Positive Displacement Pump Technical Manual

R9: 1/05
Introduction

The Technical Manual

The positive pump technical manual has two goals. The first is to provide a useful source of technical information on Fristam positive displacement pumps. The second is to help the user analyze their pumping requirements, make an appropriate pump selection and size the pump, motor and drive for best performance.

The manual is divided into five sections.

Section 1 – Contains the technical information including: performance curves, dimensional drawings and descriptions of pump seals, rotors and other options.

Section 2 – Contains tables of information useful for pump sizing.

Section 3 – Describes basic terms and concepts regarding the operation and performance of positive displacement pumps.

Section 4 – Describes how to analyze a pumping system and obtain the information required for proper selection and sizing. Also provides a systematic guide through the process of matching a pump to an application for optimum performance.

Section 5 - Contains dimensional drawings and seal assembly drawings.

Fristam Positive Displacement Pumps

The FKL and FL II are the two positive displacement pumps discussed in the manual. They share many similarities but the pumps are fundamentally different in design.

The FKL is a circumferential piston pump, meaning that its rotors run in a channel described by the pump housing and built-in internal hubs. The purpose of this design is to achieve high performance by maintaining tighter clearances and restricting product slip within the pump. The design produces higher pressures, the ability to self-prime and the capability of handling more difficult products and applications.

The FL II is a rotary lobe pump. Rotary lobes use the movement of two lobes in a pumping chamber to accomplish the pumping action. This style of pump is designed for standard duty applications.

Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
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## Section I- Technical Information

### FKL Specification Sheet

**Pump Series:** FKL 25, 50, 75, 150, 250, 400, 600  
**Design:** 3-A CIP cleanable  
**Displacement:** 0.056 – 2.24 gallons / revolution  
**Maximum Differential Pressure:** 300 psi  
**Temperature Differential:** $\Delta 140^\circ F$ (standard rotor), $\Delta 210^\circ F$ (high temp. rotor)  
**Pump Housing Material:** 316L stainless steel  
**Rotor Material:** 808 or 88 non-galling stainless steel  
**Rotor Cap and Bolt Material:** 316L stainless steel  
**Pump Cover Material:** 316L stainless steel  
**Pump Shaft Material:** 316L stainless steel  
**Product Contact Surface Finish:** standard - 32 Ra  
optional: 25 Ra, 20 Ra & electropolish (except rotors)  
**Fittings (Suction/Discharge):** 1.5” – 6” standard, optional rectangular inlet on FKL 50 - FKL 400  
**Fitting Style:** standard – Sanitary clamp (FKL 25 - FKL 250)  
standard – 150# flange (FKL 400 & FKL 600)  
optional – many options available  
**Seal Type:** Single mechanical, double mechanical, aseptic double mechanical,  
single o-ring and double o-ring  
(o-ring seals available on FKL 25 – FKL 250 only)  
**Seal Flush Requirements:** Double seals only - 3 - 12 gallons per hour at 1- 2 psi (60 psi maximum)  
**Mechanical Seal Face Materials:** Carbon / chrome oxide coated stainless steel (standard)  
silicon carbide / chrome oxide (optional)  
silicon carbide / silicon carbide (optional)  
**Elastomer Materials:** Cover Gasket: Buna (standard)  
Other O-rings: viton (standard)  
optional materials- buna, viton, chemraz, EPDM, EPDM USP class 6,  
Silicone USP class 6  
others available upon request  
**Gearbox Material:** Cast iron / zinc plated / painted  
**Paint:** Epoxy  
**Gearbox Lubrication:** SAE 15W40 oil  
**Coupling:** Woods sure-flex (standard) – other options available  
**Base Plate:** 304 Stainless Steel with adjustable legs  
**Drives:** standard - Nord integral  
other options available upon request
<table>
<thead>
<tr>
<th>Model Number</th>
<th>Displacement (gal/rev)</th>
<th>Pump Weights (lbs.)</th>
<th>Fitting Sizes</th>
<th>Special Options</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25</td>
<td>75</td>
<td>150</td>
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<tr>
<td></td>
<td>250</td>
<td>360</td>
<td>451</td>
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<tr>
<td></td>
<td>0.54</td>
<td>0.74</td>
<td>1.5&quot; clamp</td>
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<td>O-ring Seal: yes, yes, yes, yes, yes, yes, no</td>
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<td>2400</td>
<td>2.24</td>
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<td>Maximums</td>
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<tr>
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<td>N/A</td>
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<td>300</td>
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<tr>
<td>2400</td>
<td>600</td>
<td>300</td>
<td>N/A</td>
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</tr>
</tbody>
</table>
FKL Special Pump Options

Rectangular Inlet
On most models (FKL 50 – 400), a rectangular inlet is offered to enhance the pump’s ability to handle very viscous products. The large dimensional opening minimizes buildup of product at the inlet which promotes flow into the pump. Performance is maintained even when pumping very viscous materials because inlet restrictions are greatly reduced, thereby maintaining high volumetric efficiencies.

Rectangular inlets match industry standards.

High Temperature Rotors
Positive pump efficiency depends upon maintaining close internal clearances between the rotors and the pump housing. These clearances are not a problem until higher temperatures cause the shaft and rotors to expand inside the pump housing. If the proper measures are not taken, this expansion can result in rotor to cover or even rotor to housing damage.

To counteract this effect, Fristam Pumps offers a high temperature rotor. This rotor leaves greater clearances throughout the pumping cavity.

High temperature rotors are specified for pumps that are cleaned or steamed at elevated temperatures, although process conditions may be cooler.

“Chocolate” Rotors
Specially machined rotors are available to produce the larger gaps required to pump chocolate and certain other viscous and abrasive products. Usage of these rotors should be discussed with the Fristam factory, in order to assure their proper application.

Aseptic Design
Aseptic designs are available for most of the FKL models. All of the dynamic and static seals are steam traced to ensure product sterility.
Jacketed Cover
For applications that require either a heating or cooling jacket to maintain the product's state, Fristam Pumps can provide a jacketed cover. This jacketed cover is applied directly over the existing cover simply by using longer housing studs. The jacketed cover is constructed of 304 Stainless Steel.

Electropolish
Electropolish, an electro-chemical process, provides additional smoothing, cleaning and passivation of pump surfaces. It is generally used in conjunction with high polish to produce extremely smooth product surfaces. Like high polish, the electropolish process removes some material and can produce a slight reduction in pump performance when pumping low viscous products.

Note: FKL rotors cannot be electropolished. The chemical process adversely affects the non-galling alloy of which they are constructed.

High Grit Polish
25 Ra (180 grit) and 20 Ra (240 grit) internal surface finishes are options offered for those applications requiring extremely smooth product surfaces. To accomplish this, additional material is removed from standard internal surfaces using finer grit abrasives. The removal of material will open the gaps between components slightly and increase slip. Some reduction of performance will result when pumping low viscosity fluids.

Degassing Cover
Exclusively for the baking industry, Fristam offers an optional degassing cover to vent the natural gases that are produced in dough. When used with Fristam’s heavy-duty FKL Series positive displacement pump this feature gives the dough a finer texture and greater uniformity. Applications include transferring from a dough trough to a bun or bread divider or continuous conveyor belt.
Composite Curve for Size Selection

Performance Curves based on 0 psig differential pressure at 1/2 of maximum speed.
Pumps can operate in range below curve.

Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
Model: FKL 25 Sanitary Pump
Displacement: 0.056 gal/rev

Standard Port Size: 1.5 " x 1.5 "
Performance curve based on tests using 70° F water
Actual performance may vary by application or product.
Model: FKL 25 Sanitary Pump
Displacement: 0.056 gal/rev

Standard Port Size: 1.5" x 1.5"

Performance curve based on tests using 70° F water
Actual performance may vary by application or product.
Model: FKL 50 Sanitary Pump
Displacement: 0.096 gal/rev

Standard Port Size: 2.5 " x 2.5 "
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 50 Sanitary Pump
Displacement: 0.096 gal/rev
Standard Port Size: 2.5" x 2.5"
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 75 Sanitary Pump

Displacement: 0.156 gal/rev

Standard Port Size: 2.5” x 2.5”

Performance curve based on tests using 70° water

Actual performance may vary by application or product.
Model: FKL 75 Sanitary Pump

Displacement: 0.156 gal/rev
Standard Port Size: 2.5 " x 2.5 "

Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 150 Sanitary Pump
Displacement: 0.275 gal/rev

Standard Port Size: 3" x 3"
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 150 Sanitary Pump  
Displacement: 0.275 gal/rev

Standard Port Size: 3” x 3”  
Performance curve based on tests using 70° water  
Actual performance may vary by application or product.
Model: FKL 250 Sanitary Pump
Displacement: 0.54 gal/rev
Standard Port Size: 4" x 4"
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 250 Sanitary Pump
Displacement: 0.54 gal/rev

Standard Port Size: 4” x 4”
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 400 Sanitary Pump
Displacement: 0.74 gal/rev
Standard Port Size: 6" x 6"
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 400 Sanitary Pump
Displacement: 0.74 gal/rev
Standard Port Size: 6" x 6"
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
Model: FKL 600 Sanitary Pump
Displacement: 2.24 gal/rev
Standard Port Size: 6” x 6”
Performance curve based on tests using 70°F water
Actual performance may vary by application or product.
Model: FKL 600 Sanitary Pump
Displacement: 2.24 gal/rev
Standard Port Size: 6" x 6"
Performance curve based on tests using 70° water
Actual performance may vary by application or product.
**FLII Specification Sheet**

<table>
<thead>
<tr>
<th><strong>Pump Series:</strong></th>
<th>FLII 15, 58, 75, 100, 130</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design:</strong></td>
<td>3-A CIP cleanable</td>
</tr>
<tr>
<td><strong>Displacement:</strong></td>
<td>0.0056 – 0.645 gallons / revolution</td>
</tr>
<tr>
<td><strong>Maximum Differential Pressure:</strong></td>
<td>100 psi – 170 psi (depending on model)</td>
</tr>
<tr>
<td><strong>Temperature Range:</strong></td>
<td>-40°F to 200°F (standard rotor), -40°F to 350°F (high temp rotor)</td>
</tr>
<tr>
<td><strong>Pump Housing Material:</strong></td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td><strong>Rotor Material:</strong></td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td><strong>Rotor Nut Material:</strong></td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td><strong>Pump Cover Material:</strong></td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td><strong>Pump Shaft Material:</strong></td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td><strong>Gapping Spacer Material:</strong></td>
<td>316L Stainless Steel</td>
</tr>
<tr>
<td><strong>Product Contact Surface Finish:</strong></td>
<td>32 Ra - standard optional: 25 Ra, 20 Ra &amp; electropolish</td>
</tr>
<tr>
<td><strong>Fittings (Suction/Discharge):</strong></td>
<td>3/4” – 4” standard, optional rectangular inlet on the 75, 100 and 130 models only</td>
</tr>
<tr>
<td><strong>Fitting Style:</strong></td>
<td>Sanitary clamp (standard), many options available</td>
</tr>
<tr>
<td><strong>Seal Type:</strong></td>
<td>Single &amp; double mechanical</td>
</tr>
<tr>
<td><strong>Seal Flush Requirements:</strong></td>
<td>Double seals only - 3-12 gallons per hour at 1-2 psi (60 psi maximum)</td>
</tr>
<tr>
<td><strong>Mechanical Seal Face Material:</strong></td>
<td>Carbon / chrome oxide coated stainless steel (standard) silicon carbide/chrome oxide (optional) silicon carbide / silicon carbide (optional)</td>
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<td><strong>Elastomers:</strong></td>
<td>standard - Viton optional - Buna, chemraz, EPDM, EPDM USP class 6, Silicone USP class 6 others available upon request</td>
</tr>
<tr>
<td><strong>Gearbox:</strong></td>
<td>Cast iron painted, (304) Stainless Steel available on 55 and 75 models</td>
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<tr>
<td><strong>Paint:</strong></td>
<td>Epoxy</td>
</tr>
<tr>
<td><strong>Lubrication:</strong></td>
<td>Bearings – permanently greased; Timing gears – EP 220 Compound (oil)</td>
</tr>
<tr>
<td><strong>Coupling:</strong></td>
<td>Woods sure-flex (standard) – other options available</td>
</tr>
<tr>
<td><strong>Base Plate:</strong></td>
<td>304 Stainless Steel with adjustable legs</td>
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<tr>
<td><strong>Drives:</strong></td>
<td>standard - Nord Integral Many options available</td>
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## FLII Data Sheet

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<th>58S</th>
<th>58L</th>
<th>75S</th>
<th>75L</th>
<th>100S</th>
<th>100L</th>
<th>130S</th>
<th>130L</th>
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<td>Displacement (gal/rev)</td>
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<td>0.0267</td>
<td>0.039</td>
<td>0.072</td>
<td>0.098</td>
<td>0.176</td>
<td>0.274</td>
<td>0.465</td>
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<td>3/4&quot; clamp</td>
<td>1&quot; clamp</td>
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<td>2&quot; clamp</td>
<td>2.5&quot; clamp</td>
<td>3&quot; clamp</td>
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<td>yes</td>
<td>yes</td>
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</table>
FL II Special Pump Options

Rectangular Inlet
On the FLII 75 and 100 pumps, a rectangular inlet is offered to enhance the pump’s ability to handle very viscous products. The large dimensional opening minimizes buildup of product at the inlet which promotes flow into the pump. Performance is maintained even when pumping very viscous materials because inlet restrictions are greatly reduced, thereby maintaining high volumetric efficiencies.

High Temperature Rotors
Positive pump efficiency depends upon maintaining close internal clearances between the rotors and the pump housing. These clearances are not a problem until higher temperatures cause the shaft and rotors to expand inside the pump housing. If the proper measures are not taken, this expansion can result in rotor to cover or even rotor to housing damage.

To counteract this effect, Fristam Pumps offers a high temperature rotor. This rotor leaves greater clearances throughout the pumping cavity.

High temperature rotors are specified for pumps that are cleaned or steamed at elevated temperatures, although process conditions may be cooler.

High Grit Polish
25 Ra (180 grit) and 20 Ra (240 grit) internal surface finishes are options for those applications requiring extremely smooth product surfaces. To accomplish this, additional material is removed from standard internal surfaces using finer grit abrasives. The removal of material will open the gaps between components slightly. Some reduction of performance can result when pumping low viscosity fluids.

Electropolish
Electropolish, an electro-chemical process, provides additional smoothing, cleaning and passivation of pump surfaces. It is generally used in conjunction with high polish to produce extremely smooth product surfaces. Like high polish, the electropolish process removes some material and can produce a slight reduction in pump performance when pumping low viscosity fluids.

Single Lobe
The single lobe option is offered for products containing large solids. At low speeds, a single lobe rotor can handle the large particles more gently.
Jacketed Housing and Cover

For applications that require either a heating or cooling jacket to maintain the products state, Fristam Pumps can provide a jacketed housing and/or cover. On the FLII pumps, the jacket is integral to the housing and/or cover. The jacketed cover is constructed of 304 Stainless Steel.

Pressure Relief Cover

Fristam offers a spring loaded teflon diaphragm pressure relief cover for customers that require a safety valve.
Model: FL II 15-75  Sanitary Pumps

Composite Curve for Size Selection

Performance Curves based on 0 psig differential pressure at 1/2 of maximum speed.
Pumps can operate in range below curve.

Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
Model: FL II 100-130  Sanitary Pumps

Composite Curve for Size Selection

Performance Curves based on 0 psig differential pressure at 1/2 maximum speed.
Pumps can operate in range below curve.
High Temperature Rotor Correction

Viscosity (centipoise)

Differential Pressure (psi)

RPM

Viscosity Correction

Source: calculated data from Fristam Pumpen, Hamburg, Germany
Model: FLII 15 Sanitary Pump

Displacement: 0.0056 gal/rev
Standard Port Size: 3/4" x 3/4"

Performance curve based on tests using 70°F water
Actual performance may vary by application or product.
Model: FLII 58S Sanitary Pump

Displacement: 0.0267 gal/rev
Standard Port Size: 1" x 1"
Performance curve based on tests using 70° F water
Actual performance may vary by application or product.
Model: FLII 58L Sanitary Pump
Displacement: 0.039 gal/rev
Standard Port Size: 1.5” x 1.5”
Performance curve based on tests using 70° F water
Actual performance may vary by application or product.
Model: FLII 75S Sanitary Pump

Displacement: 0.072 gal/rev
Standard Port Size: 1.5” x 1.5”
Performance curve based on tests using 70° F water
Actual performance may vary by application or product.

