Seals and Packing on hydraulic systems

Introduction

Oil leakage, located anywhere in a hydraulic system, reduces efficiency and increases power losses.

Internal leakage does not result in loss of fluid from the system because the fluid returns to the reservoir. Most hydraulic components possess clearances that permit a small amount of internal leakage. This leakage increases as component clearances between mating parts increase due to wear. If the entire system leakage becomes large enough, most of the pump's output is bypassed, and the actuators will not operate properly.

External leakage represents a loss of fluid from the system. In addition, it is unsightly and represents a safety hazard. Improper assembly of pipe fittings is the most common cause of external leakage. Overtightened fittings may become damaged, or vibration can cause properly tightened fittings to become loose.

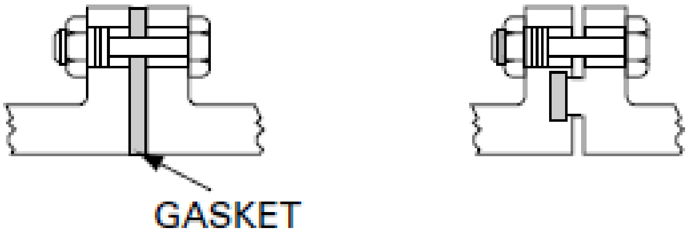
Shaft seals on pumps and cylinders may become damaged due to misalignment or excessive pressure. Seals are used in hydraulic systems to prevent excessive internal and external leakage and to keep out contamination. Seals can be of <u>the positive or non-positive type</u> and can be designed <u>for static or dynamic applications</u>.

Positive seals do not allow any leakage whatsoever (external or internal).

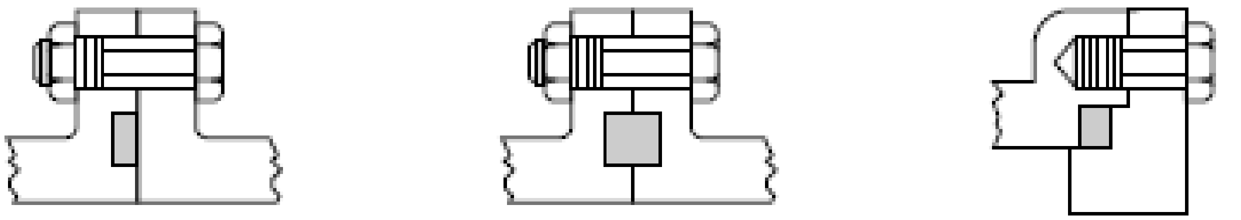
Non-positive seals (such as the clearance used to provide a lubricating film between a valve spool and its housing bore) permit a small amount of internal leakage.

Static seals are used between mating parts that do not move relative to each other. Next figure shows some typical examples, which include flange gaskets and seals. Note that these seals are compressed between two rigidly connected parts. They represent a relatively simple and non-wearing joint, which should be trouble-free if properly assembled. A number of die-cut gaskets used for flange type joints.

