

SPECIFYING HYDRAULIC POWER UNITS

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In this White Paper
You Will Learn
How to Determine the...

1. Application
2. Pump Size and Type
3. Reservoir
4. Motor Size and Type
5. Accessories Needed

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Hydraulic power units, known as HPUs, are one of the most essential parts of a hydraulic system. Without them, the system would have no power and not be able to function. Each HPU has a pump, a reservoir, a motor/engine to drive the pump, and an assortment of accessories. These elements provide and control the flow, which in turns generates pressure for the system.

Determine the Application

Hydraulic power units are determined on the system specifications of your application. These specifications are all based upon the actuation used- motors, cylinders, rotary actuators, etc. How these actuators work in the system will determine pressure and the flow rate required and how the system will be cycled.

For applications using cylinders, the flowrate is determined by the volume of the cylinder and the speed of the cylinder. The maximum system pressure is determined by the highest force needed and the cylinder's bore and piston rod areas.

For applications using hydraulic motors, the flowrate is determined by the fastest speed of the motor and the hydraulic motor's efficiency. The pressure is determined by the torque needed for the application, the hydraulic motor's volumetric displacement, and its efficiency.



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Determine the Pump Size and Type

Once you've settled on the actuator's output, you'll need to use the flow rate and pressure to size the pump.

You'll need to find a pump that matches the flowrate of your system and can handle your maximum pressure. A pump's flowrate is dependent on the pump's speed and displacement.

$$Flow [gpm] = \frac{Displacement \left[\frac{in^3}{rev} \right] \times Speed [rpm]}{231}$$

The displacement of the pump must be higher than the required displacement to account for the natural leakage of fluid past the pump seals. This leakage rate can be found in the pump's literature.

A variety of pumps are available depending on the application. If the application will have a constant flowrate then a fixed displacement pump is the best option. If efficiency isn't a concern, gear pumps are the most economical choice.

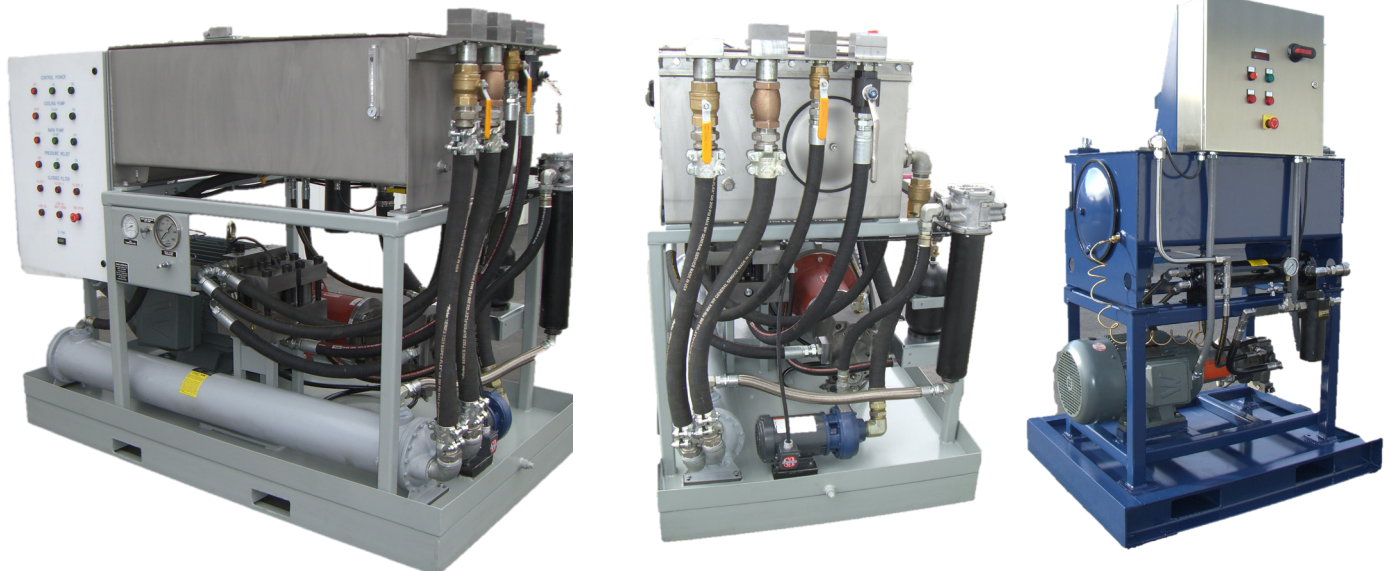
If the application has a changing flow or an appropriate motor can't be found for the flow rate, a variable displacement pump will be needed. If there will be changing pressures, loads, or torques the pump will require some form of compensated control to match the changing conditions.

