Compressor Valves and Unloaders for Reciprocating Compressors - An OEM's Perspective

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Reciprocating compressors play a major role in the chemical, petrochemical, gas, and general industry processes. Therefore, the focus by many users over the past several years has been increased production profits realized through increased availability and decreased maintenance and lost production areas that affect compressor reliability the most. Figure I is a result of surveys taken at many different customers:

Dresser-Rand recently conducted an industry investigation to identify and evaluate the factors that contribute to unscheduled shutdowns of reciprocating compressors. An important result of this investigation is summarized below in Figure 1.

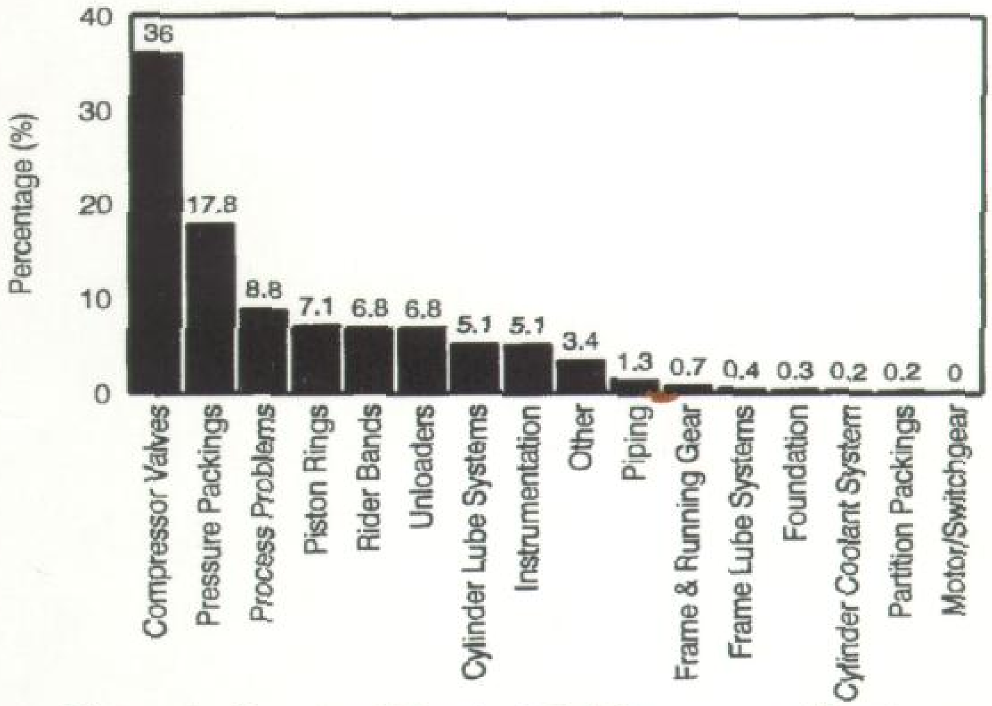

Figure 1. Causes of Unscheduled Compressor Shutdowns

As illustrated, compressor valves and cylinder unloaders were identified to be two of the top six causes of unscheduled reciprocating compressor shutdowns.

Designing and applying compressor valves and unloaders to yield good efficiency and reliability can be complex due to the many factors that can affect performance. A designer must understand the flow of gas through the valves, the way the valves operate in the compressor, and how reliability can be affected under a wide range of different gases and operating conditions. This paper presents a current overview of compressor valve and unloader design and application details proven to help improve compressor valve and unloader reliability.

How A Compressor Works

Before discussing the reliability of the compressor valves, it is important to understand how a reciprocating compressor works. The operation of the compressor is best illustrated with a pressure-volume (PV) diagram, as described below:

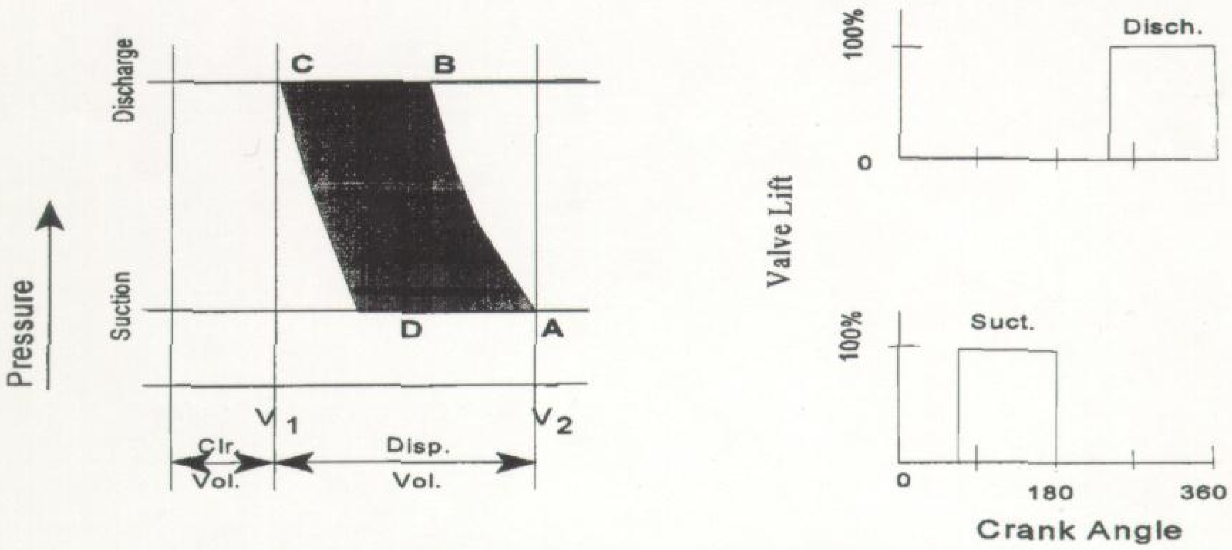

Figure 2. Ideal Pressure Volume and Spring Motion Diagrams

In the diagram, VI represents the total volume in the compressor cylinder when the piston is at top dead center, and V2 represents the volume when the piston is at bottom dead center. The clearance volume is represented by the area between the origin and VI, and the displaced (or swept) volume is represented by the area between VI and V2. Suction and discharge pressures are shown on the vertical axis.

The motion of the valves springs as the compressor valve opens and closes is also shown in Figure 2. Like the PV diagram, this represents ideal spring motion.

When the compressor piston is at point A, both the suction and discharge valves are closed, the piston is at bottom dead center, and the cylinder is full of gas at suction pressure. Piston motion compresses the gas to point B where it reaches discharge pressure. The discharge valve opens instantly to full lift as shown in the valve motion diagram. Gas is discharged into the system from points B to C until the discharge valve closes at point C. A volume of gas equal to the clearance volume remains in the cylinder at discharge pressure. As the piston moves to point D, this gas expands and falls to suction pressure at point D. The suction valve now opens instantly to its full lift, and gas flows into the cylinder from point D to A, where the suction valve closes.

