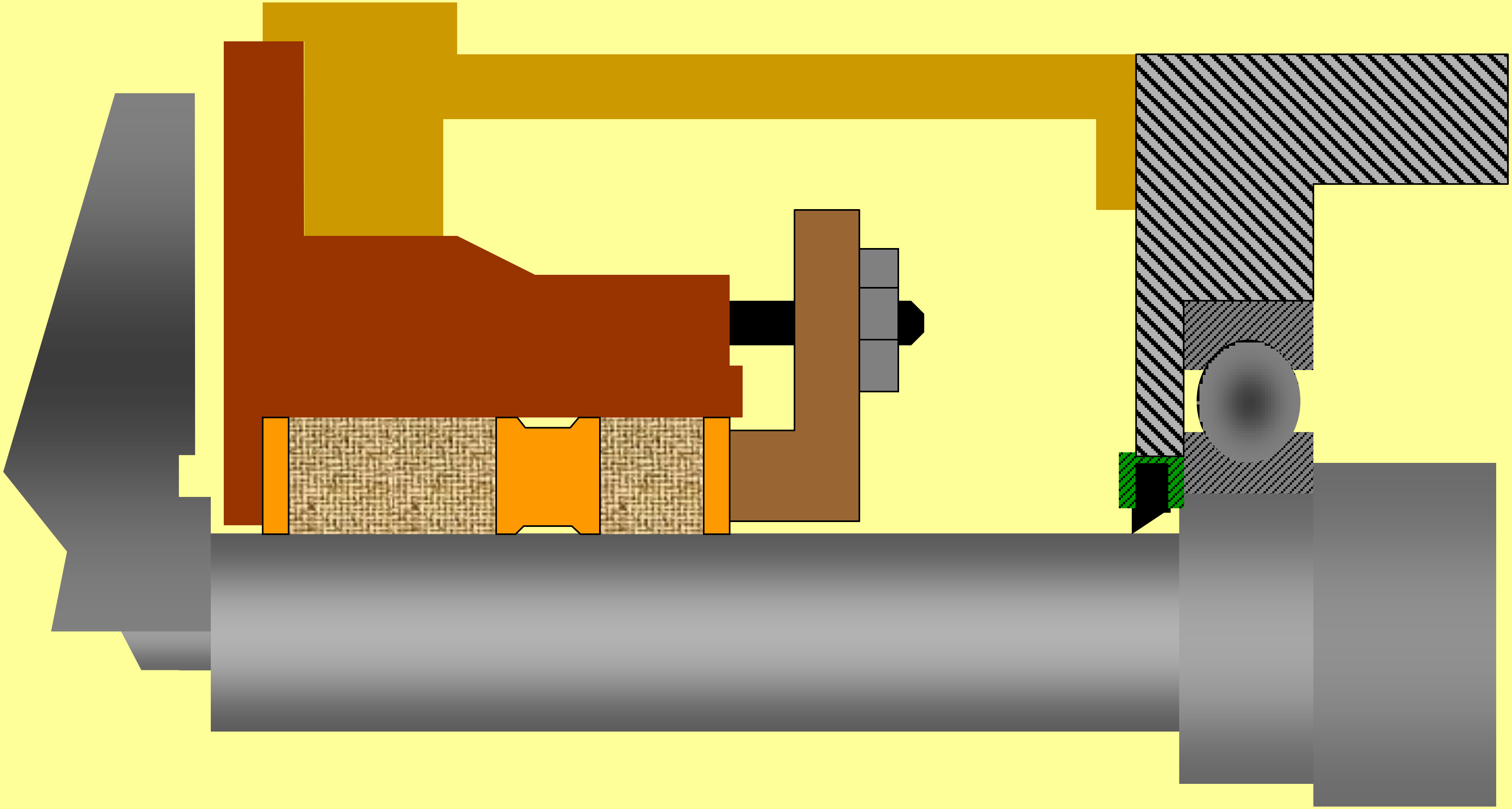


SEAL TYPE

- The mechanical seal shown in the pump photograph is a Type "1" mechanical seal. Probably the most widely recognized and also most common mechanical seal used in general service, low pressure applications.
- At Utex, we refer to this type as **RS-1**
- The assembly shown in the pump is configured with a ceramic "O-ring" type stationary seat and is also equipped with a "set screw collar".

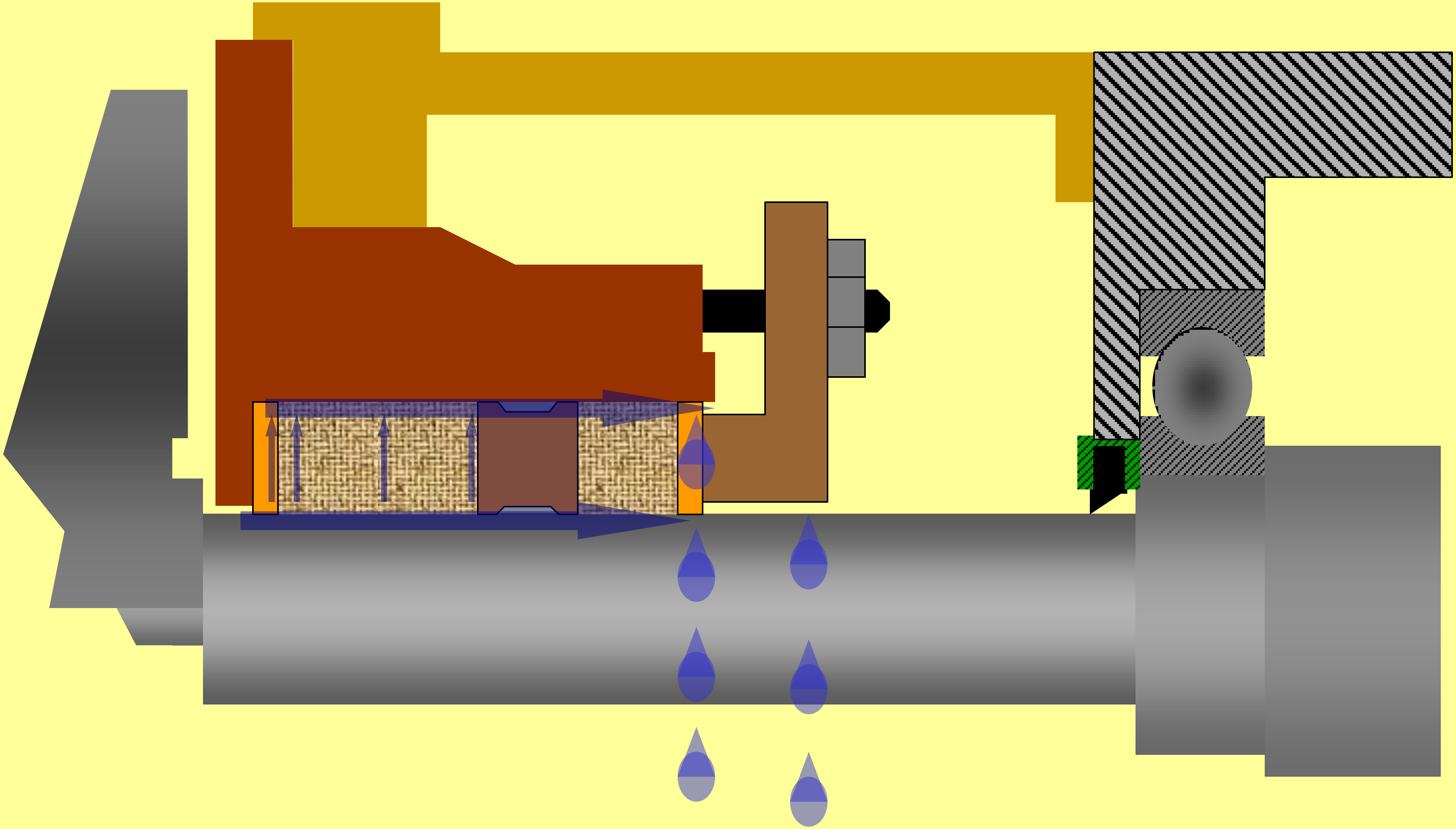
SEALING THE LIQUID

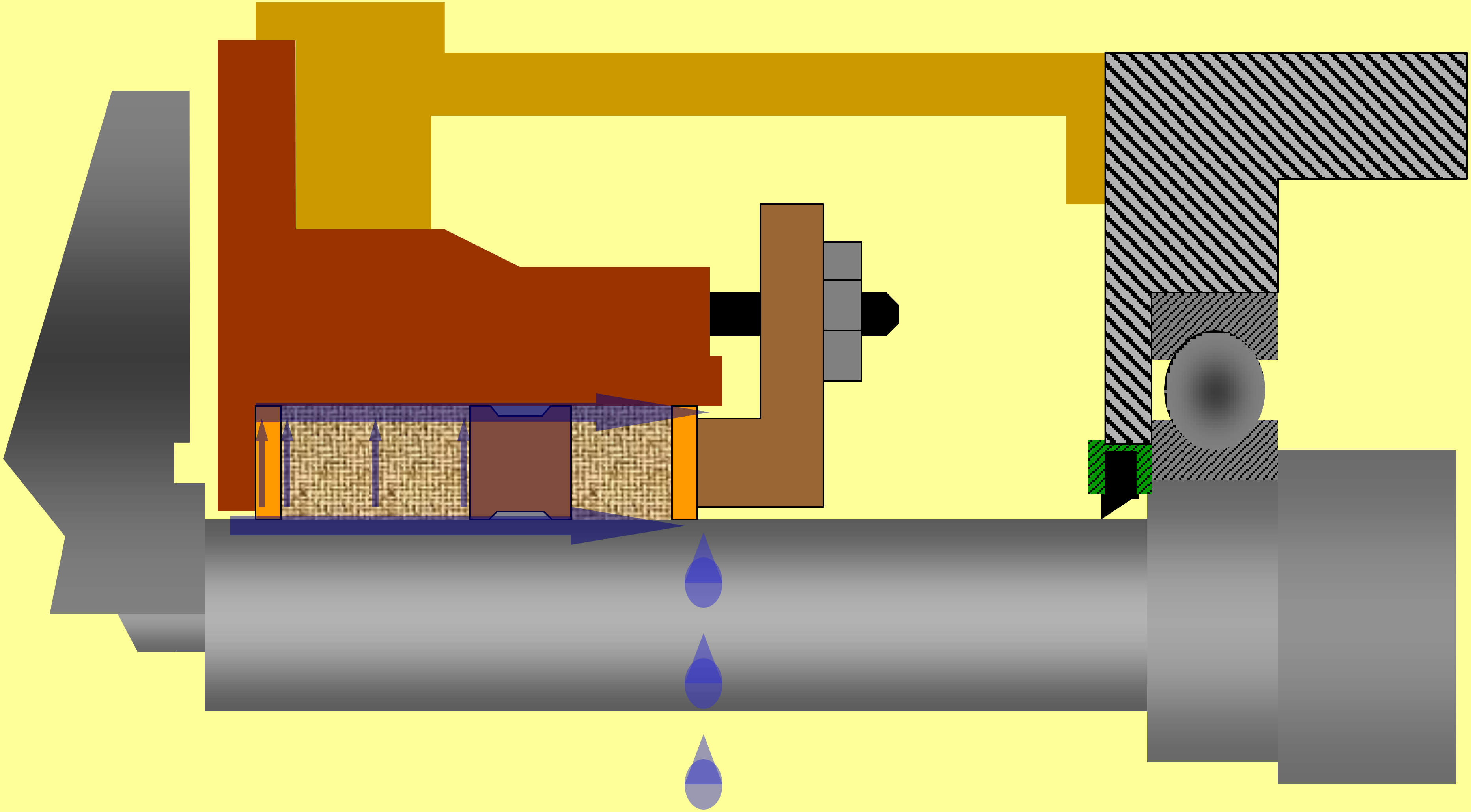
- Mechanical seals were originally designed to lend a greater sealing capability than could be achieved using common packing.
- Before the advent of mechanical seals, pump users relied primarily on “rope” or braided style packing to achieve a “seal” around the shaft. A series of pieces or “rings” were installed into the pump “stuffing box” and they were compressed tightly so that they created a difficult leak path for the liquid to negotiate in order to leak to atmosphere.

