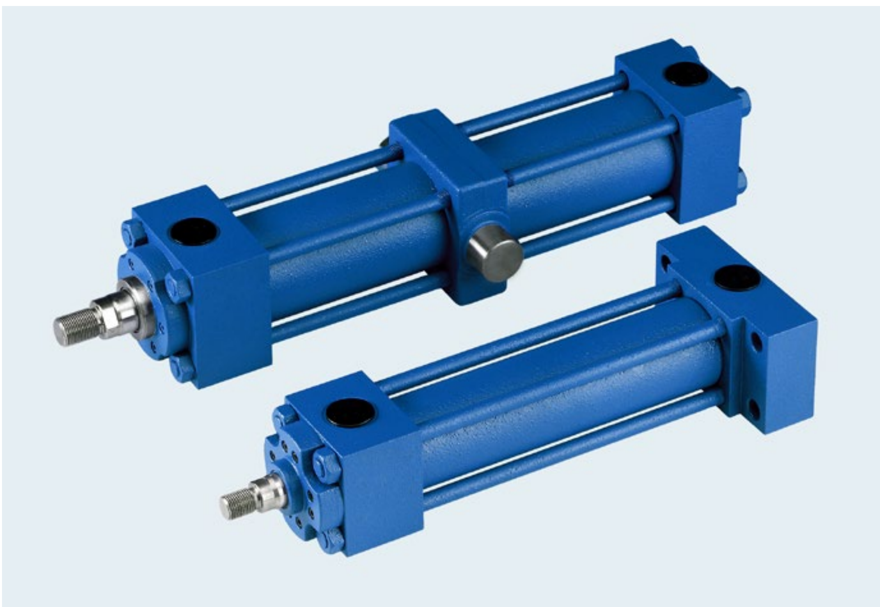
Drive & Control
profile

Cylinder selection: The key to better hydraulics



Cylinders allow hydraulic systems to apply linear motion and force without mechanical gears or levers by transferring the pressure from fluid through a piston to the point of operation.

Hydraulic cylinders are at work in both industrial applications (hydraulic presses, cranes, forges, packing machines), and mobile applications (agricultural machines, construction equipment, marine equipment). And, when compared with pneumatic, mechanical or electric systems, hydraulics can be simpler, more durable, and offer greater power.

For example, a hydraulic pump has about ten times the power density of an electric motor of similar size. Hydraulic cylinders are also available in an impressive array of scales to meet a wide range of application needs.

Selecting the right cylinder for an application is critical to attaining maximum performance and reliability. That means taking into consideration the parameters. Fortunately, an assortment of cylinder types, mounting techniques and “rules of thumb” are available to help.

Cylinder Types

The three most common cylinder configurations, including how they function, are detailed below:

- **Tie-rod cylinders**
  Use high-strength threaded steel tie-rods, typically on the outside of the cylinder housing, to provide additional stability.
- **Welded Cylinders**
  Feature a heavy-duty welded cylinder housing with a barrel welded directly to the end caps, and require no tie-rods.
- **Ram Hydraulic Cylinders**
  Just what they sound like – the cylinder pushes straight ahead using very high pressure. Ram cylinders are used in heavy-duty applications and almost always push loads rather than pull.

For all types of cylinders, the crucial measurements include stroke, bore diameter and rod diameter. Stroke lengths vary from less than an inch to several feet or more. Bore diameters can range from an inch up to more than 24 inches, and piston rod diameters from .5 inch to more than 20 inches. In practice, however, the choice of stroke, bore and rod dimensions may be limited by environmental or design conditions. For example, space may be too limited for the ideal stroke length. For tie-rod cylinders, increasing the size of the bore also means increasing the number of tie-rods needed to retain stability. Increasing the diameter of the bore or piston rod is an ideal way to compensate for higher loads, but space considerations may not allow this, in which case multiple cylinders may be required.