Two important measurements are related to the PV diagram:

- The ideal horsepower required for the compression process is represented by the shaded area "ABCD".
- The ratio between the volume of gas that enters the cylinder (point D to point A) to the swept volume (VI to V2) is referred to as the inlet volumetric efficiency.

Inherent horsepower losses are associated with real compressors, so ideal PV diagrams are never obtained. Actual PV diagrams and lift motion diagrams demonstrate that valves do not open and close instantly, nor do the moving valve elements stay fully open throughout the stroke.

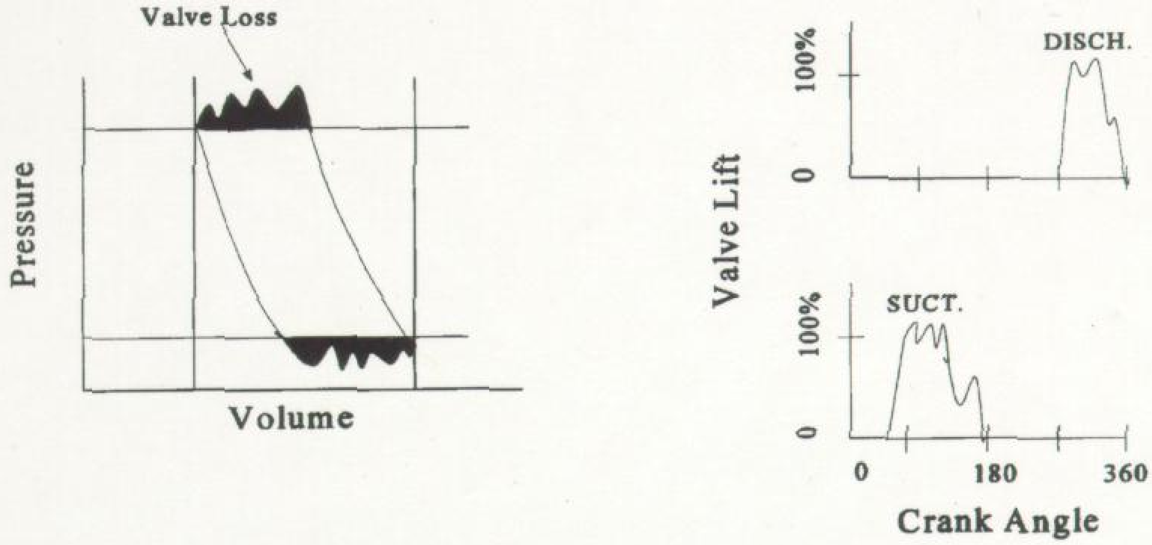

Figure 3. Realistic Pressure Volume Diagrams

The shaded areas in this figure represent the horsepower losses associated with gas flowing through the compressor valves. It is proper recognition of these losses that is the key to accurate performance predictions.

Cylinder pressure must exceed discharge line pressure in order for the discharge valve to open during the compression stroke, and suction line pressure must exceed gas pressure in the cylinder for the suction valve to open on the expansion stroke. When the valve opens, the moving element pushes against the springs.

There are other factors that affect the performance of compressor valves:

- There must be a sufficient number of valves installed in a compressor cylinder to effectively allow gas flow into and out of the cylinder efficiently.
- Valve materials must be properly selected to be compatible with the constituents in the gas stream. This is especially important when corrosives are present.
- Valves in lubricated cylinders are subject to sticktion, an adhesion of the valve elements to the seat and guard, which might delay the opening or closing of the element which can be detrimental to performance and valve reliability.
- Dirt and debris can prevent the valve from properly functioning.
- Pulsations in the inlet and discharge gas piping can alter the timing of the valve motion and decrease efficiency and reliability.

The first step in applying a valve is to select the proper valve type, materials, and pressure rating. This is determined by the pressure rating of the cylinder and the differential between the suction and discharge operating pressures, the speed of the compressor, the operating temperatures, and whether the cylinder is lubricated or non lubricated.

The second step in applying a valve is the selection of the lift. The lift is the distance that the moving elements travel from its closed position (against the seat) until fully open (against the guard). There must be sufficient pressure drop across the valve for it to open and close properly and work reliably. Too high a lift will cause the pressure drop to be too low, and the valve elements are more prone to the effects of pulsations and sticktion. Additionally, higher lifts will cause higher impact velocities on the seat and guards, which tends to decrease reliability (as illustrated in Figure 4). Conversely, a lift that is too low will cause excessive horsepower losses that result in inefficient operation. The major influence on the lift is the molecular weight of the gas being compressed. Heavier gases require a higher lift.

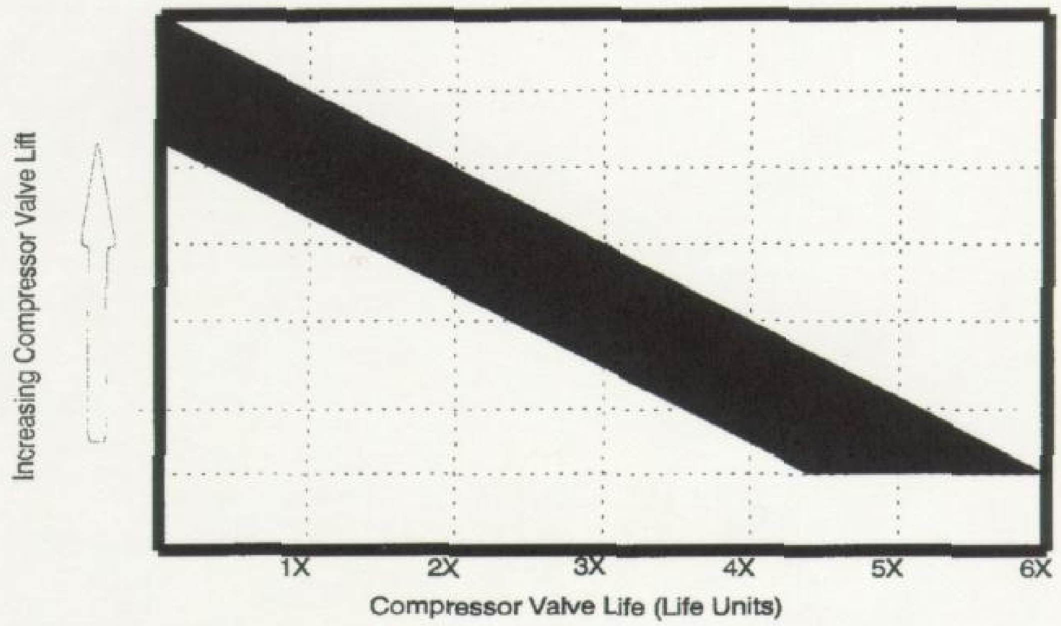

Figure 4. Affects Of Lift On Valve Life

The final step in the valve selection process is ensuring the correct spring stiffness. Valve springs are required to ensure that the moving element closes prior to the piston reaching the end of the stroke. If a spring is too stiff, the valve will flutter. A valve that flutters moves between an open and closed position, and is on average only part open. Thus, the true flow area of the valve will only be a percentage of the full flow area, which increases the horsepower requirement. This will also increase the wear rate on the valve components. An early closing of the element is another symptom of a heavy spring. This will reduce the amount of gas compressed, and decrease the capacity. If a spring is too light, the moving element will close late and the reverse flow of the gas through the valve will cause the moving elements to close at a much higher velocity, decreasing the life of the moving elements and reducing capacity. Thus, the optimum spring stiffness for the application must be selected to maximize reliability and efficiency of the valves.