Horsepower = Work Horsepower + Viscosity Horsepower
Model: FLII 75L Sanitary Pump
Displacement: 0.098 gal/rev
Standard Port Size: 2" x 2"
Performance curve based on tests using 70°F water
Actual performance may vary by application or product.
Model: FLII 100S Sanitary Pump

Displacement: 0.176 gal/rev
Standard Port Size: 2.5” x 2.5”

Performance curve based on tests using 70° F water
Actual performance may vary by application or product.
Model: FLII 100L Sanitary Pump
Displacement: 0.274 gal/rev
Standard Port Size: 3” x 3”
Performance curve based on tests using 70° F water
Actual performance may vary by application or product.
Model: FLII 130S Sanitary Pump
Displacement: 0.465 gal/rev
Standard Port Size: 3” x 3”
Performance curve based on tests using 70° F water
Actual performance may vary by application or product.
Model: FLII 130L Sanitary Pump
Displacement: 0.645 gal/rev
Standard Port Size: 4" x 4"
Performance curve based on tests using 70°F water
Actual performance may vary by application or product.
Pressure Loss Curve - 1 ½” Stainless Steel Tubing

VISCOSITY-CPS (CENTIPOISE)

PRESSURE LOSS
psf/ft Tubing

100
10
1
0.1
0.01
0.001
1 10 100 1000 10,000 100,000

Section II: General Technical Information
Pressure Loss Curve - 2” Stainless Steel Tubing

![Graph showing pressure loss across different viscosity levels and flow rates.](image-url)
Pressure Loss Curve - 2 ½” Stainless Steel Tubing

Pressure Loss (ps/ft Tubing) vs Viscosity (CPS, Centipoise)

Graph showing the relationship between pressure loss and viscosity for different flow rates (GPM).
Pressure Loss Curve - 3" Stainless Steel Tubing

Pressure Loss

Viscosity-CPS (Centipoise)

psi/ft Tubing
Pressure Loss Curve - 6” Stainless Steel Tubing

![Graph showing pressure loss against viscosity for different flow rates (500, 300, 200, 100, 70, 50 GPM) in 6” stainless steel tubing.]
## Table 1: Vapor Pressure

<table>
<thead>
<tr>
<th>Water Temperature (°F)</th>
<th>Vapor Pressure (psia)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35</td>
<td>0.09</td>
</tr>
<tr>
<td>40</td>
<td>0.121</td>
</tr>
<tr>
<td>45</td>
<td>0.147</td>
</tr>
<tr>
<td>50</td>
<td>0.177</td>
</tr>
<tr>
<td>55</td>
<td>0.213</td>
</tr>
<tr>
<td>60</td>
<td>0.256</td>
</tr>
<tr>
<td>65</td>
<td>0.316</td>
</tr>
<tr>
<td>70</td>
<td>0.362</td>
</tr>
<tr>
<td>75</td>
<td>0.429</td>
</tr>
<tr>
<td>80</td>
<td>0.506</td>
</tr>
<tr>
<td>85</td>
<td>0.595</td>
</tr>
<tr>
<td>90</td>
<td>0.698</td>
</tr>
<tr>
<td>95</td>
<td>0.815</td>
</tr>
<tr>
<td>100</td>
<td>0.949</td>
</tr>
<tr>
<td>110</td>
<td>1.275</td>
</tr>
<tr>
<td>120</td>
<td>1.692</td>
</tr>
<tr>
<td>130</td>
<td>2.223</td>
</tr>
<tr>
<td>140</td>
<td>2.889</td>
</tr>
<tr>
<td>150</td>
<td>3.718</td>
</tr>
<tr>
<td>160</td>
<td>4.741</td>
</tr>
<tr>
<td>170</td>
<td>5.992</td>
</tr>
<tr>
<td>180</td>
<td>7.511</td>
</tr>
<tr>
<td>190</td>
<td>9.340</td>
</tr>
<tr>
<td>200</td>
<td>11.526</td>
</tr>
<tr>
<td>210</td>
<td>14.123</td>
</tr>
</tbody>
</table>

## Table 2: Average Absolute Atmospheric Head

<table>
<thead>
<tr>
<th>Altitude Above Sea Level (feet)</th>
<th>Atmospheric Pressure</th>
<th>Inches of Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>14.7</td>
<td>29.9</td>
</tr>
<tr>
<td>500</td>
<td>14.4</td>
<td>29.4</td>
</tr>
<tr>
<td>1,000</td>
<td>14.2</td>
<td>28.9</td>
</tr>
<tr>
<td>1,500</td>
<td>13.9</td>
<td>28.3</td>
</tr>
<tr>
<td>2,000</td>
<td>13.7</td>
<td>27.8</td>
</tr>
<tr>
<td>3,000</td>
<td>13.2</td>
<td>26.8</td>
</tr>
<tr>
<td>4,000</td>
<td>12.7</td>
<td>25.9</td>
</tr>
<tr>
<td>5,000</td>
<td>12.2</td>
<td>24.9</td>
</tr>
<tr>
<td>6,000</td>
<td>11.7</td>
<td>24.0</td>
</tr>
<tr>
<td>7,000</td>
<td>11.3</td>
<td>23.1</td>
</tr>
</tbody>
</table>
### Table 3: Elbow Equivalent Length (feet)

<table>
<thead>
<tr>
<th>Size</th>
<th>1 to 150 cps</th>
<th>150 to 1,500 cps</th>
<th>1,500 to 15,000 cps</th>
<th>15,000 to 100,000 cps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ½</td>
<td>2.5</td>
<td>2</td>
<td>1.4</td>
<td>0.7</td>
</tr>
<tr>
<td>2</td>
<td>3.5</td>
<td>2.3</td>
<td>1.8</td>
<td>0.8</td>
</tr>
<tr>
<td>2 ½</td>
<td>4</td>
<td>2.5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>3.5</td>
<td>2.5</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>4.5</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>6.5</td>
<td>4</td>
<td>2.25</td>
</tr>
</tbody>
</table>

### Table 4: Tee Equivalent Length (feet)

<table>
<thead>
<tr>
<th>Size</th>
<th>1 to 150 cps</th>
<th>150 to 1,500 cps</th>
<th>1,500 to 15,000 cps</th>
<th>15,000 to 100,000 cps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ½</td>
<td>9</td>
<td>6.5</td>
<td>4</td>
<td>2.25</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>8.5</td>
<td>6</td>
<td>2.7</td>
</tr>
<tr>
<td>2 ½</td>
<td>15</td>
<td>11</td>
<td>7.5</td>
<td>3.75</td>
</tr>
<tr>
<td>3</td>
<td>18</td>
<td>13</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>35</td>
<td>25</td>
<td>18</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 5: Valve Equivalent Length (feet)

<table>
<thead>
<tr>
<th>Size</th>
<th>1 to 150 cps</th>
<th>150 to 1,500 cps</th>
<th>1,500 to 15,000 cps</th>
<th>15,000 to 100,000 cps</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ½</td>
<td>11</td>
<td>8</td>
<td>5.5</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
<td>13</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>2 ½</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>20</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>33</td>
<td>25</td>
<td>17</td>
<td>10</td>
</tr>
</tbody>
</table>

Source: Tables 3 - 5 were created from Crane Co. Technical Paper No. 409. Data based on the chart are satisfactory for most applications.
### Table 6: Conversion Factors and Helpful Formulas

#### Length
<table>
<thead>
<tr>
<th>Unit</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meters</td>
<td>x 3.281</td>
<td>= Feet</td>
</tr>
<tr>
<td>Centimeters</td>
<td>x 0.394</td>
<td>= Inches</td>
</tr>
<tr>
<td>Millimeters</td>
<td>x 0.0394</td>
<td>= Inches</td>
</tr>
<tr>
<td>Inches</td>
<td>x 25.4</td>
<td>= Millimeters</td>
</tr>
</tbody>
</table>