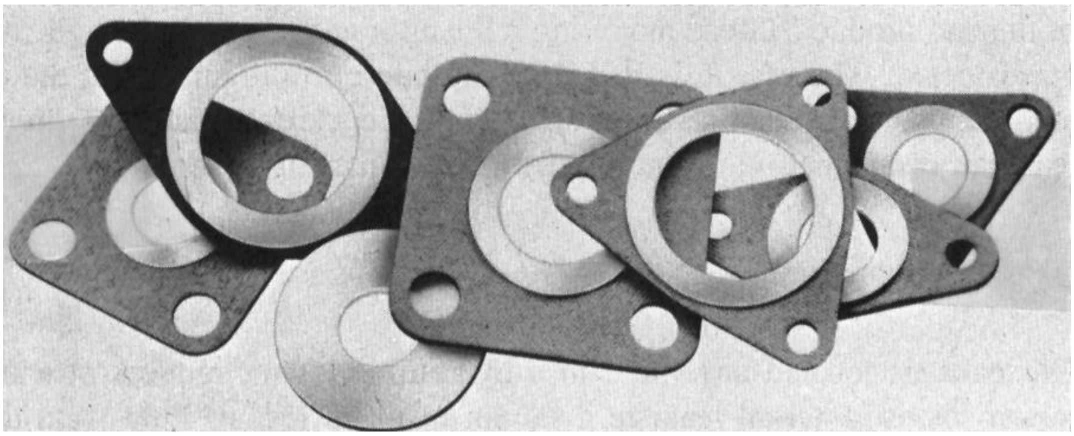
BASIC FLANGE JOINTS



METAL-TO-METAL JOINTS



Static seal flange joint applications.



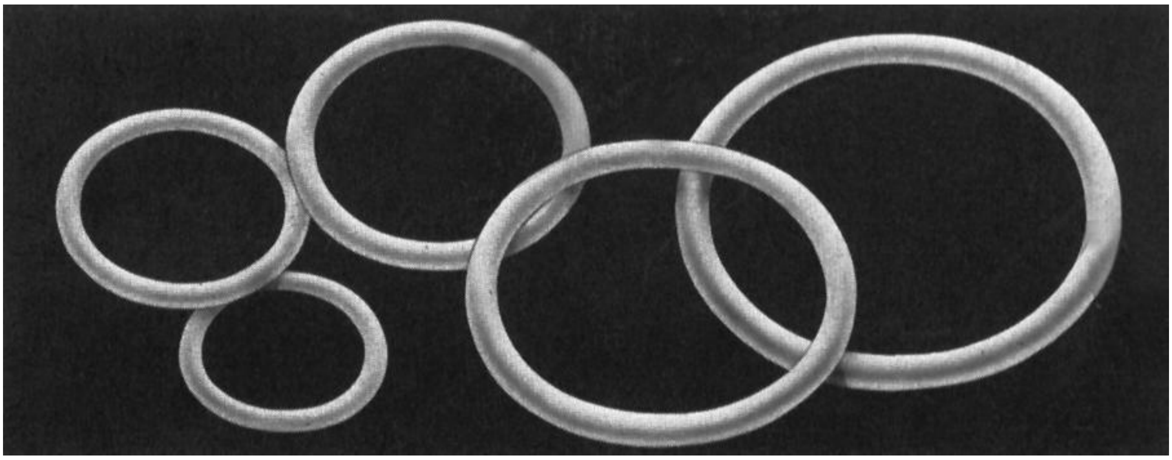
Die-cut gaskets used for flanged joints.

Dynamic seals are assembled between mating parts that move relative to each other. Hence, dynamic seals are subject to wear because one of the mating parts rubs against the seal. The following represent the most widely used types of seal configurations:

