Shanley Pump & Equipment, Inc.

# SEP

HEAVY DUTY PROGRESSIVE CAVITY PUMPS

## HOW TO SIZE & SELECT A PROGRESSIVE CAVITY PUMP

## SECTION I - APPLICATION & PRODUCT INFORMATION

There are several steps necessary for the proper selection of a Progressive Cavity Pump (P-C pump) and these are detailed below. Before using this procedure to select the most suitable pump, it is necessary to have complete application and product information.

The following should be known:

1. **CAPACITY** - The desired rate of flow in gallons per minute (GPM).

2. **DIFFERENTIAL PRESSURE** - The difference between the pressure required at the pump discharge and the pressure being supplied at the pump suction in pounds per square inch (PSI).

3. **TEMPERATURE** - Maximum temperature at which the product is to be pumped (°F).

4. **SPECIFIC GRAVITY** - Ratio of the density of the product-to-water at the pumping temperature.

5. **VISCOSITY** - The resistance to flow expressed in saybolts (SSU) at the pumping temperature.

6. **ABRASION** - Wear characteristics of the product based upon careful judgement of the abrasive nature of the solids in the product. The following broad classifications will serve as a guide:

   None - example: Clear Water
   Light - example: Dirty Water
   Medium - example: Clay Slurries, Gypsum Slurries, etc.
   Heavy - example: Heavy Slurries, Lapping Compound

7. **CORROSION** - The pH value (hydrogen-ion activity) of the product should be known in order to select suitable materials of construction in the pump. A pH of 0 to 7 is acid, pH of 7 is neutral, and a pH over 7 to 14 is alkaline.

8. **CONCENTRATION OF THE SOLIDS** - The ratio (%) of solid-to-liquid on a volume basis contained in the product. This ratio will usually determine how the characteristics of the solids influence the slurry as a whole.

9. **SIZE & NATURE OF THE SOLIDS** - The size of the particles the pump must handle. Are these solids similiar or random in size? Are they pulpy, soft or hard, light or dense, round or jagged, fibrous or stringy, abrasive or corrosive?

10. **NATURE OF THE LIQUID** - How corrosive is the liquid? Will it lubricate the solids and reduce abrasion?

## SECTION II - APPLICATION & PRODUCT EFFECTS OF PUMP PERFORMANCE

The above characteristics create unique demands requiring careful sizing and selection to provide proper materials and pump application for good performance and longevity. Typically, they can influence pump performance as follows:

### 1. Pressure

- Increasing differential pressure increases pump slip
- Higher pressures require additional stator/rotor stages
- Higher pressures and slip have an accelerating effect on the rate of abrasive wear

### 2. Temperature

- Higher temperatures affect the choice of elastomeric materials
- Higher temperatures require the use of undersize rotors

### 3. Viscosity

- As viscosity increases, pump slip will decrease
- As viscosity increases, the maximum allowable speed decreases
- As viscosity increases, the maximum allowable pressure per stator/rotor stage increases

### 4. Concentration of the Solids

- Mixed liquids and microscopic solids usually produce a viscous non-Neutonian liquid
- Many products exhibit their viscosity characteristics by virtue of a high volumetric content of finely divided solids in suspension, e.g., toothpaste, paper-coating mixes, etc.
- Higher solids in suspension content decreases maximum allowable speed and pressure per stage

### 5. Size & Nature of the Solids

- Soft solids (abrasive) reduces the maximum allowable pump speeds
- Pumps must have sufficient cavity size to pass the largest hard particle in the product

### 6. Abrasion

- The more abrasive the product, the slower the pump must operate
- Amount of wear on an abrasive application is closely proportional to the speed squared

## SECTION III - SIZING & SELECTION PROCEDURE

### STEP 1: PRELIMINARY SIZING

First, determine the preliminary size of the pump required. This selection is made by converting gallons per minute (GPM) into liters per minute (LPM).

**GPM x 3.785 = LPM**

SEP Series P-C pump size designators (50, 100, 200, etc.) represent the theoretical water displacement in liters per minute (LPM) at 0 PSI differential pressure and 400 revolutions per minute (RPM) - i.e., size 50 is 50 LPM at 400 RPM. This preliminary sizing allows selection of the closest size of pump for a clear fluid at a speed of 400 RPM. Refer to Table 1 (Page 8) for quick reference.

