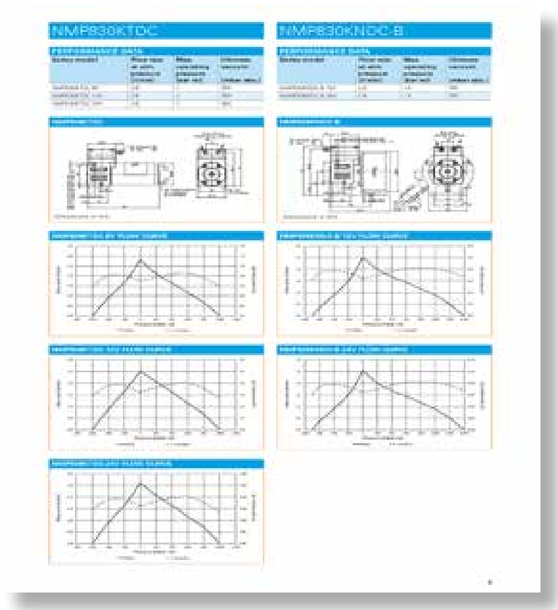
INTERPRETING PUMP PERFORMANCE CURVES

AN IMPORTANT STEP IN MATCHING THE RIGHT PUMP TO AN APPLICATION



Example of a pump manufacturer's performance curve sheet

INTRODUCTION

Pump manufacturers provide pump performance curves (also known as "pump flow curves" or just "pump curves") to assist users in the selection, testing, operation and maintenance of pumps. But not all performance curves are created equally, and each manufacturer may have different formats. Despite the differences, the common understanding of pump performance curves is they provide an expectation of certain performance levels under specific operating conditions. This information is essential for design engineers as they attempt to source and select the best pump for their system.

PUMP TERMS

Before explaining the specifics of performance curves, it helps to understand the terms used:

Gauge Pressure – a measure of pressure relative to ambient atmospheric pressure and commonly reported in pounds per square inch gauge (psig) or bar gauge (bar g).

Flow rate – the volume of fluid flowing through an area over a standard period of time; commonly reported in Liters per minute (L/min).

Atmospheric pressure – measured by a barometer and reported in the standard atmosphere unit: atm; it is the measurement of the force exerted by Earth's atmosphere.

Vacuum – a measure determined by the pressure differential between an evacuated system and the surrounding atmosphere; commonly reported in inches of mercury (inHg), millimeters of mercury (mmHg) or millibar (mbar).

PUMP PERFORMANCE CURVE DETAILS

A performance curve illustrates the expected performance capabilities across the rated pressure range. Typically, pump performance is plotted on a graph with an x-axis showing pressure and a y-axis showing flow rate. The vertical line down the center of the graph represents atmospheric pressure and divides the graph into segments of vacuum and pressure. Vacuum, on the left of the center line, is measured in mbar or inHg. Pressure, on the right of the center line, is measured in psig or bar. The point of intersection between the two curves indicates the maximum flow or free flow of that pump when operating without restrictions (see Figure 1). The end points of each curve represent the pump's respective maximum capabilities for vacuum or pressure.