1. O-rings
2. Compression packings (V- and U-shapes)
3. Piston cup packings
4. Piston rings
5. Wiper rings

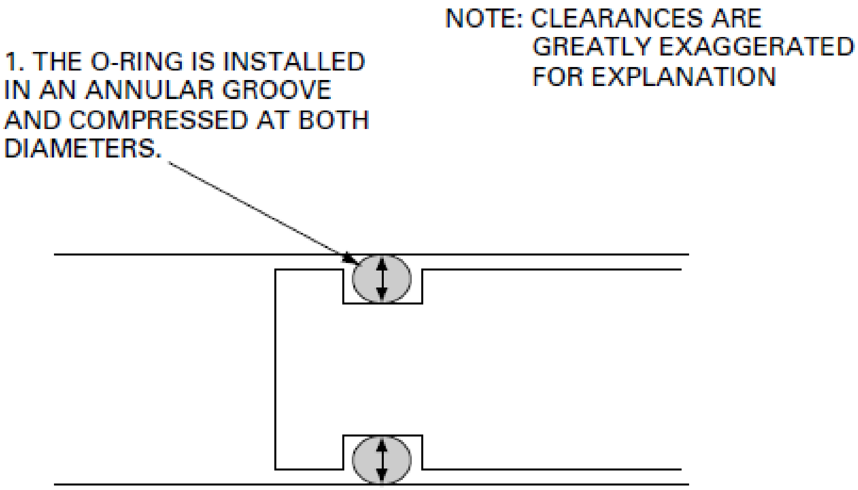
1. O-Rings

The O-ring is one of the most widely used seals for hydraulic systems. It is a molded, synthetic rubber seal that has a round cross section in its free state, for several different-sized O-rings, which can be used for most static and dynamic conditions. These O-ring seals give effective sealing through a wide range of pressures, temperatures, and movements with the added advantages of sealing pressure in both directions and providing low running friction on moving parts.



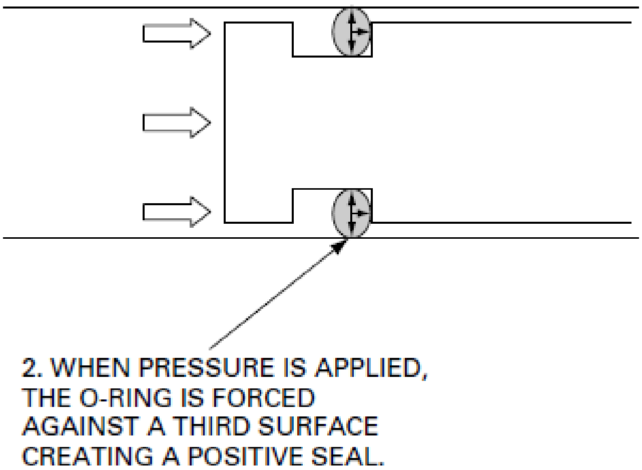
Several different-sized O-rings.

In the next figure, an O-ring is installed in an annular groove machined into one of the mating parts. When it is initially installed, it is compressed at both its inside and outside diameters.



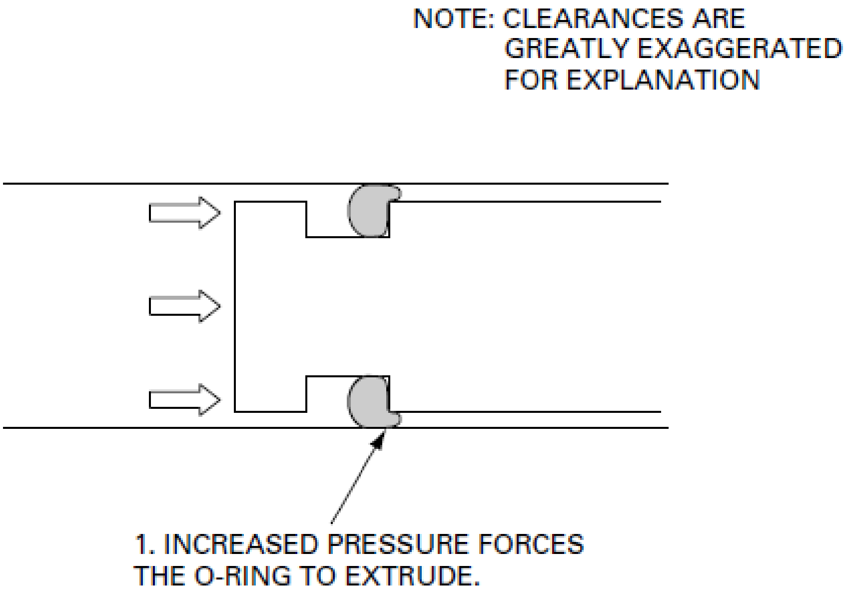
O-ring operation.

When pressure is applied, the O-ring is forced against a third surface to create a positive seal. The applied pressure also forces the O-ring to push even harder against the surfaces in contact with its inside and outside diameters. As a result, the O-ring is capable of sealing against high pressures. However, O-rings are not generally suited for sealing rotating shafts or where vibration is a problem.

