A Quick and Easy Guide to Hydraulic Pump Technology and Selection

Of gear, piston and vane pumps, one type is not better than any other type in an absolute sense—they simply are different, with individual strengths.

The hydraulic pumps found in virtually all mobile and industrial applications today use pistons, vanes, or gears to create the pumping action that produces flow. Each method features individual characteristics that differentiate it from the others and make it suitable for a particular range of applications.

**Piston pumps**

Piston pumps can have the pistons arranged in a radial or axial fashion. Radial types tend to be specialized for applications requiring very high power, while axial piston pumps are available in a wide range of displacements and pressure capabilities that make them suitable for many mobile and industrial tasks.

Axial-piston pumps consist of a set of pistons that are fitted within a cylinder block and driven by an angled swash plate powered by the input shaft. As the swash plate rotates, the pistons reciprocate in their respective cylinder block bores to provide the pumping action. (Figure 1 above)

Axial-piston pumps are available with the input shaft and pistons arranged coaxially, or with the input shaft mounted at an angle to the piston bores. Bent axis pumps tend to be slightly more volumetrically efficient for technical reasons, but they also tend to be slightly larger for a given capacity and their shape can present packaging difficulties in some applications.

A unique characteristic of a piston-type pump is that the displacement can be changed simply by changing the angle of the swash plate. Any
Fluid Power

displacement between zero and maximum is easily achieved with relatively simple actuators to change the swash plate angle.

Vane pumps
The most commonly encountered vane-type pump generates flow using a set of vanes, which are free to move radially within a slotted rotor that rotates in an elliptical chamber. A typical configuration uses an elliptical cam ring with the rotor spinning within it in a cylindrical housing and a pair of side plates to form the pumping chambers. The changing volume of the cavity between adjacent vanes creates the pumping action as the rotor rotates.

It is possible to vary the displacement of a vane-type pump, but this is not commonly done except for very specialized applications. The majority of the vane-type pumps used in industrial and mobile applications have a fixed displacement.

Vane pumps can be hydraulically balanced, which greatly enhances efficiency. Some designs place the rotating group in a cartridge, which makes them very easy to repair. The entire rotating group is easily removed and replaced by simply removing the back cover, pulling out the old rotating cartridge and replacing it with a new one.

Vane-type pumps are known for being very quiet in operation and producing very little vibration.

Gear pumps
The simplest gear-type pump uses a pair of mating gears rotating in an oval chamber to produce flow. As the gears rotate, the changing size of the chambers created by the meshing and unmeshing of the teeth provides the pumping action.

Another design uses an external rotating ring with internal gear teeth that mesh with an internal gear as it rotates. As the inner gear rotates, the tooth engagement creates chambers of diminishing size between the inlet and outlet positions to create flow.

A more sophisticated variant of this principle is the gerotor pump, which has a non-concentric inner and outer rotor with different numbers of teeth. As the pair rotates, the changing volume of the space between the rotors creates the pumping action. Replacing the meshing teeth of the gerotor pump with low-friction rolling elements produces a geroter pump.

All gear-type pumps have a fixed displacement. These pumps are relatively inexpensive compared to piston and vane type pumps with similar displacements, but tend to wear out more quickly and are not generally economically repairable.

Sweet spots
Piston-type pumps have a very good service life, provided contamination and heat are controlled. They also have the highest pressure ratings, and the significant advantage of variable displacement. This makes them the best choice for applications where high efficiency and high power density are important considerations. The ability to configure
Comparing pumps

piston-type pumps with both pressure sensing and load sensing capabilities is an important advantage, particularly in mobile applications.

Vane-type pumps are widely used in constant flow/constant pressure industrial applications because they are quiet and easily repaired. They also have the unique attribute of allowing a “soft start” because vane-type pumps typically do not achieve full output at speeds below about 600 rpm. This characteristic can significantly reduce the starting current requirements of electric motors driving a vane-type pump which extends motor life.