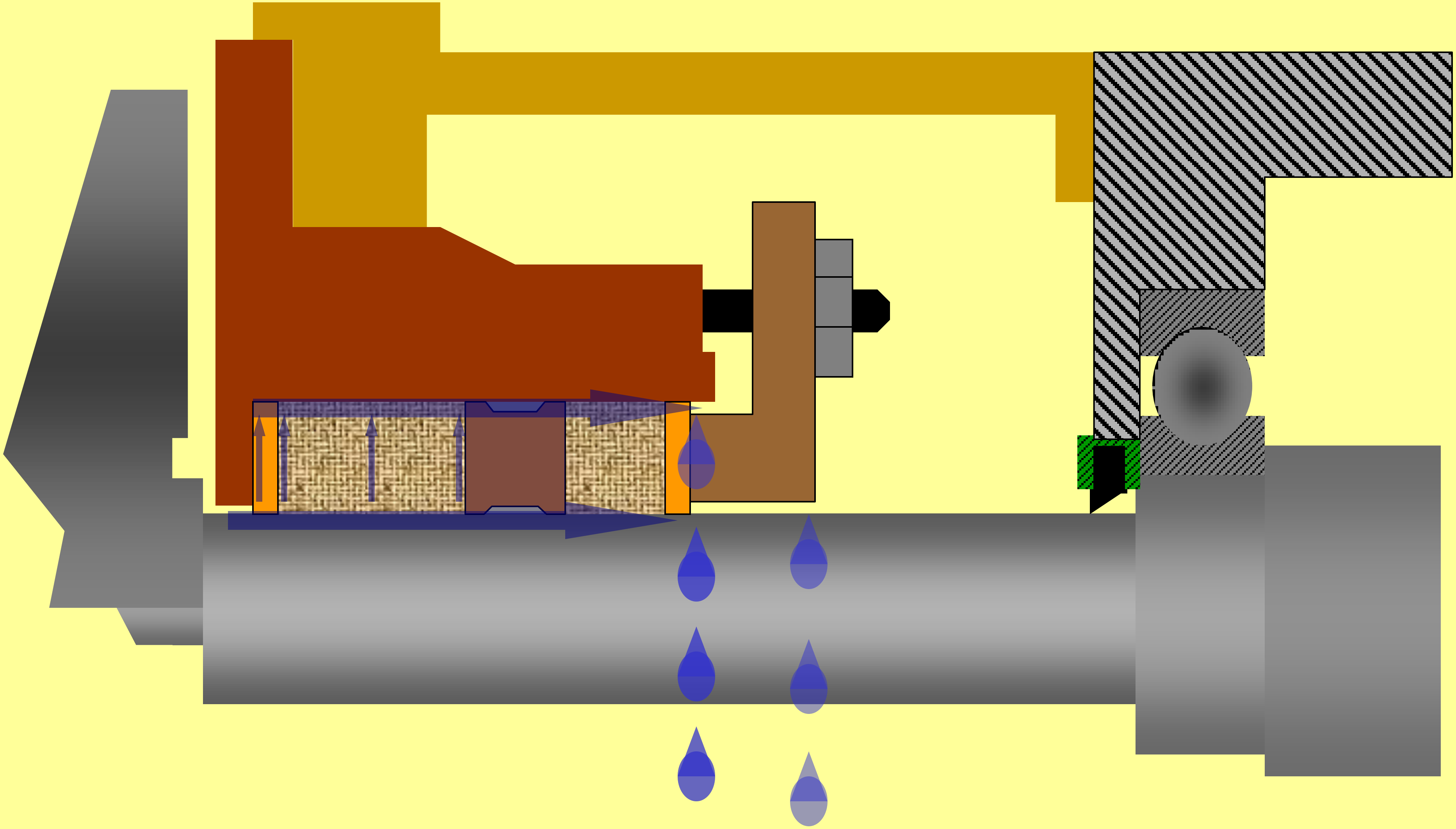


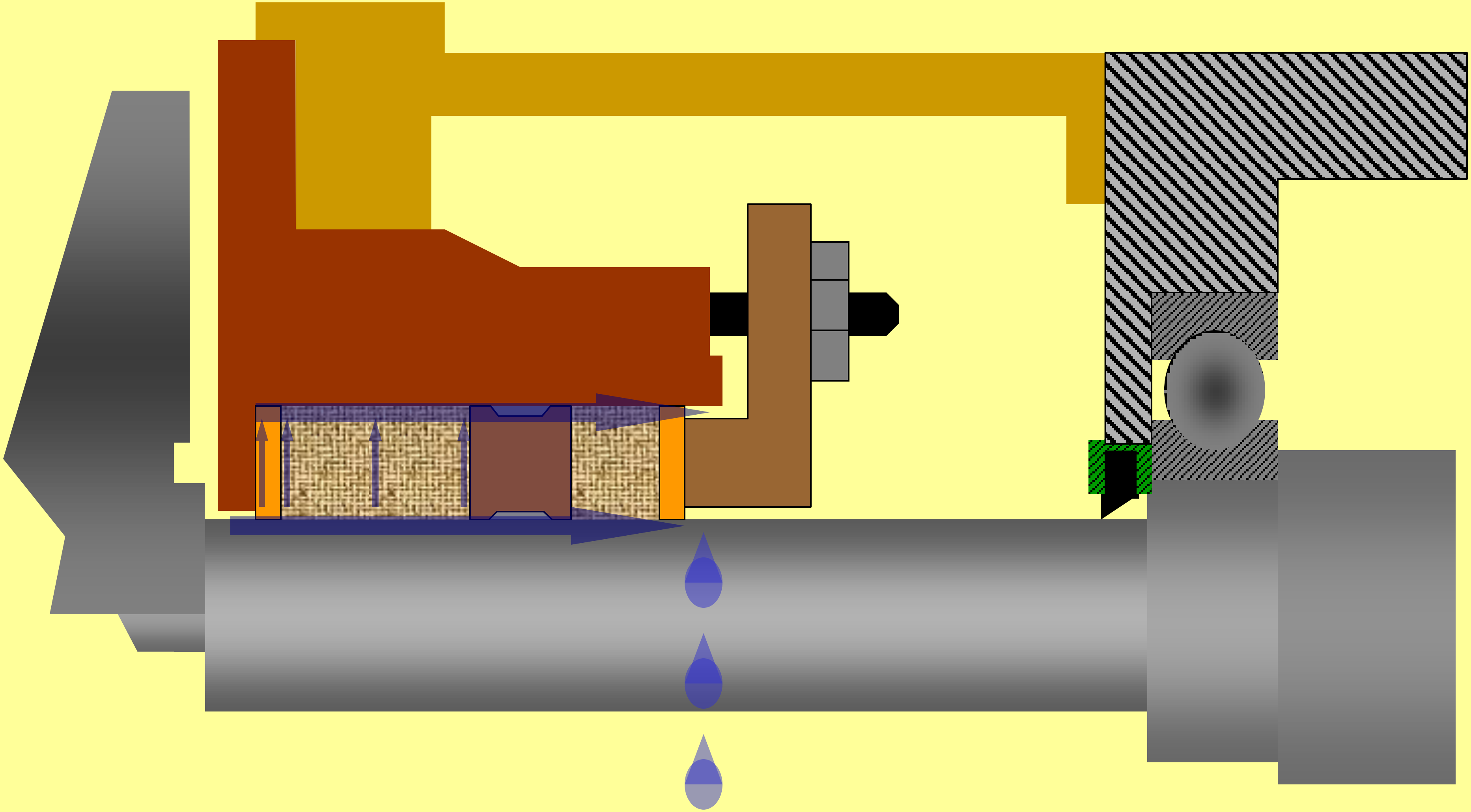
SEALING THE LIQUID

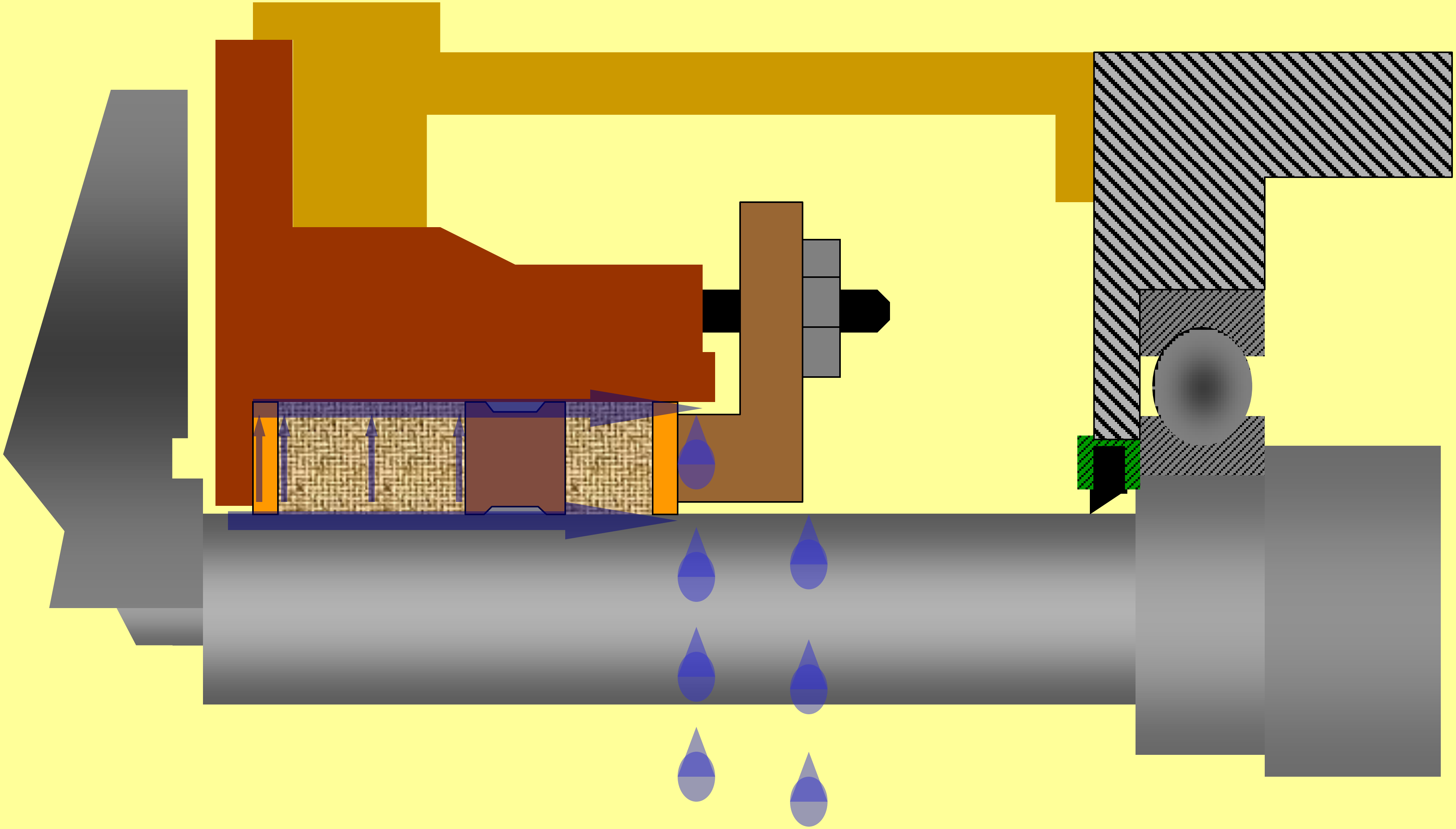
- Early packing styles did not seal very well. In fact, until recently, braided packing styles required varying amounts of leakage for lubrication. If leakage was not permitted to occur, the packing would literally “burn up” and often cause severe damage to the pump shaft. Even with adequate leakage for lubrication, pump shaft wear was a commonly expected occurrence and as the shaft wore it would in turn, cause poor shaft packing life.
- As leakage becomes more excessive, the gland is tightened to reduce leakage.





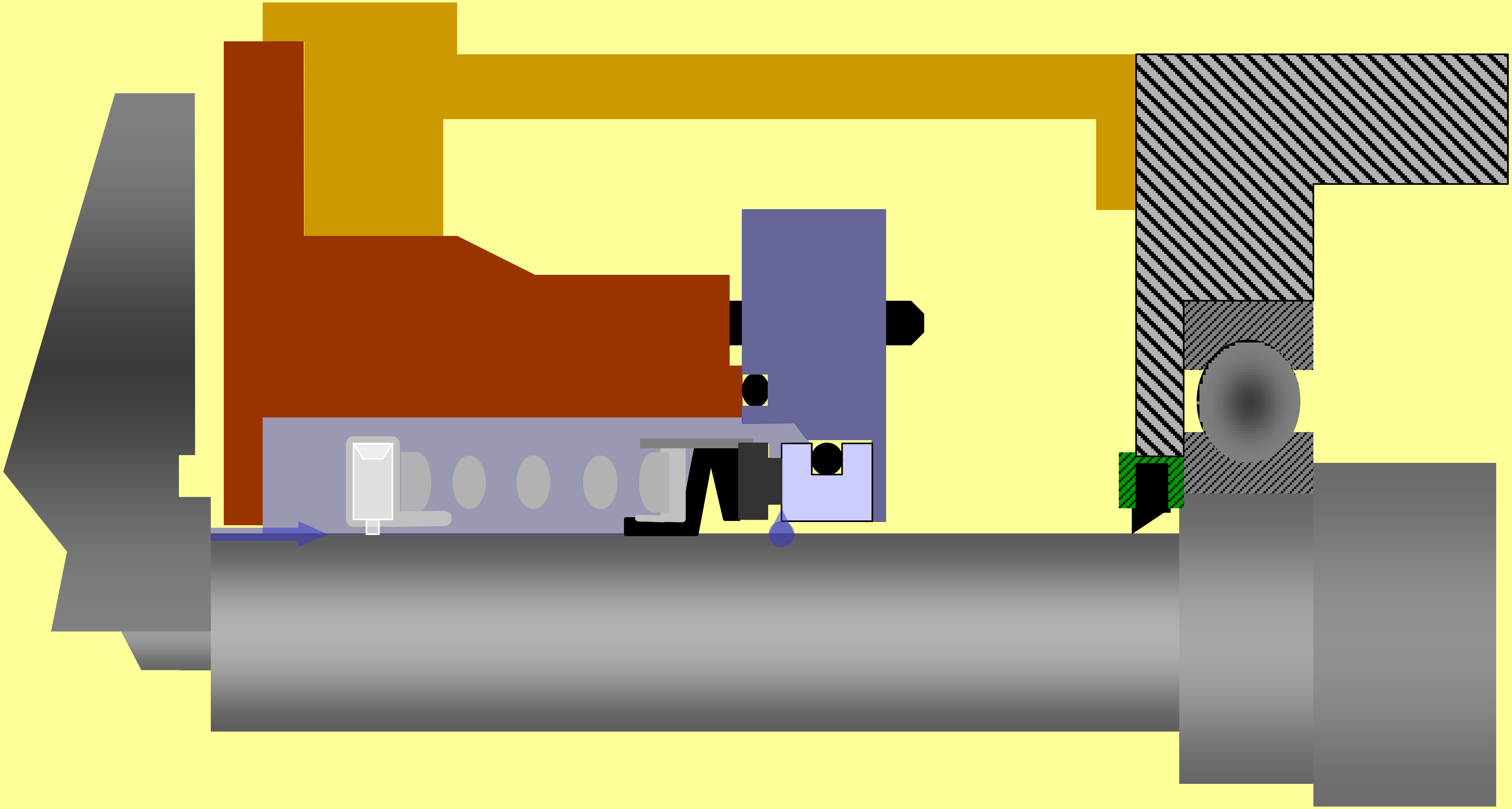


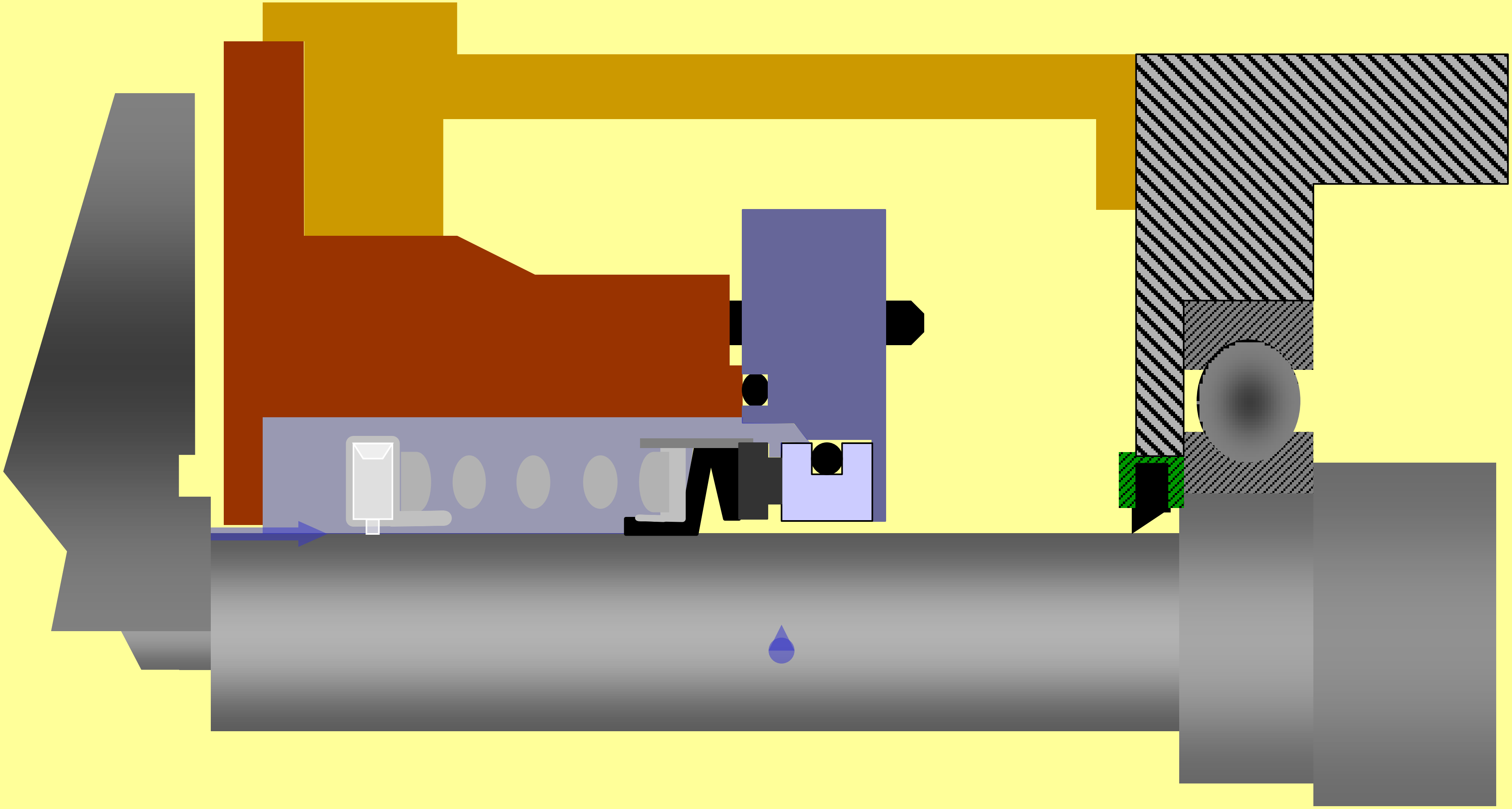




SEALING THE LIQUID

- With the introduction of mechanical seals, this leakage could be controlled to a much greater degree.
- Let’s look at the same pump with a mechanical seal installed. Note that the seal shown is an RS-1 with O-Ring type stationary and a set screw collar.





SEALING THE LIQUID

- You have probably taken notice of the illustration showing minor leakage to atmosphere. It is appropriate to point out at this time…

LESSON NUMBER ONE

ALL

MECHANICAL SEALS

LEAK

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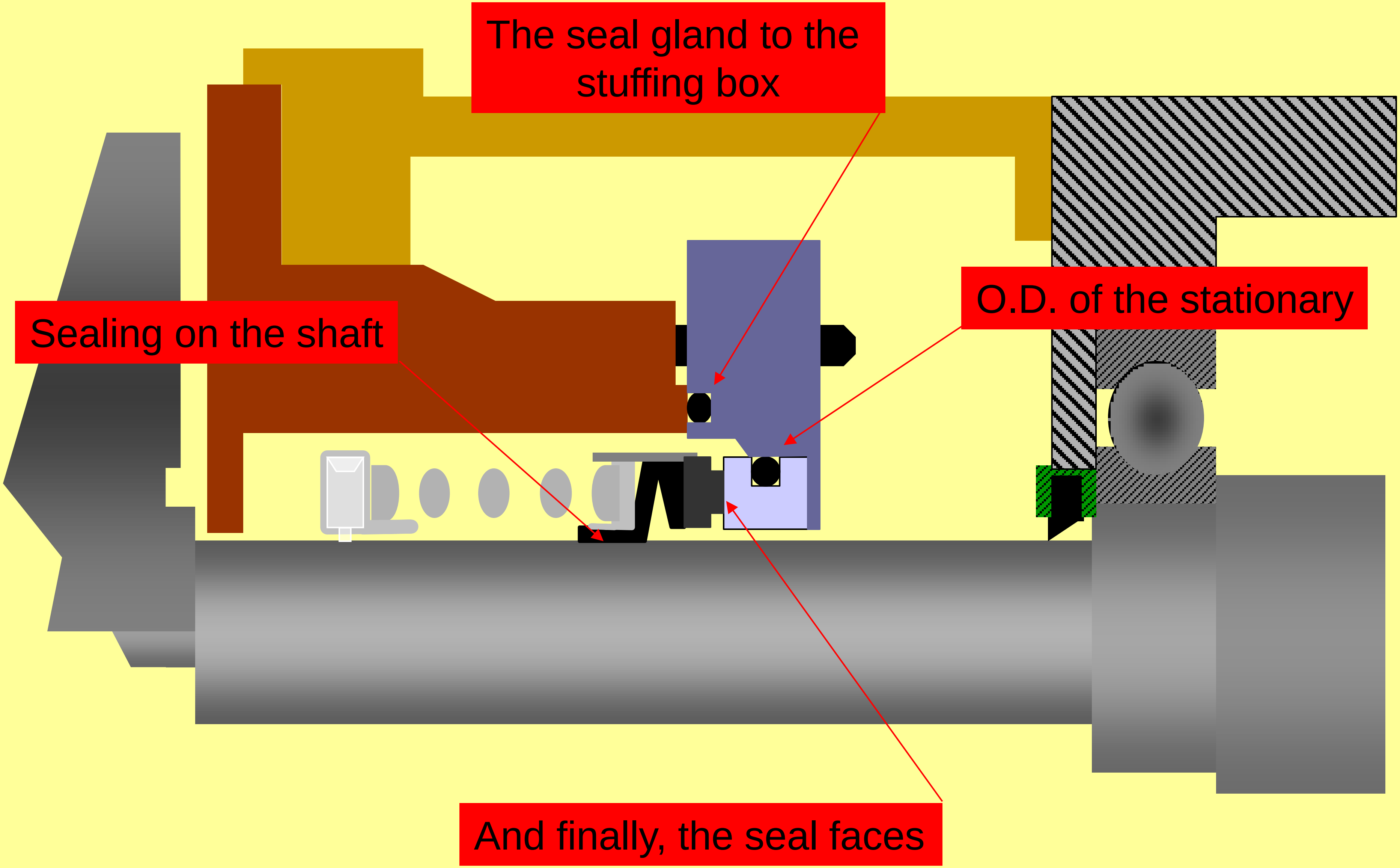
SEALING THE LIQUID

- It is a fact, all mechanical seals leak. Like packing, the mechanical seal “faces” must also be lubricated. With proper application and design however, the leakage is so minute that actual droplets of liquid are not detected. Instead, the lubricating liquid will vaporize as it crosses the seal faces and the leakage is a gas or vapor.
- Since we are discussing the sealing of the liquid at the faces, let’s take a look at the sealing points of a typical mechanical seal. Again, viewing the same pump and seal, note that there are four sealing points to consider.


The seal gland to the stuffing box
O.D. of the stationary
Sealing on the shaft
And finally, the seal faces

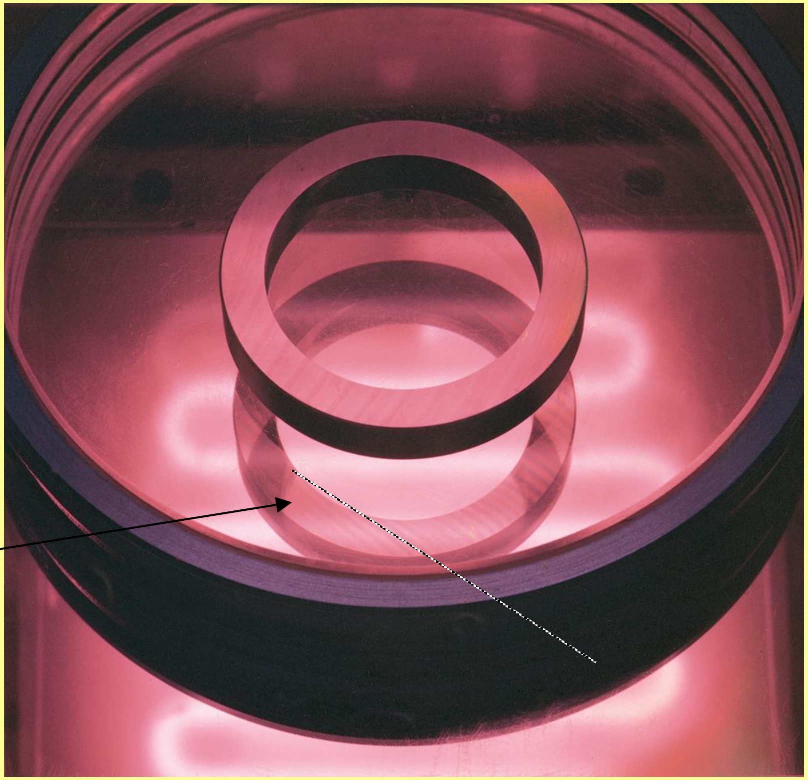
BRIEF DISCUSSION ABOUT MECHANICAL SEAL FACE DYNAMICS

FACE FLATNESS

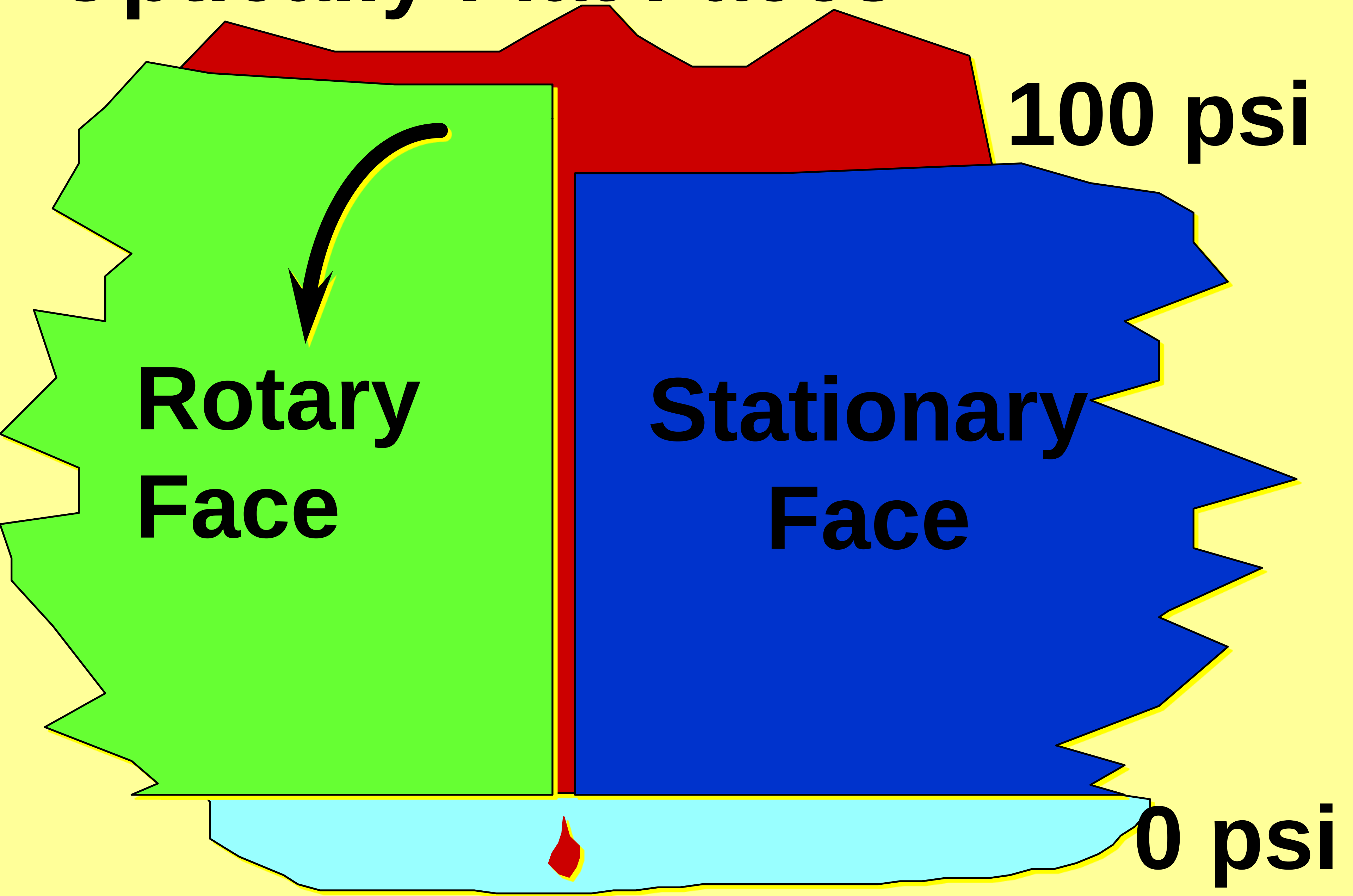
- The mechanical seal faces are obviously the most critical sealing point of a mechanical seal assembly.
- Although the faces can be manufactured from a myriad of different materials, one is typically carbon, while the other is usually a hard material. (i.e. Alox (Aluminum Oxide Ceramic), Tungsten Carbide, Silicon Carbide, etc.)
- In order for a “seal” to be achieved, the faces must be very flat. This is achieved by machining the faces, then “lapping” them to a fine finish.
- Flatness is measured in “Light Bands”. After lapping, the faces are placed on an “Optical Flat”, a clear glass surface where a monochromatic light is shined on the face. This single wavelength light will produce an image of rings or lines on the face. Each ring/line is “One Light Band”. Each light band is equivalent to .000011” or eleven millionths of an inch. This refers to the variations in the surface of the face. On most face materials, one light band is Utex’s standard.