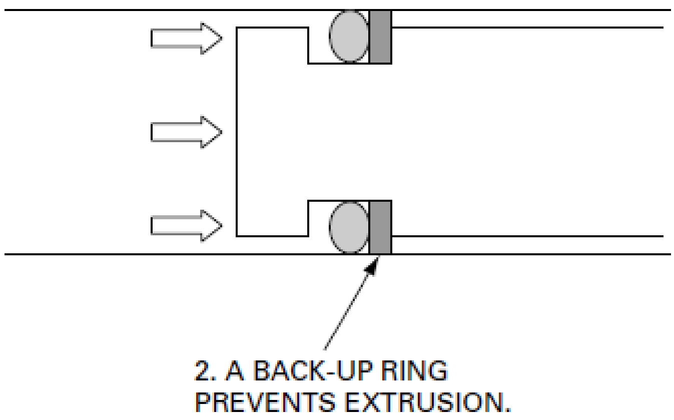


O-ring operation.

At very high pressures, the O-ring may extrude into the clearance space between mating parts. This is unacceptable in a dynamic application because of the rapid resulting seal wear.



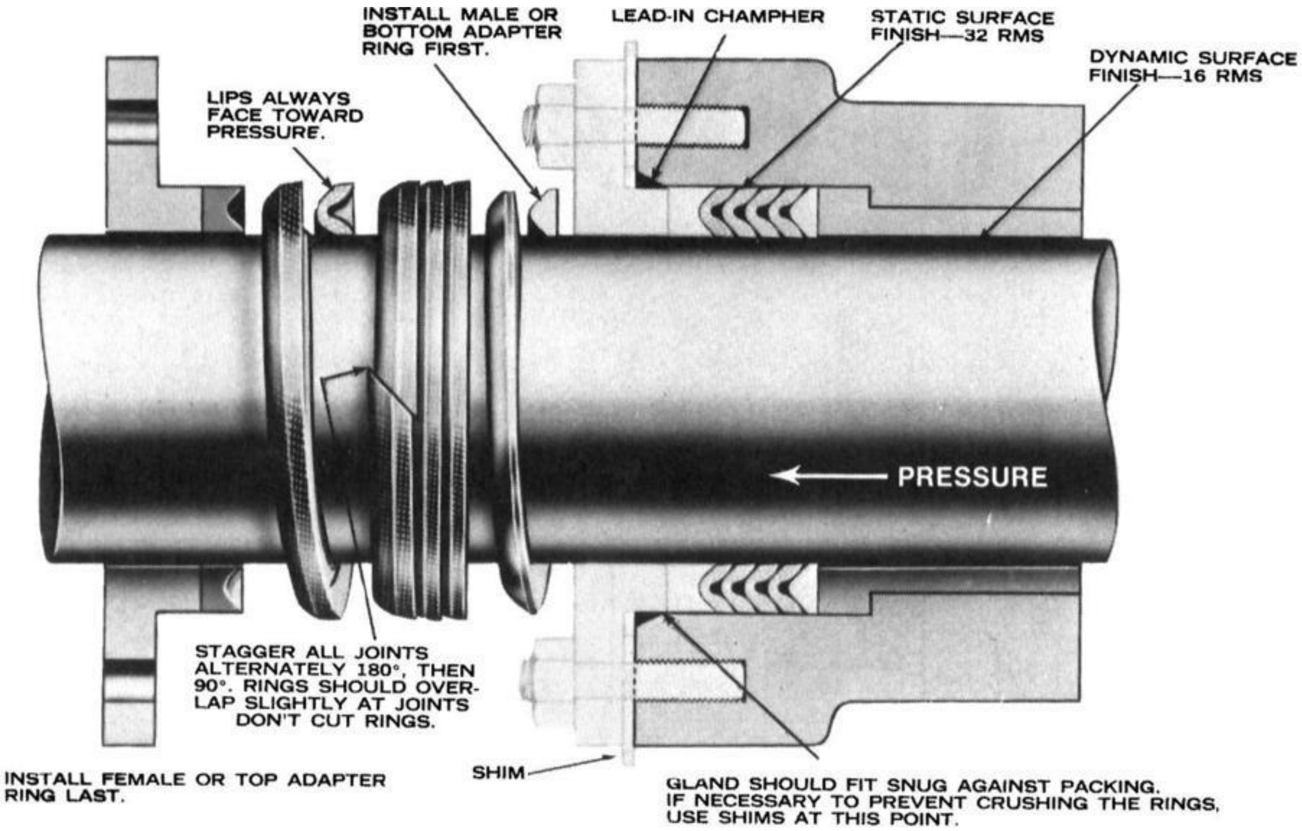
This extrusion is prevented by installing a backup ring. If the pressure is applied in both directions, a backup ring must be installed on both sides of the O-ring.



