

FRICTION-FREE, ROLLING DIAPHRAGM AIR CYLINDERS FROM CONTROLAIR MAKE YOUR ENTIRE PROCESS RUN SMOOTHER.

Diaphragm Cylinders: Virtually Frictionless and Leak-Free

Conventional pneumatic cylinders are successfully used by the millions for factory automation around the world. But hundreds of unconventional applications can benefit from the virtually frictionless operation rolling-diaphragm air cylinders.

Air cylinders are widely used for applications requiring rapid, repetitive motion. They excel at doing this because their reliable, long-life operation does not generate heat. What air cylinders are not so good at is moving a load at low speed or reacting to subtle changes in pressure without producing jerky, erratic motion.

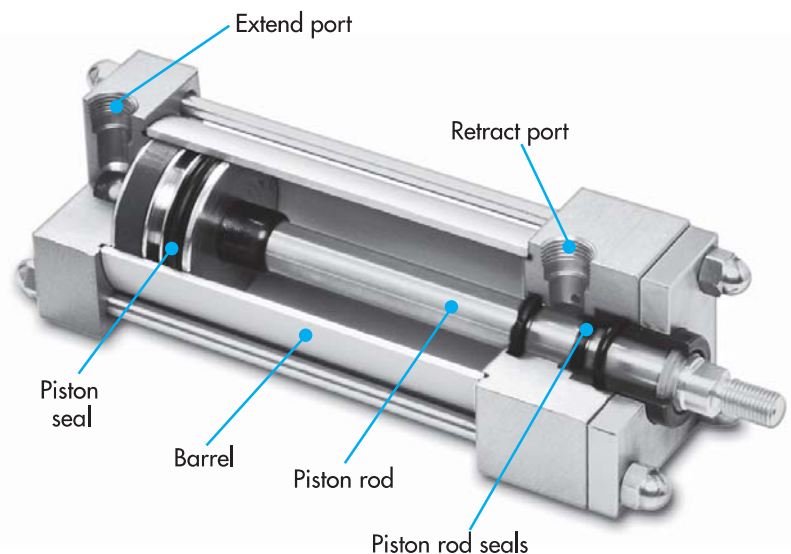
That may be the case with conventional cylinders, but rolling-diaphragm cylinders eliminate the need for a dynamic piston seal, which is the main source of erratic operation in conventional air cylinders.

Inside the Box

Major components of conventional cylinders include the barrel, two end caps, a piston, and piston rod, as shown in the figure. Routing compressed air into the left side of the cylinder causes the piston to move to the right and the piston rod to extend. Likewise, routing air into the right side (rod end) of the cylinder causes the piston to move to the left and the rod to retract.

The cylinder shown is double acting because compressed air causes the piston rod to extend and to retract. In many cases, though, the cylinder needs pneumatic power only for its push (extend) stroke. When this is the case, a single-acting cylinder becomes a more practical alternative by not consuming compressed air for the return stroke. Instead, a spring—located between the rod-end cap and the piston—pushes the piston to the left when air is exhausted from the left end cap.

Whether single acting or double acting, both types of conventional cylinders require a piston seal to prevent compressed air from escaping past the piston from the high-pressure side of the cylinder to the low-pressure side. The seal is generally made of an elastomeric material attached to the piston and slides along the inner surface of the cylinder tube. The interface of the sealing surface is critical because if its fit is too tight, the seal will wear prematurely, reducing life of the cylinder. Too loose prevents the cylinder from holding pressure,



The familiar double-acting pneumatic cylinder relies on elastomeric seals to keep compressed air from leaking past the piston from the high-pressure side to the low-pressure side. The seal creates sliding friction and is prone to wear and subsequent leakage over time.

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FRICTION-FREE, ROLLING DIAPHRAGM AIR CYLINDERS FROM CONTROLAIR CREATE THE PERFECT SEAL AND VIRTUALLY ELIMINATE BLOW-BY

resulting in position drift and inefficiency from leakage across the seal.