#### Mass
<table>
<thead>
<tr>
<th>Unit</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kilograms</td>
<td>x 2.2</td>
<td>= Pounds</td>
</tr>
<tr>
<td>Gallons of Water</td>
<td>x 8.34</td>
<td>= Pounds</td>
</tr>
<tr>
<td>Cubic Feet of Water</td>
<td>x 62.4</td>
<td>= Pounds</td>
</tr>
<tr>
<td>Pounds</td>
<td>x 0.454</td>
<td>= Kilograms</td>
</tr>
</tbody>
</table>

#### Volume
<table>
<thead>
<tr>
<th>Unit</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liter</td>
<td>x 0.264</td>
<td>= Gallon</td>
</tr>
<tr>
<td>Cubic Feet</td>
<td>x 7.48</td>
<td>= Gallon</td>
</tr>
<tr>
<td>Pounds of Water</td>
<td>x 0.119</td>
<td>= Gallon</td>
</tr>
<tr>
<td>Imperial Gallon</td>
<td>x 1.2</td>
<td>= Gallon</td>
</tr>
<tr>
<td>Gallon</td>
<td>x 3.785</td>
<td>= Liter</td>
</tr>
</tbody>
</table>

#### Pressure
<table>
<thead>
<tr>
<th>Unit</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feet of Water</td>
<td>x 0.433</td>
<td>= PSI</td>
</tr>
<tr>
<td>Inches of Mercury</td>
<td>x 0.491</td>
<td>= PSI</td>
</tr>
<tr>
<td>Atmospheres</td>
<td>x 14.7</td>
<td>= PSI</td>
</tr>
<tr>
<td>Meters of Water</td>
<td>x 1.42</td>
<td>= PSI</td>
</tr>
<tr>
<td>Bar</td>
<td>x 14.7</td>
<td>= PSI</td>
</tr>
<tr>
<td>Kilo Pascals</td>
<td>x 0.145</td>
<td>= PSI</td>
</tr>
<tr>
<td>Atmospheres</td>
<td>x 33.9</td>
<td>= Feet of Water</td>
</tr>
<tr>
<td>PSI</td>
<td>x 2.31</td>
<td>= Feet of Water</td>
</tr>
<tr>
<td>Inches of Mercury</td>
<td>x 1.13</td>
<td>= Feet of Water</td>
</tr>
<tr>
<td>Meters of Water</td>
<td>x 3.28</td>
<td>= Feet of Water</td>
</tr>
</tbody>
</table>

#### Flow
<table>
<thead>
<tr>
<th>Unit</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pounds of Water / Hour</td>
<td>x 0.002</td>
<td>= GPM</td>
</tr>
<tr>
<td>Pounds of Fluid / Hour</td>
<td>x 0.002 / SG</td>
<td>= GPM</td>
</tr>
<tr>
<td>Cubic Meters / Hour</td>
<td>x 4.4</td>
<td>= GPM</td>
</tr>
<tr>
<td>Liters / Minute</td>
<td>x 0.264</td>
<td>= GPM</td>
</tr>
</tbody>
</table>

#### Viscosity
<table>
<thead>
<tr>
<th>Unit</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centipoise</td>
<td>x 1 / SG</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>SSU</td>
<td>x 0.216</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>Saybolt Furol</td>
<td>x 2.16</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>Redwood Standard</td>
<td>x 0.237</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>Redwood Admiralty</td>
<td>x 2.34</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>Engler-Degrees</td>
<td>x 7.45</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>Ford Cup #4</td>
<td>x 3.76</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>MacMichael</td>
<td>x 0.415</td>
<td>= Centistokes</td>
</tr>
<tr>
<td>Stormer</td>
<td>x 2.81</td>
<td>= Centistokes</td>
</tr>
</tbody>
</table>

#### Power
<table>
<thead>
<tr>
<th>Unit</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>T (in - lbs.) x RPM</td>
<td>/ 63,025</td>
<td>= Horsepower</td>
</tr>
<tr>
<td>Kilowatts</td>
<td>x 1.341</td>
<td>= Horsepower</td>
</tr>
<tr>
<td>Metric Horsepower</td>
<td>x 0.9863</td>
<td>= Horsepower</td>
</tr>
<tr>
<td>Horsepower</td>
<td>x 0.746</td>
<td>= Kilowatts</td>
</tr>
<tr>
<td>Horsepower</td>
<td>x 42.44</td>
<td>= BTU / Minute</td>
</tr>
</tbody>
</table>

\[
\text{GPM} \times \text{Head (ft. of water)} \times \text{SG} \\
\text{3960} = \text{Liquid Hp}
\]

#### Temperature
<table>
<thead>
<tr>
<th>Formula</th>
<th>Factor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>°C x 1.8</td>
<td>+ 32</td>
<td>= °F</td>
</tr>
<tr>
<td>°F - 32</td>
<td>x 0.555</td>
<td>= °C</td>
</tr>
</tbody>
</table>
Positive Displacement Mechanical Seal Options

(see pages 93-95 and 105-106 for mechanical seal drawings)

Single Mechanical Seal:
The single mechanical seal design is standard and recommended for most applications.

**Seal Options:**
Chrome oxide/Carbon - standard

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating</td>
<td>Chrome oxide coated stainless steel</td>
</tr>
<tr>
<td>Stationary</td>
<td>Carbon</td>
</tr>
</tbody>
</table>

Applications: General use in applications such as transfer of food products and other products. Should not be applied where abrasion is a concern.

Carbide/Carbide

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotating</td>
<td>Silicon carbide</td>
</tr>
<tr>
<td>Stationary</td>
<td>Silicon carbide</td>
</tr>
</tbody>
</table>

Applications: Used for difficult applications involving abrasive products.

Double Mechanical Seal:
Double mechanical seals are recommended for applications involving abrasive products, sticky products, and vacuum conditions of more than 12” Hg.

**Seal Options:**
Carbon/Chrome oxide/Carbon - standard

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner stationary</td>
<td>Carbon</td>
</tr>
<tr>
<td>Rotating</td>
<td>Chrome oxide coated stainless steel</td>
</tr>
<tr>
<td>Outer stationary</td>
<td>Carbon</td>
</tr>
</tbody>
</table>

Application: General use in applications such as transfer of food products and other products. Should not be applied where abrasion is a concern.

Carbide/Carbide/Carbon

<table>
<thead>
<tr>
<th>Materials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner stationary</td>
<td>Silicon carbide</td>
</tr>
<tr>
<td>Rotating</td>
<td>Silicon carbide</td>
</tr>
<tr>
<td>Outer stationary</td>
<td>Carbon</td>
</tr>
</tbody>
</table>

Applications: Used for difficult applications involving abrasive products.
Carbide/Chrome oxide/Carbon

Materials:
- Inner stationary: Silicon carbide
- Rotating: Chrome oxide coated stainless steel
- Outer stationary: Carbon

Applications: Used for sticky products (e.g. syrups and sugar products) and abrasive products.

Elastomer Materials - (for both single and double mechanical seals)

Viton elastomers for the seal area and BUNA cover gaskets are standard.

Chemraz elastomers are used for -20°F up to 500°F in corrosive non-FDA approved applications. EPDM is optional for products incompatible with viton and for fluids below 32°F. EPDM is also the standard material for steam applications. (EPDM should not come in contact with petroleum based products.)

Kalrez, Silicone, EPDM Class 6 and Silicone Class 6 elastomers are also available upon request.

Additional seal face materials and combinations are available upon request.

Temperature Ranges for Elastomers

<table>
<thead>
<tr>
<th>Elastomer</th>
<th>Temp. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buna</td>
<td>-40°F to 250°F</td>
</tr>
<tr>
<td>Viton</td>
<td>-20°F to 400°F</td>
</tr>
<tr>
<td>EPDM</td>
<td>-65°F to 300°F</td>
</tr>
<tr>
<td>Silicone</td>
<td>-80°F to 450°F</td>
</tr>
<tr>
<td>Chemraz</td>
<td>-20°F to 500°F</td>
</tr>
<tr>
<td>Kalrez</td>
<td>0°F to 500°F</td>
</tr>
</tbody>
</table>
FKL O-ring Seal Options (see pages 96-97 for o-ring seal drawings)
The FKL o-ring seal is only available on the FKL 25, 50, 75, 150 and 250 model pumps. The o-ring seal is used in applications where the pump will be disassembled for cleaning.