FACE FLATNESS

- This illustration shows a face being inspected on an Optical Flat.
- Take notice of the light bands that are visible on the reflection of the face.
- Laying a straight edge on a tangent to the inside circumference of the face, how many light bands are crossed?



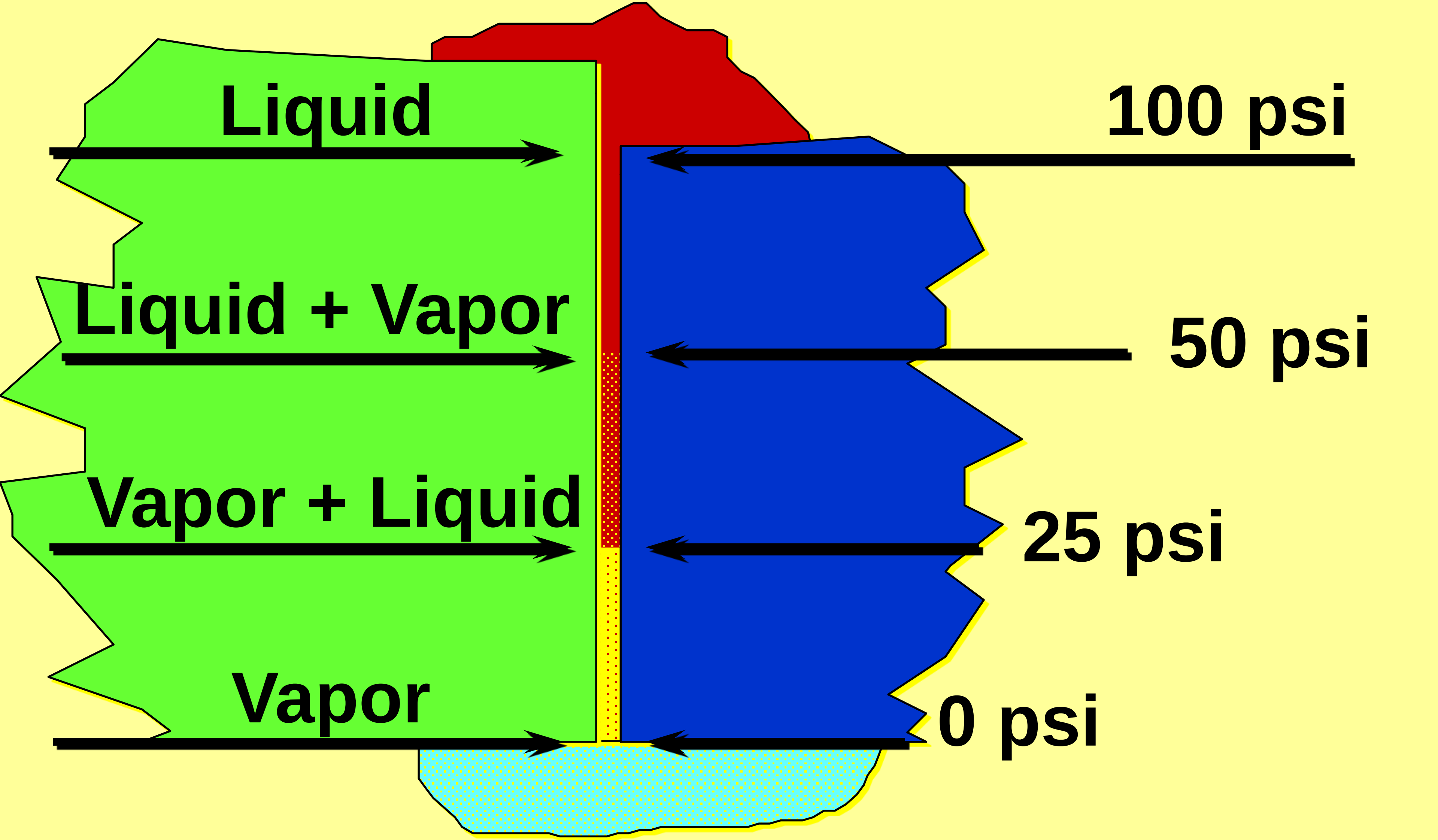
Optically Flat Faces



FACE FLATNESS

- As was stated earlier, it is hoped that the application and design of the mechanical seal is suited for the service. If so, there is leakage of only vapor through the seal faces.

Pressure Drop & Vaporization



TYPES OF MECHANICAL SEALS

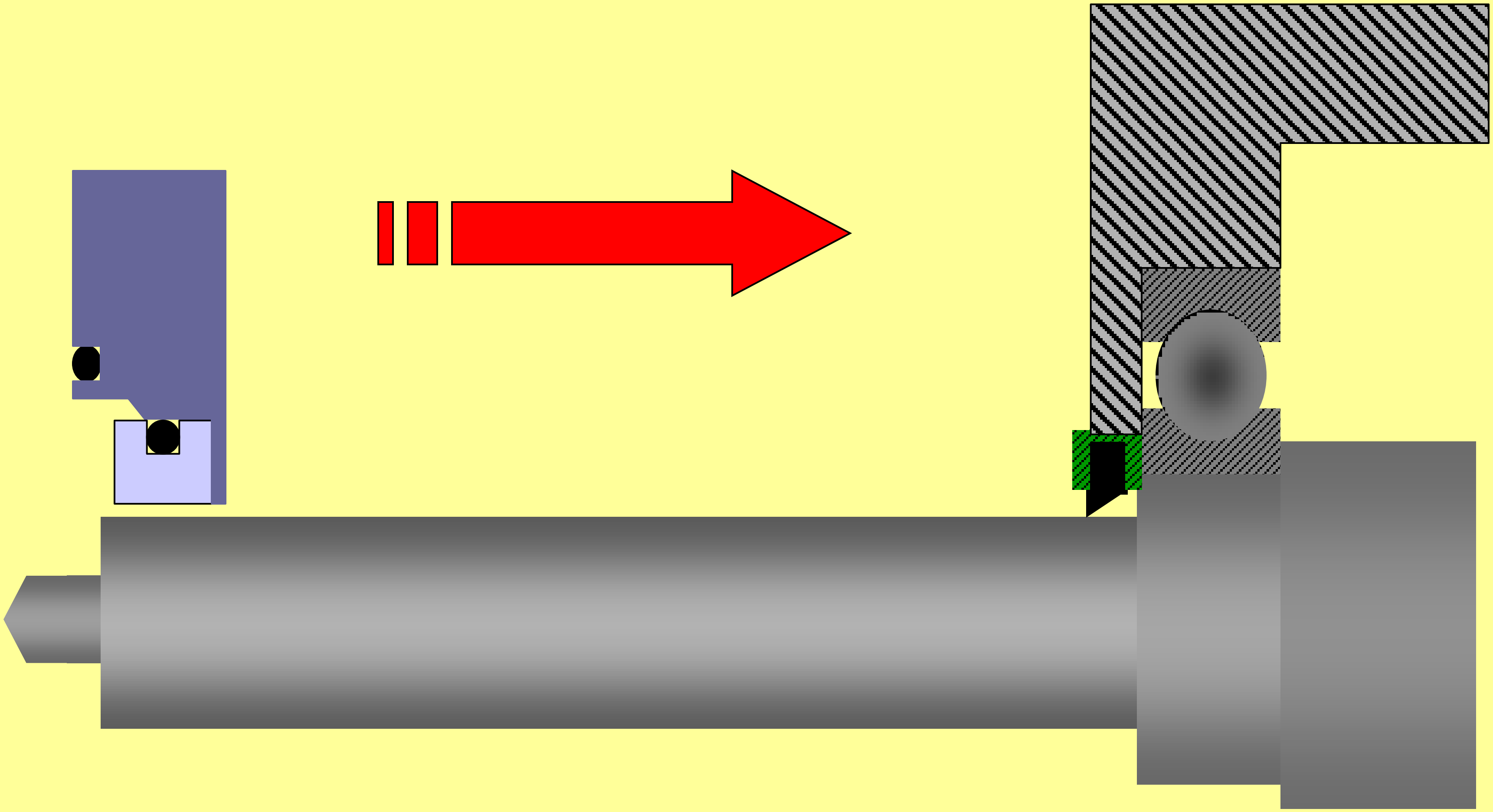
SEAL TYPES

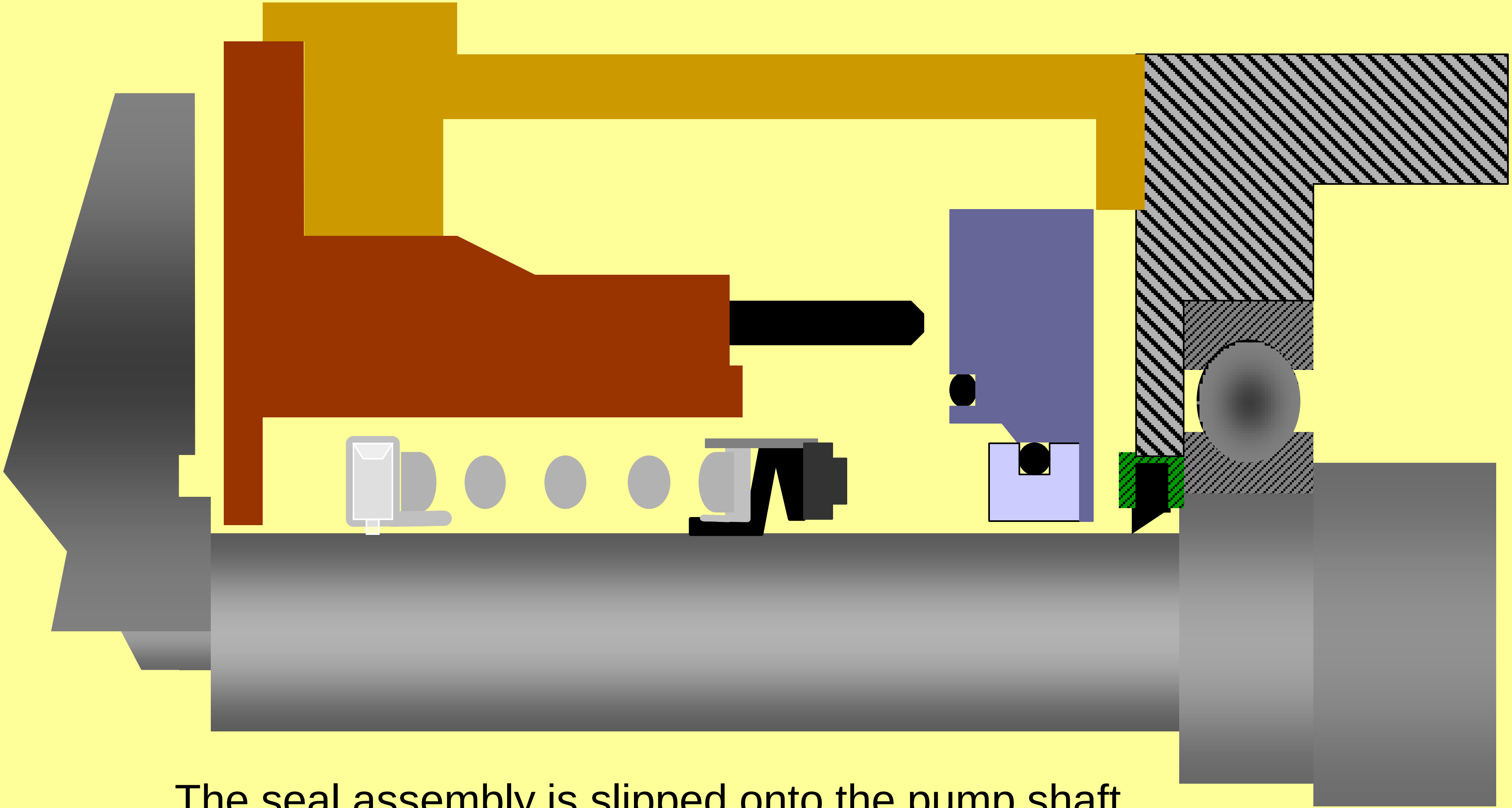
- There are obviously many different types and configurations of mechanical seals. Shaft mounted and cartridge, balanced and unbalanced, pusher and non-pusher, single and multiple, etc., etc.
- Here we will examine the basic differences without going into a great detail.

SEAL TYPES

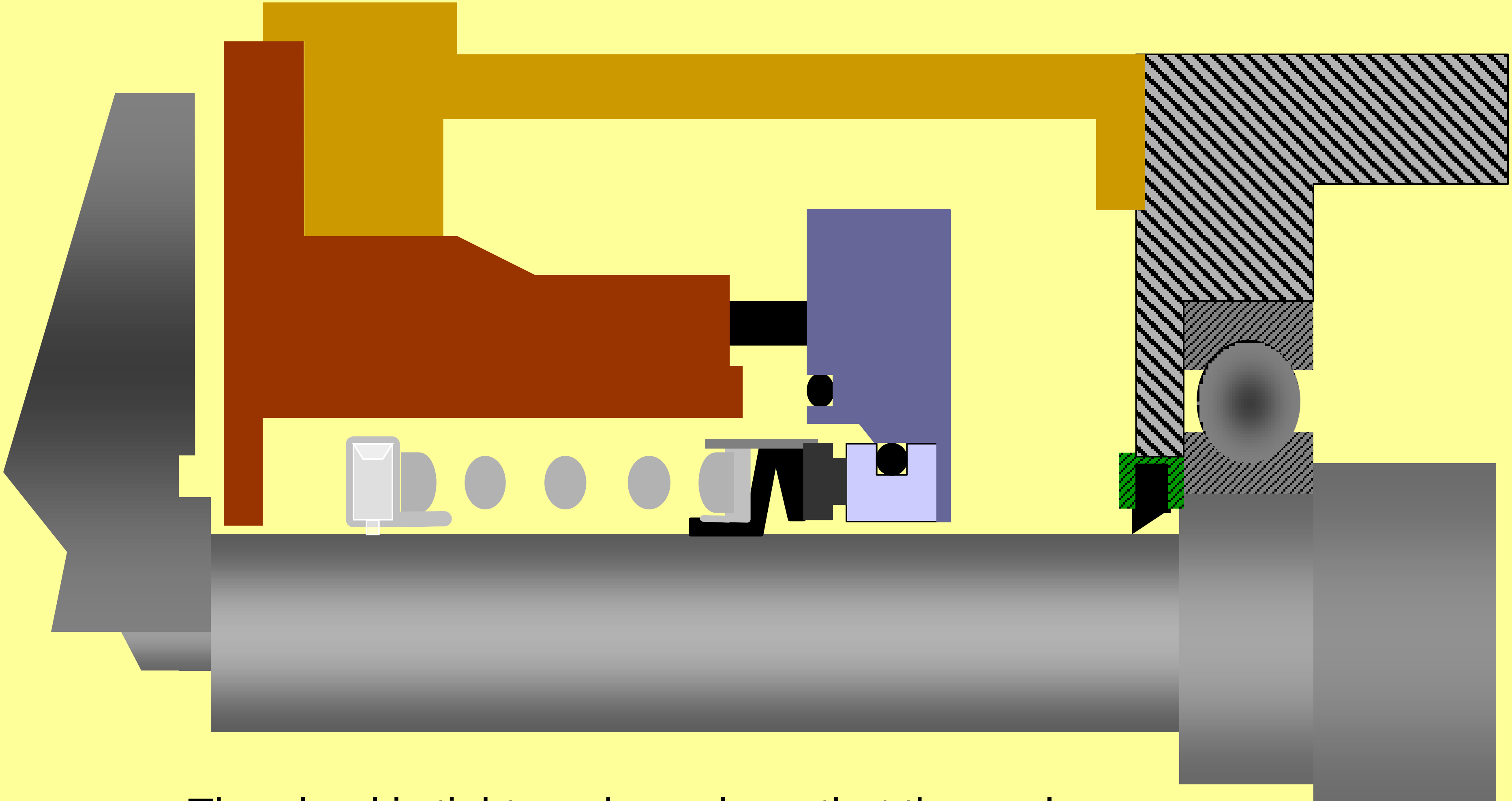
- First, let us examine shaft mounted vs. cartridge.
- A shaft mounted seal requires the pump user or assembler to actually install individual seal components into the equipment.
- Let’s look at the installation of the RS-1 that we were looking at previously.

The stationary seat must be inserted into the seal gland.