### STEP 2: PRESSURE STAGES

Next, deterine the number of stator/rotor stages required for the maximum differential pressure.

Table 2 (Page 8) lists the maximum allowable pressure for various concentration of solids. Higher solids concentration reduces the maximum allowable pressure per stator/rotor stage and permits extending the useful life of the pumping elements. The SEP Series P-C pump is the only pump which de-rates allowable pressure per stator/rotor stage and speed to obtain the same approximate life of the pumping elements as a pump on clear fluid.

Select from Table 2 (Page 8) the pressure stage corresponding to the closest maximum allowable pressure for the solids content. If the differential pressure exceeds the values in Table 2 by an amount not in excess of 5% consult Shanley Pump & Equipment Inc.

## STEP 3: SPEED LIMITATION FOR ABRASION & SOLIDS

Next, determine the maximum allowable speed as related to the abrasive characteristics of the concentration of the solids in the product to be pumped.

Table 3 (Page 8) lists the maximum allowable speeds for each size pump for four classifications of abrasion, and lists the maximum allowable speeds for each pump for various concentration of solids. Graph No. 4 (Page 13) will help determine the maximum pump speed in relation to the % solid concentration of the pumped fluid.

Depending on the product characteristics of abrasion and solids content, and whether the pumping operation is continuous or intermittent, choose the lowest speed from the table.

Speeds shown for continuous duty refer to 24 hours per day operation, while speeds for intermittent duty operation refer to 1 to 2 hours duty cycle followed by an off cycle or reduced speed operation.

## STEP 4: SPEED LIMITATION FOR VISCOSITY

Next, determine the maximum allowable speed as related to the viscosity of the product to be pumped.

On Graph 1 (Page 10), a speed correction factor ($F_{VN}$) for viscosity is plotted for varying viscosities in SSU.

Read the $F_{VN}$ value from the Graph for the viscosity of the product and multiply the speed value from Table 4 (Page 8) below by $F_{VN}$, for the preliminary size pump selected in Step 1.

## STEP 5: MAXIMUM ALLOWABLE SPEED

Compare the maximum allowable speed for abrasion and/or solids content (Step 3) and the maximum allowable speed for viscosity (Step 4). The lower of the two values will determine the speed limitation of the pump.

## STEP 6: CAPACITY SLIP FOR VISCOSITY

Now that a preliminary selection has been made for pump size and a maximum allowable speed limitation determined based on the product characteristics of viscosity and solids content, it will be necessary to check the performance curve of the preliminary pump selected to be sure it will meet the requirements of the application.

From the 400 RPM performance curve, find the difference in capacity at 0 PSI and the desired pressure. This is the slip ($S_W$) on water.

Referring to Graph 2 (Page 11) obtain the capacity correction factor ($F_Q$) for the viscosity of the product. Multiply capacity correction factor ($F_Q$) times slip on water ($S_W$) to obtain actual slip on product ($S_P$).

$$F_Q \text{ X } S_W = S_P$$

As mentioned earlier, it should be noted that as viscosity increases, pump slip will decrease.

**STEP 7: CORRECTED SPEED FOR SLIP**

From the performance curve, obtain the capacities ($Q_1$ and $Q_2$) at 0 PSI from the RPM curves closest to the operating point for the applications.

Obtain capacity ($Q_3$) by adding pump slip (Sp) from Step 6 to the required capacity (Q).

$$Q_3 = Q + S_P$$

To determine the correct speed ($N_3$) at the operating point for the application, proceed as follows:

**STEP 8: CORRECTED SPEED VS. MAXIMUM ALLOWABLE**

The pump speed calculated in Step 7 should be checked against the maximum allowable speed determined in Step 5 to be sure it does not exceed this speed limitation. If it is higher than the maximum allowable in Step 5, the next larger size pump should be selected and Steps 1 thru 7 should be repeated.