Backup ring prevents extrusion of O-ring.

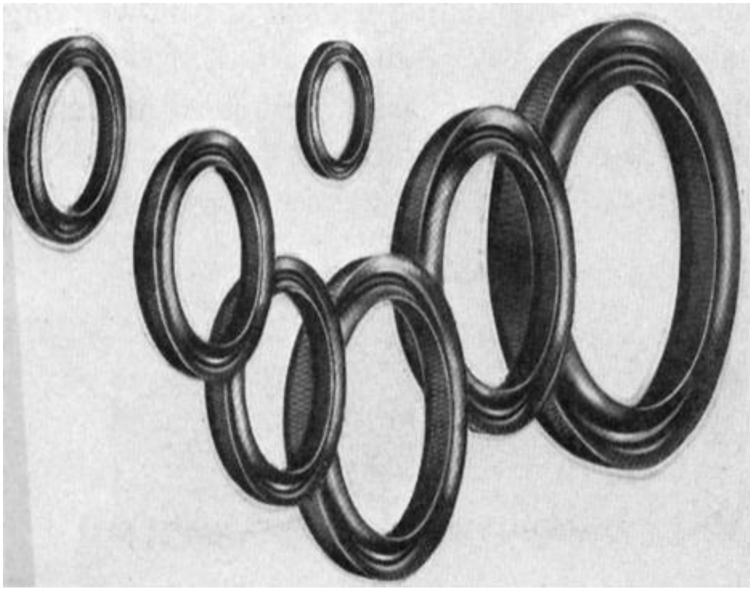
2. Compression Packings

V-ring packings are compression-type seals that are used in virtually all types of reciprocating motion applications. These include rod and piston seals in hydraulic and pneumatic cylinders, press rams, jacks, and seals on plungers and pistons in reciprocating pumps. They are also readily suited to certain slow rotary applications such as valve stems. These packings (which can be molded into U-shapes as well as V-shapes) are frequently installed in multiple quantities for more effective sealing. These packings are compressed by tightening a flanged follower ring against them. Proper adjustment is essential since excessive tightening will hasten wear.

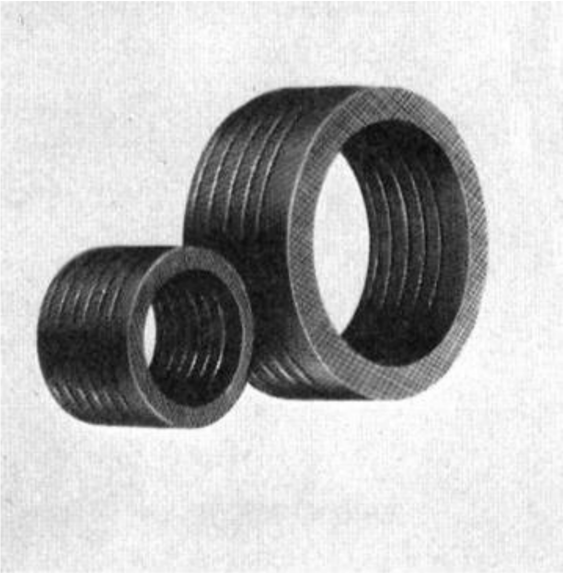


Application of V-ring packings.

