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# **Pulsafeeder Diaphragm Metering Pumps**

## **Tech Sheet 310**

### **Flow Rate Adjustment and Calibration**

#### **Introduction**

Metering pumps develop flow against discharge pressure by means of a reciprocating piston that acts upon a diaphragm. This action produces a pulsating flow at the outlet of the pump. The piston action can be transferred to the diaphragm by means of a captive chamber of hydraulic oil, or by a mechanical connection. Flow is regulated through the pump by means of a set of check valves at the inlet and outlet connections.

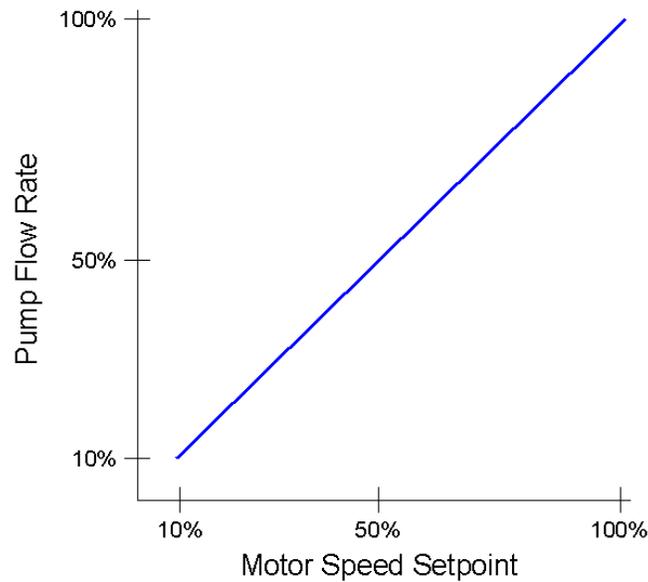
The theoretical flow rate of a pump can be calculated by determining the volume displaced by the piston on each stroke, and multiplying that by the number of strokes per some time interval, for example one minute, or one hour.

For any given pump, the actual flow rate will never be exactly the same as the theoretical flow rate. This is due to various mechanical and hydraulic losses within the system, for example time losses in the check valves, or slip of hydraulic oil past the piston seals during normal operation.

The flow rate of a metering pump can generally be adjusted in one of two ways. The user can vary the distance that the piston travels, or the speed at which it reciprocates within the pump. For changes in the piston travel, or stroke length, a mechanical adjustment within the pump is used. In order to change stroke speed (frequency), some form of variable speed drive is used to change the rotation speed of the drive motor, for example a DC-SCR drive, or an AC VFD.

#### ***Section 1, Flow Rate vs. Motor Speed Adjustment***

Under most conditions the relationship between pump flow and the adjustment of stroking speed (frequency) will be linear across the rated range of adjustment. This range is generally between 10:1 - 20:1, meaning that pump accuracy and repeatability can be maintained from 100% of rated speed, down to a minimum of 5 - 10% of rated speed.



*Figure 1, flow vs. speed adjustment*

As per the graph above, there is a linear and predictable relationship when adjusting motor speed. It is expected that at 50% speed, the flow will be approximately equal to half of the flow recorded at 100% speed. At 10% speed, flow will be approximately equal to 10% of full flow. We expect that under normal conditions, the calibration curve will pass through the origin (zero point) of both axes of the graph.

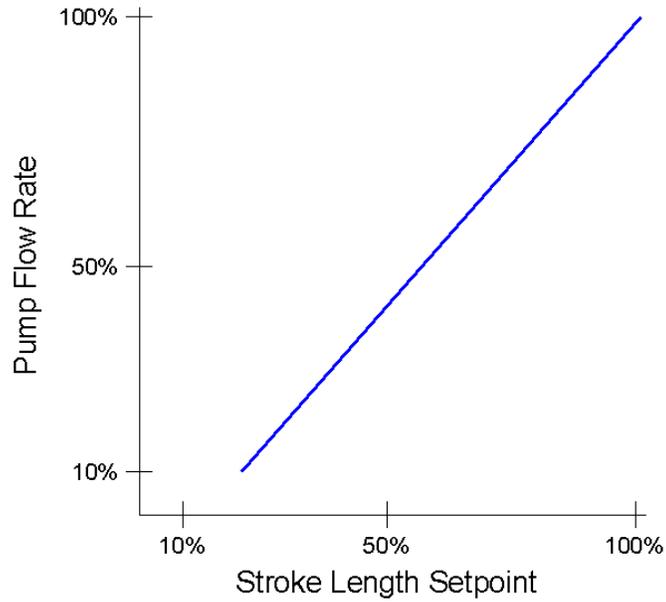
The minimum accepted value for speed adjustment is dependent upon application variables such as product characteristics and discharge pressure, among others. Generally, 10% is considered a safe minimum, with many applications capable of performing acceptably down to 5%.