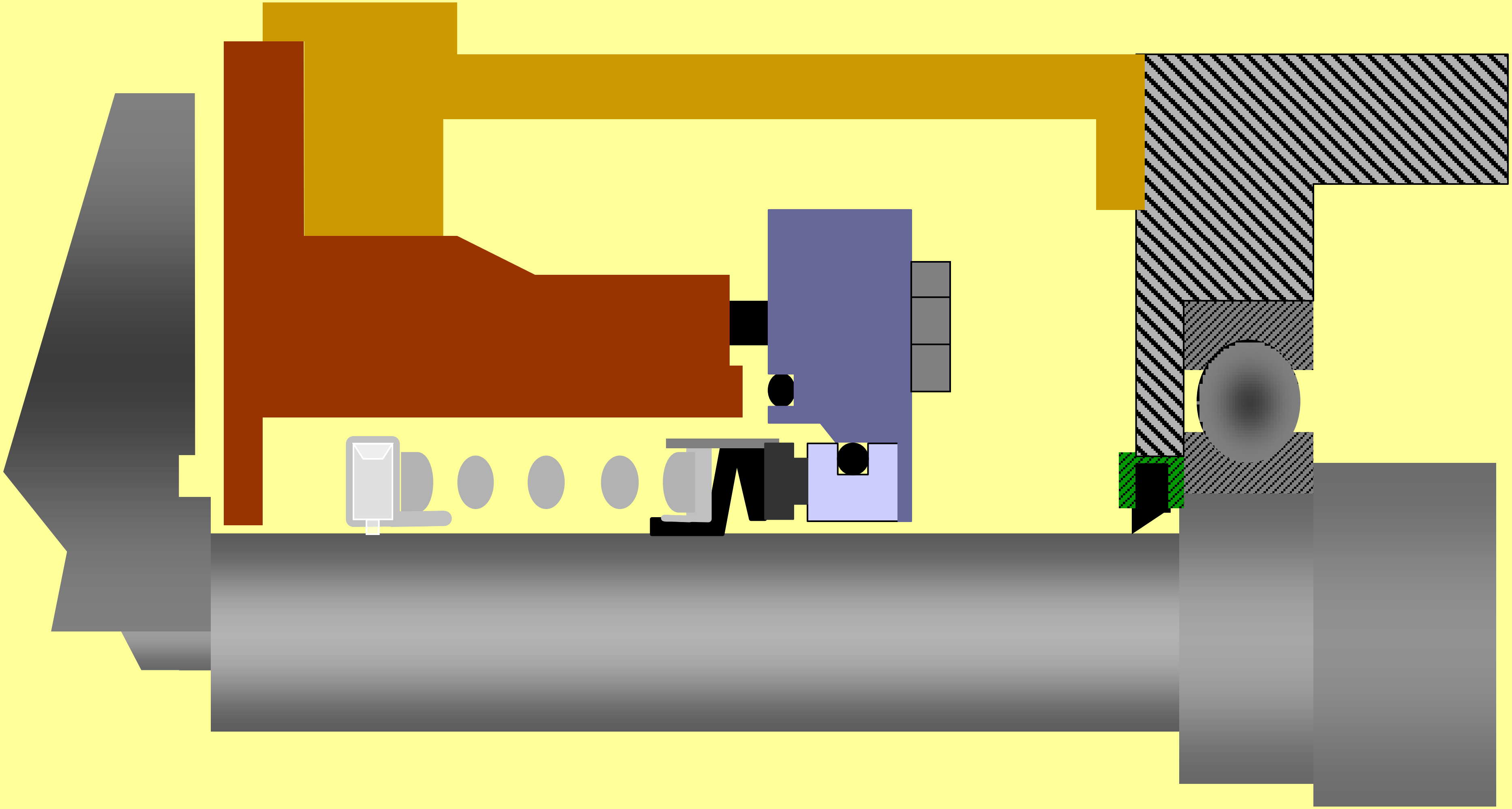


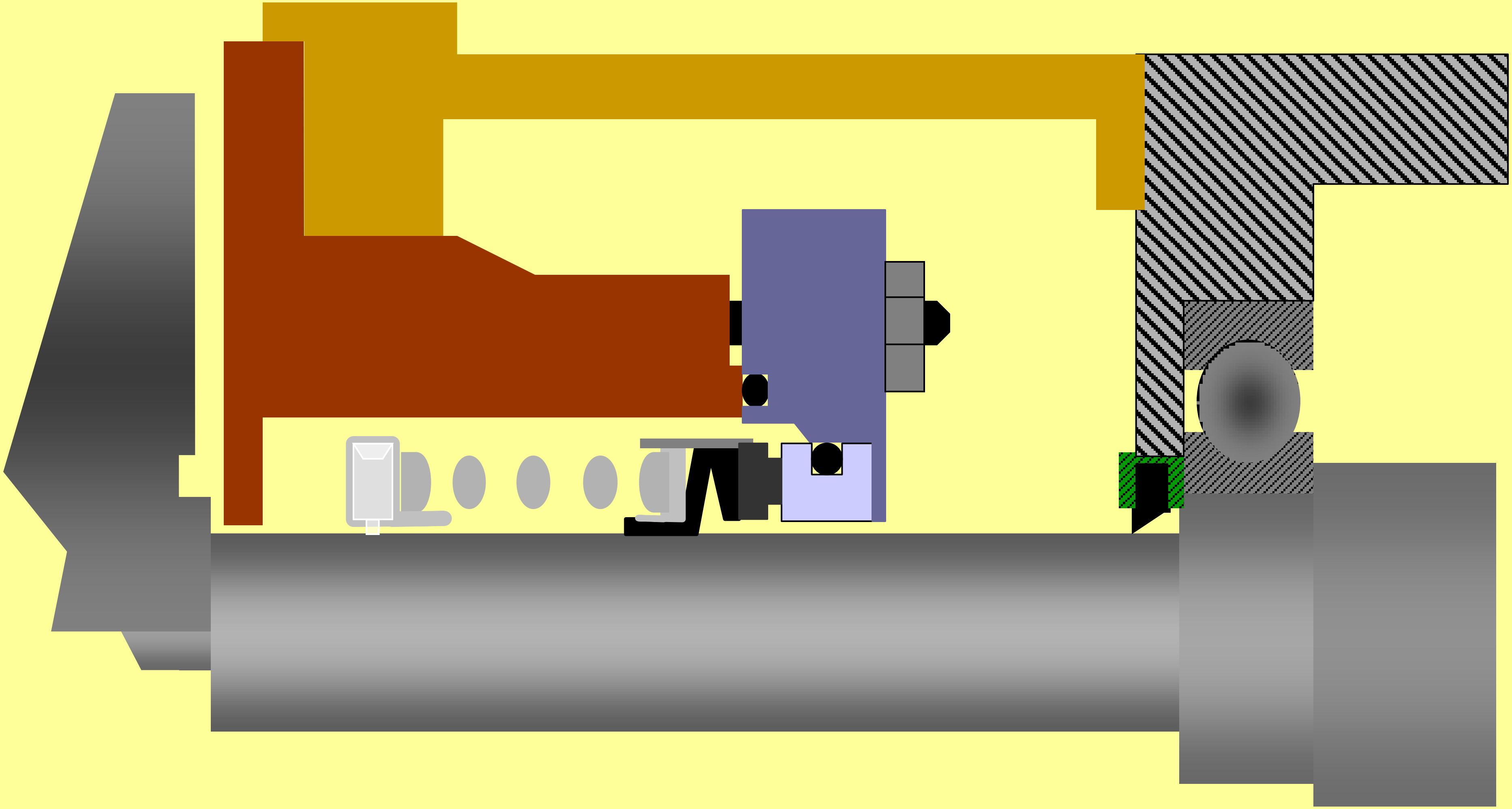


The seal assembly is slipped onto the pump shaft and the set screws tightened in the correct position to insure proper “installed length” of the assembly.



The gland is tightened evenly so that the seal
is compressed to it’s recommended length.



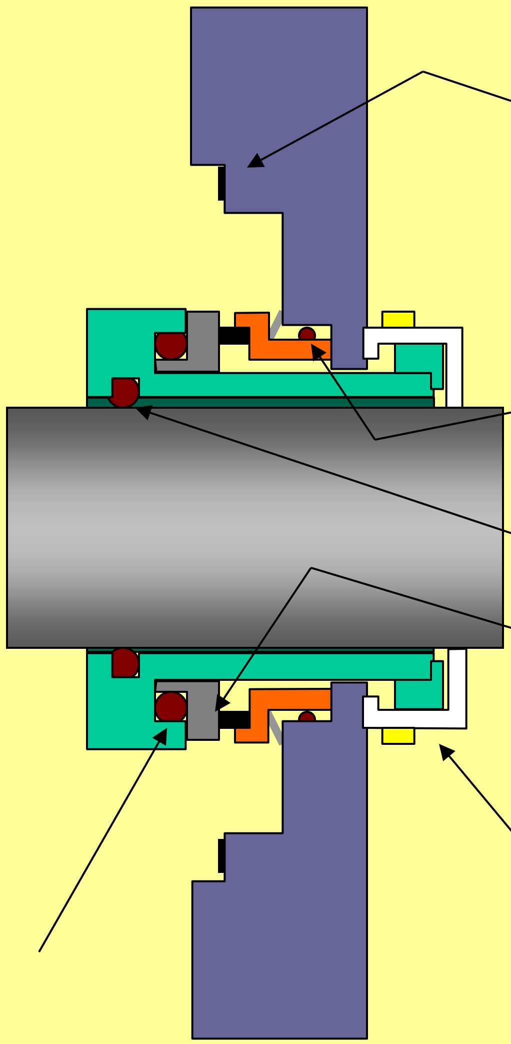


SEAL TYPES

- A cartridge type mechanical seal is a pre-assembled package of seal components making installation much easier with fewer points for potential installation errors to occur.
- The assembly is “pre-set” so that no installed length calculations must be performed for determining where to set the seal. This pre-set is achieved by the use of “set tabs” that are removed once the seal is installed and the pump assembled.

Although the assembly may look a little menacing, it is basically no different than a shaft mounted arrangement as far as sealing components and sealing points are concerned.

One additional sealing point exists in this particular cartridge assembly. Have you found it?



The same four sealing points exist here.

Seal Gland Gasket

Stationary O-ring

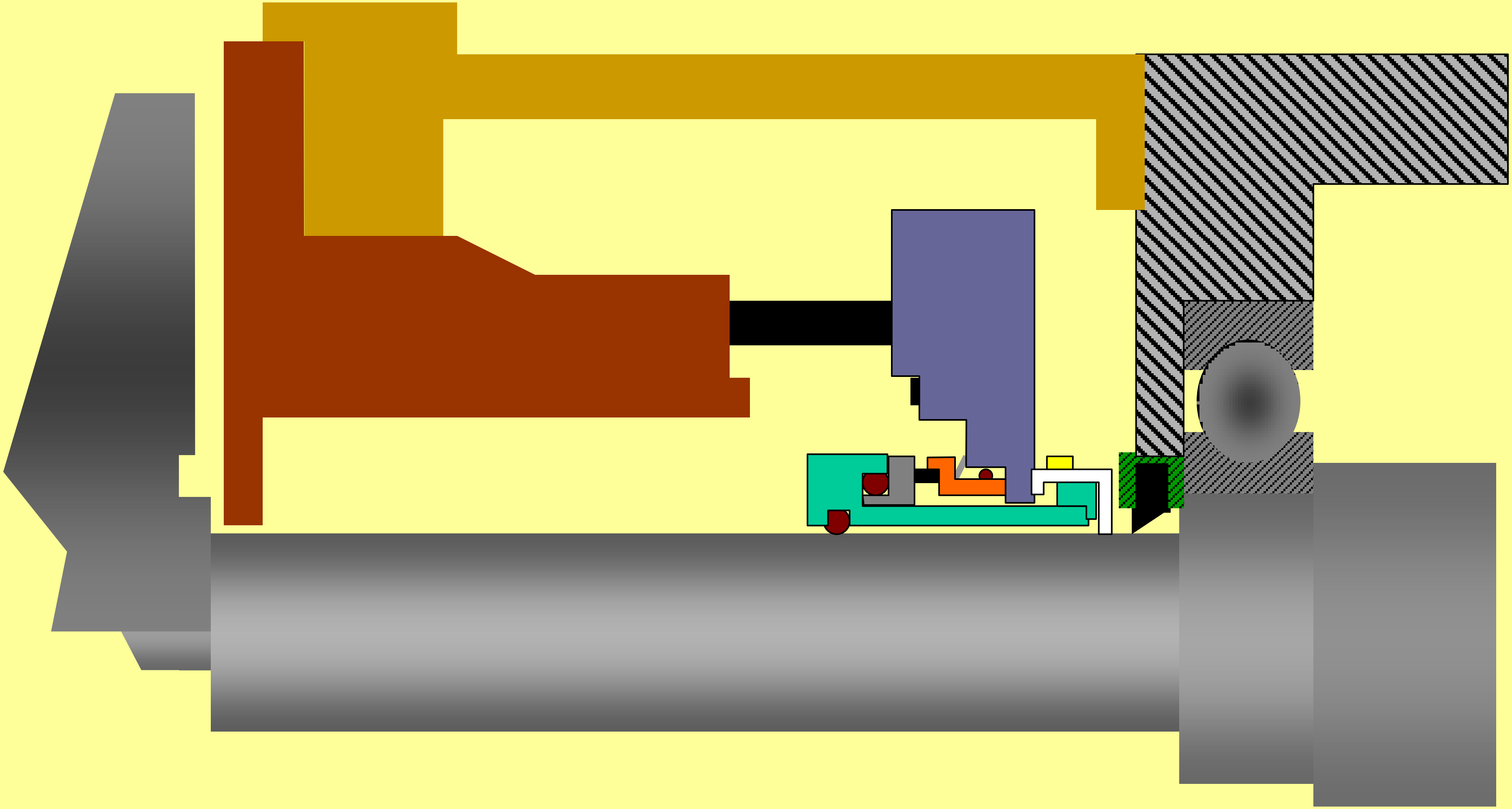
Shaft/Sleeve O-ring

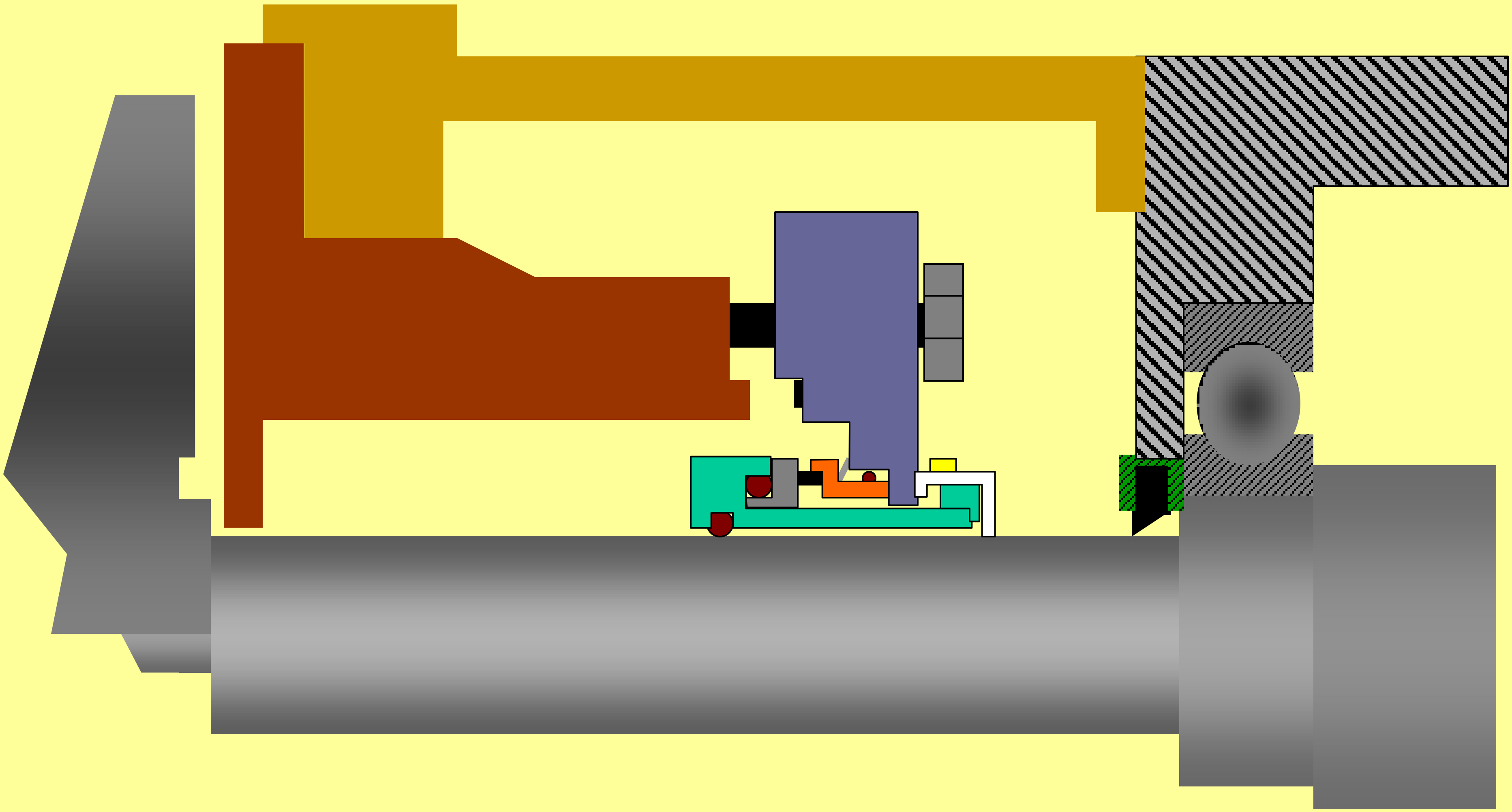
Seal Faces

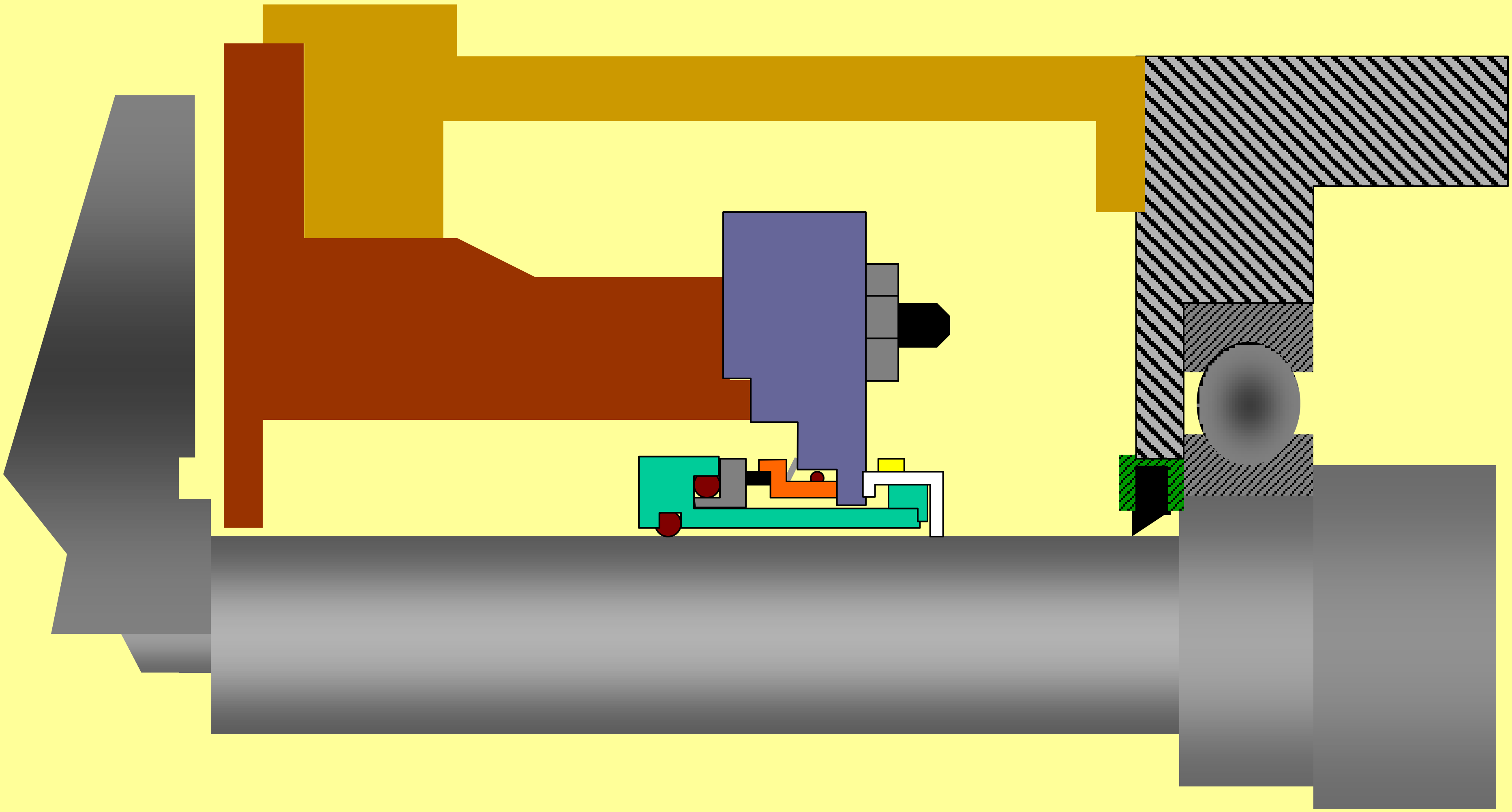
The “set tabs” are removed after installation.

SEAL TYPES

- Remember the number of steps involved in installing the shaft mounted seal.
- Now let’s look at installing the cartridge seal that we just examined.