Valve Materials

Seat and Guard Material:

Seats and guards are generally made from the same material. The selection of this material is important because the seats and outer rim of the suction valve guard are subjected to stresses. These stresses vary with the cylinder pressure throughout the compression cycle. Weaker materials require the seat to be thicker. Thicker seats increase the discharge valve clearance, which in turn increases the cylinder clearance, and reduces the amount of gas the cylinder will compress. Stronger materials will allow for thinner seats and eliminates this problem.

The seat is primarily susceptible to wear from the moving elements contacting the sealing surface. The guard is susceptible to wear from the springs cycling in the spring pockets. The material selected must be hard enough to combat this wear.

Many seats and guards are castings, usually nodular iron, which allow complex geometries that help reduce losses. Others are fully machined from bar stock. This allows for use of a wide range of materials, which gives a designer greater flexibility in adapting to many different applications. It also eliminates the possibility of finding porosity while machining the part.

The most common materials for non-corrosive environments are nodular iron and low carbon steel. For small quantities of hydrogen sulfide, nodular iron is preferred over steel because there is less chance of corrosion cracking. For highly corrosive environments, 17-4 PH or 300 series stainless are used.

Spring Materials:

The spring is the most highly stressed component of the compressor valve, and is typically the largest cause of valve failures.

The spring material should have a high stress limit, resist taking a set at normal compressor operating temperatures, and able to withstand corrosion in the gas.

Chrome silicon and chrome vanadium have very good mechanical properties, are available in spring quality wire, and will not take a set at normal compressor operating temperatures. While these materials have poor corrosion resistance, they have been known to provide acceptable service in small concentrations of corrosives in lubricated cylinders.

Hastelloy and Inconel are commonly used in corrosive applications. They have good corrosion resistance when designed at stress levels acceptable for the material, but are relatively weak in dynamic applications. These materials have low mechanical properties and good quality wire is not generally readily available. High cobalt materials such as Elgiloy and MP35N are also used in corrosive environments. These materials have good corrosion resistant properties and better mechanical properties than Hastelloy or Inconel, but are also more expensive.

Moving Element Materials:
The moving elements are subject to corrosives and high stress levels, but are also subject to high impacts against the guard when they open, and against the seat when they close. Therefore, material selection is very important to the success of the valve. This is where the most significant improvements affecting valve reliability have been made over the last decade.

Early valve designs used metallic plates which are inexpensive, able to withstand high differential pressures, and are not affected by high temperatures. However, these desirable properties are outweighed by the disadvantages of metallic elements. They are prone to impact fatigue, susceptible to corrosion damage and are very unforgiving of dirt and debris.

In the 1960s, plastic elements emerged and began to replace metallic elements. Plastic materials offer several advantages over metallic elements:

- They are able to withstand higher impact velocities than metal plates. This allows them to be applied at higher lifts and speeds, and makes them more tolerant of liquids that are often present in the gas.
- They are resistant to most corrosive elements commonly found in process gas streams.
- As a plastic element cycles in the valve, it will form to the contours of the seat and provide a better seal.
- Plastics can be easily applied in non lubricate machines because they can operate against metallic parts without causing excessive wear.
- Plastic elements help reduce wear on the seat, so seats do not have to be reconditioned or replaced as frequently.
- Small pieces of dirt or metal can embed in a plastic element without causing a failure.
- A plastic element that breaks and falls into the cylinder is less likely to do damage to other components such as the cylinder liner, piston rings, and rider bands.

In the 1970s, Nylon was the material of choice for valve elements. By the mid 1980s, PEEK (**P**oly **E**ther **E**ther **K**etone) was introduced and is currently the most commonly used material for valve elements.

Pure ***nylon*** is too weak to withstand the discharge temperatures of most compressors. There are many different glasses and sizes of fiber used for reinforcement, but is usually supplied with 30% of chopped glass fibers. It is essential that the fibers adhere to the nylon, so coupling agents are generally used to ensure that this occurs.

Nylon plates tend to change their shape in service by swelling or distorting. To reduce the effects of moisture absorption, uneven fiber orientation, thermal expansion, and molded-in stress, close control of manufacturing processes is required. Proper drying, machining, heat treating, and molding practices are critical in reducing distortion. Designing a valve with clearances that allow for thermal expansion is also recommended.

PEEK offers several advantages over nylon:

- PEEK has temperature thresholds that ensure retention and stability of load-bearing properties and dimensions at high temperatures. This provides more reliable performance.
- Tensile, flexural, and compressive strengths are maintained at high temperatures.
- It resists flex fatigue.
- It has lower water absorption rates to ensure dimensional integrity.
- It resists deformation at high temperatures.

PEEK is very difficult to mold. The molding temperature is 635° F, and controlling this temperature throughout the process is critical. Too low a temperature will lead to a high viscosity and the mold will not be filled properly. Too high a temperature will cause the resin to oxidize and form particles referred to as "char" which reduces the strength of the material.

PEEK is a more expensive material, so many manufactures will use regrind or a lower viscosity resin. "Regrind" is waste material that is ground back into a powder and blended with virgin PEEK material, which will decrease the dynamic strength of the material. Dresser-Rand uses no "regrind" because experience shows that it greatly weakens a valve element.

A low viscosity resin called "Easy Flow" was developed to allow molding at lower pressures. Tests at room temperature showed it was as strong as standard PEEK, but dynamic tests in an endurance tester show that at low impact velocities, Easy Flow plates fail by brittle fracture. As a result, "easy flow"' is not used in Dresser-Rand valve elements.

<u>Common Causes of Valve Failures</u>

High Impact Velocity On The Guard:
During each compression cycle, the moving elements impact against the guard. Tests have shown that as the impact velocity increases, the number of cycles to failure will decrease. Experience has shown that the allowable impact velocity for non-metallic elements is generally twice the allowable impact velocity of metallic elements.

The impact velocity is determined by the application. High compressor speeds, high operating pressures, and higher lifts tend to cause higher impacts.