Single O-ring Seal:
Single o-ring seals are recommended for daily teardown applications.

**Seal Options:**
Viton - standard

Applications: General use in applications such as transfer of food products and other products. Should not be applied where abrasion is a concern.

EPDM

Applications: Products not compatible with viton. EPDM should not come in contact with petroleum based products.

Double O-ring Seal:
Viton is standard for double o-ring seals.

**Seal Options:**
Viton - standard

Applications: General use in applications such as transfer of food products and other products. Should not be applied where abrasion is a concern. Contact Fristam Customer Service Department for more application information.

EPDM

Applications: Products not compatible with viton. EPDM should not come in contact with petroleum based products.

Elastomer Materials - (for both single and double o-ring seals)
Viton elastomers for the seal area and BUNA cover gaskets are standard.
Chemraz elastomers are used for -20°F up to 500°F in corrosive non-FDA approved applications. EPDM is optional for products incompatible with viton and for fluids below 32°F. EPDM is also the standard material for steam applications. (EPDM should not come in contact with petroleum based products.)
Kalrez, Silicone, EPDM Class 6 and Silicone Class 6 elastomers are also available upon request.
Additional seal face materials and combinations are available upon request.

Temperature Ranges for Elastomers

<table>
<thead>
<tr>
<th>Elastomer</th>
<th>Temp. Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buna</td>
<td>-40° to 250°F</td>
</tr>
<tr>
<td>Viton</td>
<td>-20° to 400°F</td>
</tr>
<tr>
<td>EPDM</td>
<td>-65° to 300°F</td>
</tr>
<tr>
<td>Silicone</td>
<td>-80° to 450°F</td>
</tr>
<tr>
<td>Chemraz</td>
<td>-20° to 500°F</td>
</tr>
<tr>
<td>Kalrez</td>
<td>0° to 500°F</td>
</tr>
</tbody>
</table>
Temperature Changes

Positive pump efficiency depends on internal clearances between the rotors and the pump housing. The pump can withstand certain temperature changes based on the rotors. For example, if you are running CIP solution at 180°F and your product is 50°F, that is a 130°F temperature differential. This differential is in the standard rotor range.

The temperature differential is a concern, because if there is a severe temperature change in the pump, the shaft and rotors may expand inside the pump housing. This expansion can result in rotor to cover or rotor to housing damage.

The clearances inside the FKL pump are extremely small, below are the recommended temperature differentials.

<table>
<thead>
<tr>
<th>FKL Temperature differential</th>
<th>Correct Rotor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ 140°F</td>
<td>standard rotors</td>
</tr>
<tr>
<td>Δ 210°F</td>
<td>high temperature rotors</td>
</tr>
</tbody>
</table>

Temperature expansion is less of a concern in the FL II Series.

Fristam recommends high temperature rotors for pumps that will be cleaned or steamed at elevated temperatures.

Positive Displacement Pump Cleaning Recommendations

Some recommendations for cleaning PD pumps are as follows:

When you are running products or cleaning solutions with different temperatures, you need to allow enough time for all of the wetted components inside the pump to reach a steady-state temperature before you start the pump. If your process does not allow you to stop the pump during this transition, you need to install rotors that provide larger clearances. Note: that the clearances inside the FKL pump are extremely small.

If the process lines are to be cleaned with the pump, use a by-pass loop around the pump during the CIP mode to maintain pipe velocity. Once the wetted components are at a steady temperature, the pump can be started and run around 100 RPM with a backpressure of at least 10 PSI. As the product viscosity increases, the required backpressure may need to be increased as well.

Contact Fristam if you have any questions.
Section III: Positive Pump Basics

A. Definitions and Terms

Density
Density is the mass of a substance per unit volume. Generally, we express density in units of pounds per cubic inch.

Specific Gravity
Specific gravity is used to compare the density of a product to the density of water. The specific gravity of a product is expressed as its density divided by the density of water. This number will have no units, because it is simply a ratio.

Brix
Also called degrees Brix (°Brix), it is a hydrometer scale for sugar solutions. It is expressed as grams of soluble solids per 100g of liquid and is temperature corrected. Sugar content is approximately proportional to the °Brix value, with sugars contributing 55 to 75% of the °Brix.

Viscosity
Viscosity is a measurement of a product’s resistance to flow. Low viscosity products (i.e. water) have little resistance to flow, while higher viscosity products have a greater resistance to flow. It is key to positive pump sizing and operation because it affects slip within the pump as well as the pressure required to overcome frictional loss in the lines. The product’s resistance to flow produces system backpressure and heat. It will be explained later that the increased resistance to flow can be seen in the relationship between the frictional pressure loss (psi / foot tubing), flow rate (gpm), and product viscosity (cps) in the pressure loss charts shown on pages 42-47. It will also be explained that this same resistance to flow, by higher viscosity products, can be seen in reduced product slip inside the pump.

Newtonian vs. Non-Newtonian Fluids
A Newtonian fluid will have the same viscosity whether or not it is in motion. Examples of this type of fluid would be water and high fructose corn syrup (HFCS). A non-Newtonian fluid will have a different viscosity depending on the velocity of its flow. The majority of fluids are of this type, some examples would be ketchup, orange juice concentrate and shampoo.

Thixotropic Fluids
A thixotropic fluid is a type of non-Newtonian fluid that will become less viscous as the shear rate increases. This is also known as shear thinning, ketchup is a good example of this type of fluid. While the product is static, or standing still, the viscosity can be very high. As the fluid begins to flow it becomes less viscous and starts to run like water. After it sits again, it becomes very viscous. This thinning is due to shear in the fluid. As the fluid begins to move, the molecules will slide over each other and require less force to stay in motion. This force causes a shear stress in the fluid.
**Apparent Viscosity**

As previously explained, non-Newtonian fluids have less viscosity in motion, than at rest. The viscosity of a product in motion is known as its apparent viscosity. When a non-Newtonian fluid is in motion the apparent viscosity should be used for calculating the pressure drop. The apparent viscosity can be measured using a viscometer and plotting the results as a “Viscosity vs. Shear Rate” curve. This curve can be used with a shear rate curve for the tubing that is used in the system, to determine the apparent viscosity.

1. Find the product’s flow rate (75 gpm) on the “Flow Rate vs. Shear Rate” curve for tubing.

2. Draw a line to the right until it intersects the 3” tubing diameter.

3. Follow the line down to find the shear rate. Shear rate = 125

4. Find the shear rate on the “Viscosity vs. Shear Rate” curve for the product.

5. Move up until you intersect the line.

6. Move left to find the apparent viscosity. Apparent viscosity = 1500 cps.

*Figure 1*

*Figure 2*
**Atmospheric Pressure**

Atmospheric pressure is the force exerted by the weight of the atmosphere. At sea level, the average atmospheric pressure is 14.7 pounds per square inch (psia). Refer to Table 2 (page 48) for the average atmospheric pressure at different elevations.

**Gauge Pressure**

Gauge pressure is the pressure read on a gauge installed in a system. At sea level the average atmospheric pressure is 14.7 psia, this would be equal to 0 psi gauge pressure. This is measured in units of pounds per square inch gauge or psig.

**Absolute Pressure**

Absolute pressure is calculated by adding the atmospheric pressure to the gauge pressure. This is measured in units of pounds per square inch absolute or psia.

**Static Pressure (Head)**

Static pressure is the pressure exerted by a column of liquid above the centerline point of measurement.

\[ p_s = \left( \frac{Z}{2.31} \right) \times s_g \]

- \( p_s \) = static pressure (psia)
- \( Z \) = liquid level (ft)
- \( s_g \) = specific gravity (product)
- 2.31 = conversion factor (dimensionless)

**Vacuum**

Vacuum refers to a pressure that is below the normal atmospheric pressure. If the tank feeding the inlet of a pump is at an absolute pressure less than atmospheric, the tank is said to be under vacuum. Vacuum is typically measured in units of inches of mercury (inches Hg). This number must be converted to psia, for NIPA calculations. For the conversion, see Table 6 on page 50.