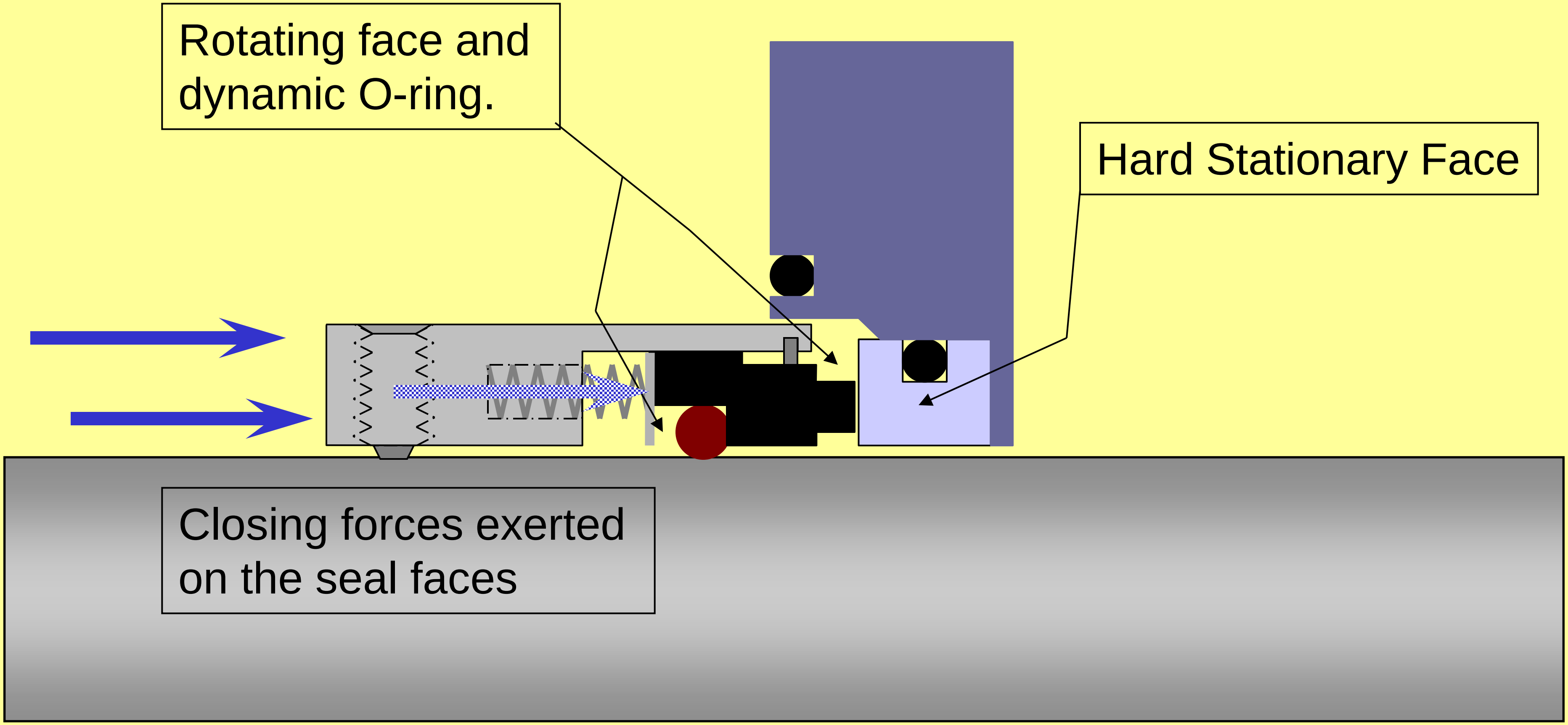




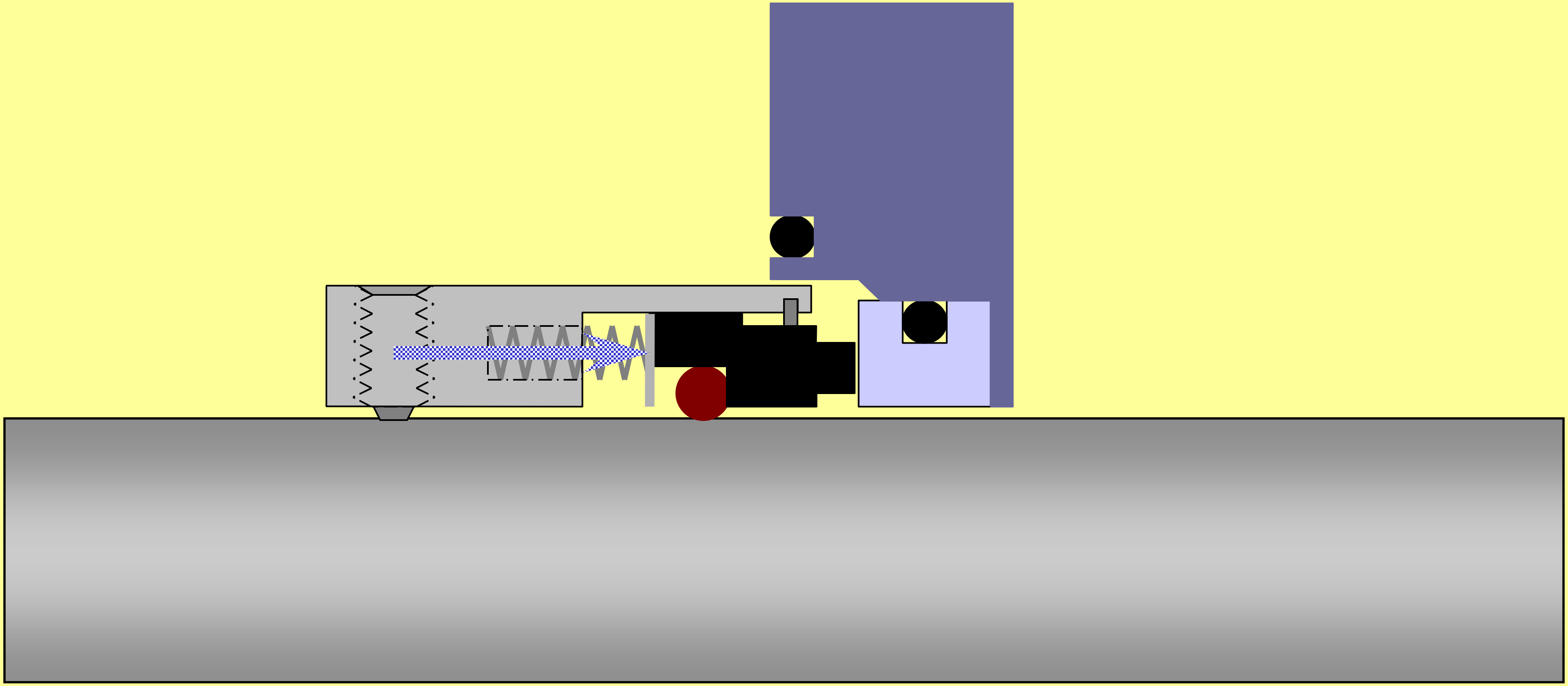
PUSHER VS. NON-PUSHER

- Both pusher and non-pusher types can be either shaft mounted or cartridge assemblies.
- The basic difference between pusher and non-pusher types have to do with the dynamics of the shaft packing or O-ring and whether or not it moves as the seal wears.
- As the seal faces wear down over time, they must be closed to compensate for lost face material. If the shaft O-ring must move when this compensation takes place, it is pushed forward by the components of the seal and by stuffing box pressure. If the seal is configured with a “dynamic” O-ring of this type the seal is called a pusher type.

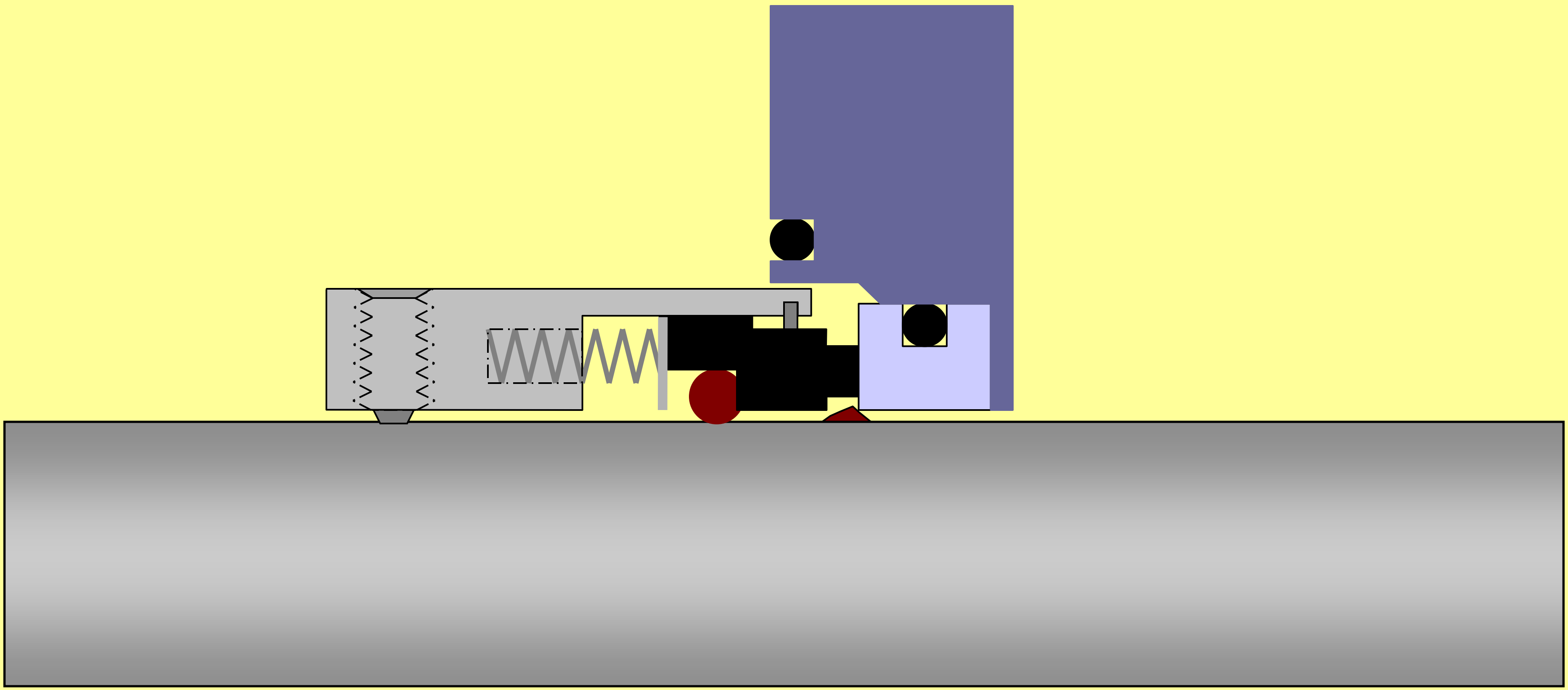
Illustrated here is a Type RS-81, a common pusher seal. As the seal springs and other pressures in the stuffing box are exerted on the seal, closure of the faces is achieved.



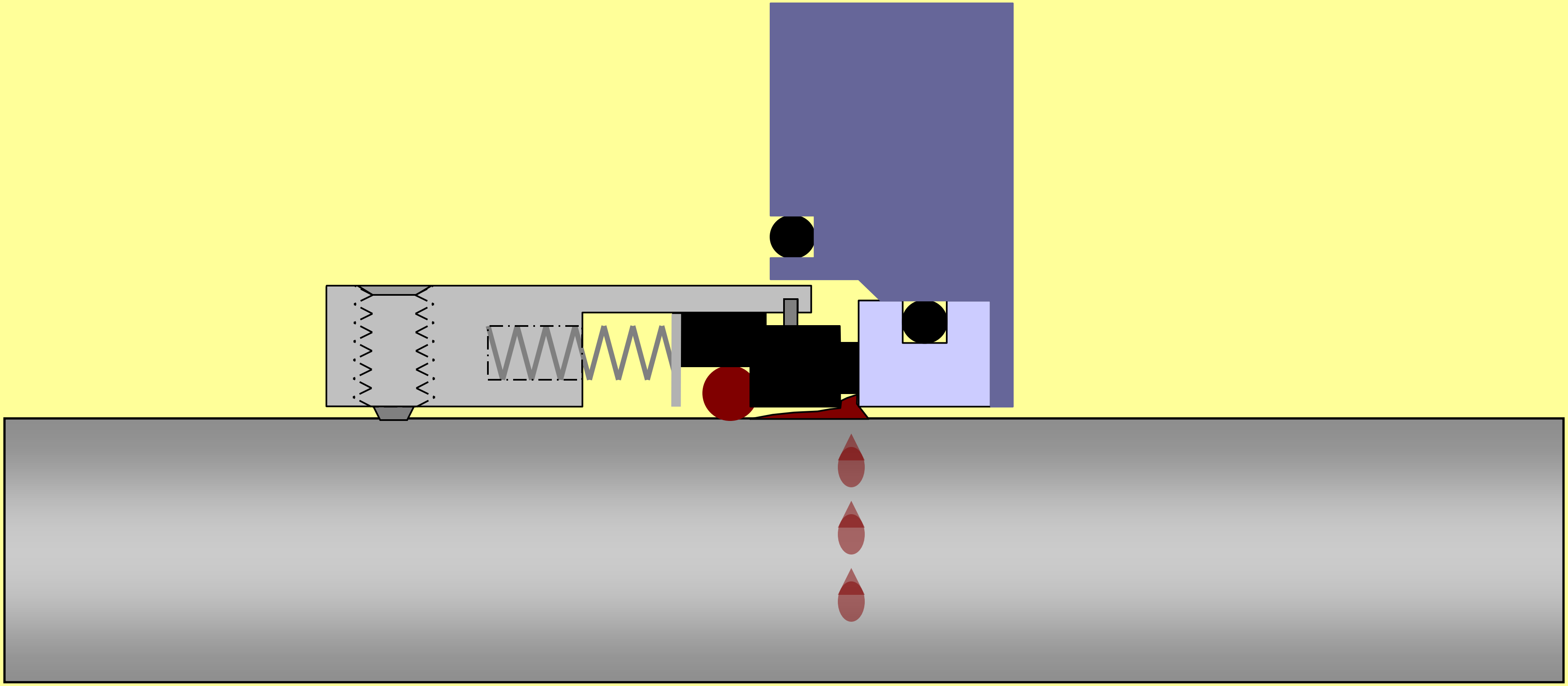
As the softer carbon face wears down, the rotating face must move to maintain face closure.

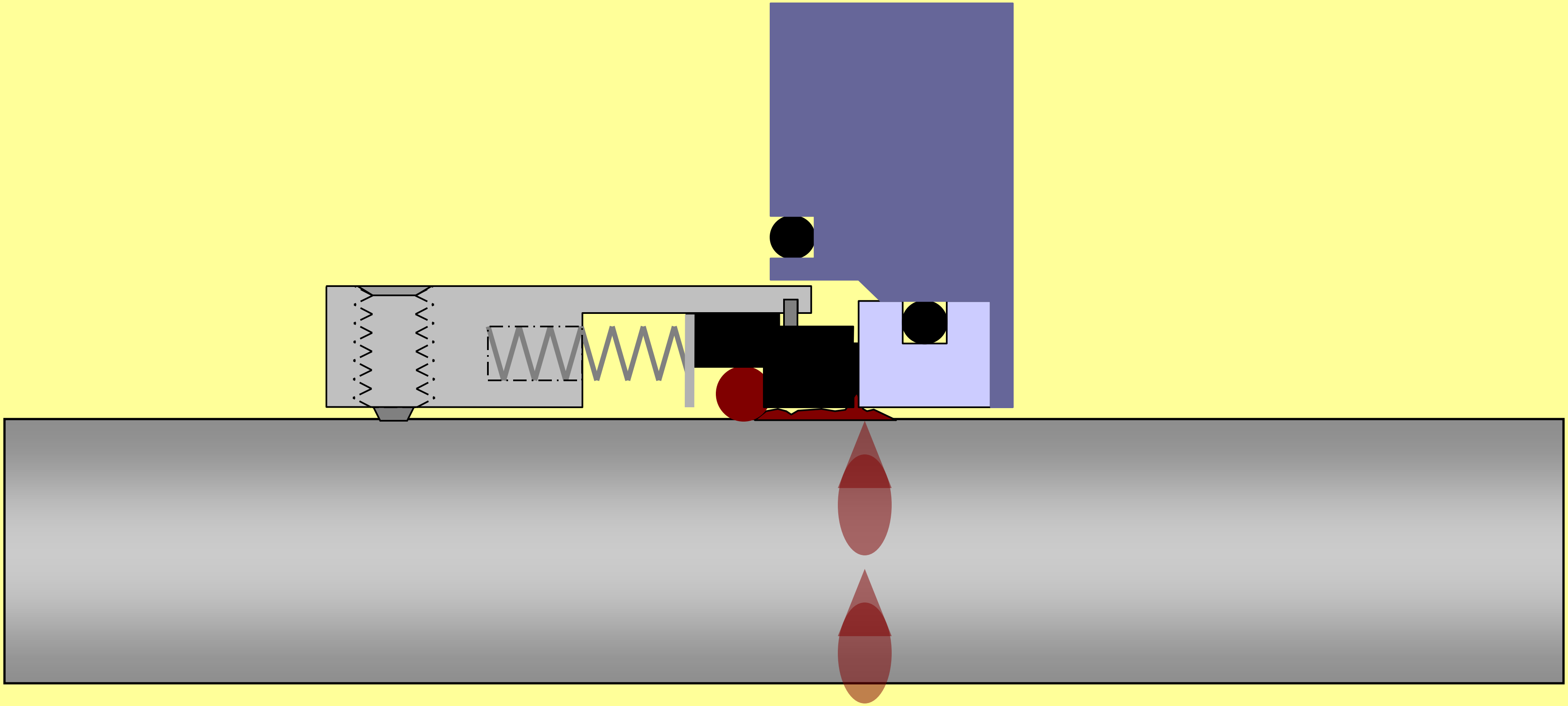


Minute particles of carbon and solids from the process liquid that migrate across the seal faces build up on the shaft.



This build up will ultimately cause the seal to “hang up” and in most cases, failure will occur well before the seal is actually “worn out”.



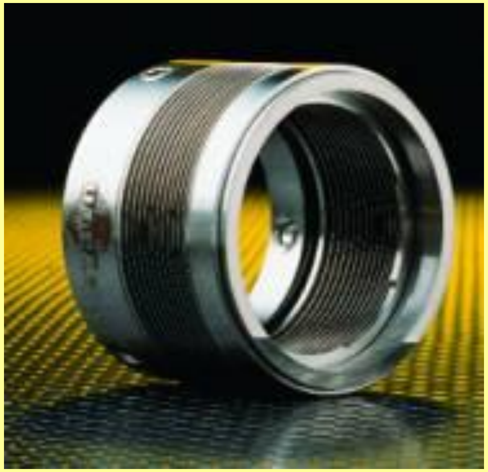


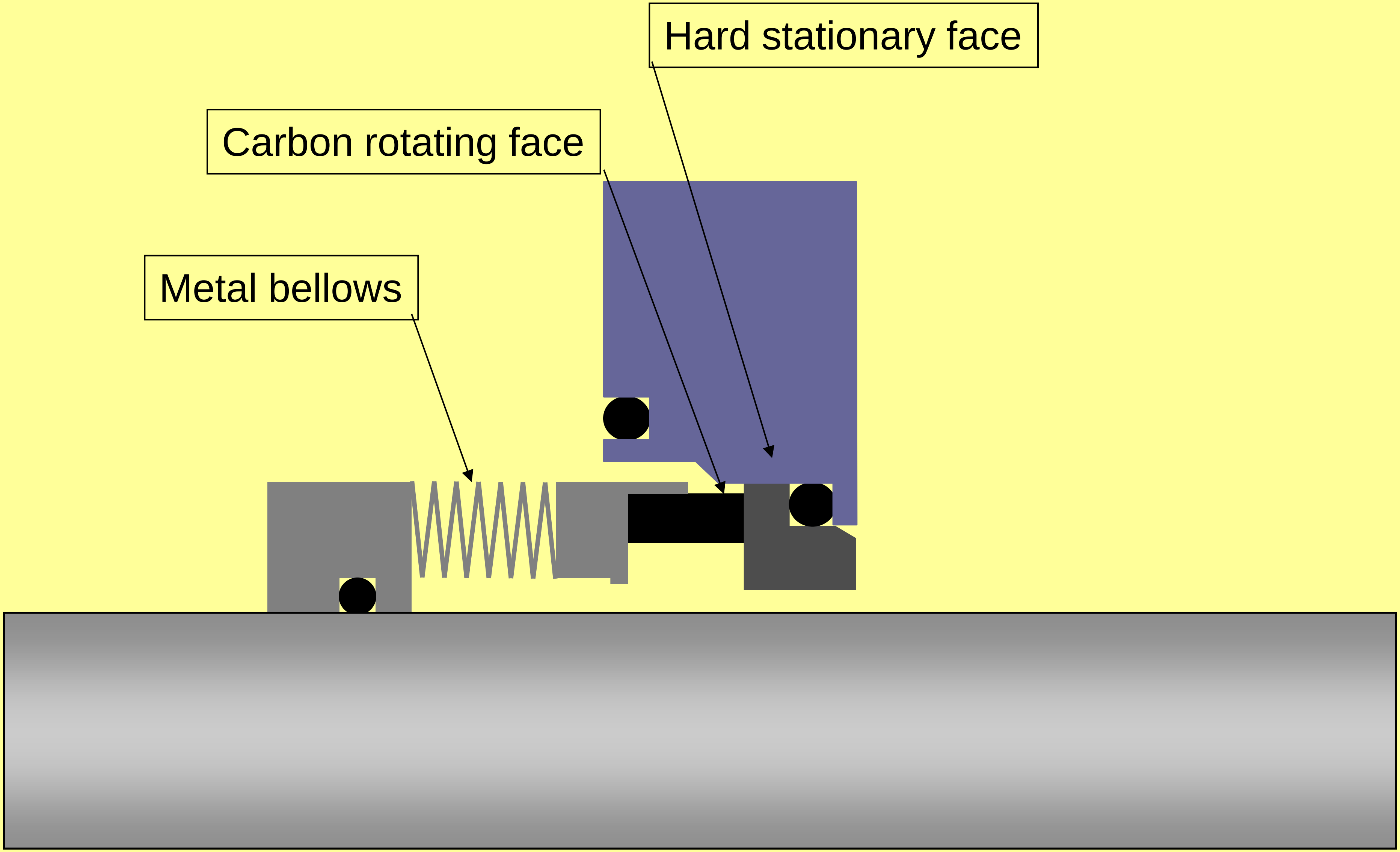
PUSHER VS. NON-PUSHER

- There are seal types that have no dynamic O-rings. All O-rings are "static" and the seal components compensate for face wear without "pushing" any sealing points.
- One of these types is called a "Bellows Seal". The bellows can be constructed of metal, rubber or PTFE. The RS-1 seen earlier in this presentation is an "Elastomer (or Rubber) Bellows Seal".
- Let's consider the metal variety.