**STEP 9: PARTICLE SIZE**

Progressive cavity pumps must have sufficient cavity size to pass the largest particle in the preduct. There is a limit to the size of particle that can enter the stator/rotor cavity at the inlet and be conveyed through the pumping element. Be sure this is specified as "largest particle size in the product" and not another manufacturer's pump cavity size.

Table 5 (Page 8) lists the maximum allowable hard particle sizes for each size of pump. Reference should be made to this Table to check the initial preliminary sizing of the pump selected in Step 1.

**STEP 10: TEMPERATURE**

Limitation on the use of elastomeric stators because of elevated temperatures is shown in Table 8 (Page 9). High temperatures tend to destroy the resiliency of the stator. Refer to this Table for the various stator materials.

The use of undersize rotors may be necessary if pumping temperatures are in excess of 40 °C (140 °F). Be sure to specify the maximum pumping temperature for the application. Reference Table 9 (Page 9) for undercutting of rotors.

**STEP 11: CHEMICAL RESISTANCE**

Limitations on the use of elastomeric materials may arise when the product being pumped attacks the stator material causing swelling or deterioration. To help you select the best stator material and other pump construction materials for your application, contact Shanley Pump & Equipment Inc. or the nearest stocking distributor to help you select the best elastomer material.

Some applications may require the use of metal or rigid plastic stators. These types of stators; however, should never be used when abrasion is present. Consult Shanley Pump & Equipment Inc. for recommendations.

**STEP 12: DRIVER HORSEPOWER**

Having determined the correct size pump, its speed and the number of pressure stages for the application, refer to the performance curve for the pump selected in order to select initial driver horsepower.

From the performance curve, obtain the water absorbed horsepower (HP) at the operating pressure from the RPM curve closest to the correct pump speed ($N_3$) to deterine water absorbed HP:

$\frac{N_3}{N}$ x HP = *water absorbed HP at correct pump speed
(closest RPM curve)

For Graph 3 (Page 12) obtain the power correction factor ($F_P$) for viscosity. This is plotted for varying viscosities in centistokes and corrects the water absorbed HP for the viscosity and specific gravity of the product being pumped. Multiply viscosity correction factor ($F_P$) times water HP from above.

Water absorbed HP at correct pump speed x $F_P$ = Product absorbed HP at correct pump speed

From the above, an initial driver can be selected to provide the required running HP to match the product absorbed HP requirement.

## STEP 13: STARTING TORQUE

In addition to the absorbed HP requirement of the pump, a check must be made to see if the driver selected in Step 12 has sufficient torque capability to start the pump.

The SEP Series P-C pump, like other progressive cavity pumps, uses a resilient elastomeric material for the stator with a slight radial interference fit of the rotor in the stator. There is an increase in friction between rotor and stator on standing caused by the stator material flowing into the microfine grooves or surface irregularities of the rotor. Because of this, additional torque must be applied to the rotor shaft to break the rotor away from the stator at start up. As a general rule, this maximum break-out friction is three (3) times the running friction, but actual starting torque requirements vary considerably with the solids content and lubricating effect of the product being pumped.

Table 7 (Page 9) lists factors to apply to the starting torques shown on the performance curves. Depending upon judgement of lubricating properties of the fluid in the product and solids content, select from the Table the appropriate factor and multiply this by the difference between the minimum ($T_{MIN}$) and the maximum ($T_{MAX}$) starting torque values shown on the performance curve. Add this difference to the minimum ($T_{MIN}$) starting torque to obtain the starting torque requirement of the pump.

$T_{MIN} + (T_{MAX} - T_{MIN})$ = Starting torque requirement of the pump

To determine the horsepower required to start the pump, we must compare the starting torque requirement above with the starting torque available from the initial driver selected in Step 12. The torque available is determined by the equation:

$$\text{Torque (ft-lbs)} = \frac{\text{HP} \times 5252}{\text{RPM}} \times \text{starting torque multiplier (see Tab 11)} \times \text{*efficiency of reducer}$$

*Note: Assume 90% for gear reduction and 85% for V-belt reduction

The starting torque available from the driver must always exceed the starting torque requirement of the pump. It is too small, choose the next larger size motor or use a high starting torque (NEMA Design C) motor with higher starting torque multipliers (consult Shanley Pump & Equipment Inc. or local motor supplier for availability).

