Head versus Pressure

Why Pumps Use Feet of Head Instead of Pressure

Understanding why **pump curves** and specifications use head (ft) instead of pressure (psi) is key to selecting, sizing, and troubleshooting pumps. While pressure and head are related, they are not the same. Head provides a universal, fluid-independent measure of pump **energy**, making it easier to compare pump performance and design systems reliably.

What is Head?

Head measures the energy per unit weight that a pump imparts to a liquid and is commonly expressed as the vertical height the liquid could be lifted. For nearly incompressible liquids with similar viscosity such as water, glycol solutions, or most oils, pump head is independent of fluid density.

- Head is expressed in feet (ft) or meters (m)
- Head represents energy, not pressure
- Head applies equally to a liquid the pump handles, allowing easier comparison of pump performance across different fluids

For example, a pump rated for 100 feet of head will raise:

- Water 100 feet
- Glycol 100 feet
- Brine 100 feet

Even though the height for each liquid is the same, the pressure at the bottom differs depending on the fluid's density.

What is Pressure?

Pressure measures the force a liquid exerts per unit area, expressed in psi, kPa, or bar. Unlike head, pressure depends on fluid density.

Head measures how high a pump can lift a liquid.

Pressure measures how hard that liquid pushes.

Why not use Pounds Per Square Inch (PSI)?

Because pressure varies with fluid density, using psi would require redefining pump performance for every fluid. A pump delivering 50 psi to water will deliver a different energy (head) for oil or another fluid at the same pressure.

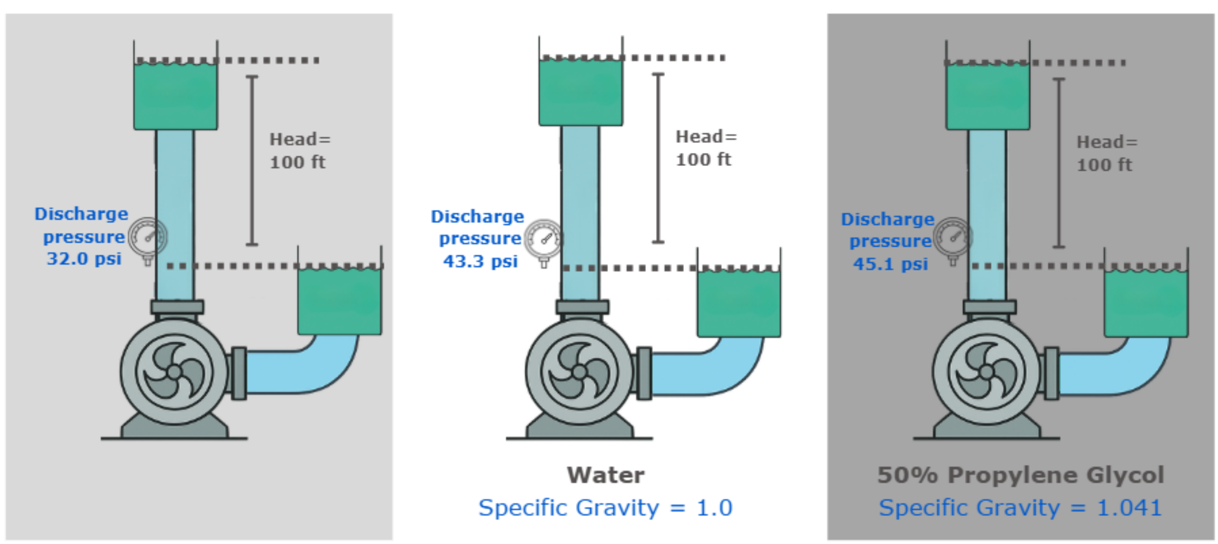
The same pump producing 100 ft of head will generate different pressures depending on the fluid's density. Heavier fluids generate higher pressure, while a lighter fluid produces lower pressure. For example, a pump delivering 100 ft of head produces about 43.3 psi with water. If the fluid is denser than water, like a glycol solution, the pressure is higher; if it is lighter, such as gasoline, the pressure is lower.

Pressure Varies with Fluid Density

Fluid	Density versus Water	PSI at 100 feet Head
Water	Baseline (1.0)	~43.3 psi
50% Ethylene Glycol	Heavier (~1.07-1.08)	Higher than 43.4 psi (~46-47 psi)
Gasoline for Vehicles	Lighter (~0.72-0.76)	Lower than 43.4psi (~21-33 psi)

In the example below, identical pumps are designed to deliver 100 ft of head for three different liquids: gasoline, water, and 50% propylene glycol. Each liquid has a different specific gravity. Because pressure depends on specific gravity, the same 100 ft of pump head results in different discharge pressures for each liquid.