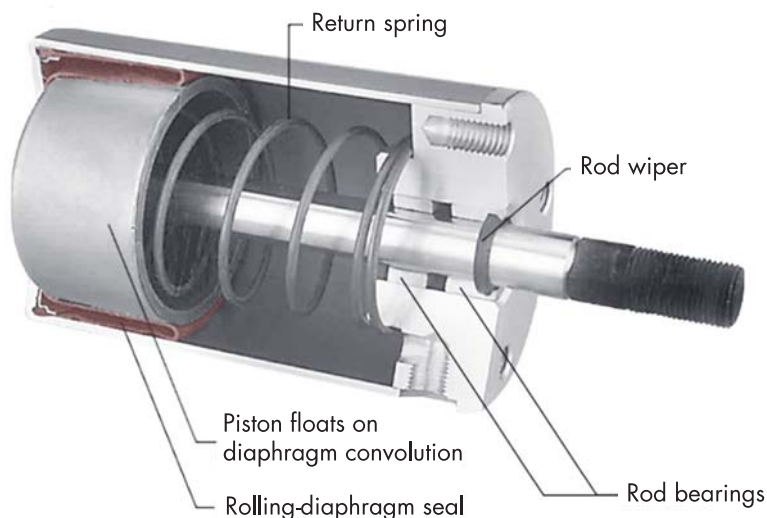
The inescapable disadvantage of sliding motion is friction—a force that opposes motion between the seal and the inner circumference of the cylinder tube. When the piston is at rest, the friction is static. Static friction keeps the piston from moving until enough force is applied by air pressure or the load to overcome the frictional force. Once the piston begins moving, friction becomes dynamic. Dynamic friction between the seal and tube's inner surface acts to slow down motion of the piston.

In most cases, static friction exceeds dynamic friction. This characteristic is what causes erratic motion at low speed. As a gradual increase in pressure will not move the piston until static seal friction is overcome. Once this happens, the piston moves, and friction transitions from static to dynamic. This transition occurs almost instantaneously, but because the dynamic friction is lower, resistance to motion suddenly drops, and the piston jumps forward.

The sudden movement of the piston causes a slight increase in the pressurized volume behind the piston. This can cause the pressure to drop below the level required to overcome dynamic friction, the piston will abruptly stop. As pressure behind the piston again increases, static friction will eventually be overcome, and the piston will jump ahead again. This stick-slip operation—often referred to as stiction—repeats rapidly and often is described as chatter at low speed.

However, stiction does not occur with rolling diaphragm cylinders because they do not have sliding piston seals. The

Inside a Rolling-Diaphragm Cylinder



A single-acting rolling diaphragm cylinder keeps compressed air inside a sealed chamber, which eliminates the need for a piston seal. The result is zero leakage and no sliding friction.

result is cylinder speed that can be fine tuned for smooth motion even with varying loads at low speeds.

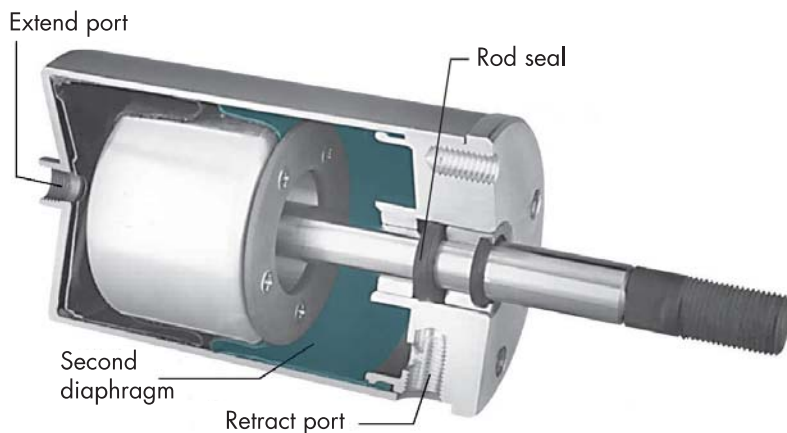
In addition, friction also causes seals to wear over time, allowing air to leak from the high-pressure side of a cylinder to the low-pressure side. This leakage—often referred to as blow by—raises operating cost by increasing compressed air demand. The leakage also makes it difficult to maintain position because air leaking past the piston causes drift—as air pressure equalizes on both sides of the piston, the piston rod will eventually move to a fully retracted or fully extended position, depending on the direction the load is applied.