**TABLE 1**

| CAPACITY 0 PSI, 400RPM | PUMP SIZE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 50 | 100 | 200 | 380 | 550 | 750 | 1000 | 1450 | 2700 |
| LPM | 50 | 100 | 200 | 380 | 550 | 750 | 1000 | 1450 | 2700 |
| GPM | 13.2 | 26.4 | 52.8 | 100.4 | 145.2 | 198.2 | 264.2 | 383.1 | 713.2 |

**TABLE 2**

| NUMBER OF PRESSURE STAGES | ATTAINABLE PRESSURE PER STAGE BY % SOLID CONTENT | |
|---|---|---|
| | 0% | 5% |
| 1 | 87 | 72 |
| 1 E/W | 174 | 145 |
| 2 | 174 | 145 |
| 2 E/W | 348 | 290 |

**TABLE 3**

| MAXIMUM ALLOWABLE RPM RELATED TO FLUID ABRASIVENESS AND SOLID CONTENT | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PUMP SIZE | ABRASIVE CHARACTERISTICS | | | | | | | | SOLIDS IN SUSPENSION SOLIDS CONTENT (% BY VOLUME) | | | |
| | CONTINUOUS OPERATION | | | | INTERMITTENT OPERATION | | | | CONTINUOUS OPERATION | | INTERMITTENT OPERATION | |
| | NONE | LIGHT | MEDIUM | HEAVY | NONE | LIGHT | MEDIUM | HEAVY | 0% | 5% | 0% | 5% |
| 50 | 850 | 570 | 430 | 290 | 850 | 595 | 445 | 400 | 850 | 570 | 850 | 595 |
| 100 | 700 | 470 | 350 | 235 | 700 | 490 | 370 | 250 | 700 | 470 | 700 | 490 |
| 200 | 600 | 400 | 300 | 200 | 600 | 420 | 315 | 210 | 600 | 400 | 600 | 420 |
| 380 | 500 | 335 | 250 | 170 | 500 | 350 | 260 | 175 | 500 | 335 | 500 | 350 |
| 550 | 480 | 320 | 240 | 160 | 480 | 335 | 250 | 170 | 480 | 320 | 480 | 336 |
| 750 | 450 | 300 | 225 | 150 | 450 | 315 | 235 | 160 | 450 | 300 | 450 | 315 |
| 1000 | 420 | 280 | 210 | 140 | 420 | 295 | 220 | 150 | 420 | 280 | 420 | 294 |
| 1450 | 400 | 270 | 175 | 120 | 400 | 280 | 210 | 140 | 400 | 270 | 400 | 280 |
| 2700 | 400 | 270 | 175 | 120 | 400 | 280 | 210 | 140 | 400 | 270 | 400 | 280 |

**TABLE 4**

| PUMP SIZE | SPEED VALUE |
|---|---|
| 50 | 850 |
| 100 | 700 |
| 200 | 600 |
| 380 | 500 |
| 550 | 480 |
| 750 | 450 |
| 1000 | 420 |
| 1450 | 400 |
| 2700 | 400 |

**TABLE 5**

| PUMP SIZE | SPHERE MAX. DIA. | FIBER MAX. LEN. |
|---|---|---|
| 30 | 0.12 | 1.65 |
| 100 | 0.15 | 1.89 |
| 200 | 0.2 | 2.36 |
| 380 | 0.27 | 3.11 |
| 550 | 0.3 | 3.32 |
| 750 | 0.37 | 3.86 |
| 1000 | 0.37 | 3.86 |
| 1450 | 0.55 | 5.12 |
| 2700 | 0.79 | 8.26 |

**TABLE 6**

| SOLID CONTENT (% BY VOLUME) | <=5% | <=15% | >15% | <=5% | <=15% | >15% | <=5% | <=15% | >15% |
|---|---|---|---|---|---|---|---|---|---|
| LUBRICATING PROPERTIES | LOW | MED. | HIGH | MED. | HIGH | LOW | HIGH | LOW | MED. |
| FACTOR (f) | 0.5 | 0.5 | 0.5 | 0.5 | 0 | 1 | 0 | 0.5 | 0.5 |