High Impact Velocity On The Seat:
Like impacts on the guard, the moving element also impacts on the seat during each compression cycle. Again, the critical velocity is determined by the material, and plastic elements can withstand nearly double the impact of metallic elements.

The impact against the seat is determined by the spring stiffness used to close the element. A spring that is too light will cause the element to close late. The reverse flow of the gas, rather than the spring, will cause the element to close. The gas pressure will close it at a much higher velocity than the spring, causing the element to "slam" against the seat. If the spring is too stiff, the valve element tends to flutter, which may cause the element to contact the seat several times during each cycle.

Sticktion is another factor that can contribute to late valve element closing. Sticktion occurs when a thin film of oil causes the moving element to stick to the seat or guard. If the spring is not stiff enough to provide the extra force it now takes to close the element when it is fully open against the guard, it will close late with excessive impact velocity against the seat. If seat sticktion is excessive, the pressure force opening the moving elements will build, and will cause excessive impact velocities against the guard when the valve opens.

Seat impact failures are characterized by chipping on the outside edge of plastic elements, and cracks that begin on the outside edge of metal elements.

Wear:
A certain amount of wear in a compressor valve is unavoidable because the valve has moving parts that impact and slide against one another. Wear rates in a non-lubricated service should be expected to be higher than in a lubricated machine. There are several places where wear can occur:

- Between the seat and the moving element. If metal elements are used, the wear rates of these parts will increase.
- Between the moving element and the spring.
- Between the bottom of the spring and the bottom of the spring pocket.
- Between the side of the spring and the side of the spring pocket.

The wear rates in these areas will be accelerated if there is a significant amount of dirt in the gas, if the cylinder is inadequately lubricated, by pulsations, and by flutter.

Corrosion:
Compressor valves are frequently subjected to gases with corrosive elements present. These corrosive elements can cause the moving element or the spring to fail prematurely due to corrosion related fatigue. If the gas composition is known in the design stages, then proper materials can be selected to limit the effects.

Application Conditions:
Poor gas quality often results in reduced valve reliability. Dirt and debris in the gas will cause accelerated wear, and can cause poor sealing between the moving element and the seat. In extreme conditions, the flow holes in the seat and guard can become blocked and choke off the flow of gas through the valve.

Liquids in the gas stream will also contribute to poor reliability. Large amounts of liquids will cause high impact velocities or over stressing of the moving elements. This is commonly referred to as slugging. Liquids also tend to reduce the effectiveness of lubrication.

Finally, pulsations with high amplitudes or acoustically resonant frequencies may increase stresses on the moving elements, and produce surges that can cause coil-to-coil contact on the valve springs. Valves with low pressure drops and light springs are especially susceptible to the effects pulsations.

Process Poppet Valves

Maximum Pressure Rating: 2000 psi differential/4000 psi discharge
Service: Typical speeds up to 600 RPM

Poppet valves have been used for many years in gas transmission service. With recent developments in materials, this technology has been employed very effectively and reliably in process compressor applications over the past several years.

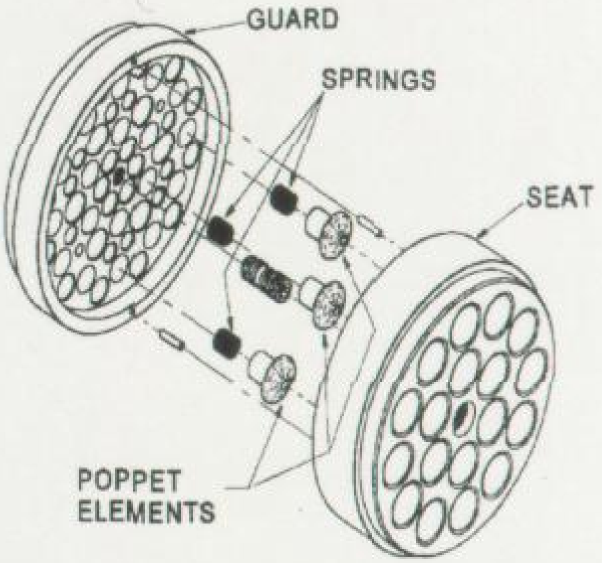

Figure 5. Process Poppet Valve

As illustrated in Figure 5, poppet valves have several identical elements each with its own spring. Dresser-Rand's process poppet valve offers the following features:

- The poppet is the same size for all valves. The number of poppets changes with valve size, but all of the poppets are identical regardless of lift and application. Fewer parts are required for inventory, which helps to lower inventory costs.
- The newly designed poppet is shaped for maximum reliability. The sloped underside of the head of the poppet provides more thickness at the point of impact. The diameter of the stem is larger, providing more area to make contact with the guard. Both of these design features, combined with large radii in critical areas leads to low bending and compressive stresses in the poppet head.
- The poppet material is HiTemp©, Dresser-Rand's special blend of PEEK. All of Dresser-Rand's PEEK parts are made from the highest quality virgin PEEK with no regrind allowed. The poppet also provides all of the advantages of a plastic moving element, including excellent resistance to corrosives, the ability to withstand higher impact velocities, and increased resistance to dirt and liquids.
- The springs used with the poppet valve have a larger diameter and free length which helps to lower fatigue stresses and extend the life of the springs.
- The process poppet valve has proven extremely successful in dirty and wet gases. Streamlined flow paths minimize the buildup of dirt and impurities that tend to collect in a plate or ring type valve. There are fewer places for dirt to gather because there are fewer edges and corners. The large vent hole at the bottom of the spring pocket allows dirt and oil to get out of the spring pocket rather than gathering and damaging the spring. Finally, the large flow holes in the seat and guard allow dirt to pass through the valve very easily.
- Lubricated and non-lubricated designs are available which allow the poppet valve to be applied in a wide range of gases and operating conditions.

- A unique centerbolt design improves safety by preventing it from falling into the cylinder bore.
- The poppet valve internals (poppets and springs) are generally interchangeable between the suction and discharge valve. This minimizes inventory and maintenance costs.
- The process poppet valve is extremely easy to recondition. Often, reconditioning of the valve involves cleaning of the seat and guard and replacement of the valve internals (poppets and springs). If there is a scratch or nick on the set bevel (sealing surface), this surface can be cleaned up using a bevel cutting tool in a conventional drill press.