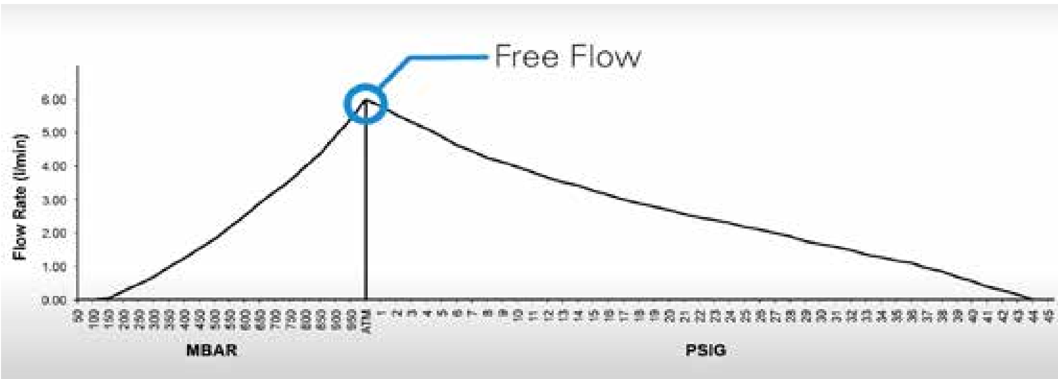


Figure 1: Typical diaphragm pump performance curve with free flow identified

USING VACUUM AND PRESSURE TEST CONDITIONS TO INTERPRET A FLOW CURVE

In the following sample scenarios, a typical performance curve can be created by measuring simulated pressure and vacuum test conditions. The vacuum test condition utilizes the pump, gauge and flow meter configuration shown in the schematic of Figure 2. The free flow rate of this example pump is measured at approximately 6 L/min., as shown previously in Figure 1.

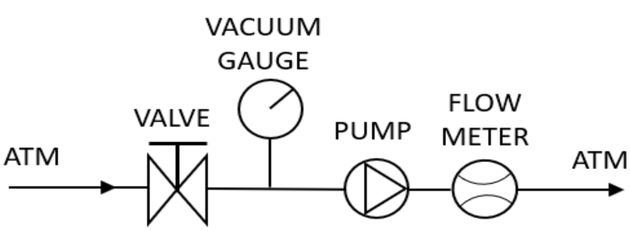


Figure 2: Vacuum test condition schematic

When the valve on the inlet side of the pump is closed to a vacuum gauge reading of 550 mbar, the pump curve can be referenced to predict an expected flow rate of approximately 2.1 L/min. This flow rate predication is found by drawing a vertical line up from the 550 mbar data point on the left segment of the x-axis until the flow curve is intersected. From that intersection, a horizontal line is drawn to the y-axis with an intersection point of about 2.1 L/min (see Figure 3).

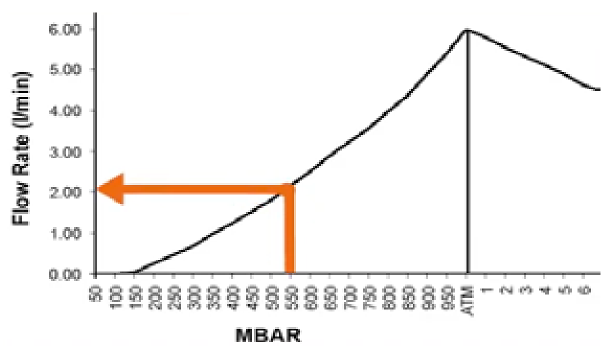


Figure 3: Vacuum test condition flow rate prediction

The pressure test condition is measured by utilizing the equipment configuration shown in Figure 4. When the valve on the outlet side of the pump is closed to a pressure gauge reading of 22.5 psig, the flow rate of the pump is expected to drop off from the free flow rate of 6 L/min.

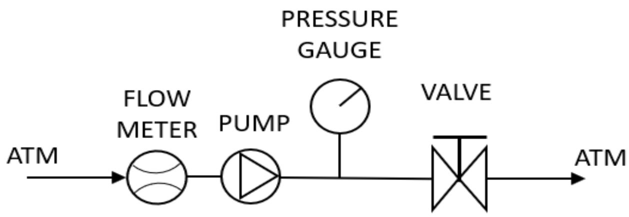


Figure 4: Pressure test condition schematic

A vertical line is drawn up from the 22.5 psig data point on the right segment of the x-axis to the point of intersection with the flow curve. A horizontal line is then drawn from that point of intersection to the y-axis where a flow rate of approximately 2.3 L/min is predicted. (see Figure 5).