**TABLE 7**

| TYPICAL STARTING TORQUE MULTIPLIERS (STANDARD NEMA B, TEFC.3/230/460V) | | | | |
|---|---|---|---|---|
| MOTO | TYPICAL MOTOR RPM | | | |
| SIZE | 3600 | 1800 | 1200 | 900 |
| 1/2 | - | - | - | 1.40 |
| 34 | - | - | 1.75 | 1.35 |
| 1 | - | 2.75 | 1.70 | 1.35 |
| 1 1/2 | 1.75 | 2.50 | 1.65 | - |
| 2 | 1.70 | 2.35 | 1.60 | - |
| 3 | 1.60 | 2.15 | 1.55 | - |
| 5 | 1.50 | 1.85 | 1.50 | - |
| 7 1/2 | 1.40 | 1.75 | 1.50 | - |
| 10 | 1.35 | 1.65 | 1.50 | - |
| 15 | 1.30 | 1.60 | 1.40 | - |
| 20 | 1.30 | 1.50 | 1.35 | - |
| 25 | 1.30 | 1.50 | 1.35 | - |
| 30 | 1.30 | 1.50 | 1.35 | - |
| 40 | 1.25 | 1.40 | 1.35 | - |
| 50 | 1.20 | 1.40 | 1.35 | - |
| 60 | 1.20 | 1.40 | 1.35 | - |
| 75 | 1.05 | 1.40 | 1.35 | - |
| 100 | 1.05 | 1.25 | 1.25 | - |
| 125 | 1.00 | 1.10 | 1.25 | - |
| 150 | 1.00 | 1.10 | 1.25 | - |

**TABLE 8**

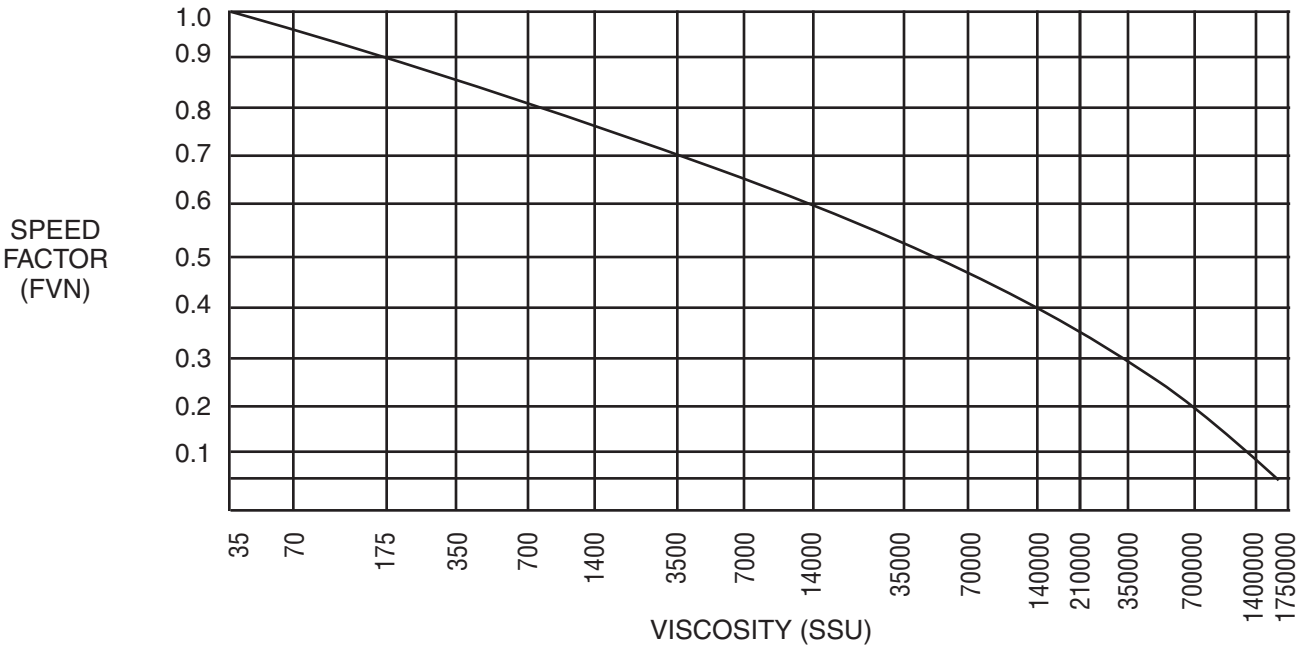
| MAXIMUM TEMP. FOR ELASTOMERS | |
|---|---|
| ELASTOMER | MAX. TEMP, DEG. F |
| NAT. RUBBER HARD | 176 |
| NAT. RUBBER SOFT | 176 |
| BUNA N | 230 |
| BUNA N LIGHT | 194 |
| NEOPRENE | 212 |
| HYPALON | 284 |
| BUTYL HARD RUB. | 248 |
| VITON | 302 |
| THIOKOL | 104 |
| POLYURETHANE | 158 |
| TEFLON, FILLED | 302 |