Cylinder Mounting Methods

Mounting methods also play an important role in cylinder performance. Generally, fixed mounts on the centerline of the cylinder are best for straight line force transfer and avoiding wear. Common types of mounting include:

- **Flange Mounts**
  Very strong and rigid, but have little tolerance for misalignment. Experts recommend cap end mounts for thrust loads and rod end mounts where major loading puts the piston rod in tension.
- **Side-Mounted Cylinders**
  Easy to install and service, but the mounts produce a turning moment as the cylinder applies force to a load, increasing wear and tear. To avoid this, specify a stroke at least as long as the bore size for side-mount cylinders (heavy loading tends to make short-stroke, large-bore cylinders unstable). Side mounts need to be well aligned and the load supported and guided.
- **Centerline Lug Mounts**
  Absorb forces on the centerline, but require dowel pins to secure the lugs to prevent movement at higher pressures or under shock conditions.
- **Pivot Mounts**
  Absorb force on the cylinder centerline and let the cylinder change alignment in one plane. Common types include clevises, trunnion mounts and spherical bearings. Because these mounts allow a cylinder to pivot, they should be used with rod end attachments that also pivot. Clevis mounts can be used in any orientation and are generally recommended for short strokes and small- to medium-bore cylinders.

Other Key Specification Parameters

- **Operating Conditions**
  Cylinders must match a specific application in terms of the amount of pressure (psi), force exerted, space requirements imposed by machine design, and so forth. But knowing the operating requirements is only half the challenge. Cylinders must also withstand high temperatures, humidity and even salt water for marine hydraulic systems. Wherever temperatures typically rise to more than 300° F, standard Buna-N nitrile rubber seals may fail. Choose cylinders with Viton synthetic rubber seals instead. When in doubt, assume operating conditions will be more rugged than they appear at first glance.
- **Cylinder Fluid**
  Most hydraulics use a form of mineral oil, but applications involving synthetic fluids, such as phosphate esters, require Viton seals. Once again, Buna-N seals may not be adequate to handle synthetic fluid hydraulics. Polyurethane is also incompatible with high water-based fluids such as water glycol.
- **Seals**
  This is probably the most vulnerable aspect of a hydraulic system. Proper seals can reduce friction and wear, lengthening service life, while the wrong type of seal can lead to downtime and maintenance headaches.
- **Cylinder Materials**
  The type of metal used for cylinder head, base and bearing can make a significant difference. Most cylinders use SAE 660 bronze for rod bearings and medium-grade carbon steel for heads and bases, which is adequate for most applications. But stronger materials, such as 65-45-12 ductile iron for rod bearings, can provide a sizable performance advantage for tough industrial tasks.

The type of piston rod material can be important in wet or high-humidity environments (e.g., marine hydraulics) where 17-4PH stainless steel may be more durable than the standard case-hardened carbon steel with chrome plating used for most piston rods.

Now let's review a few more key questions to consider:

- **What is the maximum psi at for the application?** Keep in mind pressures may vary greatly depending on the specific job the system is doing. Cylinders are rated for both nominal (standard) pressure and test pressure to account for variations. System pressure should never exceed the nominal rated design pressure of the cylinder.
- **Push or pull – or both (double action)?** The answer to this question may require a specialized double-acting cylinder if the hydraulic system is doing "double duty." (Single-acting cylinders extend the piston under hydraulic pressure; double-acting cylinders extend and retract the piston under pressure.) In a push application, it is extremely important to size the rod diameter properly to avoid rod buckling. In a pull application, it is

important to size the annulus area (piston diameter area minus the rod diameter area) correctly to move the load at the rated design pressure of the cylinder.

- **What push or pull tonnage is required?** Always assume peak loads will require additional strength. The rule of thumb is to choose a cylinder with a tonnage rating of 20% more than required for the load.
- **What stroke length will be required?** Space may not be available for the ideal length. A telescopic configuration may be required, or even a radial configuration allowing the cylinder to move in more than one axis. Long-stroke cylinders, which are more at risk for bending or misalignment, require additional support.
- **What mounting method is being used (flange, trunnion, threaded, fixed centerline, non-centerline, etc.)?** Flange mounting is probably the best solution since the load is transferred along the centerline of the cylinder. Non-centerline mounting calls for additional support to avoid misalignment.
- **Finally, perhaps the most important question of all – how much support will the piston and cylinder require?** Depending on stroke length, a stop tube may be required to prevent excessive wear and jack-knifing. However, a stop tube will not prevent rod bending – an oversize rod may be required, based on Euler calculations. Perhaps the most common error in hydraulic design is underspecifying the piston rod, making the cylinder more prone to stress, wear and failure.

Fortunately, these questions and more can be addressed through computer programs that perform calculations automatically and allow engineers to determine and test cylinders on-screen before the actual components are specified.

To summarize, there are numerous variations and combinations of features involved when specifying cylinders – more than meet the eye at first glance. Calculations and careful attention to spec sheets are important, but seeing the “big picture” (working environment, potential load levels, size considerations, etc.) is just as important to ensuring optimum performance from a hydraulic system.

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