In many applications these packings are spring-loaded to control the correct force as wear takes place. However, springs are not recommended for high-speed or quick reverse motion on reciprocating applications.



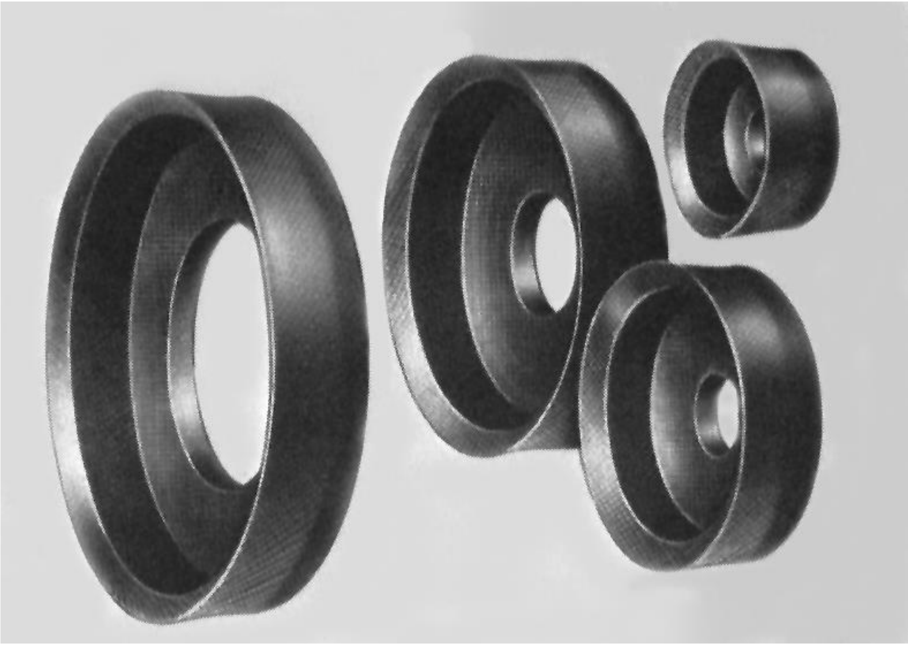
Several different-sized V-ring packings.



Two different-sized sets of V-ring packings stacked together.

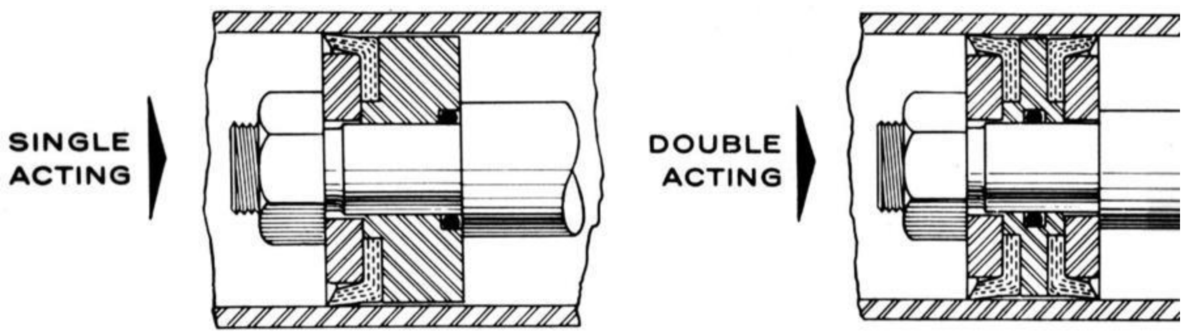
3. Piston Cup Packings

Piston cup packings are designed specifically for pistons in reciprocating pumps and pneumatic and hydraulic cylinders. They offer the best service life for this type of application, require a minimum recess space and minimum recess machining, and are simply and quickly installed.



Several different-sized piston cup packings.