HPS Valves

Maximum Pressure Rating: 4000 psi differential/8000 psi discharge
Service: Typical speeds up to 600 RPM

The HPS valve is a very versatile valve. As illustrated in Figure 6, it consists of a number of circular plates each acted on by a number of springs. The plates are guided on the diameter to hold them in position over the slots in the seat. Advantages of the HPS valve are:

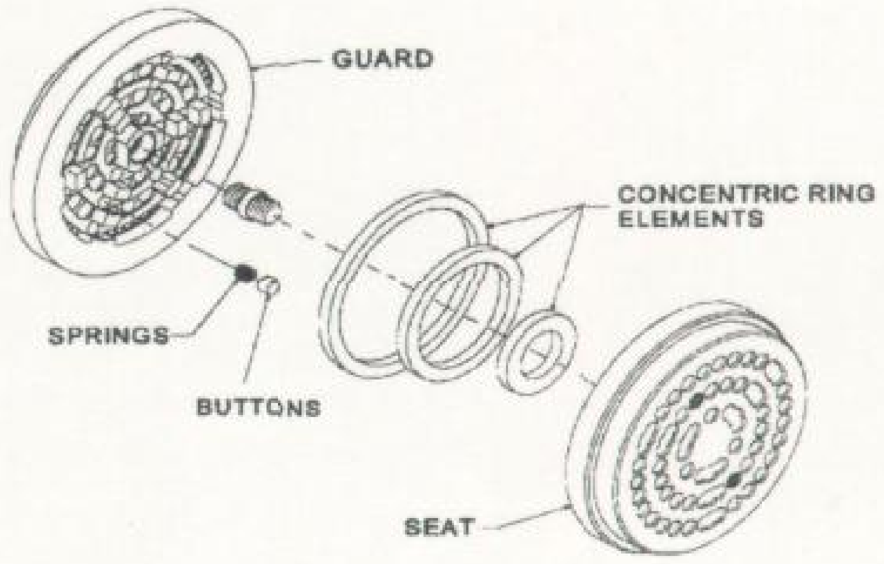

Figure 6. HPS Valve

- The rings and buttons are made of Hi-Temp© PEEK. This provides the same advantage as those described in the process poppet. Metal rings are available for high pressure or high temperature applications.

- The HPS valve has balanced flow through the seat, lift, and exit areas, creating a lower pressure drop across the valve, which limits the valve losses and increases the efficiency of the valve.

- The centerbolt is designed with a right hand thread on one half and a left hand thread on the other half. This allows it to be fully contained within the valve. There is a blind hole in the seat and the hole in the guard is not tapped the whole way through, so if the centerbolt were to break, it would not be allowed to fall into the bore and cause secondary damage to the liner, rings, or rider bands.

- The valve internals (rings, springs, and buttons) are generally interchangeable between the suction and discharge valve which minimizes inventory and maintenance costs.

- Lubricated and non-lubricated designs are available to allow the HPS valve to be applied in a wide range of gases and operating conditions.

PF Valves

Maximum Pressure Rating: 3000 psi differential/6000 psi discharge
Service: Typical speeds up to 1800 RPM

The PF valve is a ported plate type valve. Like the HPS valve, the PF is very versatile and can be used in many different applications. The ported plate valve is similar to the concentric ring valve except the rings are joined together by radial ribs to form a single plate. As illustrated in Figure 7, several coil springs make direct contact with the bottom of the plate eliminating the buttons on top of the springs. This is an advantage as the compressor speeds get higher because the button can build up momentum and "overshoot," causing coil-to-coil contact in the spring.

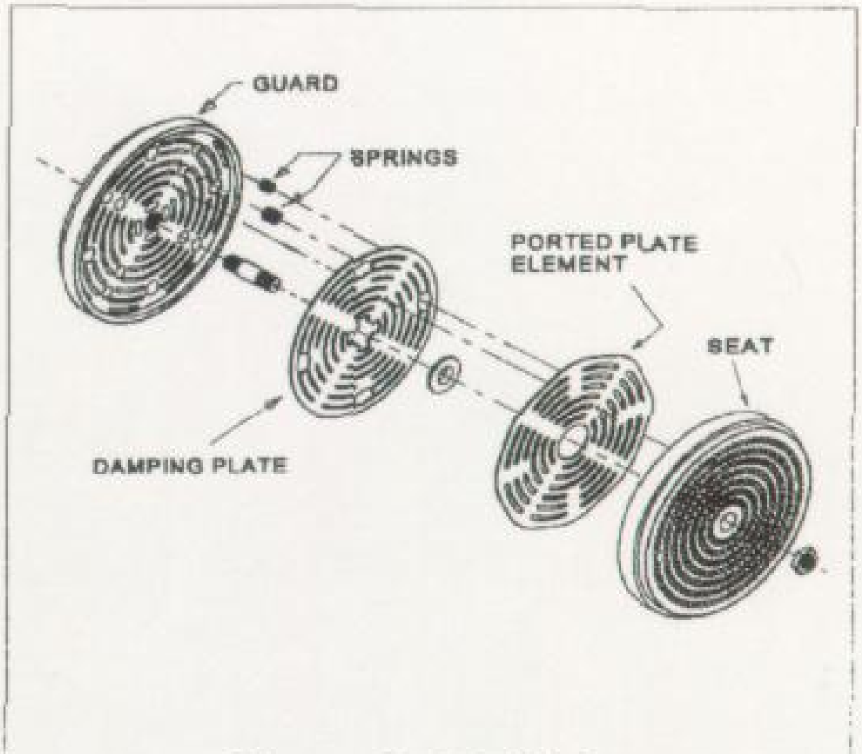

Figure 7. PF Valve

Advantages of the PF valve are:

- The PF valve uses a patented scalloped plate (as illustrated in Figure 8). Since the plate rarely travels parallel to the seat, the outside edge of the plate makes the initial contact on impact. This results in high stresses on the outer edge, and the plate cracks -- the most common cause of failure in a plate valve.

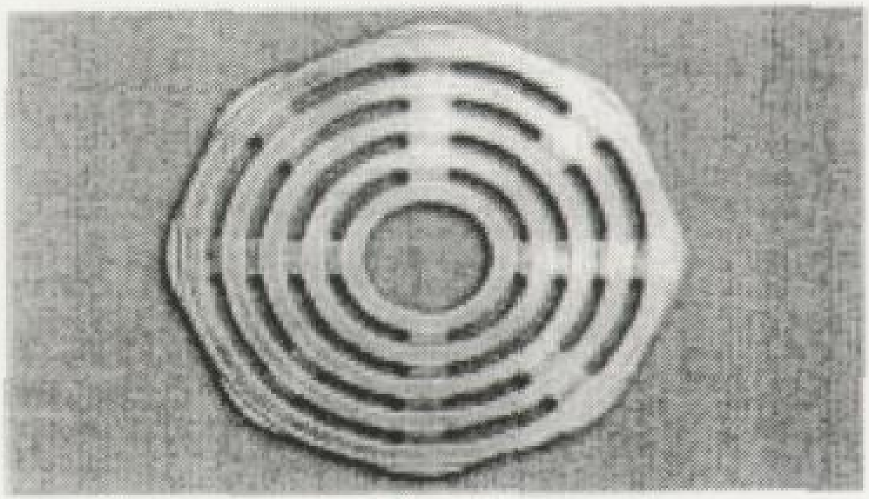

Figure 8. Scalloped Plate

- Scallops added to the outside edge of the plate on the radial ribs increase the cross sectional where the plate makes it impact. As a result the plate is strengthened by the scallops and the ribs, and the possibility of a plate failure is reduced. Consequently, impact failures of scalloped plates have become rare.