Determine the Reservoir

When first designing a reservoir, the volume should be 3-4 times the pump flowrate. This volume can be increased or decreased, depending on multiple factors. The bigger the reservoir, the more heat and air can be dissipated from the system, but the more space is used. The reservoir size can be decreased by placing it in a cool environment or adding a cooler to improve heat loss. The reservoir size may need to be increased when in hot environments or when multiple large volume cylinders are in the system.

Reservoir placement is dependent on the minimum inlet pressure needed to start the pump. If the pump doesn't have this minimum pressure, cavitation can occur. Best practice is to have the inlet pressure be slightly above atmospheric.

Reservoir shape is based off environmental and economic constraints. Overhead reservoirs utilize vertical space and aid in overall system efficiency but can cause issues while servicing. Vertically mounted reservoirs, where the pump is submerged in the reservoir, are compact and provide increased cooling and prevent cavitation but can be difficult to maintain. L-shaped reservoirs allow



for greater heat dissipation, but are expensive and take up space.

Determine the Motor Size and Type

Once a pump has been selected, a motor or engine needs to be found to run the pump. Electric motors have consistent torque ratings, are quieter, and are more compact than gas and diesel engines. Engines are typically used in applications where electricity would be inefficient to power the drive, such as mobile hydraulics. In general engines are less commonly used to drive hydraulic pumps in modern applications.

If the system has constant flow and pressure, the motor's horsepower rating is simply based on pressure, flowrate and overall efficiency of the pump. Each pump has an overall efficiency curve that can be used to find the efficiency at different speeds, Some commonly used overall efficiency values of pumps are:

Piston Pump Efficiency = 0.94

Gear Pump Efficiency = 0.83

$$Power [hp] = \frac{Flow [gpm] \times Pressure [psi]}{1714 \times Efficiency}$$

The highest calculated torque the motor will experience is based on the displacement, pressure, and overall efficiency

$$Torque [in * lb] = \frac{Displacement \left[\frac{in^3}{rev} \right] \times Pressure [psi]}{2\pi \times Efficiency}$$

Motor manufacturers list the torque generated at specific power ratings and speeds. The torques listed by the manufacturer need to be at least 20% greater than the highest torque calculated.

For gasoline and diesel engines, the above equations can be used, but the peak power and torque may not occur at the same speed. Refer to the power curves found in the engine's literature to find where the highest power and torque fall to check that they fall within the system's parameters.

When looking at gasoline and diesel engines, a good place to start is an engine rated to twice the calculated power and to review the power curves. Check the power curve to see where the torque at the calculated power is. If the torque is too small, move onto a larger engine, and if the torque is much higher than needed, size down to smaller engine. This may take a few iterations.

An appropriate bellhousing will need to be selected to attach the motor to the pump with a coupler rated for the motor's horsepower.

Determine Accessories Needed

Depending on how the system is cycled, certain accessories can be added or removed. Some are critical to every system, while some should only be installed in specific situations

Filtration is necessary in every HPU, with a filter connecting the low-pressure side of the system to the reservoir. But added filtration may be needed depending on the environment and application to increase the life of the system. For example, a dusty environment might require additional air filtration to the reservoir while an application with less wear resistant hydraulic fluid may need higher

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rated filters. If proportional control valves are being used, each proportional valve will need a high-pressure filter downstream of its inlet.

Heat exchangers can be installed in systems if there's concern about the fluid temperature effecting viscosity. Coolers are often use when an HPU is to be constantly cycled, have a large amount of heat generated from the relief valve being used often, have a small reservoir, placed in a hot environment, or in any situation where large amounts of heat will be generated. A rule of thumb is to size coolers so that the heat removed is 1/3 of the power input to the system. Heaters are less commonly used and are placed in HPUs located in cold environments.

Valves are an important part of hydraulic systems, allowing for refined control. Every HPU needs a relief valve, which prevents the system from becoming over pressurized and dumps the excess fluid back to the reservoir. Most systems have directional control valves that control how the direction the actuator will move. More advanced applications use proportional valves, which allow for a more fine-tuned control of the pressure and flowrate. More basic valves like check, ball, and flow valves control how and where the flow goes.

Manifolds are very beneficial to applications with more than one actuator or multiple accessories. They allow for better flowrates to each actuator and more compact and organized system setups.

Pressure and temperatures gauges/transducers are often placed on HPUs for safety and maintenance, as they allow for troubleshooting the system. While not required, they can help lengthen the system lifespan, and at least one pressure gauge is recommended, usually placed between the directional control and pump.

Accumulators can be added into systems for many reasons, such as a backup system in case of a power loss, cycles that require a low pressure for long periods with brief periods of high pressure, and to absorb shock loads.

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