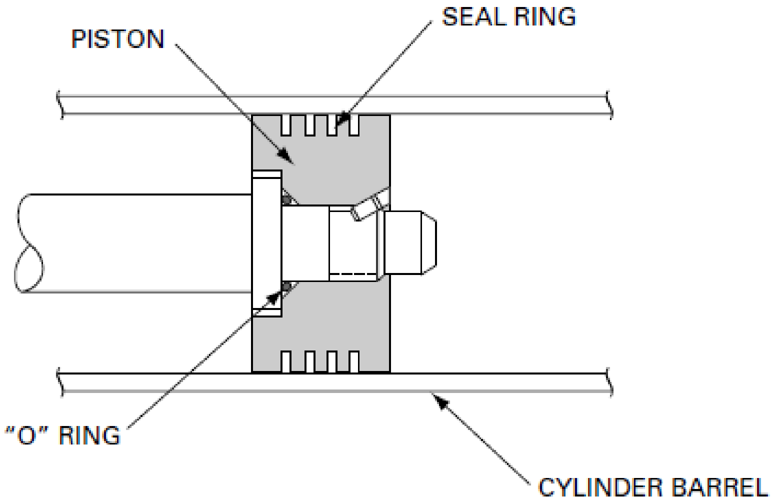
Next figure shows the typical installation for single acting and double-acting operations. Sealing is accomplished when pressure pushes the cup lip outward against the cylinder barrel. The backing plate and retainers clamp the cup packing tightly in place, allowing it to handle very high pressures.



Typical applications of piston cup packings.

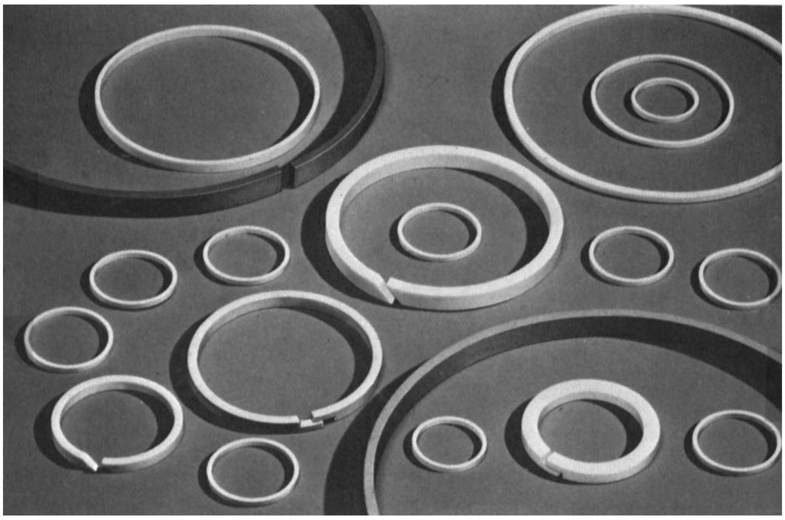
4. Piston Rings

Piston rings are seals that are universally used for cylinder pistons. Metallic piston rings are made of cast iron or steel and are usually plated or given an outer coating of materials such as zinc phosphate or manganese phosphate to prevent rusting and corrosion. Piston rings offer substantially less opposition to motion than do synthetic rubber (elastomer) seals. Sealing against high pressures is readily handled if several rings are used.



Use of piston rings for cylinder pistons.

Figure shows a number of nonmetallic piston rings made out of tetrafluoroethylene (TFE), a chemically inert, tough, waxy solid. They have an extremely low coefficient of friction of 0.04 that permits them to be run completely dry and at the same time prevents scoring of the cylinder walls. This type of piston ring is an ideal solution to many applications where the presence of lubrication can be detrimental or even dangerous. For instance, in an oxygen compressor, just a trace of oil is a fire or explosion hazard.