- Hi-Temp© PEEK plates.

- The PF valve at lower lifts has flow area equal to concentric ring and process poppet valves at higher lifts. Limiting the lift is very important in a high speed compressor because the valve opens and closes many times more than in a slower speed machine.

- Lubricated and non-lubricated designs are available so that the PF can be applied in a wide range of gases and operating conditions.

- Valve internals (plates and springs) are generally interchangeable between suction and discharge valves which minimizes inventory and maintenance costs.

Poppet Valves for Gas Transmission

Maximum Pressure Rating: 400 psi differential/1000 psi discharge
Service: Typical speeds up to 330 RPM

Poppet valves were originally developed for use in gas transmission applications. This generally involved slow speeds, low temperatures, and very low compression ratios. Because the ratios are so low, it is very important to limit the valve losses. This is done by building in extremely high lifts. This is possible because the slow speeds and low pressures create lower impact velocities, so the strength of the poppet is not compromised.

Besides the lift, the difference between the process poppet valve and the pipeline poppet valve is the poppet element itself. Due to the low impact velocities, the pipeline poppet has a smaller diameter stem. Also, the material of the poppet is nylon because the operating pressures and temperatures are very mild and the added expense of PEEK is not necessary.

Unloaders

Unloaders are used in several instances:

- At start-up when the machine cannot be started under load

- To prevent an overload when there is an upset in operating conditions

- For capacity control when the amount of gas to be delivered is changed.

Inlet Valve Unloading:

An inlet valve unloader opens the suction port so that the gas that enters the cylinder on the suction stroke is pushed back into the inlet passage during the return stroke. This means that there will be no compression, and no gas discharged.

One style of inlet valve unloader is the finger unloader (as illustrated in Figure 9). The finger unloader has a plunger with fingers attached that fit into the seat of the valve. To unload the cylinder, the fingers push and hold open the moving element in the suction valve. During the compression stroke, the gas in the cylinder is pushed through the open valve elements and back into the inlet passage.

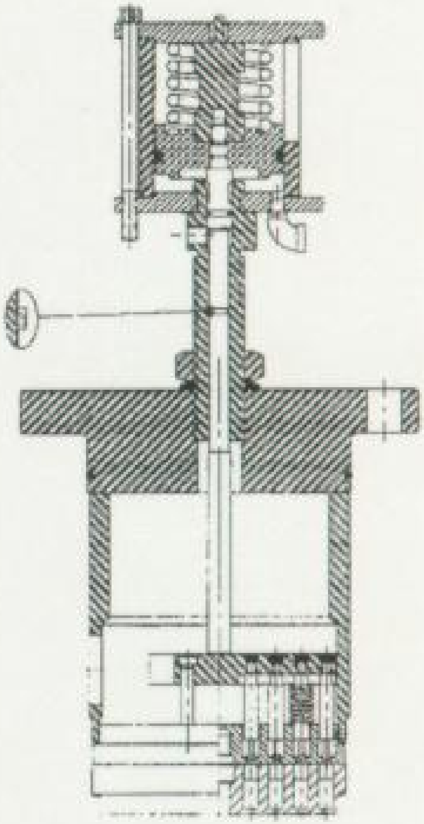

Figure 9. Finger Unloader

The other style of inlet valve unloader is the port/plug unloader (as illustrated in Figure 10). This type of unloader uses a valve blank (port unloader) or a special partial valve (plug unloader) with a hole in the center of it. The partial valve has one or more rings of the moving elements outside of this hole. The unloader has a sleeve at the bottom which seals that hole when the cylinder is loaded. To unload the cylinder, the hole in the center of the valve is opened, and the gas in the cylinder is pushed out that hole during the compression stroke.

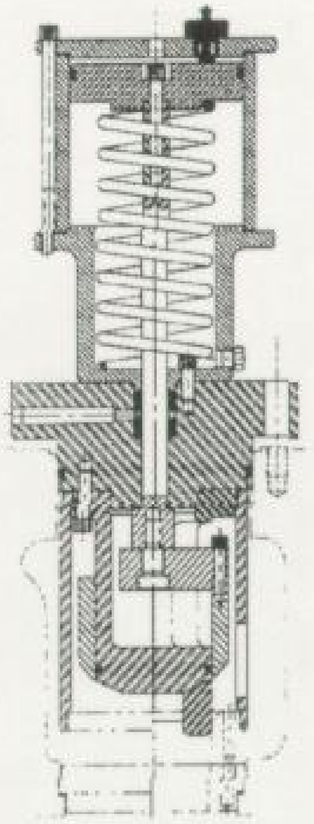

Figure 10. Port Unloader

The advantages of the Dresser-Rand port/plug unloader are numerous:

- The sleeve style unloader valve has minimal area exposed to differential pressure which results in improved sealing with normal plant operating air pressure.
- Standardized components will reduce parts inventory and cost and improve availability.
- The unloader packing gland is an o-ring design for better gas containment. The packing gland also has venting and purge capabilities.
- The unloader spring is located in the operator, removed from the gas stream, so it cannot be affected by dirt, liquids, or corrosives.
- An aluminum operator piston and stainless steel piston housing ensure that the unloader will not corrode and seize open or closed when exposed to weather.
- Alignment fingers and a special shoulder bolt ensure that the unloader is properly aligned with the blank or partial valve to ensure a positive seat and minimal leakage.
- If the unloader valve and the sealing surface are not perfectly aligned, a shoulder bolt allows an automatic minor adjustment to ensure a positive seal.
- The stepped unloader rod design assures safe operation because any trapped cylinder pressure cannot shoot it out of the cylinder during unloader removal.

- An indicator pin on top of the unloader tells the operator whether the cylinder is loaded or unloaded.
- In the case of the port unloader, a replaceable donut is used in the place of a valve so standard cylinder port machining is used and a replaceable sealing surface is provided. This also means that the number of valves to maintain is reduced.

The current trend in the industry is to minimize the use of finger unloaders and/or replace them with port/plug style unloaders because the port/plug unloaders provide better compressor reliability and reduced maintenance effort.

Clearance Pocket Unloading:
Clearance pocket unloaders are used to open and close a fixed volume clearance pocket. The clearance pocket adds fixed clearance to the cylinder and enables additional capacity control that can not be achieved through cylinder end unloading.

