The subject of this bulletin covers the reading and understanding of pump performance curves. It will cover all three types of curves including centrifugal, submersible, and engine driven.

DEFINITIONS

Total Dynamic Head (TDH) – This is the combination of the Total Static Head and the Friction Loss of the piping system. The value of Total Dynamic Head is the combination of the suction and discharge gauge readings.

Gallons Per Minute (GPM) – Quantity of flow over the specified time.

Efficiency – This is the percentage of work received from a pump in relation to the amount of energy used.

Net Positive Suction Head Required (NPSHr) – This is the amount of atmospheric pressure required to move liquid through the suction side of the pump. NPSHr is directly related to pump design.

Static Lift – This is the vertical distance from the water level in the source to the center line of the suction piping entering the pump.

Reprime – This is the term used to qualify the second and subsequent attempts to lift water after initially priming and achieving dynamic operation. The term is used frequently in conjunction with static lifts in relation to the pump’s ability to lift liquid with a reduced amount of water in the volute pump casing. At shutdown after initial priming and operation, a percentage of the water from the volute returns to source. This reduced water level would be defined as a “reprime level”.

READING A PUMP PERFORMANCE CURVE

A pump performance curve is defined as a manufacturer’s chart plotting head versus flow. While this is true, most curves include a wealth of additional information. This information may have to do with the subject of power consumption, efficiency, priming, solids capability, or pump parts information. After design and fabrication of a pump, a prototype is tested to determine the pump’s capabilities from high pressure, low flow conditions to low pressure, high flow conditions. After testing and documenting the pump’s capabilities at the extremes of pressure and flow, a pump performance curve is finalized. There are many types of pumps capable of delivering different flow rates at different pressures. Prior to pump selection, troubleshooting through speed and gauge readings, or use of the curve during routine maintenance, always ensure that the curve available is the correct curve for the subject pump. Every pump model has its own exclusive curve. In any case, pump performance curves are a necessity in selecting and troubleshooting the pump for every application.

BASIC PUMP PERFORMANCE CURVE

This section covers curves for basic pumps or pumps sometime referred to as “bare shafted” pumps which require some type of driver. The following is a list of information by numbers found on these types of curves, the description of this information, and where it can be located on the curve.
The information provided in this area of the pump performance curve usually contains the performance curve number, pump volute casing part number, pump impeller part number and diameter, basic model number, the suction and discharge size openings, the specific gravity of the product that was used to test the pump, and the speed or speeds at which the pump is capable of operating.

The information provided in this area may vary. It may provide general specification information or reprime data.

The information provided in this area of the pump performance curve is total dynamic head. This value is found through the calculation of friction loss within the piping system added to the total static head. This value is also the combination of dynamic gauge readings from the suction and discharge. The values within this area are noted in Meters (M), Pounds Per Square Inch (PSI), and Feet (FT).

The information provided in this area of the pump performance curve is flow. The values in the area are noted in U.S. Gallons Per Minute (GPM), Litres Per Second (LPS), and Cubic Meters Per Hour (M /H).

The information provided in this area of the pump performance curve is the performance of the pump. It is shown in the form of H/Q or head/capacity lines. These head/capacity lines are noted by the speed required to achieve the head noted along the left side of the curve and capacity noted along the bottom.

The information provided in this area is the Net Positive Suction Head Required (NPSHr) by the pump. Its value is found to the right of the NPSHr curve in the chart labeled “NPSH”. The values in the chart are in feet and meters.

The information provided in this area is the efficiency. This particular pump ranges from 40 to 58 percent efficient.

This dimensional line denotes the full operating range or envelop of which the pump will perform satisfactorily.

A pump performance curve has basically three values, two of which like any mathematical equation have to be known to find the third. While troubleshooting a pump, two of the three that can be measured and known are speed (tachometer reading of the pump) and the total dynamic head (suction and discharge gauge readings).
With these two known values, we can plot a condition point on the curve and find a flow rate from these two values. If a design condition point is supplied, it usually is done so in the form of a total dynamic head and a flow rate. Below are the two ways to determine the third unknown, among other information, by knowing the two. Let’s take a look at both.

All curves should be reviewed in the same manner when used during the design stage. During the design process, we know that the total dynamic head of the pump is 56 feet and the flow rate required is 800 GPM. From these two known values, follow the steps listed below to plot a condition point on the below curve. After plotting the condition point, we can determine other details of the requirements such as speed, horsepower, efficiency, etc.

1. Locate the value of 56 feet of total dynamic head and draw a horizontal line across the curve at this value.

2. Locate the flow rate of 800 gallons per minute and draw a vertical line upwards from this value until it intersects the horizontal line drawn at 56 feet.

3. The intersection of these two lines can now be defined as the condition point.

Let’s take a look at what this condition point can tell us.

4. **Speed** – The condition point rests on the head capacity curve noted by 1250 RPM. Therefore, the pump must be operated at 1250 RPM to achieve this condition point.

5. **Horsepower** – The condition point falls below the 20 horsepower line. It can be estimated by its location between the 15 and 20 that the pump will consume approximately 18 horsepower. If the application calls for non-overloading across the head capacity curve, 25 horsepower will be required for this particular pump’s characteristics.

6. **Efficiency** – The condition point is located between the two 58 percent notations. Outside of this area which is defined as best efficiency point (BEP) would decrease left and right of the 58 percent area.