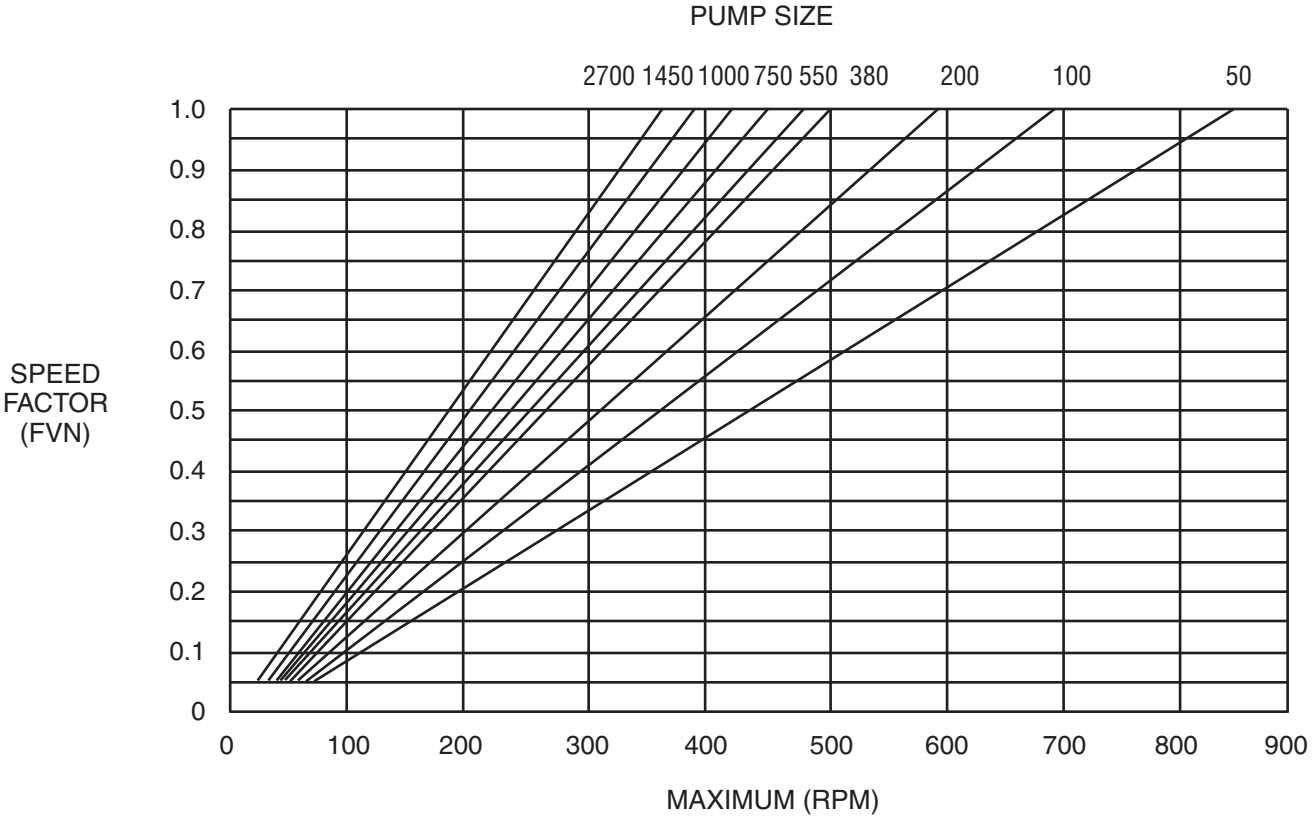
**TABLE 9**

| | | NOMENCLATURE DESIG. | |
|---|---|---|---|
| UNDERCUT ROTOR TEMP. LIMITS | | NORMAL STATOR | E/W STATOR |
| STANDARD CUT | BET. 140-195 F | - | g |
| MEDIUM UNDERCUT | BET. 195-240 F | m | e |
| HIGHT UNDERCUT | ABOVE 240 F | h | f |