**Vapor Pressure**

The vapor pressure of a fluid is the pressure required at a given temperature to keep the fluid from turning to vapor. Water at 210°F has a vapor pressure of 14.123 psia. See Table 1 for the water vapor pressure on page 48.

**NIPR – Net Inlet Pressure Required**

NIPR is the pressure required by a pump to perform smoothly without cavitating. NIPR is measured in psia.

**NIPA – Net Inlet Pressure Available**

NIPA is the absolute pressure available at the inlet of the pump. NIPA is measured in psia.
**Cavitation**

Cavitation is the formation of vapor bubbles due to insufficient pressure at the inlet of the pump. High product temperature and/or low pressure on the inlet side of the pump can lead to insufficient pressure. Over time, cavitation can seriously damage a pump. Additional pressure energy would be required to supply the pump with the energy it requires to keep from cavitating. Four ways to increase NIPA are raise the level of the product in the tank, pressurize the tank, lower the pump or decrease the product temperature.

If the NIPR of the pump is greater than the NIPA in the system, the pump will cavitate. If the NIPR is less than the NIPA, the pump will not cavitate.

**B. How a Positive Pump Operates**

*Positive Displacement Pump Operation (assuming sufficient NIPR)*

Positive displacement pumps use two opposing, rotating elements (rotors) to displace product from the suction side of the pump to the discharge side of the pump. As the rotors rotate, the chamber formed between the rotors, housing and cover collects the product on the inlet side of the pump and carries the product to the discharge side of the pump.

*Slip and Efficiency -*

Positive pumps sometimes do not pump the full displacement for which they are rated because of a phenomenon called slip. To allow a positive pump's rotors to rotate, small clearances must be maintained between the rotors and housing. At lower viscosities these clearances allow some product to slip from the discharge side to the inlet side as the pump operates. The product that slips by will partially fill the inlet cavity. This amount of product must be “repumped” preventing the pump from reaching its full rated capacity and decreasing its volumetric efficiency.
• Internal clearances – The tighter the clearances, the less slip occurs.
• Viscosity – The amount of slip varies inversely with viscosity. The thicker the product, the less slip will occur. This reduction in slip eventually reaches a point called “zero slip”.
• Zero slip – Zero slip is the point at which the product is thick enough that it will no longer flow past the rotors. This point varies depending upon the internal clearances of the pump. The FKL reaches zero slip at 200 cps and the FL II achieves it at 500 cps. At these points the amount of differential pressure no longer becomes a factor.

Volumetric Efficiency = Actual Flow/Flow at Zero Slip

Full volumetric efficiency is achieved on all products with viscosities above the zero slip point.

Actual flow for products between one and the zero slip point will depend on the interaction of product viscosity and the differential pressure. At a constant product viscosity below zero slip, increasing the discharge pressure increases the product slip. At a constant discharge pressure, decreasing the product viscosity increases the product slip.

For products with a viscosity between 1 and 200 cps for the FKL and between 1 and 500 cps for the FL II the flow rate is dependent on the product viscosity and the differential pressure. At a constant product viscosity below zero slip, increasing the discharge pressure increases the product slip. At a constant discharge pressure, decreasing the product viscosity increases product slip. As the slip increases, the volumetric efficiency of the pump decreases because the full volume of the suction chamber is not available for new product.

Slip = (Flow @ 0 psi) – (Flow @ 10 psi)

Slip = 100 gpm - 70 gpm
Slip = 30 gpm
VE = 70%

Figure 8 shows the effect that increasing the discharge pressure has on slip and volumetric efficiency. At 0 psi, the volumetric efficiency is 100%. As the pressure increases, product slips from the discharge side of the pump to the suction side.

Volumetric Efficiency = \frac{\text{Flow @ 10 psi}}{\text{Flow @ 0 psi}}

\text{VE} = \frac{70 \text{ GPM}}{100 \text{ GPM}} \times 100
Figure 9 shows that as product viscosity increases, slip decreases. As product slip decreases, volumetric efficiencies increase. At 200 cps the slip is zero and volumetric efficiency is 100%, assuming that the net inlet pressure of the pump is satisfied. At 200 cps, the zero psi pressure line is used for sizing the FKL.

**Differential Pressure**

The differential pressure that the pump must generate is key to sizing. Differential pressure is the total pressure against which a pump must work. Generally the suction pressure is negligible and the discharge pressure makes up nearly all of the differential pressure. If the suction gauge pressure is positive, the differential pressure across the pump is the discharge pressure minus the suction gauge pressure.

Differential Pressure (psi) = Discharge Pressure (psi) – Suction Pressure (psi)

The pressure gradient inside the pump shows that the positive pressure on the suction side (Figure 10) of the pump assists the rotor movement and reduces the product slip inside the pump. Pressurized tanks and product levels above the pump on the suction side contribute to positive suction pressures.

The pressure gradient inside the pump shows that the negative pressure on the suction side (Figure 11) of the pump pulls against the movement of the rotors and increases product slip inside the pump. A vacuum drawn on a tank and frictional losses in inlet piping contribute to negative suction pressures.
**Pump Speed**

Pump speed is affected by product viscosity and the differential pressure. At zero slip, the pump speed will be directly related to the flow rate and displacement. The zero psi line on the pump curves may be used to determine the pump speed. In the FKL pump the slip stops at a product viscosity of about 200 cps and in the FL II pump it stops at about 500 cps.

For water like products with a viscosity of one cps, calculate the differential pressure. Select the curve labeled with that differential pressure to determine the pump speed required.

If the product viscosity falls in between 1 cps and zero slip, you need to use a viscosity correction to determine the pump speed. The FL II viscosity adjustment curve is on page 32.

**Work Horsepower (WHp)**

The power required to pump the product through a system. This is based on the pump speed and the pressure against which it is working.

**Viscosity Horsepower (VHp)**

The power required to move product through the pump. This is based on the pump speed and the viscosity of the product as it passes through the pump. The measurement is taken with zero backpressure on the pump.
C. Frictional Losses through Sanitary Tubing

Friction loss is the loss of pressure energy through the interaction between the product and the tubing. The higher the product viscosity, the more pressure energy is lost through friction. This manual contains six graphs on pages 42-47 that can be used to calculate the system pressure drop through 1 ½", 2", 2 ½", 3", 4" and 6" tubing. Use the product’s apparent viscosity and required flow rate to determine the frictional pressure drop through 1 foot of tubing, then multiply by the length of tubing in your system to obtain the total tubing frictional loss.

Examples 1, 2 and 3 show the effect of product viscosity and tubing size on frictional loss.

Example 1 – Determine the pressure loss resulting from 50 gpm of water at 1 cps flowing through 100 ft. of 1 ½” tubing. (see figure 14)

Directions:
1) Locate the product viscosity on the horizontal axis.
2) Move up vertically until you intersect the system flow rate.
3) Move horizontally and record the pressure loss in psi / foot tubing.

Given:
\[ p_f = \text{tubing frictional loss (psi)} = f \times L \]
\[ f = \text{frictional pressure loss (psi/ft tubing)} \]
\[ L = \text{tubing length (ft)} \]

Refer to figure 14:
\[ f = 0.1 \text{ psi/ft} \]
\[ L = 100 \text{ ft} \]
\[ p_f = 0.1 \text{ psi/ft} \times 100 \text{ ft} \]
\[ p_f = 10 \text{ psi} \]

Example 2 – Now determine the pressure loss resulting from a flow rate of 50 gpm of 300 cps product flowing through 100 ft. of 1 ½” tubing.

\[ f = 1.1 \text{ psi/ft} \]
\[ L = 100 \text{ ft} \]
\[ p_f = 1.1 \text{ psi/ft} \times 100 \text{ ft} \]
\[ p_f = 110 \text{ psi} \]

Increasing the product viscosity from 1 cps to 300 cps increases the frictional pressure losses from 0.1 psi/ft to 1.1 psi/ft.
Example 3 – (see figure 15) Increasing the tube size will reduce pressure loss through the piping system. 300 cps viscosity product flowing at 50 gpm through 1 ½” tubing will develop 110 psi of system backpressure. Now repeat the example using 2” tubing and compare the result.

\[ f = 0.32 \text{ psi/ft} \]

\[ L = 100 \text{ ft} \]

\[ p_f = 0.32 \text{ psi/ft} \times 100 \text{ ft} \]

\[ p_f = 32 \text{ psi} \]

Increasing the tubing diameter from 1 ½” to 2” decreases the pressure loss by 0.78 psi/foot of tubing.