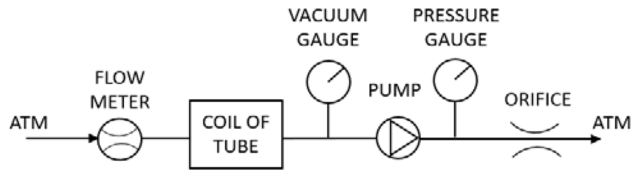


Figure 6: Pressure and vacuum test condition schematic

In the example illustrated above, there is a coil of tubing on the inlet side of the pump and a restrictive orifice on the outlet, both of which will impact the flow performance of the pump. For some example data points shown in Figure 7, assume that the coil of tube adds 887 mbar of restriction on the inlet while the orifice on the outlet side generates 10 psig of backpressure.

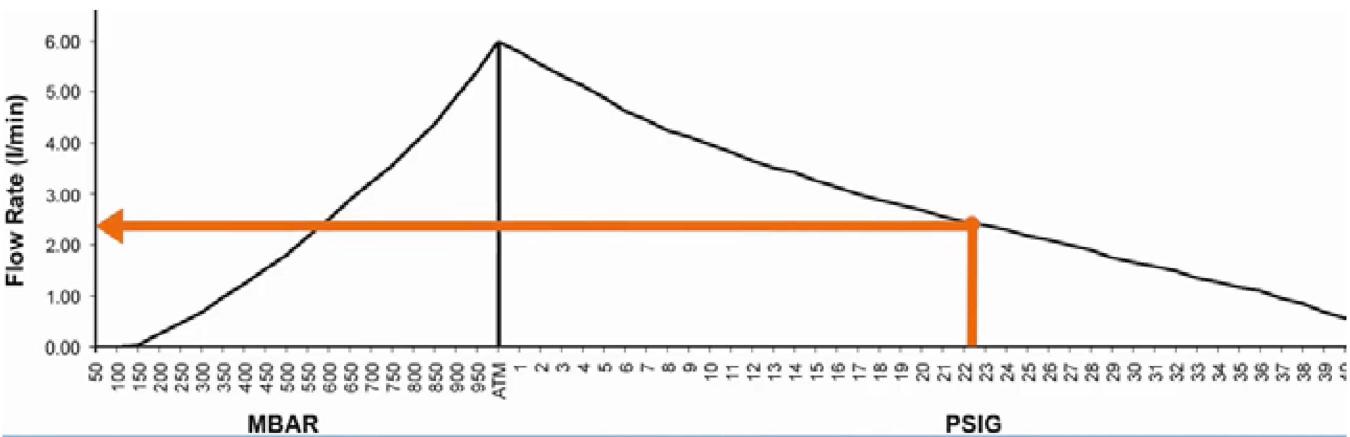


Figure 5: Pressure test condition flow rate prediction

MANIPULATING THE CURVE

Within many real-world applications, a pump may have both vacuum and pressure conditions, as demonstrated in the schematic shown by Figure 6. In situations like this, with a slight manipulation of the chart, a pump performance curve can still be used to estimate the flow rate of the pump.

As previously demonstrated, a vertical line drawn up from the pressure segment of the x-axis intersects the flow curve. But in this instance, the horizontal line drawn from the point of intersection towards the y-axis stops at the center line for