# SPEED CORRECTION FOR VISCOSITY

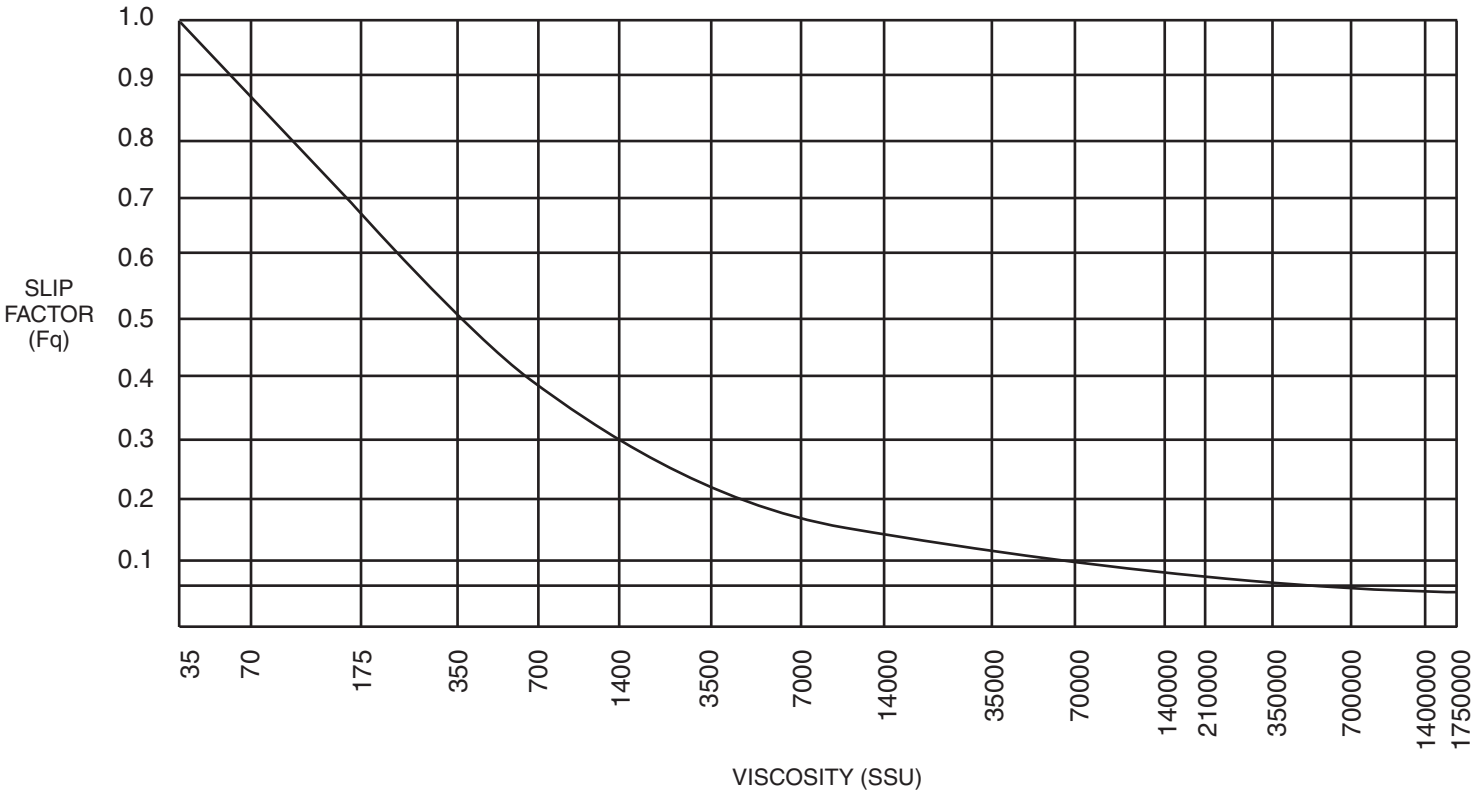
## GRAPH 1



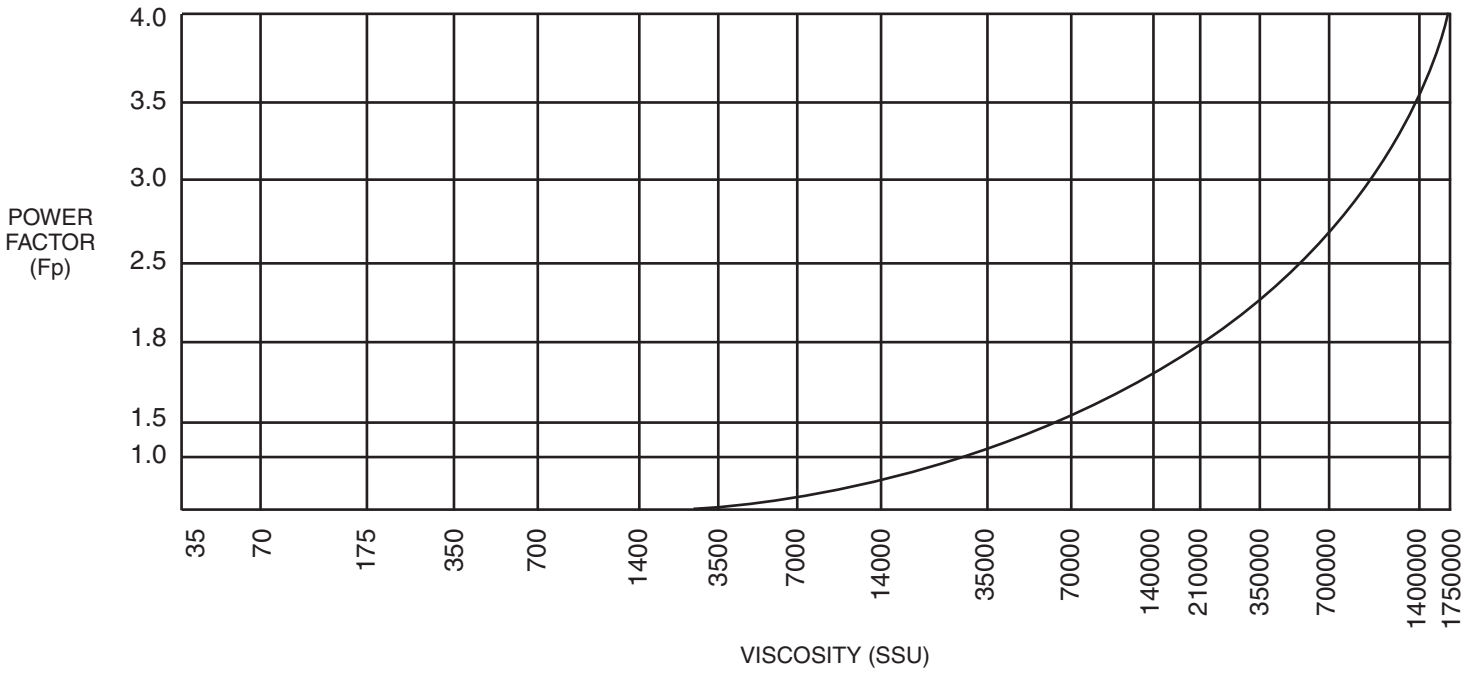
# SLIP CORRECTION FOR VISCOSITY

## GRAPH 2



# POWER CORRECTION FOR VISCOSITY

## GRAPH 3



# SPEED CORRECTION FOR SOLID CONTENT

## GRAPH 4