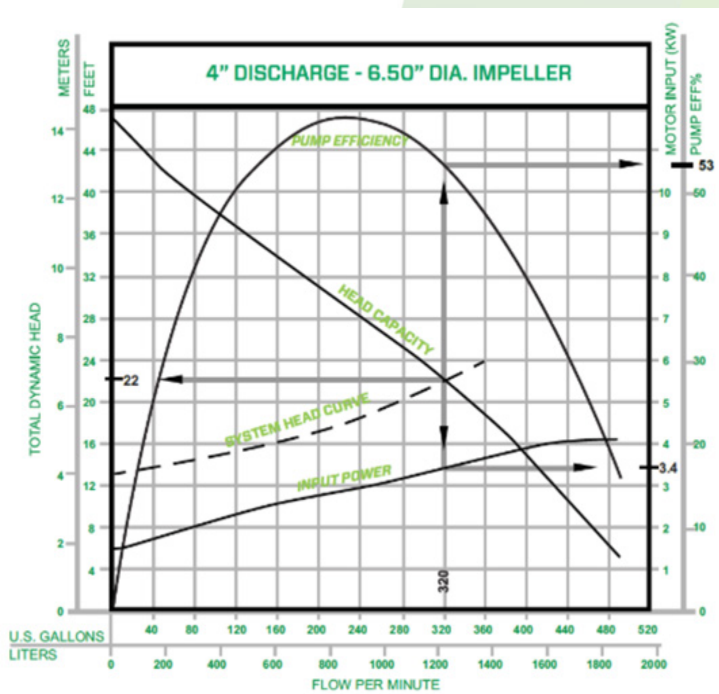
ZOELLER PUMP COMPANY

The key to reading a pump curve is remembering they are based on the principle of plotting data using the x and y axis. The curves that can be plotted are Head vs Capacity, Input Power vs Capacity, and Pump Efficiency vs Capacity. Therefore, the constant between each curve is the Capacity, which is plotted on the 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 head capacity curve, which is associated with a specific impeller diameter. 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 with which the pump will operate with that impeller. Now, at the determined flow rate, move down vertically to the input power curve intersection, then move horizontally to the kW input y axis where the appropriate value for motor input can be read. Likewise, moving up vertically, the pump efficiency can be read by keeping the flow constant once again. Using this method with Figure 1 below, the design point is 320 GPM at 22' TDH. The input power and pump efficiency are 3.4 kW and 53%, respectively.

Figure 1



Each of the above data points is calculated from the performance data obtained when testing a pump. The pump test can either be conducted at the factory or in the field with the appropriate equipment. Head, capacity, current, input power, and voltage are all read by the testing equipment. Power factor, motor efficiency, motor input horsepower (EHP), brake horsepower (BHP), hydraulic horsepower (WHP), total efficiency, and pump efficiency must be calculated or searched in tables provided by the manufacturer. So, what exactly do all these terms mean?

Here's a quick guide:

Head: a measure of the pressure or force exerted by the fluid, total dynamic head (TDH)

Capacity: the rate of liquid flow that can be carried, gallons per minute (GPM)

Current: the amount of electricity flowing in a circuit, measured in amps

Input power: the electrical input to the motor, expressed in kilowatts (kW). A measure of the rate at which work is done.

Voltage (V): the potential or electrical magnetic force (EMF) in an electrical circuit

Motor efficiency: a measure of how effectively the motor turns electrical energy into mechanical energy, the ratio of power input to power output

Motor input horsepower (EHP): the power input to the motor, expressed in horsepower (HP)

Brake horsepower (BHP): the power delivered to the pump shaft, expressed in horsepower (HP)

Hydraulic horsepower (WHP): the pump output, 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 referred 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

Power factor: the ratio of the real power to the apparent power in an alternation current (ac) circuit

In the above terms, 'motor' refers only to the device which drives the hydraulic end, and 'pump' refers only to the hydraulic end. Often, people understand the terms measured by the test equipment but may not understand the calculated terms and how they relate to one another.

Below are the formulas for these terms.

Motor input horsepower (EHP): Power input (kW) x 1.341 (EHP = BHP / 1Motor Efficiency)

Brake horsepower (BHP): 1Motor efficiency x EHP (BHP = WHP / Pump Efficiency)

Hydraulic horsepower (WHP): [Head (ft) x Capacity (GPM)] / 3960

Total efficiency: (WHP / EHP) x 100% Pump efficiency

Example (see figure 1):

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

Therefore...

- Motor input horsepower (EHP) = 3.4 x 1.341 = 4.56 HP
- Brake horsepower (BHP) = 0.737 x 4.56 = 3.36 HP
- Hydraulic horsepower (WHP) = [22 x 320] / 3960 = 1.78 HP
- Total efficiency = (1.78 / 4.56) x 100% = 39.0%
- Pump efficiency = (1.78 / 3.36) x 100% = 53.0%

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

Cost to operate for a year: duty cycle x power input x electrical cost ($/kW hour) x hours in a year

From our example, we'll assume a 25% duty cycle and 7¢/kWh.

Cost to operate for a year = 0.25 x 3.4 x 0.07 x 8760 = $521.20

Another term defined above, power factor, is the ratio of the Watts drawn by the motor (Real Power) to that supplied by the electrical utility for the power consumed (Apparent Power). This is important to some users as they may be penalized for electrical use when the power factor is below a predetermined percent, 90% for example.

$$\text{Power Factor} = \frac{\text{Watts (actual)}}{\text{Watts (theoretical)}} = \frac{\text{power input (KW)} \times 1{,}000}{{}^{2}\text{Current (amps)} \times \text{Voltage} \times \sqrt{\text{phase}}} = \frac{3.4 \times 1{,}000}{9.9 \times 230 \times \sqrt{3}} = 0.86$$

All the pump curves in the Zoeller Engineered Products catalogs are calculated by these principles. With a better understanding of what we are reading, we can better educate ourselves and our customers about our products.

[1] Motor efficiency can usually be found in a chart from the motor manufacturer.

[2] Found from meter read