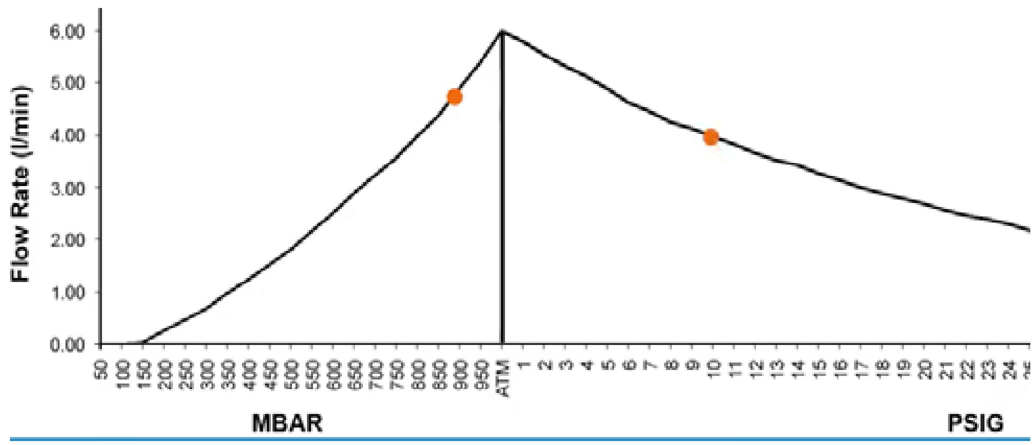


Figure 7: Pressure and vacuum example data points

atmospheric pressure. A slight manipulation of the vacuum segment of the flow curve is needed to move the segment downwards until the top of the vacuum curve intersects with the point on the center line. With this newly modified flow curve, the same process is repeated to find the intersect of the curve at 887 mbar. Figure 8 displays the resulting flow rate estimate of 2.94 L/min in this test scenario in which both pressure and vacuum conditions exist.

The pump performance curves should be referenced and interpreted to assist in the selection of the best pump for use in the application. And as the previous example demonstrates, the presence of both pressure and vacuum conditions in any application is common but the performance curves can provide good estimates for use in the pump selection.

COMPANION VIDEO

Want an even clearer understanding of the material covered in this piece? See the companion video, in which all points are aided by animated pump performance curve illustrations and voice-over instruction. In addition, you'll see the actual pump set-ups used to demonstrate each point. Go to https://bit.ly/2Qnh3wI.

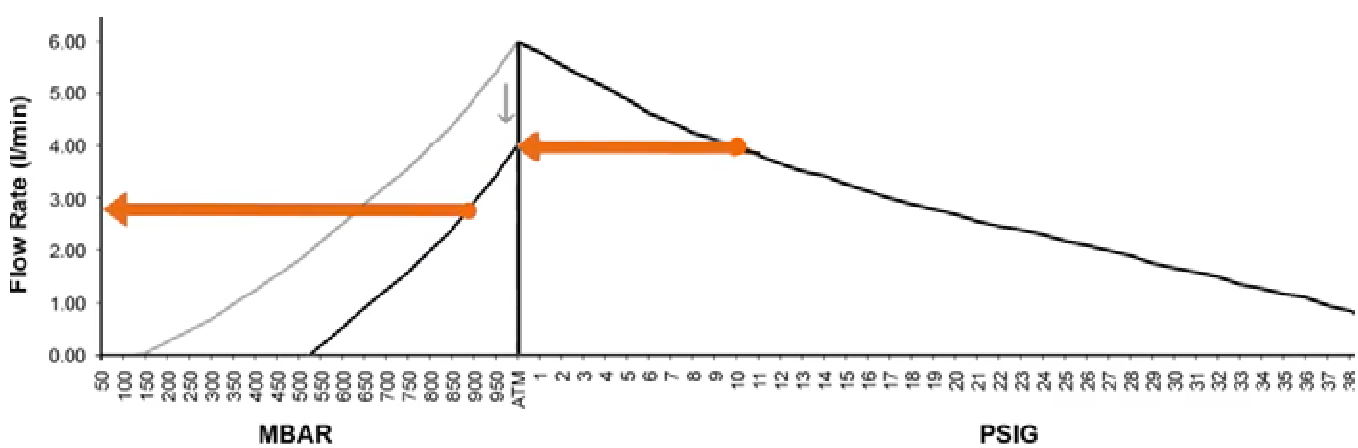
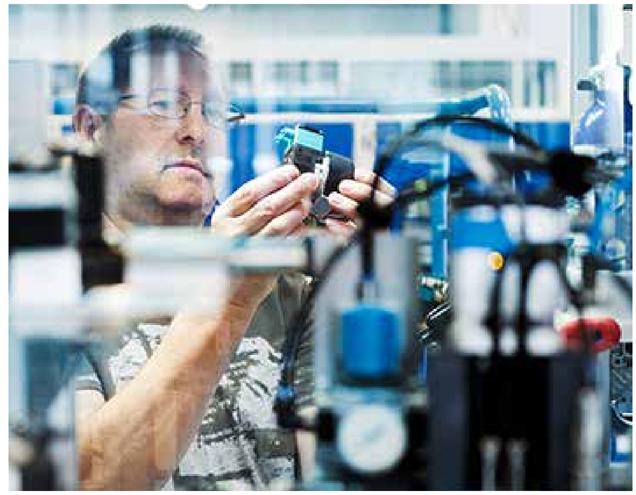