Notes:

- Maximum input speed is 1750 rpm for most Pulsafeeder pump models, although some are rated at 1140 rpm motor speed. Models operating on 50 Hz electrical systems will be rated with a maximum input speed of 1450 rpm. See the pump documentation for your equipment for details.
- Maximum flow from any specific pump may be somewhat higher than nameplate rated flow, in order to allow for manufacturing tolerances and application variances. Proper flow tests (see Section 4) will ensure accurate results from any given installation.

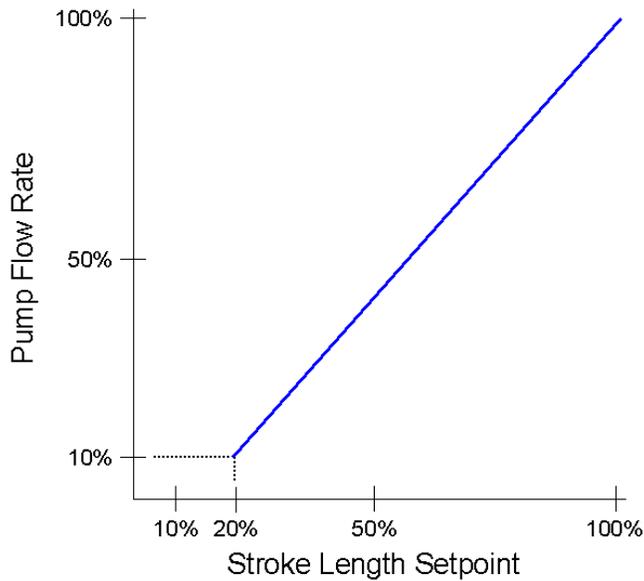
## **Section 2, Flow Rate vs. Stroke Length Adjustment**

The relationship between pump flow and the adjustment of piston stroking distance (length) will also be linear across the rated range of adjustment, however the results are not proportional to the adjustment scale. This range is generally limited to approximately 10:1, meaning that pump accuracy and repeatability can be maintained from 100% of stroke length, down to a minimum of 10% of stroke length. In most applications, stroke lengths shorter than 10% result in inadequate action of the diaphragm to ensure accurate, repeatable performance. Under certain application conditions the realistic lower limit for stroke adjustment may be somewhat higher than 10%.



*Figure 2, flow vs. stroke length adjustment*

The graph above illustrates the linear and predictable relationship when adjusting stroke length. However, the lower end of the flow graph shows that the relationship is not linear to the adjustment scale. In this case the calibration curve does not pass through the origin (zero point) of both axes of the graph. This is further illustrated by the following example:



*Figure 3, stroke length adjustment to achieve 10% flow*

In the illustration in Figure 3, the flow graph shows that for a pump flow of 10%, the setpoint for stroke length needs to be approximately 20%. It is important to note that the

response of stroke length adjustment is still a linear relationship. However, a pump set to 10% on the stroke scale may not actually produce 10% of its rated flow. This relationship is due to losses in hydraulic efficiency and other effects of operating at very small displacements per pump stroke.

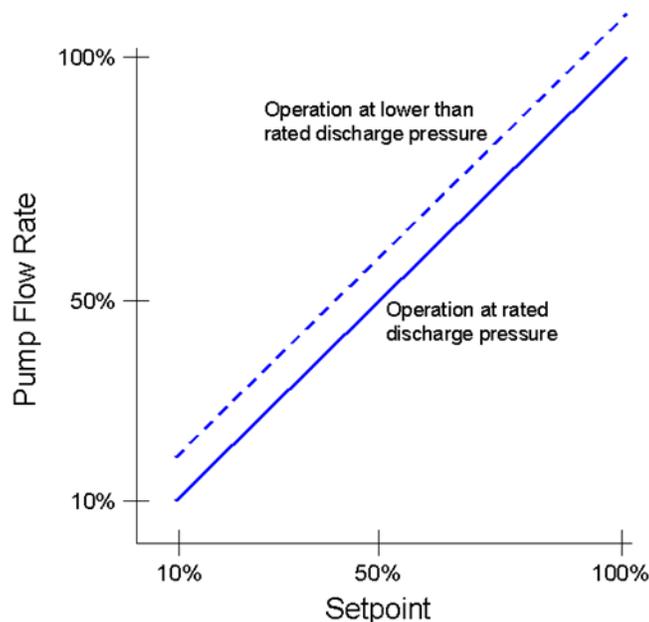
It is important to note that the pump is still capable of producing a flow rate that is 10% of its full flow rating. However, this amount of flow is produced at a setpoint greater than 10% of the mechanical stroke length.