![Figure 15 - Example 3 - Pressure loss curve - 2” tubing](image-url)
D. Calculating System Pressure
Refer to the pump inquiry sheet and use the system components specified to calculate the discharge and suction pressures of the system.
Product Section I

Product: X
Discharge Pressure: to be calculated
Viscosity: 200 cps
% Solids: none
Particulate Size: none
Specific Gravity: 1.35
Temperature: 150°F
Abrasiveness: --

Flow: 50 GPM
Inlet Pressure: to be calculated
Thixotropic: --
Dilatent: --
Newtonian: X
CIP Temperature: 150°F
SIP Temperature: --
Non-Abrasive: X

System Component Section II

For applications where the duty point is not specified a complete description of the process system is required. Fill in the suction and discharge piping components below.

Suction Tubing

Tubing Size: 2"
Tubing Length: 6'
Elbows: 1
Tees:
Valves:
Vertical: 5' (from liquid level)
Misc.

Discharge Tubing

Tubing Size: 1 1/2"
Tubing Length: 100'
Elbows: 3
Tees: 0
Valves: 0
Vertical: 10'
Misc.

Comments: Sizing Example - plant is located at an elevation of 4000'
1. Total Discharge Pressure Losses

Several factors will go into calculating the total discharge pressure of the system. In our example, we must calculate the frictional losses resulting from 200 cps product flowing through 100’ of 1 ½” tubing and three elbows at 50 gallons per minute. The elevation change of ten feet must also be included in the discharge pressure calculation.

**Static Pressure**

Determine the static pressure resulting from the elevation change from the centerline of the pump to the discharge of the system

\[ p_s = \text{static pressure (psi)} \]

\[ Z = \text{liquid level (ft)} = 12' - 2' \]

\[ sg = \text{specific gravity} = 1.35 \]

\[ p_s = \left( \frac{Z}{2.31} \right) \times sg \]

\[ p_s = \left( \frac{10}{2.31} \right) \times 1.35 \]

\[ p_s = 5.84 \text{ psi} \]

**Frictional Loss – Tubing**

Determine the frictional loss through 1 ½” discharge tubing.

Refer to the pressure loss curves pages 42-47 to determine the friction loss resulting from 50 gpm of 200 cps product through 100’ of 1 ½” tubing.

1) Locate 200 cps on the horizontal axis of the chart.

2) Move vertically until you intersect the 50 gpm flow rate line.

3) Move horizontally and record the pressure loss in psi / foot of tubing.

\[ p_f = \text{tubing frictional loss (psi)} \]

\[ f = \text{friction factor} = 0.7 \text{ psi / ft} \]

\[ L = \text{total length of tubing (ft)} = 100 \text{ ft} \]

\[ p_f = f \times L \]

\[ p_f = 0.7 \times 100 \]

\[ p_f = 70 \text{ psi} \]
**Frictional Loss – Elbows and Tees**

To calculate the frictional loss for the fittings, we will first convert the fittings into an equivalent length of tubing. Refer to Table 3 (page 49) to determine the equivalent length of the three elbows in the discharge tubing. Note that as the viscosity increases, the loss goes down for any one tubing size. This happens because the higher viscosity product flows through the fitting with less turbulence.

Next, we will calculate the pressure loss over that length of tubing.

\[ p_f = \text{frictional loss in fittings (psi)} = L_e \times n \times f \]

\[ L_e = \text{equivalent length / elbow (ft/elbow)} = 2 \text{ ft/elbow} \]

\[ n = \text{number of elbows} = 3 \]

\[ f = \text{frictional pressure loss (psi/ft)} = 0.7 \text{ psi/ft} \]

\[ p_f = L_e \times n \times f \]

\[ p_f = 2 \times 3 \times 0.7 \]

\[ p_f = 4.2 \text{ psi} \]

**Total Frictional Pressure Loss**

Combine the tubing frictional loss and the frictional loss in fittings to find the total frictional pressure loss.

\[ p_t = \text{total frictional loss (psi)} = p_f + p_c \]

\[ p_f = 70 \text{ psi} \]

\[ p_c = 4.2 \text{ psi} \]

\[ p_t = 70 + 4.2 \]

\[ p_t = 74.2 \text{ psi} \]

**Total Discharge Pressure Losses**

Combine the total frictional pressure loss and the static pressure to find the total discharge pressure loss.

\[ p_d = \text{total discharge pressure (psi)} = p_t + p_s \]

\[ p_s = 5.84 \text{ psi} \]

\[ p_d = 74.2 \text{ psi} + 5.84 \]

\[ p_d = 80.04 \text{ psi} \]
2. Pump Suction – Calculating NIPA

The NIPA (net inlet pressure available) should be calculated to determine the pressure energy available to the pump. The NIPA of the system should be compared to the NIPR (net inlet pressure required) of the pump model being considered to execute the specific duty. If the NIPA of the system is less than the NIPR for the pump, the system should be modified to increase the NIPA or a pump model requiring less NIPA should be considered.

**Atmospheric Pressure**

Refer to Table 2 (page 48) to determine the average atmospheric pressure.

The altitude above sea level is 4,000 ft.

\[ p_a = 12.7 \text{ psia} \]

**Static Pressure**

The total height above the centerline of the pump inlet is 5 feet (Figure 20).

\[ p_s = \text{static pressure (psi)} \]
\[ Z = \text{total height (ft)} = 5 \text{ ft} \]
\[ s_g = \text{specific gravity} = 1.35 \]
\[ p_s = \left( \frac{Z}{2.31} \right) \times s_g \]
\[ p_s = \left( \frac{5}{2.31} \right) \times 1.35 \]
\[ p_s = 2.92 \text{ psi} \]

**Vapor Pressure**

Determine the vapor pressure for water by looking at Table 1 (page 48).

Since our product does not have a vapor pressure table, most do not, we will use the table for water. The table for water is similar to what a table for another fluid would be like (Figure 21).

The product temperature is 150°F.

\[ v_p = 3.718 \text{ psia} \]
**Frictional Loss – Tubing**

Refer to the pressure loss curves pages 42-47 to determine the frictional loss in psi / foot of tubing for a 200 cps product traveling at 50 gpm through 6 feet of 2” tubing.

\[ p_f = \text{tubing frictional loss (psi)} \]

\[ f = \text{frictional pressure loss (psi/ft tubing)} = 0.21 \text{ psi/ft (Figure 22)} \]

\[ L = \text{tubing length (ft)} = 6 \text{ ft} \]

\[ p_f = f \times L \]

\[ p_f = 0.21 \times 6 \]

\[ p_f = 1.26 \text{ psi} \]

**Frictional Loss - Elbows and Tees**

Refer to Table 3 (page 49) for the equivalent length of tubing for 200 cps product flowing through one 2” elbow.

\[ p_e = \text{frictional loss in fittings (psi)} \]

\[ L_e = \text{equivalent length / elbow (ft/elbow)} = 2.3 \text{ ft (Figure 23)} \]

\[ n = \text{number of elbows} = 1 \]

\[ f = \text{frictional pressure loss (psi/ft)} = 0.21 \text{ psi/ft} \]

\[ p_e = L_e \times n \times f \]

\[ p_e = 2.3 \times 1 \times 0.21 \]

\[ p_e = 0.48 \text{ psi} \]

**Total Frictional Losses**

Combine the tubing frictional loss and the frictional loss in fittings, to find the total frictional loss.

\[ p_t = \text{total frictional loss (psi)} \]

\[ p_t = \text{tubing frictional loss (psi)} = 1.26 \text{ psi} \]

\[ p_t = \text{frictional loss in fittings (psi)} = 0.48 \text{ psi} \]

\[ p_t = p_f + p_e \]

\[ p_t = 1.26 + 0.48 \]

\[ p_t = 1.74 \text{ psi} \]
**NIPA**

Net Inlet Pressure Available

- \( p_a \) = atmospheric pressure (psia)
- \( p_z \) = static pressure (psi)
- \( v_p \) = vapor pressure (psi)
- \( p_t \) = total frictional loss (psi)

\[ NIPA^* = p_a + p_z - v_p - p_t \]

\[ NIPA = 12.7 + 2.92 - 3.718 - 1.74 \]

\[ NIPA = 10.162 \text{ psia} \]

* NIPA is calculated in absolute pressure (psia)

**3. Differential Pressure**

For proper pump selection, the differential pressure should be calculated. When calculating the differential pressure, use the gauge pressure at the inlet and not the NIPA.