Gear pumps are very common in constant flow/constant pressure applications on mobile equipment because of their low cost and dirt tolerance. They are also widely used as charge pumps to pressurize the inlets of piston and vane pumps because of their excellent inlet vacuum tolerance.

**Other considerations**

Sizing a pump is not really dependent on which technology is chosen. In all cases, it is best to start with the load and then work back through the system calculating losses at each point. Once the theoretical pressure and flow characteristics are calculated, the input horsepower requirement can be determined. A 20% safety factor is commonly used in determining the pump input horsepower requirement to account for efficiency losses in the pump.

Mobile applications that may encounter overrunning loads often require special valve plates that alter the stroke of a piston pump more quickly than standard units. Such proper valving reduces the internal forces in the pump allowing it to come out of stroke more quickly to respond to the load condition.

You should also be aware that many pump options often are not listed in manufacturer’s catalog literature. It is always a good policy to consult with the pump manufacturer or your local representative when sizing or selecting a pump for a specific application.

Today’s hydraulic pumps are sophisticated, precision products that will enhance the customer value of the equipment they power. Knowing the characteristics of each of the common pump technologies and selecting the units that deliver the best balance of cost versus performance in your application is the best way to maximize that value. 🌟

**Eaton Corp.**

www.eaton.com/hydraulics

---

**Pressure**

Piston pumps have the highest pressure capabilities of the three technologies, up to 7250 psi (500 bar) for those in common use, and as high as 10,000 psi (690 bar) for certain specialized units. Vane and gear pumps are commonly limited to pressures up to about 4000 psi (275 bar).

**Input Speed**

Piston pumps have the highest input speed capabilities.

**Power Density**

Hydraulic power density is directly related to operating pressure; the higher the pressure the greater the power density. Piston pumps offer the highest power density with vane and gear types following in that order.

**Conversion Efficiency**

Like power density, the conversion ratio of input power to output power is directly related to operating pressure. Piston pumps offer the highest conversion ratio, followed by vane and gear pumps in that order. The ability of piston and vane pumps to be hydraulically balanced is also a factor in their greater conversion efficiency.

**Dirt Tolerance**

No hydraulic component is immune to damage from dirt! But of the three pump technologies, the gear-type is the most dirt tolerant, followed by vane and piston pumps in that order.

**Inlet Vacuum Tolerance**

Positive inlet pressure is always preferred in hydraulic pump applications to avoid wear and premature failure. However, of the three technologies, gear-type pumps are the most vacuum tolerant handling vacuums up to 10 in.-Hg (254 mm-Hg). Vane-type pumps can handle inlet vacuum up to 6 in.-Hg (152.4 mm-Hg) and piston-type pumps up to 4 in.-Hg (101.6 mm-Hg).

**Noise and Vibration**

Vane-type pumps are the quietest and most vibration-free followed by piston- and gear-type pumps in that order. It is worth noting that piston pumps can be significantly quieted by altering the metering notch geometry on the valve plate. Doing so, however, reduces their efficiency. There is no free lunch.

**Size and Weight**

Gear pumps tend to the lightest for a given displacement, followed by vane and piston pumps in that order. Note also that all three types can be “ganged” by stacking multiple sections together. This is more commonly done with gear and vane pumps, but double piston pumps are also available.

**Fluid Compatibility**

Piston and gear pumps tend to offer the greatest range of fluid compatibilities. Note that it is often necessary to de-rate a pump when it is used with non-petroleum fluids.

Fluid compatibility depends on the type of seals, O-rings and materials used in the construction of a pump. It’s best to consult the manufacturer before using any alternative fluids.

**Life Expectancy and Repairability**

Piston and vane pumps offer longest service life of the three technologies and both are repairable.

Usually only a well-equipped maintenance shop has the capability to repair and test piston pumps.

Vane-type pumps are, by far, the easiest to repair. They also have inherent wear compensation built in which helps give them long service life.

Gear-type pumps have the shortest service life, and are more often replaced than repaired due to cost.