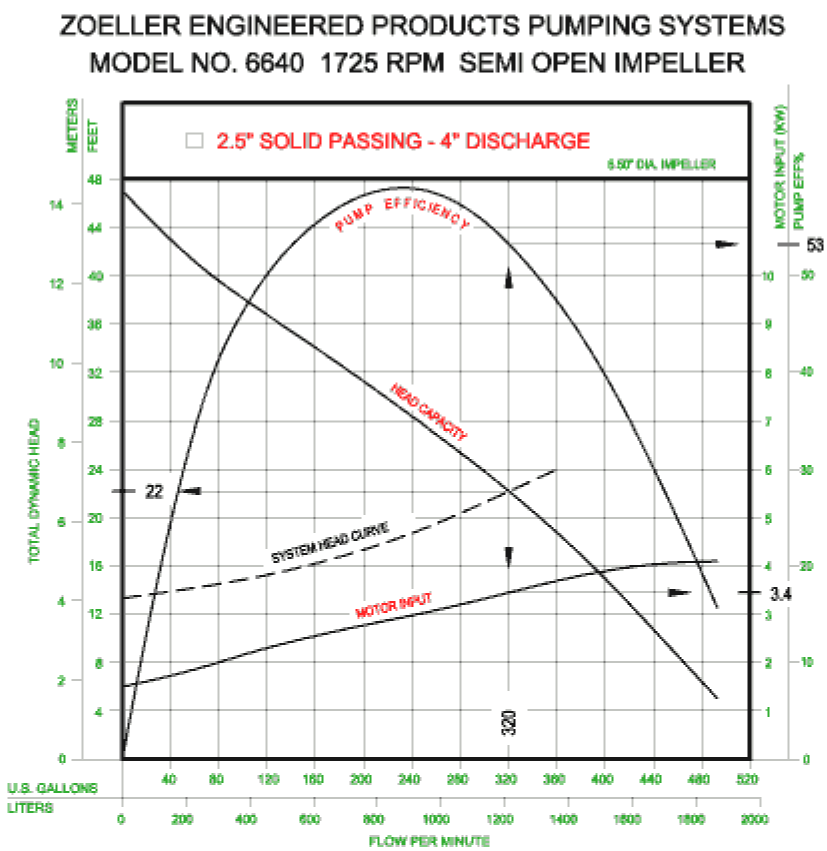
How to Read Pump Curves
& What They Mean

Contributed by Zoeller Engineering Department

The key thing to remember when reading a pump curve is all curves are based upon the principle of plotting data using the x and y axis. With this in mind, the curves typically plotted are head vs. capacity, power input vs capacity, and pump efficiency vs. capacity. Therefore the constant between each curve is the capacity or x-axis. To determine the performance data at a particular point, first locate the operating point of the pump. This is the point where the system head curve crosses the pump's head vs. capacity curve. From this point move horizontally to the left until you intersect the y-axis. This will give you the head at which the pump will operate. Next go back to the operating point. By moving vertically down to the x-axis, you can find the capacity that the pump will operate. Now, at the determined flow rate, moving vertically to the input power curve intersection, then move horizontally to the kW input y-axis the appropriate value for motor input can be read. In like manner the pump efficiency can be read by keeping the flow constant once again. By using this method and Figure 1 the design point is 320 GPM @ 22' TDH. The power input and pump efficiency are 3.4 kW and 53%, respectively.



Each of the above items is calculated from the performance data obtained when testing a pump. The pump test can either be done at the factory or in the field with the appropriate equipment. Head, capacity, current, power input, and voltage are all items that are read by the test equipment. Power factor, motor efficiency, motor input horsepower (EHp), brake horsepower (BHp), hydraulic horsepower (WHp), total efficiency, and pump efficiency must be calculated or looked up in tables.

Now that I have thrown out all these terms, what do they mean? The following is a glossary from the

SWPA Handbook and the Hydraulic Institute for the above terms.

• **Head** - a measure of the pressure or force exerted by the fluid.

• **Capacity** - the rate of liquid flow that can be carried.

• **Current** - the amount of electricity measured in amps which is flowing in a circuit.

• **Power input** - the electrical input to the motor expressed in kilowatts (kW). A measure of the rate at which work is done.

• **Voltage** - the potential or electrical magnetic force (EMF) in an electrical circuit.

• **Power factor** - the ratio of the true power to the volt-amperes in an alternation current (ac) circuit.

• **Motor efficiency** - a measure of how effectively the motor turns electrical energy into mechanical energy. It is the ratio of power input to power output.

• **Motor input horsepower (EHp)** - the power input to the motor expressed in horsepower.

• **Brake horsepower (BHp)** - the power delivered to the pump shaft expressed in horsepower.

• **Hydraulic horsepower (WHp)** - the pump output or the liquid horsepower delivered by the pump.

• **Total efficiency** - the ratio of the energy delivered by the pump to the energy supplied to the input side of the motor. Sometimes refered to as the ‘wire to water efficiency’.

• **Pump efficiency** - the ratio of the energy delivered by the pump to the energy supplied to the pump shaft.

In the above terms, motor refers only to the device that drives the hydraulic end; and pump refers only to the hydraulic end.

Usually most people understand the terms measured by the test equipment but do not understand the calculated terms and how they relate to each other. First, I’ll give the formulas for the terms then we will look at an example for the performance curve in Figure 1.

$$\text{Power factor} = \frac{\text{Watts (actual)}}{\text{Watts (theoretically)}} = \frac{\text{Power input (kW)} * 1000}{\text{(1) Current (amps)} * \text{Voltage} * \sqrt{\text{phase}}}$$

Motor input horsepower (EHp) = Power input (kW) * 1.341

Brake horsepower (BHp) = (2)Motor efficiency * EHp

Hydraulic horsepower (WHp) = [Head (feet) * Capacity (GPM)] / 3960

Total efficiency = (WHp / EHp) * 100%

Pump efficiency = (WHp / BHp) * 100%

1) Found from meter readings.

2) Motor efficiency is usually looked up in a chart from the motor manufacturer.

Now let's look at an example. At our design point of 320 GPM @ 22' TDH the power input and pump efficiency are 3.4 kW and 53%. From a certified test or using a multimeter after the unit is installed, one can find that the current is 9.9 amps at 230 volts, 3 phase. The motor efficiency at this point is 73.7%. Therefore,

$$\text{Power factor} = \frac{3.4 * 1000}{9.9 * 230 * \sqrt{3}} = 0.862$$

Motor input horsepower (EHp) = 3.4 * 1.341 = 4.56 Hp

Brake horsepower (BHp) = 0.737 * 4.56 = 3.36 Hp

Hydraulic horsepower (WHp) = [22 * 320]/3960 = 1.78 Hp

Total efficiency = (1.78/4.56) * 100% = 39.0%

Pump efficiency = (1.78/3.36) * 100% = 53.0%

Since we are dealing with so much math, I'll throw in one more useful formula.

Cost to operate for a year = Duty cycle*Power input*Electrical cost ($/kW hour)*Hours in a year

From our example assuming a 25% duty cycle, and 7¢/kWh

Cost to operate for a year = 0.25*3.4*0.07*8760 = $521.2

All of the pump curves in our catalog as well as our competitors' are calculated by these principles. With a better understanding of what we are reading we can better educate ourselves and customers about our product.