On a Roll

A rolling-diaphragm cylinder seals the high-pressure side of the piston within a cylindrical membrane (diaphragm). The membrane is shaped like a top hat with the peak of the hat fastened to the end of the piston and the “brim” clamped to the cylinder cap (see illustration). This forms a long-lasting, frictionless seal between the piston head and cylinder wall.

With the cylinder's piston rod fully retracted, the diaphragm is collapsed within itself. As fluid (usually compressed air) flows into the cap end of the cylinder, pressure builds

Double the Action



The double-acting diaphragm cylinder uses a second diaphragm to retract the piston when greater control is required in the cylinder's return stroke.

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and pushes the piston to extend the piston rod. As this occurs, the diaphragm expands. But instead of stretching the diaphragm, expansion causes it to unfold (roll) at one end, which increases its axial length. The piston rod is retracted by the external load or by an internal spring.

Because rolling-diaphragm cylinders have no sliding friction from seals, rod stroke is extremely sensitive to changes in pressure. The design exhibits low hysteresis and positively seals compressed air within the diaphragm. This reduces operating cost by eliminating blow-by leakage—a waste of compressed air.

Even though rolling-diaphragm cylinders eliminate the sliding motion of a piston seal and rod seal, they still require a rod bearing. Rod bearings typically offer much lower friction per unit area than rod seals because the bearing does not have to provide a tight seal. Plus, the bearing-to-rod area is only a fraction that of the piston-to-bore area. Therefore, the combination of these two factors makes rod-to-bearing virtually negligible.

Options Add to Versatility

In applications where virtually isn't good enough, ball-bearing rod bearings can be specified. Rather than the sliding contact of bushing-type rod bearings, these bearings provide support through rolling of steel balls over a hardened steel piston rod.

Another useful option is double-acting operation. Even though single-acting cylinders are practical for many applications and provide more economical use of compressed air, sometimes a double-acting operation is a must. For these cases, a cylinder with a pair of opposed rolling diaphragms can be used. This option does, however, require a rod seal, so some of the advantages of the rolling-diaphragm design are lost. However, because the rod circumference is so much smaller than the piston's, the double-acting rolling-diaphragm cylinder still exhibits substantially less friction than conventional cylinders.

Cylinders By the Numbers

As with their conventional counterparts, rolling-diaphragm cylinders come in a variety of standard, sizes, designs, and mounting configurations. Standard bores for single-acting designs (with standard or ball bearing rod bearing) range from 2.3 to 4.5 in., with standard strokes from 1.8 to 4.2 in. Double-acting cylinders come in 2.3- and 3.4-in. bores, with 1.3- and 2.5-in. strokes, respectively. All three come with end-cap, clevis, or foot mounting.

Standard pressure rating is 145 psig (10 bar) in temperatures from -40 to 225° F (-40 to 107° C). Temperatures from -75 to 400° F (-59 to 204° C) can be accommodated with optional diaphragm materials. Other common options include modifications to bearing and rod

materials, rod configurations, and spring design.

The virtually frictionless and leak-free operation of rolling-diaphragm cylinders makes them ideal for such applications as web tensioners, precise positioners, dancer rolls, valve actuators, roll loaders, impact absorbers, and accumulators. Rolling diaphragm cylinders are also ideal to improve the performance of existing machines. Any short-stroke application requiring operation without stiction is a strong candidate to reap the many benefits of rolling-diaphragm cylinders. Furthermore, with manufacturer approval, they can be used with media other than compressed air, even liquids—where leak-free operation can prove especially beneficial.

Smooth Operator

Friction-free, rolling diaphragm air cylinders from ControlAir can make your entire operation run smoother.

Virtually frictionless conversion of pneumatic pressure to linear force and outstanding features.

The rolling diaphragm creates the perfect seal for friction-free cylinders. It's a durable, flexible top hat-shaped membrane with the peak fastened to the end of the piston and the "brim" clamped to the cylinder cap. This forms a long-lasting frictionless seal between the piston head and cylinder wall. Custom material design allows for operation at temperatures from -75°F to 400°F.



- **Super sensitivity**
- **Absolutely no lubrication required**
- **Low hysteresis**
- **No blow-by leakage**
- **Wide temperature variations**

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Visit controlair.com to learn how our rolling diaphragm air cylinders reduce stiction and virtually eliminate blow-by for superior performance.

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