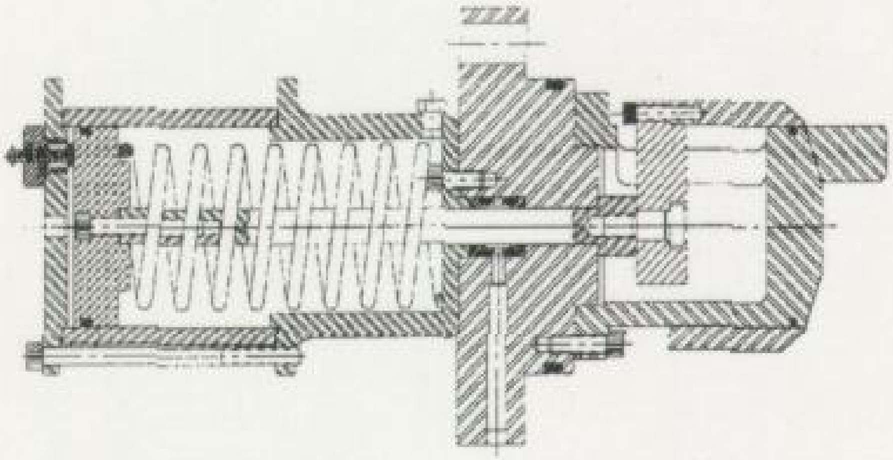

Figure 11. Clearance Pocket Unloader

When clearance is added to the cylinder, the throughput of the cylinder and horsepower requirement is decreased. On the compression stroke, the clearance volume must be filled before the gas will reach discharge pressure and open the discharge valve, so less gas is discharged. This also leaves extra gas at discharge pressure trapped in the clearance pocket, which has to expand during the suction stroke and delays the opening of the suction valve.

The clearance pocket unloader is similar to the port/plug unloader and has the same features. It is sometimes used on a valve port with a double deck suction valve to open a valve cap pocket, but is more commonly found in the outer head where it seals directly against a bevel in the head.

Valve Retainers

Setscrew Valve Retainer:
The typical setscrew valve retainer (as illustrated in Figure 12) is a threaded setscrew that passes through the valve cover and contacts the cage on top of the valve. That setscrew is tightened, and the force is transferred to the cage and valve, which crushes the valve seat gasket. The seal between the cylinder and the valve cover is a gasket, and the seal between the valve cover and the setscrew is generally a lead gasket and seal nut.

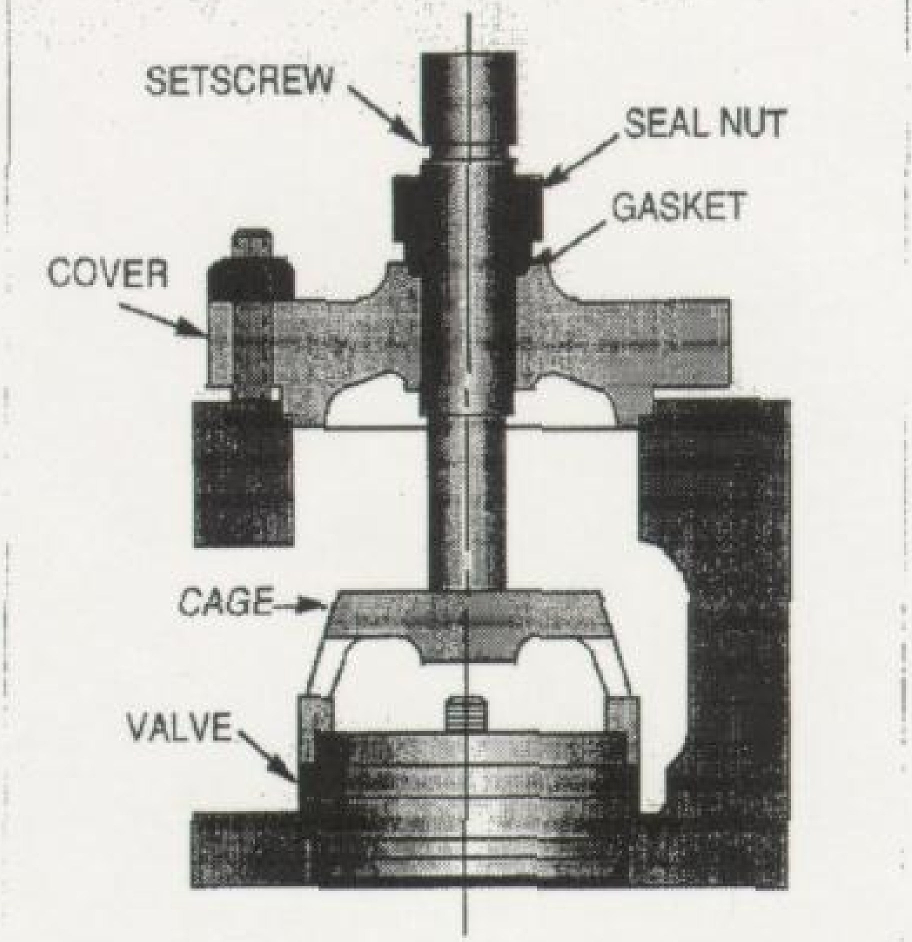

Figure 12. Typical Setscrew Retainer

There are several maintenance and reliability issues with this arrangement:

- It is often difficult to tighten the larger diameter setscrews.
- It is often necessary to retorque the setscrews to ensure they remain tight. This requires the compressor to be shut down as tightening should not be done with the unit running.
- The lead gasket and seal washer do not provide a good seal and usually allow gas to leak past the threads in the center of the valve cover.

RAM Valve Retainer:

The RAM valve retainer (as illustrated in Figure 13) was developed and patented by Dresser-Rand to take the place of the typical setscrew design. It also crushes the valve seat gasket by applying a load to the cage.