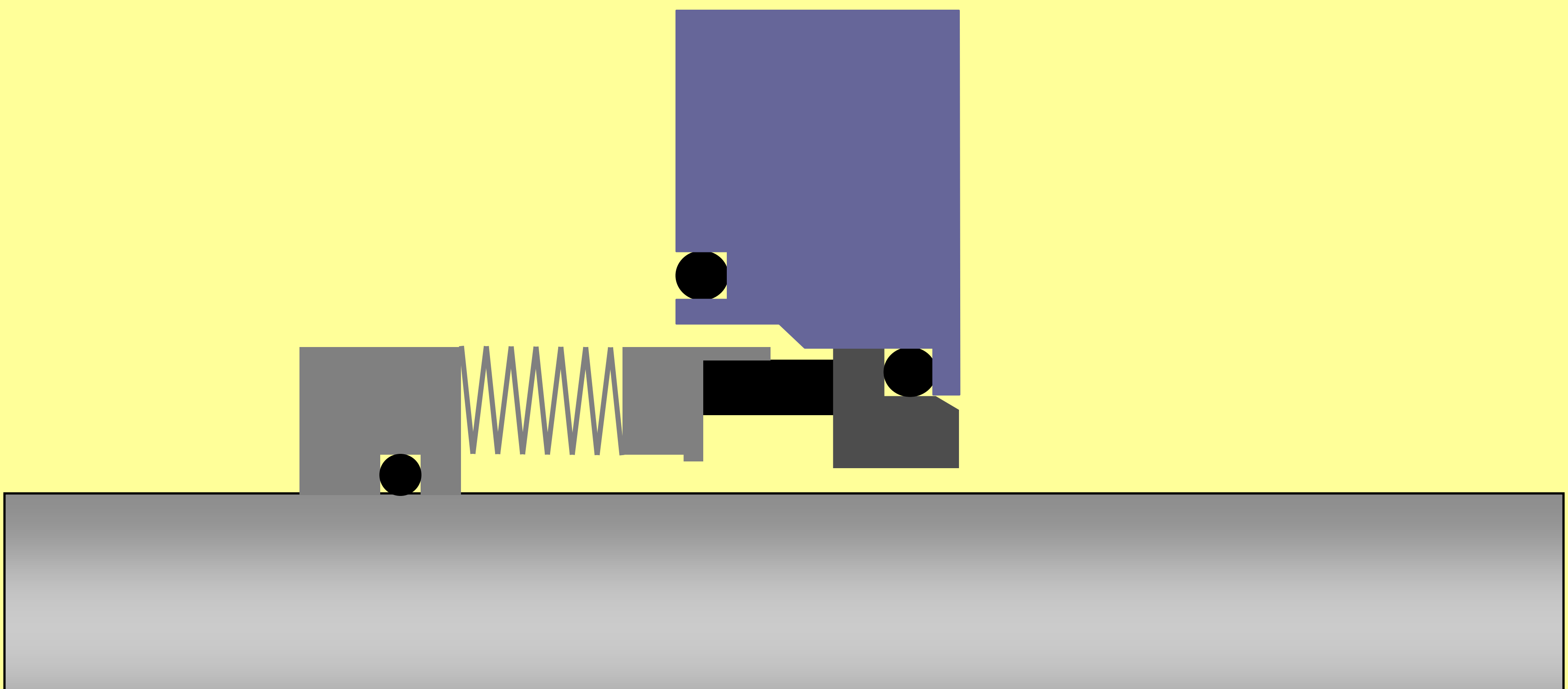
METAL BELLOWS

- Metal bellows are constructed by welding “leaflets” into a series of “convolutions”. This series of convolutions is referred to as the “Bellows Core”.
- The photo shown here is a shaft mounted “Utex-MB”.
- Now take a look at how a bellows seal compensates for face wear.

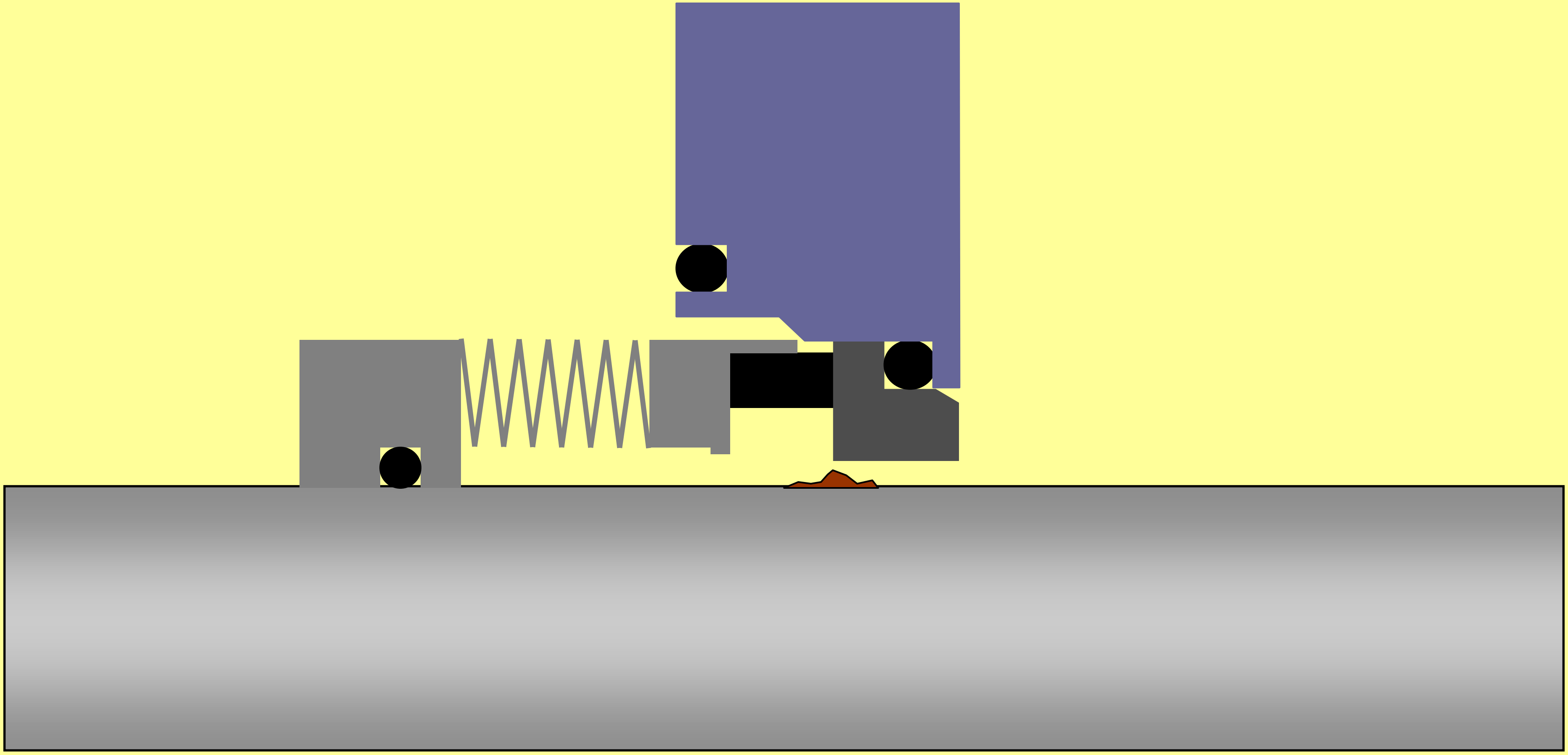


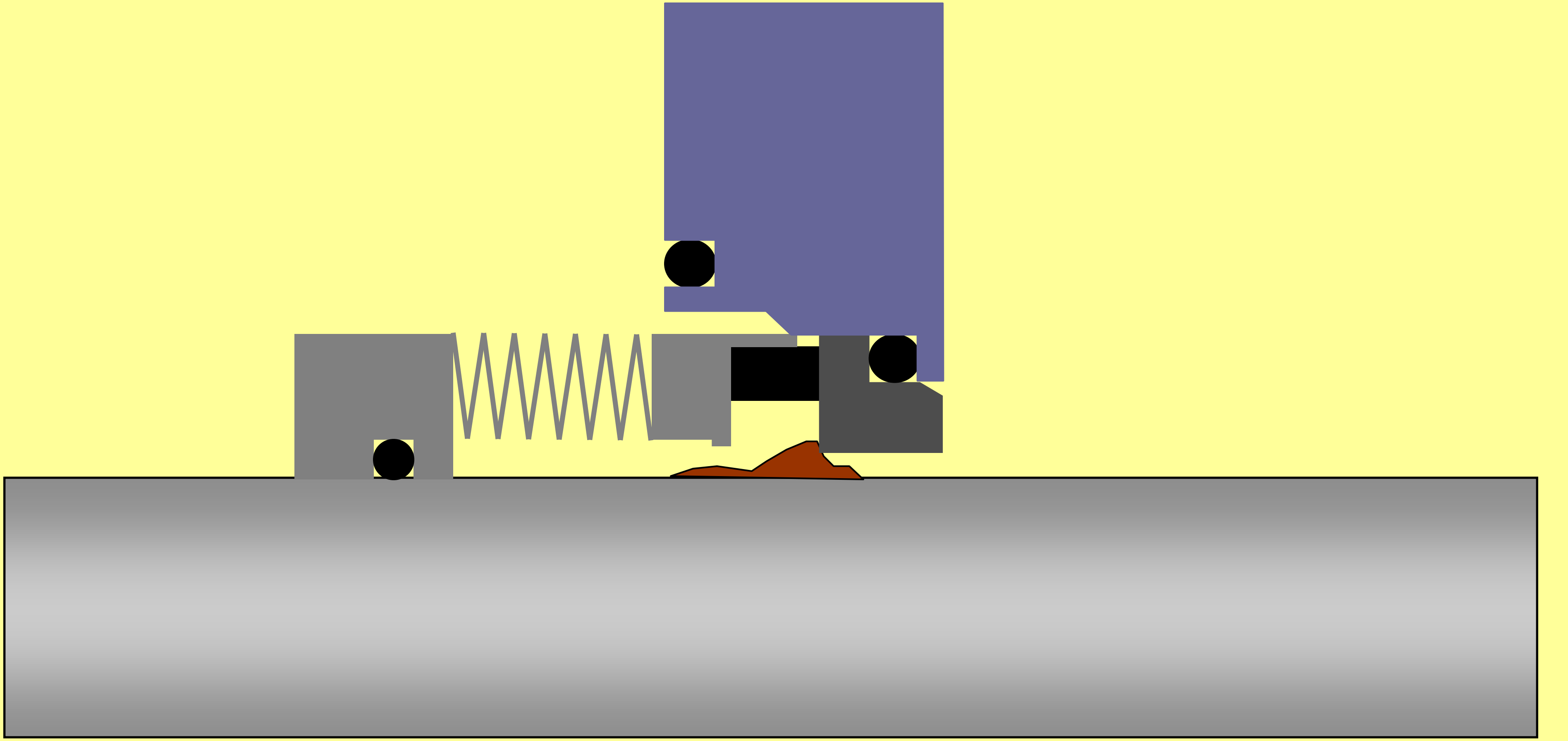


Hard stationary face
Carbon rotating face
Metal bellows

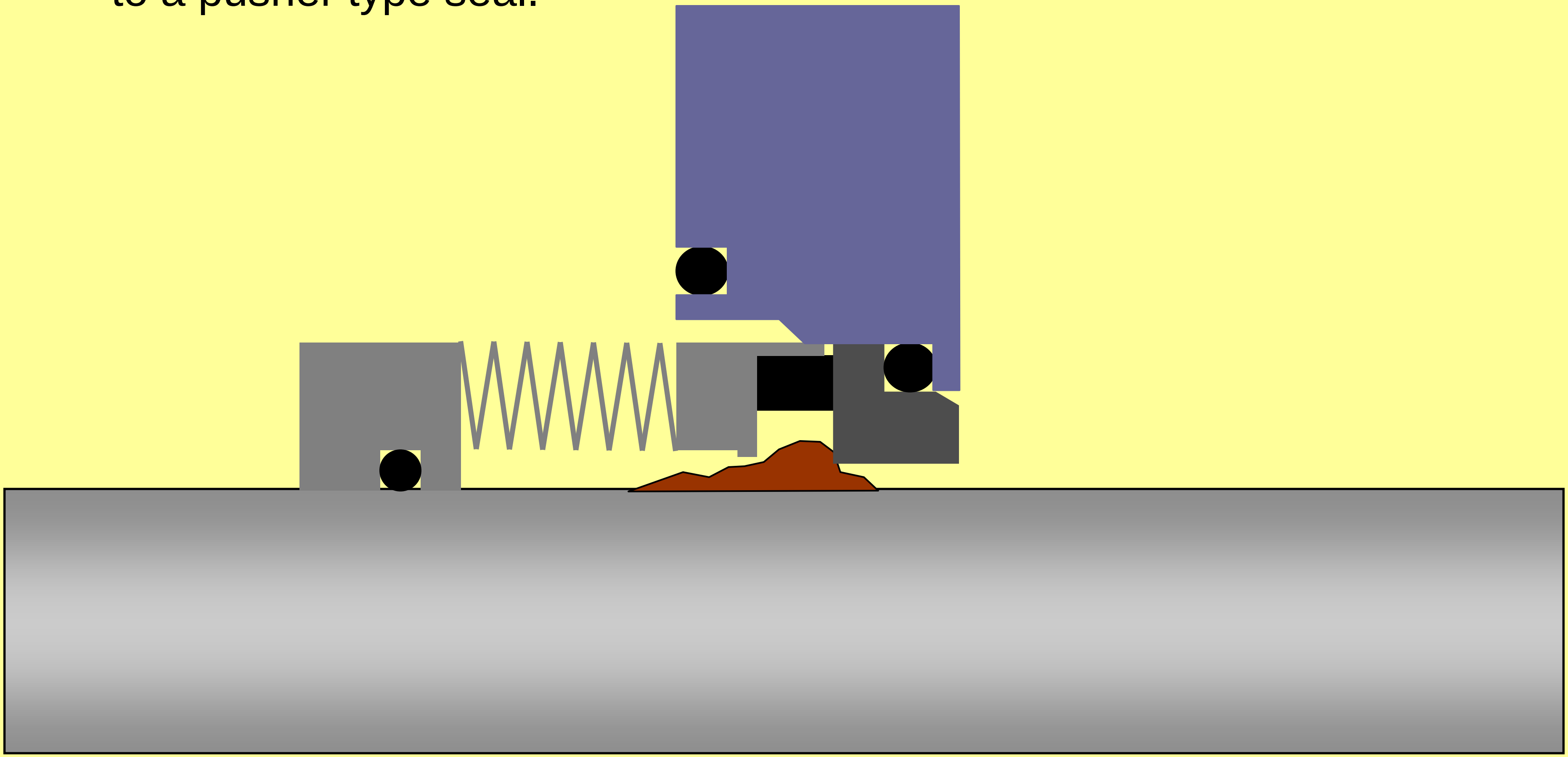


The bellows core expands to compensate for face wear.





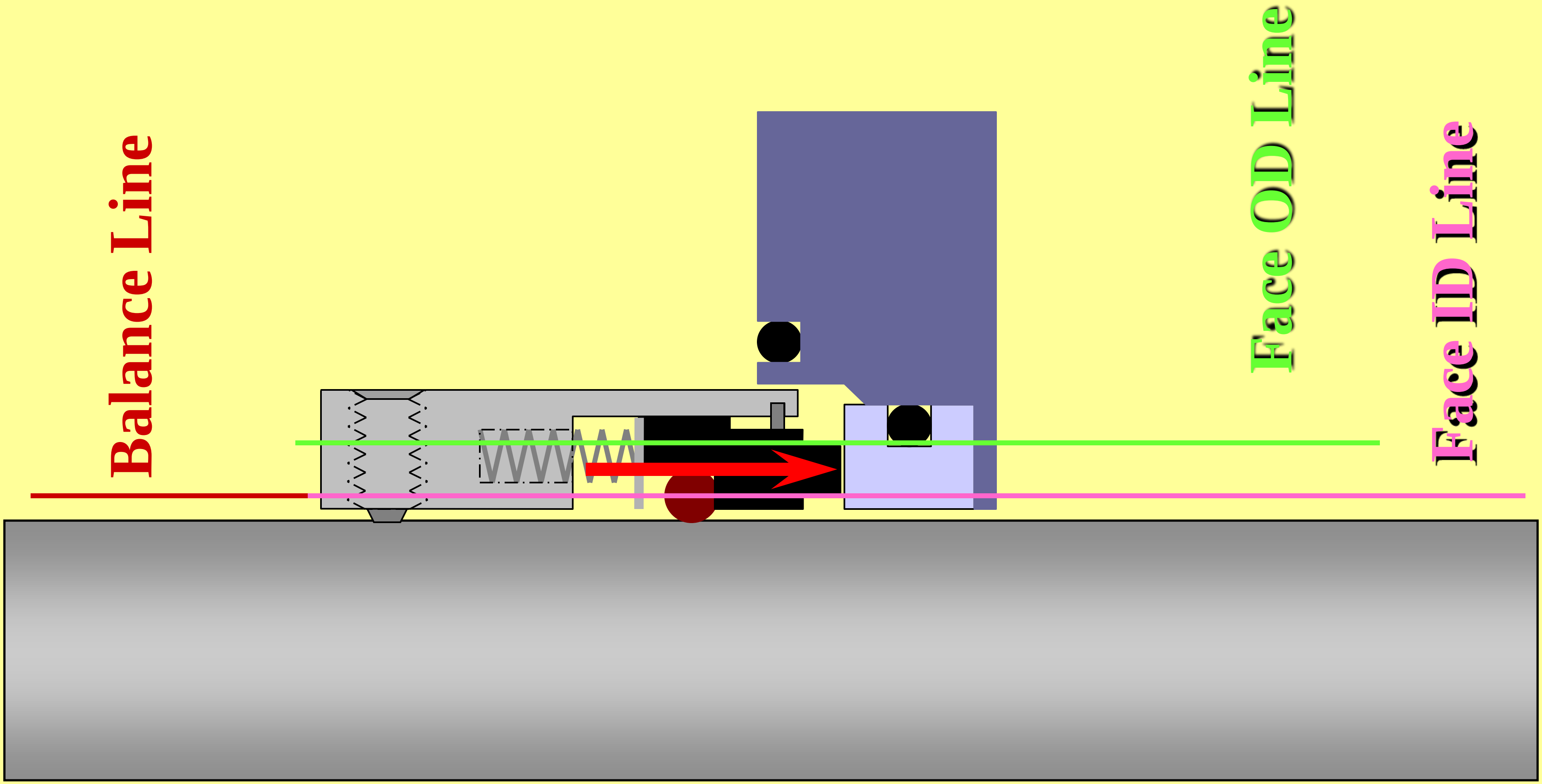
Debris can build up without causing hang up. This feature is probably the most notable selling point when comparing a bellows seal to a pusher type seal.