7. **NPSHr** – The value of NPSHr is found by reading vertically from the flow rate to the intersection with the NPSH @ 1550 RPM line. From that intersection draw a horizontal line to the right to the NPSH chart. The value is 7 feet.

8. **Reprime Lift** – The speed required to deliver the head and flow of the condition point (1250 RPM) can be located in this chart. The chart notes that the pump is reprime capable to 21 feet.
The information provided in this area of the pump performance curve usually contains the performance curve number, pump volute part number, pump impeller part number and diameter, basic model number, the suction and discharge size openings, the specific gravity of the product that was used to test the pump, and the speed or speeds at which the pump is capable of operating.

The information provided in this area may vary. It usually provides general specification information in regards to engine governor settings, low speed operation, engine manufacturer and model number, and the pump’s solids handling capabilities.

The information provided in this area of the pump performance curve is total dynamic head. This value is found through the calculation of friction loss within the piping system added to the total static head. This value is also the combination of dynamic gauge readings from the suction and discharge. The values within this area are noted in Meters (M), Pounds Per Square Inch (PSI), and Feet (FT).

The information provided in this area of the pump performance curve is flow. The values in the area are noted in U.S. Gallons Per Minute (GPM), Litres Per Second (LPS), and Cubic Meters Per Hour (M/H).

The information provided in this area of the pump performance curve is the performance of the pump. It is shown in the form of H/Q or head/capacity lines. These head/capacity lines are noted by the speed required to achieve the head noted along the left side of the curve and capacity noted along the bottom.

The information provided by the vertical lines, noted by a distance, is the performance of the pump when subjected to suction lifts noted.

MATCH THE INFORMATION WITH THE CORRESPONDING NUMBER NOTED ON CURVE NO. 2.

Curve No. 2: Example of an Engine Driven Pump Curve
Let’s look at plotting a condition point on the engine driven pump performance curve below. Let’s assume that the total dynamic head was measured and is 90 feet and the measured speed is 1900 RPM. (Engine speed can be used for direct coupled pumps unit.)

1. Locate the total dynamic head of 90 feet and draw a horizontal line to the right side of the curve.

2. Locate the head capacity curve noted by the measure engine speed of 1900 RPM.

3. Moving from left to right on the curve, these two lines will intersect within the curve. This intersection is known as the condition point.

4. From this condition point, draw a vertical line downward to the flow rate. The flow rate should be 1600 GPM.

5. If the pump was applied on a suction lift greater than 18 feet, the flow rate would be reduced due to NPSH. Therefore, to find the reduced flow rate, follow the horizontal line at the condition point back toward the left for higher lifts. The intersection of the horizontal line or total dynamic head line and the vertical static lift lines are the respective condition points for the higher lifts.

6. For example, let’s assume the previously mentioned condition point controlled by the installation of the pump and system was place on a lift of 20 feet, the new flow rate would be approximately 1480 GPM.

7. If the same system were to pump the level down to lift the liquid 25 feet, the new flow rate would be 1000 GPM.
This section covers curves for submersible pumps. The following is a list of information found on these types of curves, the description of this information, and where it can be located on the curve noted as Curve 3.

1. The information provided in this area of the pump performance curve usually contains the performance curve number, pump volute part number, pump impeller part number and diameter, basic model number, discharge size, the specific gravity of the product that was used to test the pump, and the speed of the pump.

2. The information provided in this area may vary. It usually provides general specification information in regards to motor horsepower, voltage, and phase. Other information provided in this area may include solids handling capabilities.

3. The information provided in this area of the pump performance curve is total dynamic head. This value is found through the calculation of friction loss within the piping system added to the total static head. This value is also the combination of dynamic discharge gauge reading and any corrections made in elevation and friction loss from the point the pressure was measured. The values within this area are noted in Meters (M), Pounds Per Square Inch (PSI), and Feet (FT).

4. The information provided in this area of the pump performance curve is flow. The values in the area are noted in U.S. Gallons Per Minute (GPM), Litres Per Second (LPS), and Cubic Meters Per Hour (M/H).

5. The information provided in this area of the pump performance curve is the performance of the pump. It is shown in the form of H/Q or head/capacity line. This head/capacity line is noted by the speed of the submersible motor required to achieve the head noted along the left side of the curve and capacity noted along the bottom.

6. The information provided by these lines is power consumption. The information reflected by these lines is amperage at rated voltage and kilowatts. The value of this information is obtained in conjunction with the legend on the lower right.
Let's look at plotting a condition point on the submersible pump performance curve below. If the pump were applied to a system that included a wet pit dry pit installation, then a suction and discharge gauge reading would be necessary. Otherwise, measure the discharge pressure and take any corrections into account. Let's assume that a total dynamic head was measured at 470 feet.

1. Locate the total dynamic head of 470 feet and draw a horizontal line to the right side of the curve.

2. The intersection of the head capacity curve and this horizontal line is known as the condition point.

3. From this condition point, draw a vertical line downward to the flow rate. The flow rate should be 1400 GPM.

4. From this we can review the amperage of the motor. Let's assume that the pump is built for and operated on 460 volt service. The vertical line drawn downward from the condition point intersects three amperage and kilowatt lines across the bottom. From the intersection of this vertical line through the respective voltage, draw a horizontal line to the right side chart noted “KW” and “AMP”. In this case, the amperage of the pump, if measured, should be 260 amps.

It should be noted that the information as presented assumes that data is representative of equipment in good working condition. Such things as excessively worn components or poor clearances, or poor site power will result in slightly different results.