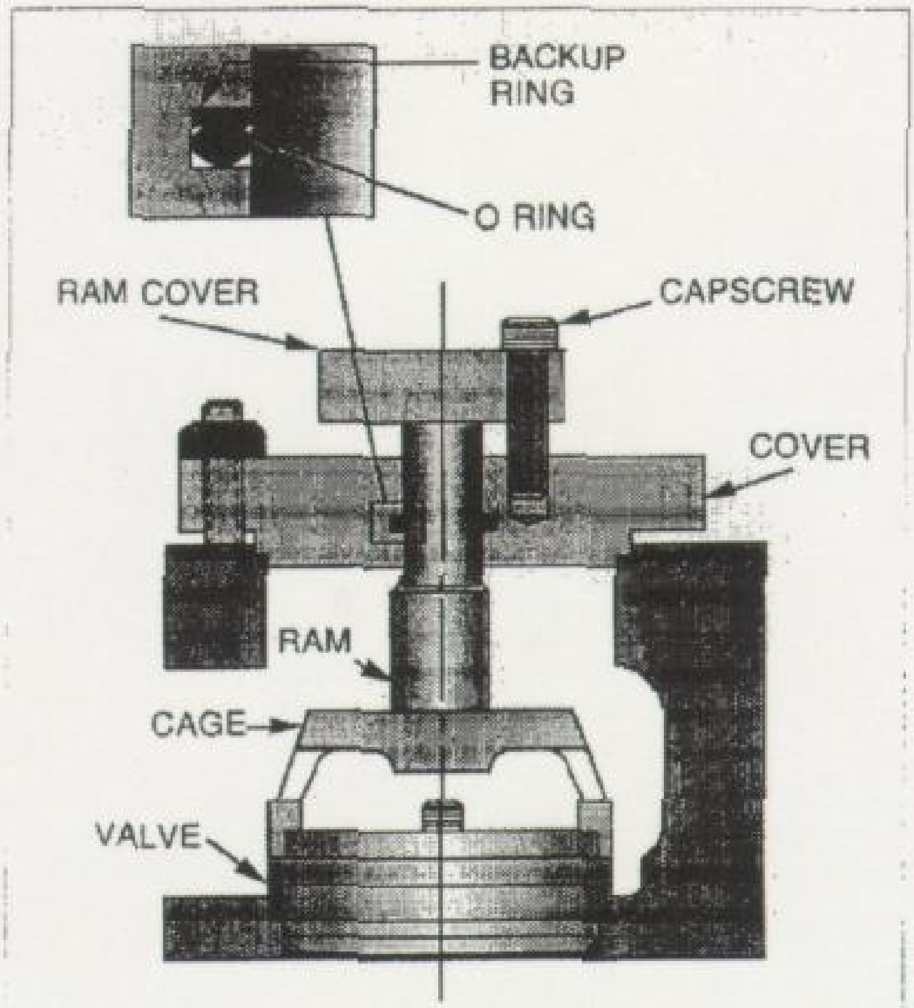

Figure 13. RAM Valve Retainer

However, the design is quite different, and offers several advantages:

- The amount of torque required to crush the valve seat gasket is greatly reduced by distributing the load among several capscrews rather than a single setscrew, eliminating the problem of overloading the cage or valve shelf. It allows the user to tighten accurately using a standard torque wrench.
- Fugitive emissions are reduced by an o-ring used to seal between the RAM and the valve cover. The o-ring provides a much better seal than the lead gasket and seal washer.
- The multiple capscrews also aid in keeping the valve tight in the cylinder. If the setscrew were to come loose, a shelf on the RAM under the valve cover will ensure that the RAM cannot shoot out of the cylinder and cause an injury.
- It is very easy to convert machines in the field to the RAM design by removing the old equipment and installing the new. There are no modifications required.

O-ring Valve Cover:
An alternative to the RAM valve retainer is the o-ring valve cover (as seen in Figure 15). The o-ring valve cover incorporates an o-ring seal and is used in conjunction with a barrel type cage.

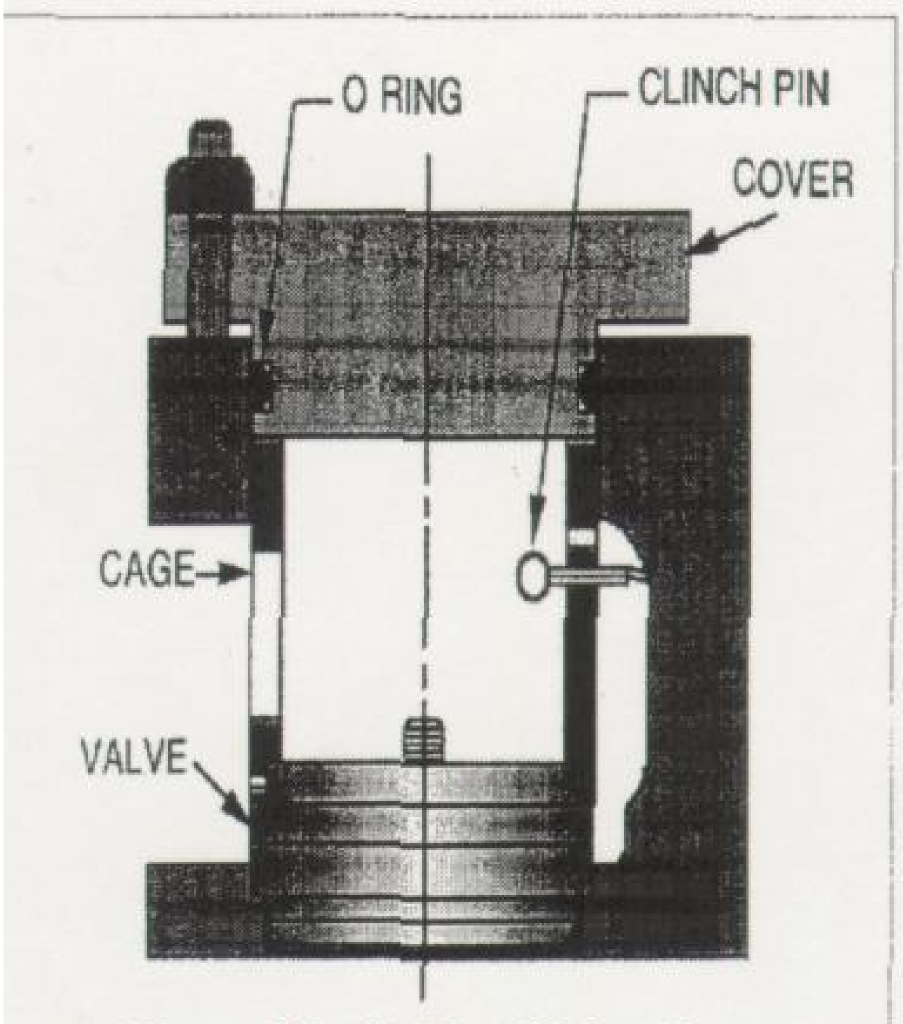

Figure 15. O-Ring Valve Cover

The o-ring cover has several advantages:

- Fugitive emissions are controlled because the valve cover has no hole in the center, so there is one less leak path for the gas. Additionally, the seal between the valve cover and the cylinder is an o-ring which contains gas much better than a flat gasket.
- Much like the RAM the torque requirement is reduced because it is distributed over several valve cover studs rather than a single setscrew.
- The o-ring cover has proven to perform well in a variety of applications.
- Most new units are now manufactured standard with o-ring valve covers. Existing units can also be converted to an o-ring cover. However, this requires the compressor cylinder to be machined to incorporate the required tolerances and finishes for the o-ring to seal properly.

About the Author:

Skip Foreman is currently a Valve Marketing Engineer in the Engineered Replacement Products Group (Valve Team) with Dresser-Rand Product Services in Painted Post, NY. His prior experience includes 3 years as a Valve Application Engineer responsible for supporting compressor valve products. In 1994, he joined Dresser-Rand where his current responsibilities include applying new technology and field support. Skip received a BS degree in Engineering Technology from Texas A&M University.

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