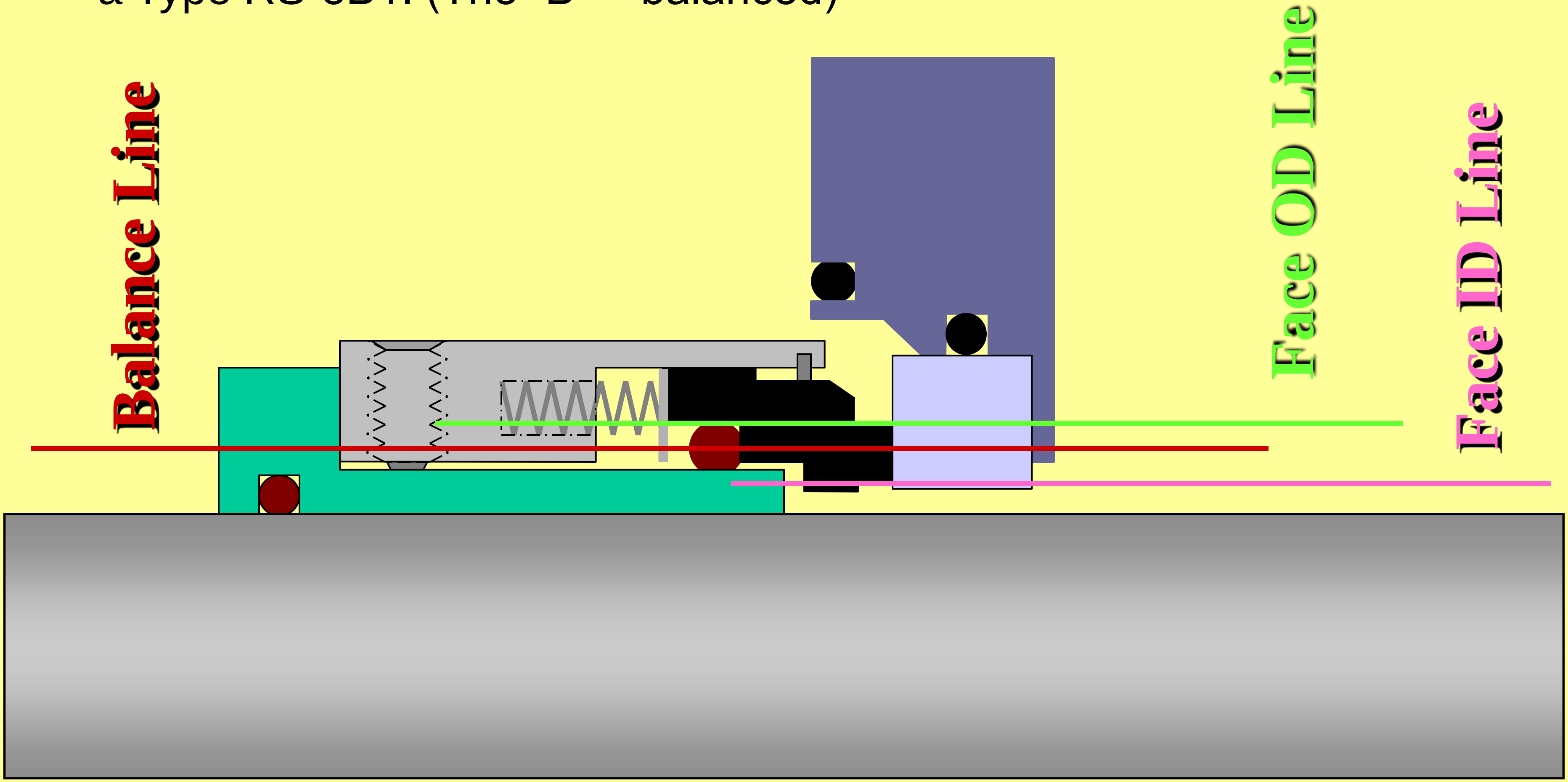
BALANCED VS. NON-BALANCED

- When speaking of "Balance" in reference to mechanical seals, we are not talking about Mechanical or Rotational Balance. Instead, we are referring to Hydraulic Balance.
- Since mechanical seals are subject to stuffing box pressure, this pressure is utilized to achieve and maintain seal face closure in a non-balanced seal.
- If stuffing box pressure is very high, typically over 100psi., then the closing force may be too great to allow the "Boundary Layer Liquid" that lubricates the faces to be sufficient and the faces will wear prematurely.
- A balanced seal compensates for higher pressures by locating the seal faces such that stuffing box pressure has less effect on face closure.

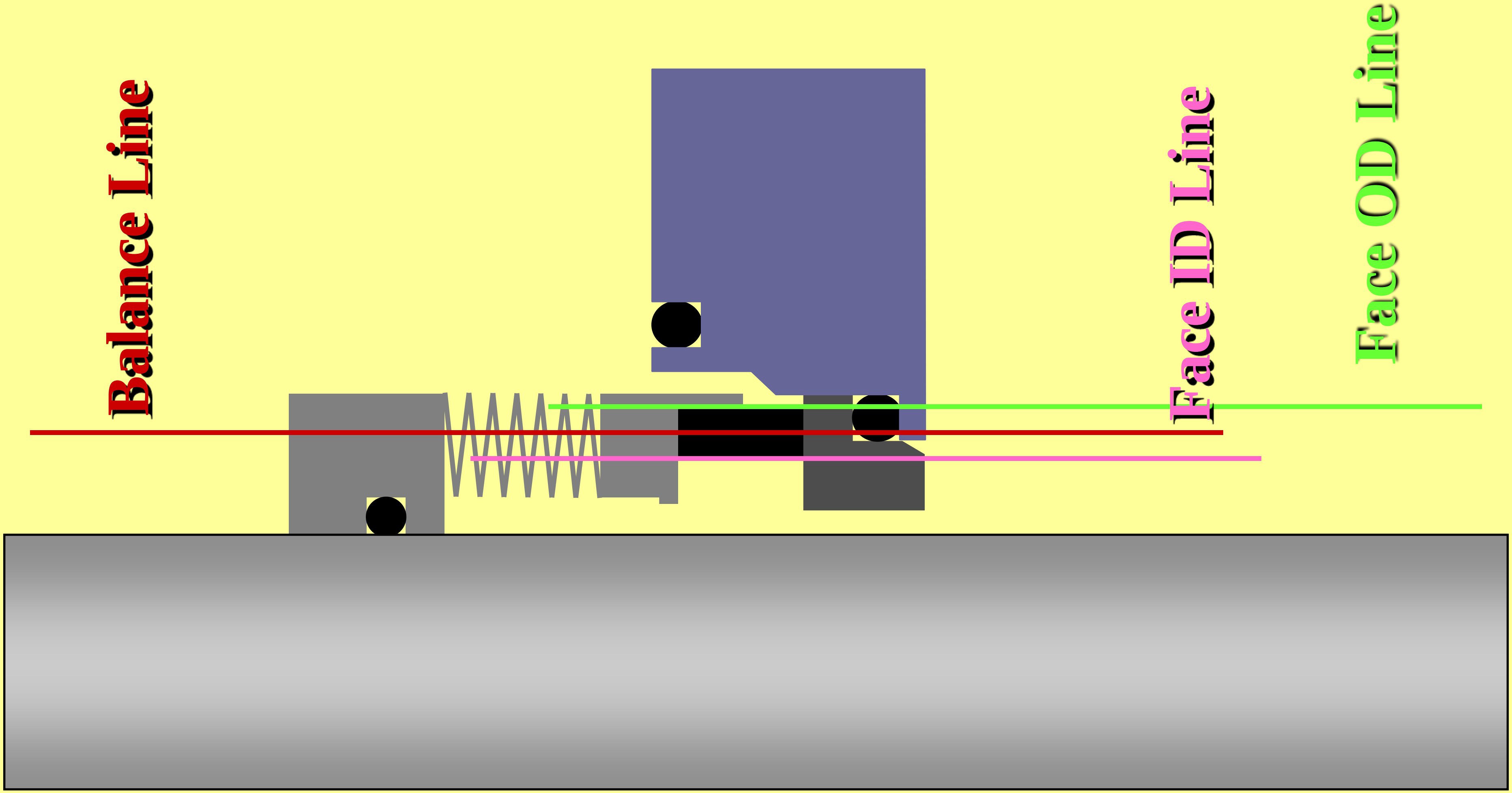
A non-balanced seal has faces located outside the “Balance Diameter” of the seal. Stuffing box pressure is applied to the faces virtually evenly.



The faces of a balanced seal are located so that a portion of the face contact occurs inside the balance diameter resulting in reduced closing force due to stuffing box pressure. This seal is a Type RS-8B1. (The “B” = balanced)



Most metal bellows seals are balanced.

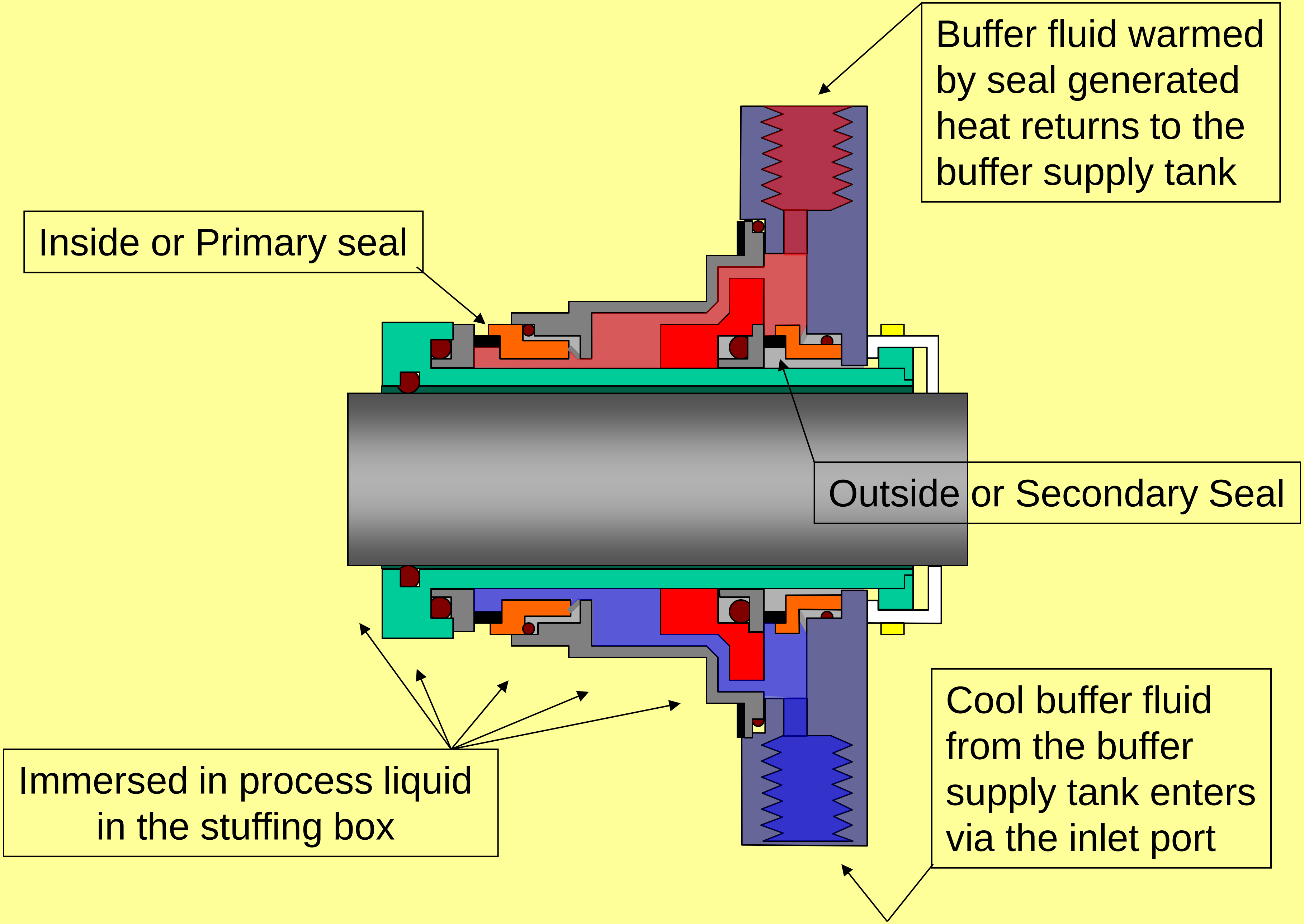


SINGLE VS. MULTIPLE

- Most rotating equipment is equipped with a single seal. This is what we have been examining thus far. Single shaft mounted seals, cartridges seals, balanced seals etc.
- Some applications call for a multiple seal configuration. These are typically dual seal arrangements but can also be a series of three or more. For our purposes we will examine dual seal arrangements since that really covers 99% of multiple seal applications.

DUAL SEALS

- Dual seals can be either pressurized or non-pressurized. This is in reference to the artificial environment that is provided to exist “between” the seals.
- A non-pressurized dual seal, also known as a “Tandem” arrangement, means that the inner, or primary seal is functioning as would a single seal. It is subject to stuffing box conditions, i.e. stuffing box pressure, process liquid to lubricate the faces and usually immersion of seal components in the process liquid. The secondary, or outside seal runs in a non-pressurized “Buffer” liquid that is supplied from an outside source, typically a nearby supply tank.
- In a non-pressurized dual arrangement, the outside seal is primarily there as a containment device in the event that the inside or primary seal is lost. A “Back up” or safety mechanism if you will.
- Let’s look at a Dual Cartridge Seal.


Buffer fluid warmed by seal generated heat returns to the buffer supply tank
Inside or Primary seal
Outside or Secondary Seal
Immersed in process liquid in the stuffing box
Cool buffer fluid from the buffer supply tank enters via the inlet port

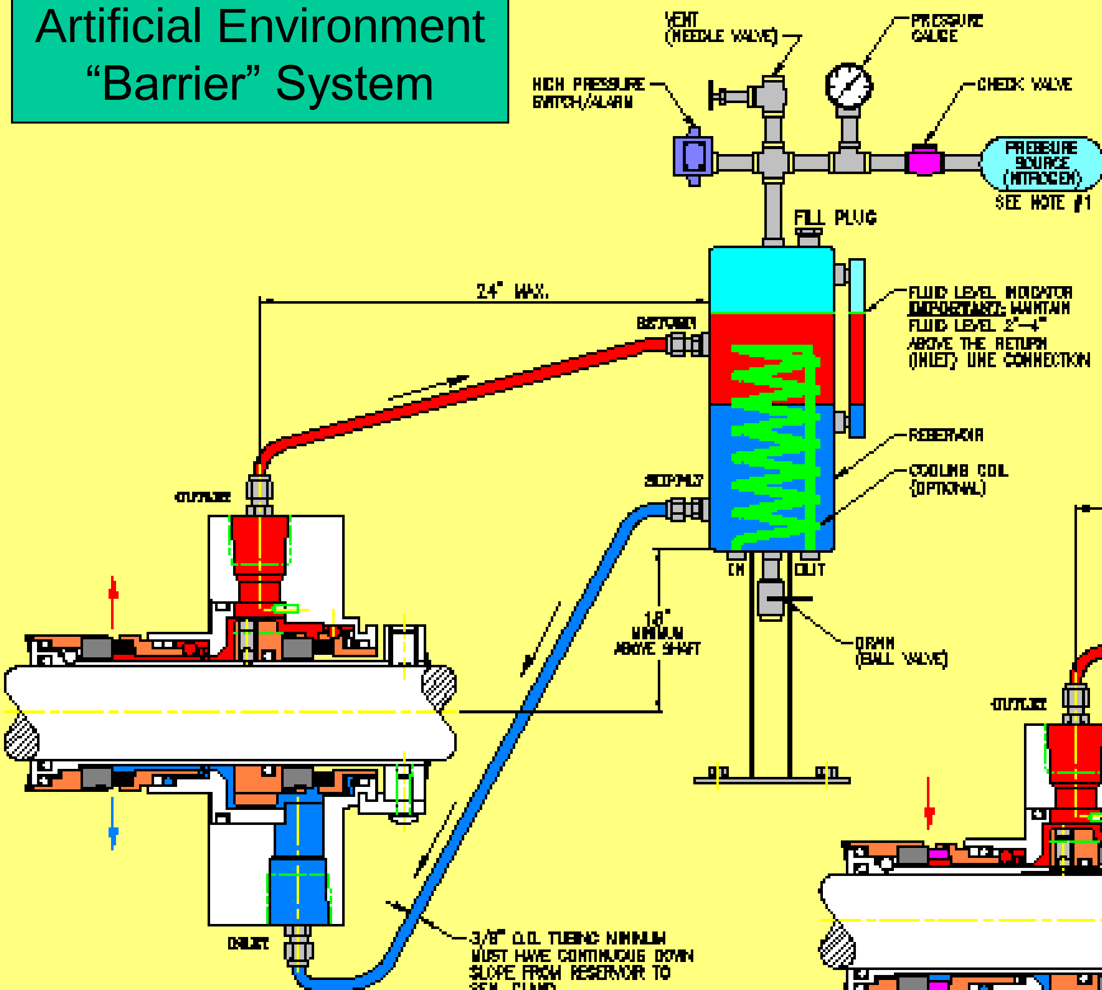
DUAL SEALS

- Since the outside or secondary seal runs in a non-pressurized clean lubricating liquid, it will generally last for an extended period of time. When the inside or primary seal fails, the leakage through the faces will be contained by the secondary seal until the pump can be shut down for seal replacement.
- Failure indication and shutdown devices can be attached to the buffer supply so that the pump operators know when the primary seal has failed.

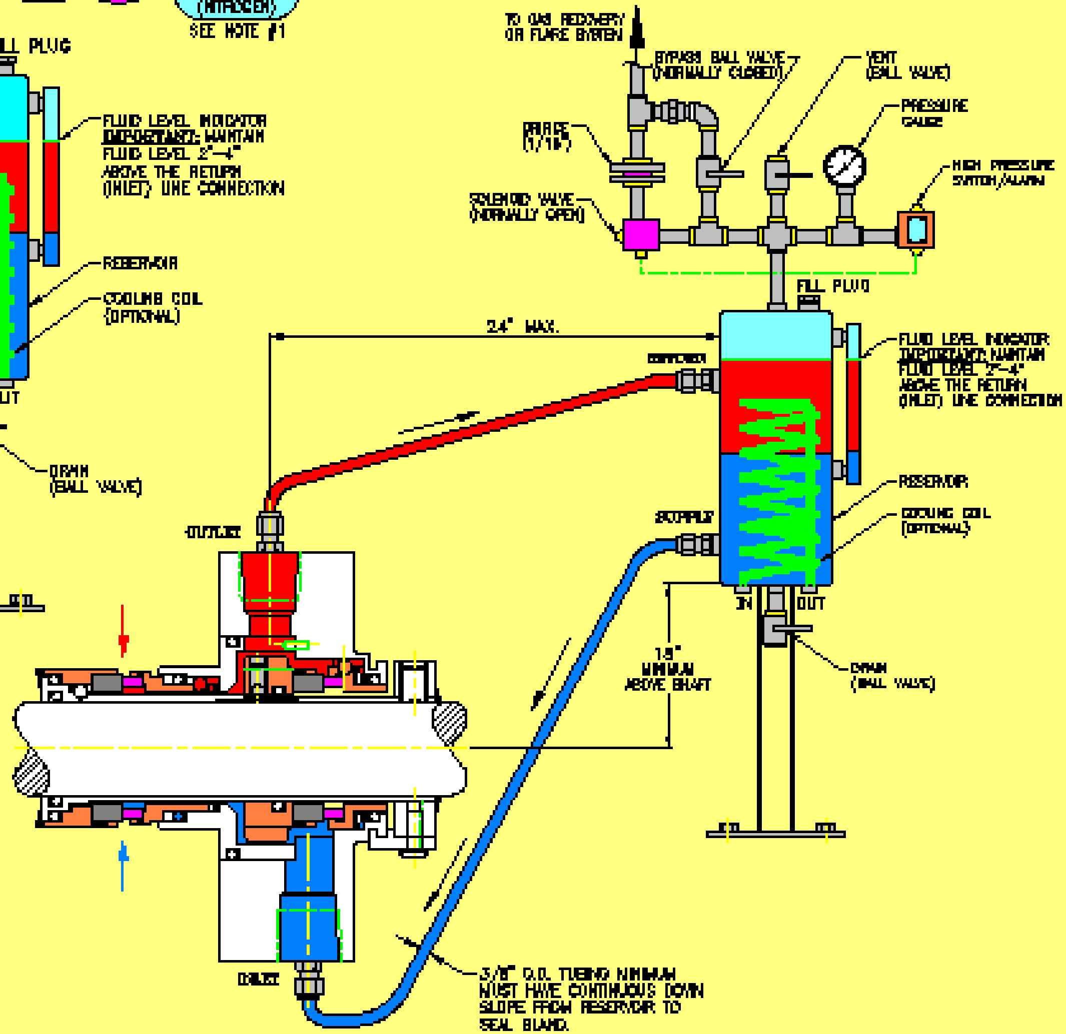
DUAL SEALS

- When pumping volatile liquids, hazardous, corrosive, abrasive, etc. it is sometimes necessary to insure that the process liquid does not enter the atmosphere or the artificial environment created for the seal or even the seal faces.
- Pressurizing the artificial environment, 20 to 30 psi. above the pump stuffing box pressure will prevent process liquid from crossing the primary seal faces. Instead, boundary layer film liquid is supplied to the primary seal by the artificial environment or “Barrier”.
- The arrangement of seals can be the same as a non-pressurized in most cases. The difference is in how the seals perform.
- In a pressurized dual seal, the outboard or secondary has the tougher job of the two. It operates sealing high barrier pressure while the inboard or primary seal has clean lubricating liquid applied at differential pressure of only 20 to 30 psi.
- Now let’s look at the environmental controls for operating dual seals.