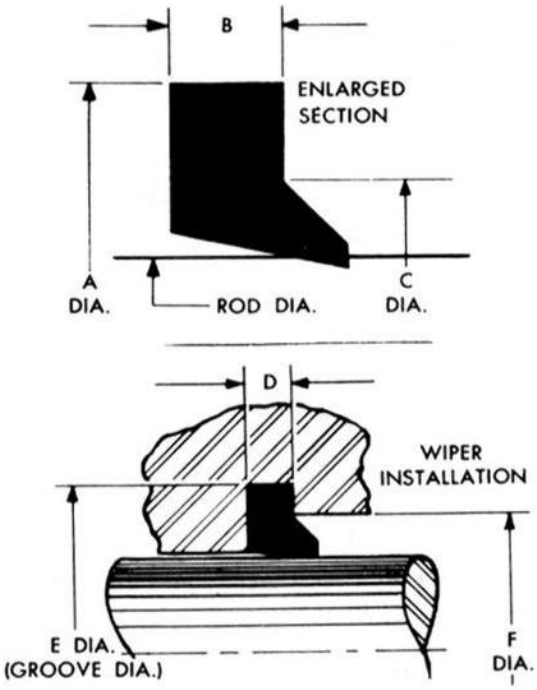
TetraFluoroEthylene (TFE) nonmetallic piston rings.

5. Wiper Rings

Wiper rings are seals designed to prevent foreign abrasive or corrosive materials from entering a cylinder. They are not designed to seal against pressure. They provide insurance against rod scoring and add materially to packing life.

Several different-sized wiper rings.

Next figure shows a typical installation arrangement. The wiper ring is molded from a synthetic rubber, which is stiff enough to wipe all dust or dirt from the rod yet pliable enough to maintain a snug fit. The rings are easily installed with a snap fit into a machined groove in the gland. This eliminates the need for and expense of a separate retainer ring.



Installation arrangement

Natural rubber is rarely used as a seal material because it swells and deteriorates with time in the presence of oil. In contrast, synthetic rubber materials are compatible with most oils. The most common types of materials used for seals are leather, Buna-N, silicone, neoprene, tetrafluoroethylene, viton, and, of course, metals.

1. Leather. This material is rugged and inexpensive. However, it tends to squeal when dry and cannot operate above 200°F, which is inadequate for many hydraulic systems. Leather does operate well at cold temperatures to about -60°F.

2. Buna-N. This material is rugged and inexpensive and wears well. It has a rather wide operating temperature range (-50°F to 230°F) during which it maintains its good sealing characteristics.

3. Silicone. This elastomer (a natural or synthetic polymer having elastic properties) has an extremely wide temperature range (-90°F to 450°F). Hence, it is widely used for rotating shaft seals and static seals where a wide operating temperature is expected. Silicone is not used for reciprocating seal applications because it has low tear resistance.

4. Neoprene. This material has a temperature range of -65°F to 250°F. It is unsuitable above 250°F because it has a tendency to vulcanize (harden (rubber or a similar material) by treating it with sulfur at a high temperature.).

5. Tetrafluoroethylene. This material is the most widely used plastic for seals of hydraulic systems. It is a tough, chemically inert, waxy solid, which can be processed only by compacting and sintering. It has excellent resistance to chemical breakdown up to temperatures of 700°F. It also has an extremely low coefficient of friction. One major drawback is its tendency to flow under pressure, forming thin, feathery films. This tendency to flow can be greatly reduced by the use of filler materials such as graphite, metal wires, glass fibers, and asbestos.

6. Viton. This material contains about 65% fluorine. It has become almost a standard material for elastomer-type seals for use at elevated temperatures up to 500°F. Its minimum operating temperature is -20°F.

Reducing oil leakage

Hydraulic fluid leakage can occur at pipe fittings in hydraulic systems and at mist-lubricators in pneumatic systems. This leakage represents an environmental issue because the federal Environmental Protection Agency (EPA) has identified oil as a hazardous air pollutant. To resolve this issue, the fluid power industry is striving to produce zero-leakage systems. New seals and fittings are being designed that can essentially eliminate oil leakage. In addition, prelude and non-lube pneumatic components are being developed to eliminate the need for pipeline-installed lubricators and thus prevent oil-mist leaks.