Pressure of liquids with varying specific gravity, delivering the same head



Same pump, same head, different pressure. For incompressible liquids with similar viscosity, a **centrifugal pump** will produce approximately the same head at a given speed and impeller diameter. However, higher-viscosity fluids reduce developed head and pump efficiency. In contrast, the pressure varies depending on the liquid's specific gravity (density) being pumped. This is why pump curves are expressed in feet of head rather than PSI.

Head is constant.

Pressure varies with density.

Why Pump Head Isn't Suitable for All Fluids

The head concept works because standard pumps are designed for nearly incompressible fluids, such as water, wastewater, and most oils, where the density remains relatively constant. However, head is not a universal measurement for all fluids.

Limitations of Using Head with Non-Liquids

- Liquids resist compression, which makes pump head a reliable and meaningful measure of the energy imparted by a pump. Gases, in contrast, readily compress and expand. Although head can be defined mathematically for gases, centrifugal pumps are specifically designed to operate with incompressible liquids. When gases or multiphase mixtures are present, changes in density invalidate head-based pump performance curves. In such cases, the energy that would raise a column of liquid is instead absorbed by gas compression, resulting in little useful pressure rise. For these applications compressors or blowers, not centrifugal pumps, are the appropriate equipment.
- Pump performance becomes unpredictable. Pump curves, flow, head, efficiency, and power, are developed using liquid behavior. When gases or multi-phase mixtures are present:
  - Flow rates become unstable
  - Head calculations lose meaning
  - Published pump curves no longer apply
- **Cavitation** and loss of prime risks increase. Pumps rely on a continuous liquid column. When fluids lack sufficient density:
  - Vapor pockets or air entrapment can form
  - Loss of prime may occur
  - Cavitation, vibration, overheating, and mechanical damage can result

Pump head is meaningful only for incompressible liquids. For gases or compressible fluids, compressors, blowers, or vacuum pumps are required.

The Engineer's Advantage: Head is Universal

Pump curves express performance in feet of head because this:

Makes Curves Independent of Fluid Type

One pump curve works for water, glycol, or other liquids.

Shows True Pump Energy

Head represents the pump's added energy, not the system's pressure.

Allows Apples-to-Apples Comparison

Two pumps delivering 90 ft of head provide equivalent performance, even if discharge pressures differ due to fluid density.

Avoids Confusion from System Conditions

System changes may change due to:

- Elevation
- Temperature
- Fluid density
- Piping layout
- Pressurized vessels and tanks

The pump head–flow relationship is fixed for a given speed and impeller, but the actual operating head and flow rate change with system conditions.

How Head and Pressure Relate

Pressure and head are related through fluid density. A column of water 2.31 feet high will exert a pressure of 1 psi based on water at approximately 65 ^{0}F.

For water at standard conditions:

$$Pressure\ (psi) = \frac{Head\ (ft)}{2.31} \text{ or } Head\ (ft) = Pressure\ (psi)\ x\ 2.31$$

When the fluid is not water, one must account for the specific gravity (SG):

$$Pressure\ (psi) = \frac{Head(ft)\ x\ specific\ gravity\ (SG)}{2.31}$$

Or

$$Head\ (ft) = \frac{Pressure\ (psi)}{(0.433\ x\ specific\ gravity\ (SG))}$$

Total Dynamic Head (TDH)

Pump sizing uses **TDH**, which is the total energy the pump must overcome:

- Static lift/static head
- Friction losses (pipe, fittings, valves)
- Velocity head
- Pressure requirements of discharge equipment.

Total dynamic head defines system requirements, while head allows engineers to select the correct pump independent of fluid type or density.

Wilo is Your Solutions Provider

Pump head and pressure are closely related, but they serve different purposes. Head provides a fluid-independent measure of pump energy, making it the preferred way to express pump performance on curves and in system design. Pressure, on the other hand, varies with fluid density and temperature, which can make it misleading if used alone. Understanding the distinction ensures accurate pump selection, reliable operation, and efficient system performance.

At **Wilo**, we support customers at every stage of pump lifecycle management. From helping you understand pump performance and system requirements to providing **high-quality pumps**, **parts**, and **engineering expertise**, Wilo ensures your system operates efficiently, safely, and reliably. When it comes to **selecting the right pump** for your **application**—whether dealing with water, glycol, or other liquids—Wilo is your solutions provider for performance you can trust.

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