Application Note to the Field	Minimum Flow Rate for Gear Pumps
Application Note Number: 1602-5	**Date: February 3, 2016**

Turndown Ratio of a Gear Pump

A gear pump is an excellent choice for metering fluids. Often times the pump is called upon to meter a range of flow rates. The ratio of this range (maximum flow divided by minimum flow) is called the *turndown ratio* or simply, the *turndown*. For example, the range of 10 GPM to 1 GPM would be a turndown of 10:1.

First, it is important to distinguish between the motor and the pump. When adjustable flow of a gear pump is required, the best and most common way to do so is by adjusting the motor RPM, usually by means of a VFD (Variable Frequency Drive). When using this method, the turndown ratio of the motor must be considered and should fall into the required range of the pump. This ratio will vary depending on the manufacturer and type of motor, so it is best to check with the manufacturer for their specifications. A common turndown ratio for Baldor Premium Efficiency TEFC motors is 10:1 constant torque, which allows a 4-pole 60 Hz motor to safely operate from 1800 to 180 RPM (or under full-load from 1750 to 175 RPM), which is adequate for the majority of gear pump applications.

The turndown ratio of the pump is not as straightforward, because there is not one fixed answer. In theory, the pump can be run all the way down to zero RPM, if the conditions are right. Conditions which allow the pump to achieve a high turndown ratio (10:1 or more) are moderate to high viscosity (2 cP and above) and stable differential pressure. If the differential pressure varies, so can the flow rate, which can negatively impact metering accuracy. If this is a concern, a backpressure valve can be used to stabilize the pressure. A closed loop control system with a flowmeter feedback can also be used to increase the accuracy for a given system. At extremely low RPM, small pulsations may occur, caused by the slow rotation of the gear teeth. If a thin fluid is used, the pump is subject to excessive slip, which reduces the efficiency and accuracy, and narrows the RPM range the pump can successfully operate in, thus preventing a large turndown. The average turndown for a thin fluid (< 2 cP) is 2:1.

There is no fixed rule for the maximum turndown ratio of a gear pump; it varies by application. However, with the proper conditions, ratios in the range of 20:1 are achievable. For higher ratios or thin fluids, a recirculating loop may be a more accurate alternative.

Metering Pump Selection

When metering, the pump size plays an important role. To achieve an accurate flow over a wide range, the smallest pump which fits inside the range is often the best selection. This allows a wider operating speed range and more discrete operating points, therefore allowing more controllability.

As an example, to achieve a flow rate of 1-2 GPM for a 20 cP fluid at 100 PSI differential pressure, there are three pump options, as shown in the table below:

Pump Size	Min RPM (1 GPM)	Max RPM (2 GPM)	Turndown Ratio	Motor		VFD	
				RPM Range	RPM Span	Hz Range	Hz Span
H5R	750	1470	1.96 : 1	750-1470	720	25-49	24
H5F	540	1040	1.93 : 1	540-1040	500	18-35	17
H7N	340	655	1.93 : 1	340-655	315	11-22	11

The smallest size pump offers the largest RPM range. Therefore, the most controllability for flow rates in between the Min and Max is achieved with the smaller pump.

Note: The Hz Range above is the VFD frequency range corresponding to the motor speed range (assuming zero slip between synchronous speed and actual motor speed). Since the motor used is a 4-pole motor, the VFD frequency is twice the motor speed in Hz. This relation is given by the following formula:

$$\boldsymbol{VFD\ Frequency\ [Hz] = 2 * Motor\ Speed\ [RPM] * \frac{1\ [Hz]}{60\ [RPM]}}$$

For example, the VFD frequencies corresponding to motor speeds of 750 and 1470 RPM are given by:

$$VFD\ Frequency, Min = 2 * 750\ [RPM] * \frac{1\ [Hz]}{60\ [RPM]} = 25\ Hz$$

$$VFD\ Frequency, Max = 2 * 1470\ [RPM] * \frac{1\ [Hz]}{60\ [RPM]} = 49\ Hz$$