Notes:

- Maximum stroke length varies for different pump models. This is why pump stroke is usually referred to in percentage as opposed to absolute values. The pump Specification Sheet for your model will show the true maximum stroke length (in inches or millimeters) for your pump.
- Maximum flow from any specific pump may be somewhat higher than nameplate rated flow, in order to allow for manufacturing tolerances and application variances. Proper flow tests (see Section 4) will ensure accurate results from any given installation.

### **Section3, Flow Rate vs. Discharge Pressure**

Discharge pressure at the outlet of the pump will also affect the flow rate realized from a specific model in a specific application. Pulsafeeder metering pumps are rated in our Sales Literature and on Nameplates and Specification Sheets for flow at their maximum rated discharge pressure. Many pumps are run in applications where they do not fully utilize all of the available discharge pressure capability. When a pump is used at lower than its full rated pressure capability, there will be gains in efficiency that result in higher than rated flow.



*Figure 4, flow vs. discharge pressure*

In the graph above, the solid line represents the expected flow curve when the pump is run at its full rated discharge pressure capability. The dashed line indicates the expected gain in flow when the same pump is run at some pressure lower than its full capability.

As a general rule, expected flow can be estimated as:

*A gain of 1% of rated flow, for every 100 psi of unused discharge pressure capability*

For example, a pump that is rated for use at pressures up to 1,000 psi is utilized in an application at only 200 psi. The difference of 800 psi of “unused” pressure capability will result in a gain of approximately 8% flow. This gain will be relatively linear across the adjustment range of the pump.

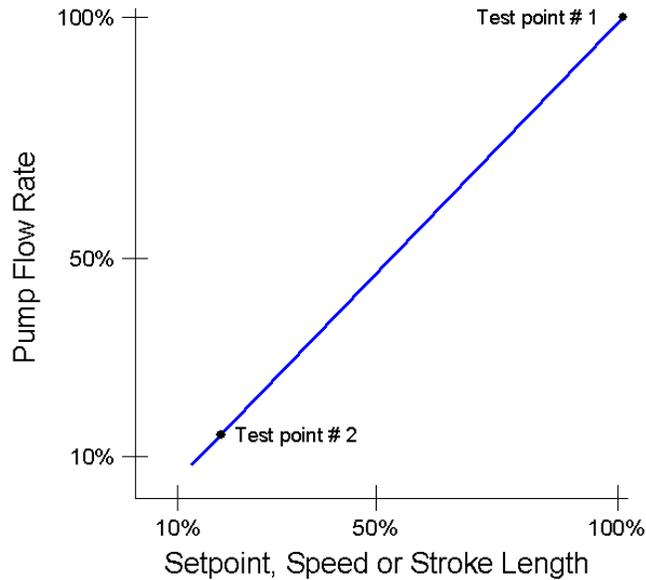
This formula is meant to be a guide only, and exact flow at any given setpoint and pressure is best determined by testing the pump under actual process conditions (see Section 4)

#### ***Section 4, Calibration of Pump Flow***

Standard pump flow curves are provided by Pulsafeeder upon request for all pumps. These curves serve to illustrate pump performance under factory test conditions. These would include operation at rated discharge pressure, pumping water as a test medium, with proper suction conditions and at normal ambient temperature.

Many variables will affect a pump’s actual performance in the field, including process conditions, product characteristics, piping arrangements, temperature, pressures, etc. For the best accuracy, it is important that the end user perform tests to measure and understand the operation of a given pump in their process system.

These tests generally consist of measurement of the flow rate of the pump, either using a graduated calibration column on the suction side, or a calibrated flow meter in the discharge, at a variety of setpoints. It is generally recommended that at least two points be chosen for testing. In most instances, the 100% flow setpoint will be the first test point, and a lower setting will be the second. In some applications it may be sensible for this low setting to be the minimum for that pump (for example 10% stroke length, or perhaps 5% speed). In other cases, the second test point might be chosen as the normal setpoint that is expected for that pump in that specific process.



*Figure 5, sample field test flow curve*

As in the example above, these two (or more) points can be connected with a best-fit line that will accurately describe the response of the pump over its rated flow range.

For applications where speed is variable as well as stroke, two curves will be required to give an accurate picture of the response to the two variables. If it is expected that both variables (motor speed and stroke length) will be adjusted at the same time, then additional test points representing various combinations of stroke length and speed setting may be required.

Each type of metering pump, for example Pulsa Series, PULSAR, or SHADOW models, will have a stated accuracy rating. This rating serves as a basis for predicting pump performance. However, the accuracy of any pump will be affected by the accuracy of the related equipment, for example an electronic stroke length controller, or a variable speed drive. It is understood that the accuracy ratings of these devices are additive.

For example, if a pump has a rated accuracy of +/- 1%, and is equipped with a stroke length controller rated at +/- 1%, and also a DC-SCR variable speed drive with an accuracy rating of +/- 1%, then the total rating of this system will be +/- 3%.