Figure 8: Pressure and vacuum test conditions with curve manipulation for flow rate estimate

BEYOND THE PUMP PERFORMANCE CURVE WITH KNF

Standard off-the-shelf KNF products are capable of operating anywhere underneath their published pump performance curves, but through a modular engineering design approach, KNF pumps can also operate above the curve (see Figure 9). Through engineer-to-engineer conversations, the exact requirements for individual applications are discovered. KNF engineers offer customizations to motors, flow path, and connections to balance performance, lifetime, and cost goals. Many material options are available for chemical resistance requirements. Customized pumps comprise the majority of KNF business and with no minimum quantities, the possibilities for any customer, from startup, to design firm, to Fortune 500 are endless. With proven expertise in applications such as medical device, IVD, inkjet printing, environmental monitoring, fuel cells, analytical instruments, and cleaning and disinfection, KNF can provide the best pump within the required performance range. Contact KNF for more information on designing the perfect pump for your application.



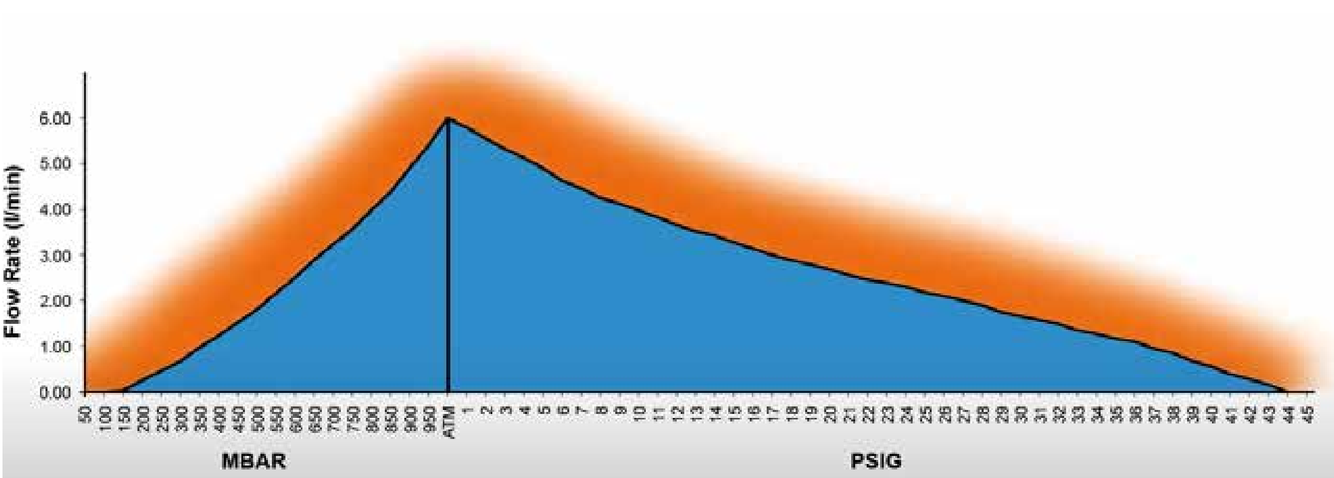


Figure 9: Performance potential (orange) for customized KNF pump ***(illustrative purposes only)***

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