Pressurized Dual Seal Artificial Environment “Barrier” System

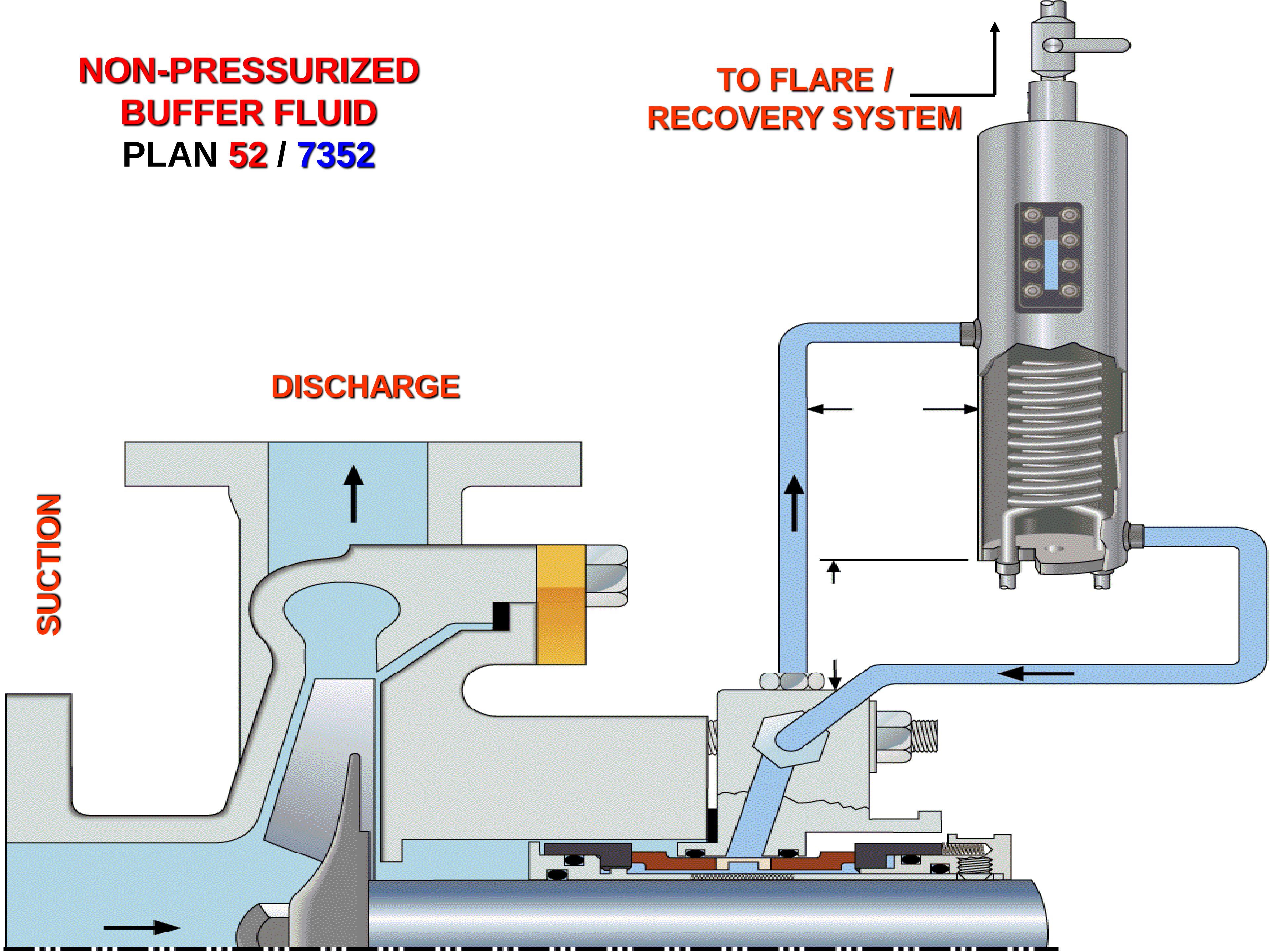


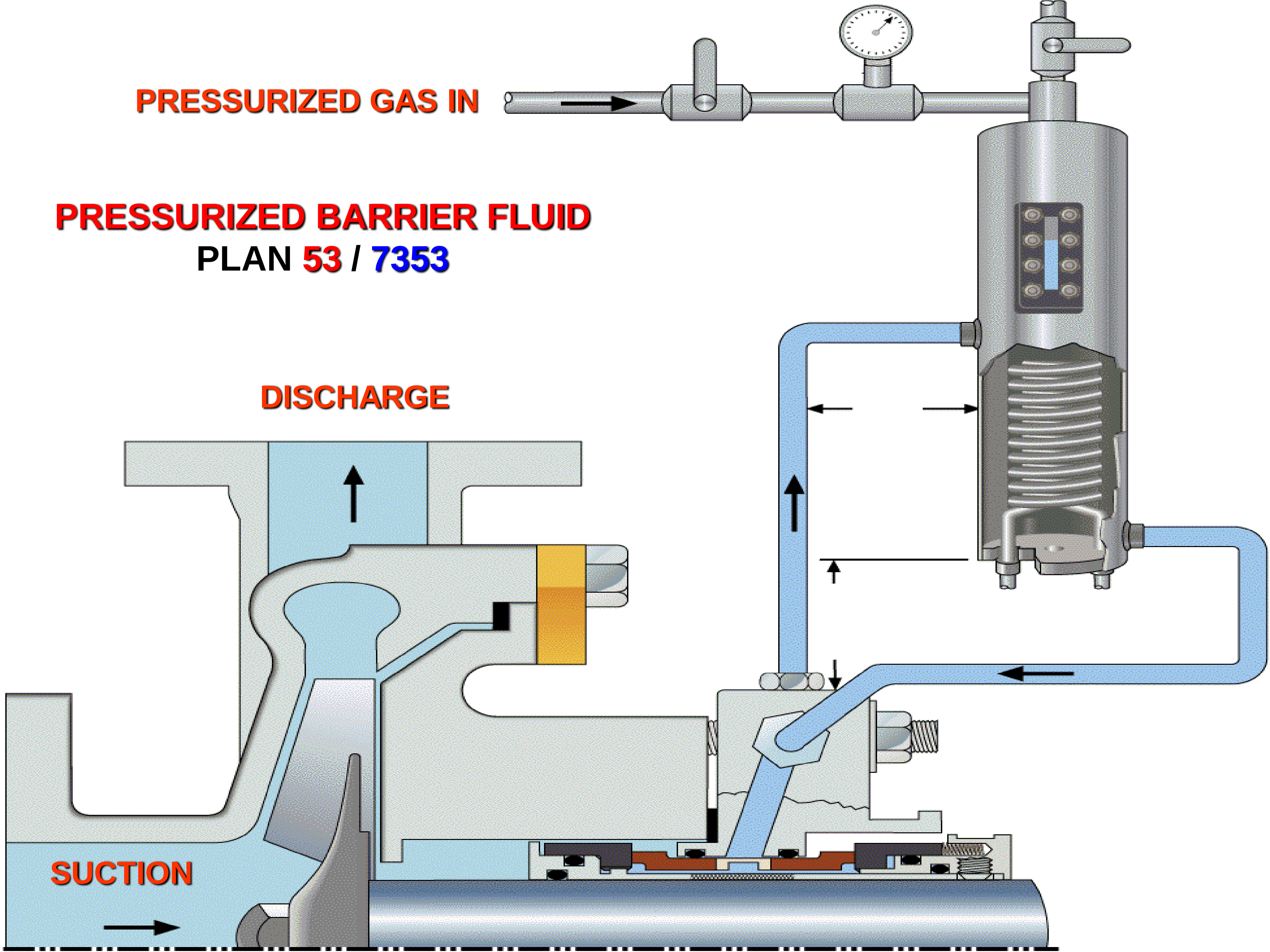
Non-Pressurized Dual Seal Artificial Environment “Buffer” System



NON-PRESSURIZED BUFFER FLUID

PLAN 52 / 7352




PRESSURIZED GAS IN
PRESSURIZED BARRIER FLUID
PLAN 53 / 7353
DISCHARGE
SUCTION

DUAL SEALS

- There are many more types of environmental control arrangements that are discussed in other programs. This presentation simply covers the basics. For more detailed information on this topic, contact your supervisor or a Sealing Technologies Representative.

SPLIT SEALS

- Some types of machinery are cumbersome to maintain. Large shafts, heavy components, and immovable drivers are some of these concerns.
- Often, a typical mechanical seal is impractical to use by the nature of it’s installation requirements.
- In these cases it is frequently beneficial to use a Split Seal.
- In a Split Seal, all components are literally cut or split in half and they are assembled onto the equipment without removal or disassembly of the major equipment components.
- Obviously, these seals are prone to leak more readily than non-split seals so they are generally applied to processes where some leakage is acceptable. Even with some leakage, they will out perform common packing.
- Split Seals are often used on mixers, agitators and large volume, large shafted pumps.

UTEX EZ-SEAL

- The Utex EZ-Seal is split radially as shown in this photo.
- All internal components are also split and they are assembled onto the equipment shaft without removing the equipment from it’s operating position or tearing down it’s major components.

UTEX EZ-SEAL

SPLIT SEALS

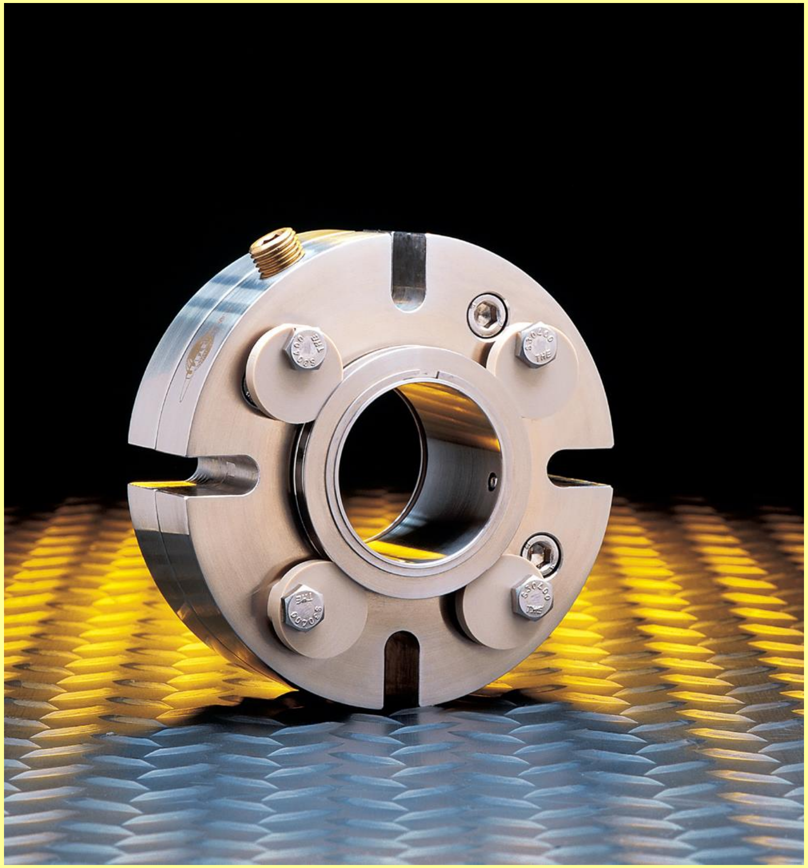
- Aside from the fact that the components are split, split seals operate virtually the same way that most single cartridge or shaft mounted seals operate.
- By nature of their split design, their application is limited to lower pressures and non-volatile liquids.
- Now let’s move onto our final discussion topic, Gas Buffer Seals.

GAS BUFFER SEALS

- The final seal type that we will look at during this course is the Gas Buffer Seal.
- Gas Buffer Seals are the latest advancement in sealing technology. There are as many different types as there are Sealing Product Manufacturers.
- They were designed to facilitate capabilities similar to a dual seal without requiring elaborate environmental controls or in the case of pressurized dual seals, without liquid contamination of the process liquid.
- We will briefly discuss the features of the Utex DCG Seal.

DUAL CO-AXIAL GAS SEAL

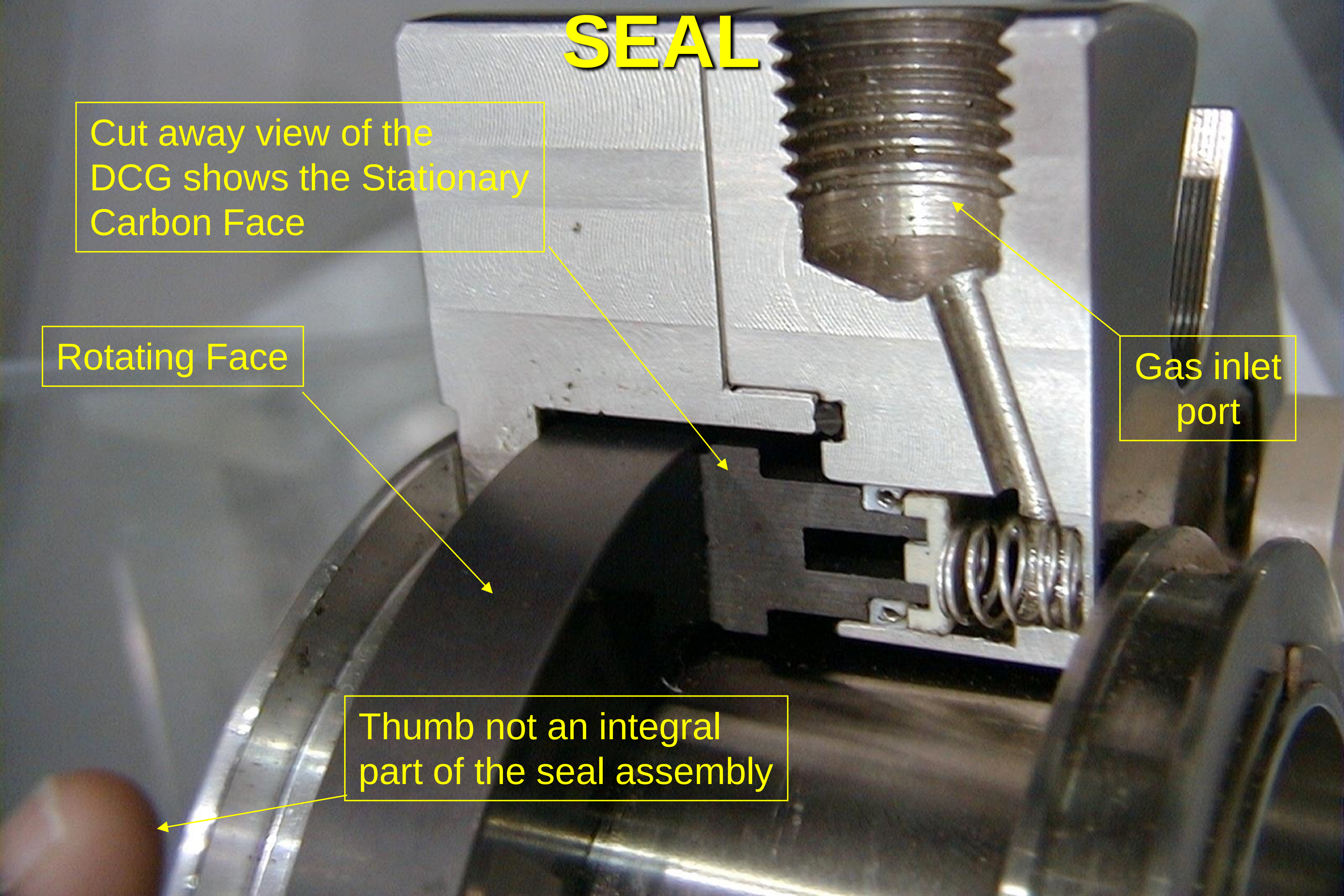
- The DCG Seal is a cartridge arrangement that contains a "Gas Lift-Off Seal".
- In a Gas Lift-Off seal, the faces theoretically never contact. There is no fluid film between the faces and since they never contact, there is no need for it.
- A cut-away drawing of this seal will follow.



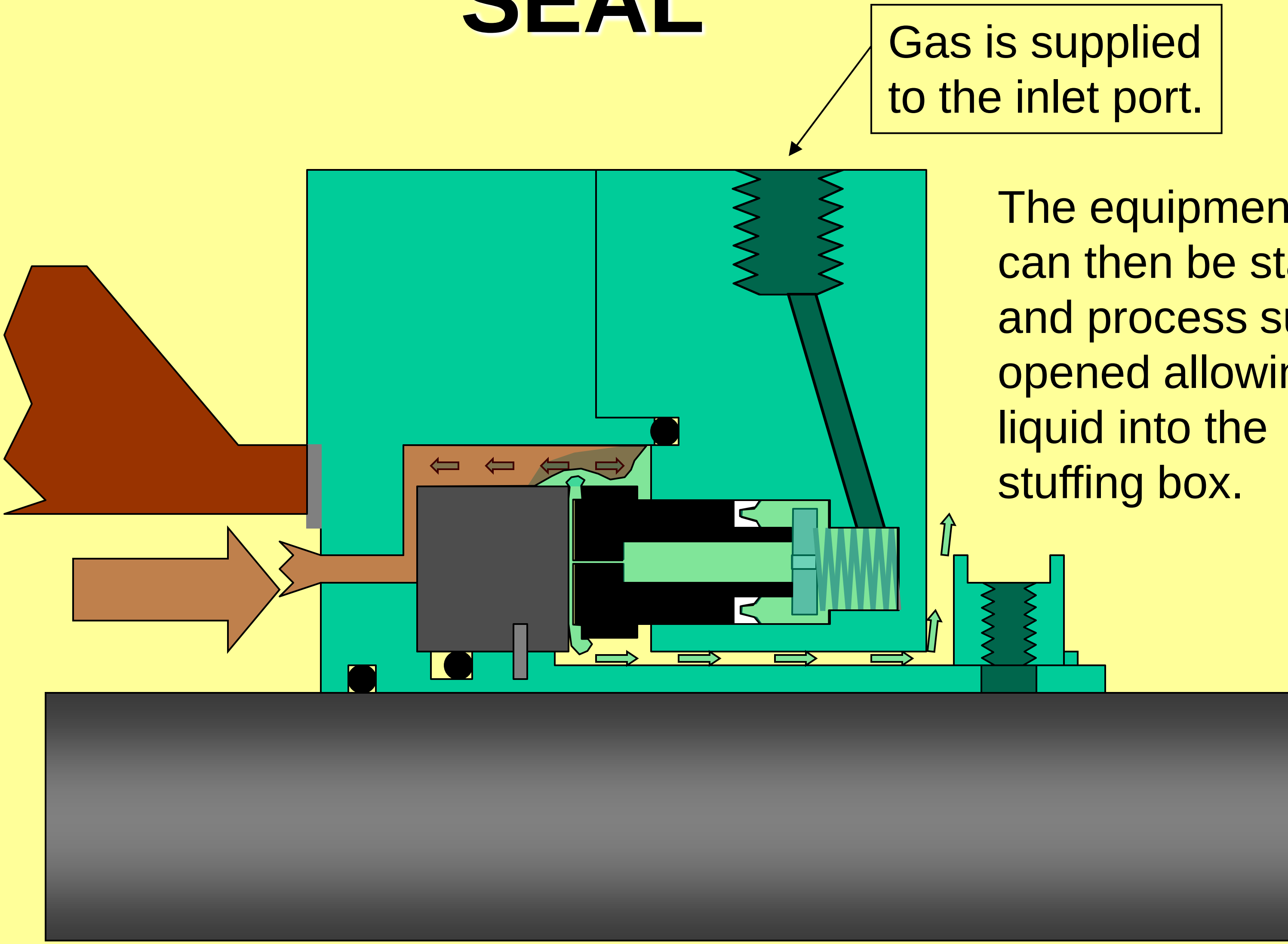
DUAL CO-AXIAL GAS SEAL

- This control panel is used to adjust the gas flow (Nitrogen, Clean Plant Air, CO_2, etc.) that is inject into the seal gland port at 25 to 30 psi. over stuffing box pressure. The gas flows through holes in the carbon stationary, separating the faces.
- As the seal operates, an envelope of gas surrounds the seal faces keeping process liquid out.

UTEX DUAL CO-AXIAL GAS SEAL



UTEX DUAL CO-AXIAL GAS SEAL



The equipment can then be started and process suction opened allowing liquid into the stuffing box.

GAS BUFFER SEALS

- More detailed discussion of Gas Seals and their application is available.

PROGRAM SUMMARY

- Through this program we have looked at the basic principles and designs of mechanical seals.
- It is important to understand that detailed explanation of each topic discussed here is available.
- Hopefully this presentation has helped to improve your understanding of mechanical seals.
- Review this program again and as you have questions, comments or suggestions, ask your supervisor or a Sealing Technologies Representative. We want this training program to be as effective as possible and your input is valuable.
- Thanks, and enjoy working with mechanical seals.

UNDERSTANDING

MECHANICAL SEALS

PROGRAM END