The values used in these examples were calculated above.

**Gauge Pressure at Inlet**

- \( p_s \) = gauge pressure at inlet (psi)
- \( p_z \) = static pressure (psi) = 2.92 psi
- \( p_t \) = total frictional loss (psi) = 1.74 psi

\[ p_s = p_z - p_t \]

\[ p_s = 2.92 - 1.74 \]

\[ p_s = 1.18 \text{ psi} \]

**Differential Pressure**

- \( P \) = differential pressure
- \( p_d \) = total discharge pressure (psi) = 80.04 psi
- \( p_s \) = gauge pressure at inlet (psi) = 1.18 psi

\[ P = p_d - p_s \]

\[ P = 80.04 - 1.18 \]

\[ P = 78.86 \text{ psi} \]
IV. Selecting a Positive Displacement Pump

Choosing a Model

A. Gather all application information including product nature, viscosity, temperature, NIPA, flow rate and pressure loss.

B. Decide what model pump to use, FLII or FKL. For simple applications the more economical FLII pump will work, when the duty exceeds the capabilities of this pump the FKL should be applied.

The FKL and FL II Product Lines – Better Choices for Better Performance

To best match the broad range of positive displacement pump applications Fristam provides two product lines, the FKL and the FL II. While sharing many similarities the pumps are fundamentally different in design.

The FKL is a circumferential piston pump, meaning that its rotors run in a channel described by the pump housing and built-in internal hubs. The purpose of this design is to achieve high performance by maintaining tighter clearances and restricting product slip within the pump. The design produces higher pressures, the ability to self-prime and the capability of handling more difficult products and applications.

The FL II is a rotary lobe pump. Rotary lobes use the movement of two lobes in a pumping chamber to accomplish the pumping action. This style of pump is designed for standard duty applications.

Choosing Between the FKL or FL II

The FKL can be selected for any application within the capabilities of it or the FL II. Within its range, the FL II will often be a more attractive selection because of its economy and simplicity. The FL II should be considered for applications within the following parameters.

- Pressures to 170 psi
- Viscosities to 50,000 cps
- Flooded suction with at least 7 psia available
- Mechanical seals required
- 316L stainless steel rotors required
- Product is low to moderately shear sensitive
**Selecting a Pump Size**

Use the composite curves to make your initial pump selection.

1. Locate the product viscosity on the horizontal axis (1).
2. Locate the required flow rate on the vertical axis (2).
3. Determine the intersection between the flow rate and product viscosity (3).
4. Select a pump model above the intersection (3).

When selecting, keep in mind that it is best to run a positive displacement pump at no more than 400 to 500 rpm. The lower speeds reduce seal wear, extend pump life, reduce suction pressure requirements and produce quieter operation. The composite curves are based on the maximum speed of the pumps; therefore, the model selected will usually be one or two above the duty point.

For example: For a flow rate of 50 gpm and a product with a viscosity of 200 cps, the model directly above the duty point is a FLII 75L. However, if we look at the individual curve (page 37) for this pump we will see that it would have to run above the desired speed range. Therefore, we will select a FLII 100S.

![Composite Pump Chart](Figure 24)
Determining Pump Speed

Viscosity Adjustment

Viscosity adjustment is not necessary for products with a viscosity above the pump's zero-slip point. Also, viscosity adjustment is not necessary for products at 1 cps, since the curves are calculated at 1 cps. The zero slip point is 500 cps for the FLII and 200 cps for the FKL. Speed must be increased for products with a viscosity below the zero slip point in order to deliver the required flow rate. This is the most confusing part of PD selection. It is necessary because, as discussed on pages 58-61 (How a Positive Pump Operates), pump performance will vary for viscosities below the zero slip point. The adjustment converts the slip factor for different viscosity products into an equivalent based on water.

For the FLII, use the curve on page 31 and for the FKL use the curve on page 11.

1. Locate the calculated differential pressure on the vertical axis (1).
2. Follow the pressure line, down and to the right, until it intersects (3) the product viscosity (2).
3. Record the adjusted pressure value on the vertical axis (4). This value is the pressure that will be used on the slip curve.
High Temperature Rotor Adjustment

For applications that fall below the zero slip point and require high temperature rotors, another speed adjustment is necessary. The increased clearances produced by these rotors require this adjustment, to compensate for the additional slip they produce.

For any of the FLII pumps, use the curve on page 32 and for the FKL pump use the curve on page 11.

1. Locate the calculated differential pressure on the vertical axis (1).
2. Follow the pressure line, down and to the right, until it intersects (3) the product viscosity (2).
3. Read all the way to the left until you find the line representing the model that was selected (4).
4. Record the additional speed at the horizontal axis (5). This number will be added to the speed calculated for the pump.

Figure 26 - FL II High Temperature Rotor Correction Curve
Determining Pump Speed

To determine the pump speed:

1. Locate the required flow rate on the pump curve (1).
2. Move horizontally until you intersect the correct pressure (2). This will depend on the viscosity of the product. For products with a viscosity of 1 cps, the correct pressure line will be the differential pressure. For viscosities between 1 and 500 cps for the FLII pump, the correct line will be the viscosity-adjusted pressure. For viscosities above 500 cps for the FLII, the correct line will be 0 psi.
3. Move straight down until you intersect the horizontal axis (3).

Determining Horsepower Requirements

1. Determine the Work Horsepower (WHp). Continue to move down until you intersect the differential pressure (4), not the adjusted pressure. Read the power off the vertical axis directly to the left (5).
2. Determine the viscosity horsepower (VHp). Continue to move down (from the differential pressure point) until you intersect the product viscosity (6). Read the power off the vertical axis directly to the left (7).
3. Add these two numbers together to calculate the overall brake horsepower.

\[
BHp = WHp + VHp
\]
**Net Inlet Pressure Required (NIPR)**
Check the Net Inlet Pressure Required (NIPR) for the selected pump. For the FLII pumps, be sure that the NIPR is at least 7 psia. For the FKL, each pump has its own curve.

**Determining Drive Torque Requirements**
Calculate the application torque. The application torque will be used to help size the pump drive and the coupling used to connect the drive to the pump. Each of these components will have a maximum allowable torque and the application torque cannot exceed this.

\[ T = \frac{(63,025 \times BHp)}{\text{speed}} \]
Example 1

Water at 1 cps, 1.0 SG and 68°F

The duty will be 20 gpm @ 200 psi and the NIPA will be 4 psia.

The pressure of this duty point exceeds the maximum of any of our FLII pumps and the NIPA is relatively low, therefore we will select a FKL pump for this application.

Look at the composite curve (page 11) and select a model. See page 72 for more explanation.

The model that will work best is the FKL 50.

This duty will not require a viscosity or temperature adjustment since the product is at 1 cps. The actual slip line can be read off the curve.

Calculate the pump speed, horsepower and application torque.

![Figure 29](image-url)
For example 1, the FKL 50 requires 494 rpm to deliver 1 cps product at 20 gpm against 200 psi.

\[ BH_p = WH_p + VH_p \]

\[ BH_p = 6.1 + 0.4 \]

\[ BH_p = 6.5 \]

\[ T = \text{Torque (in/lbs.)} \]

\[ T = \frac{BH_p \times 63,025}{\text{speed}} \]

\[ T = \frac{6.5 \times 63,025}{494} \]

\[ T = 829 \text{ in-lbs} \]

Check the NIPR of the pump using Figure 30.

The NIPR is 2.7 psia, therefore the NIPA of 4 psia is more than enough. The final selection would be a FKL 50, running at 494 rpm with a 7.5 hp drive and having a torque of 829 in-lbs.
Example 2
High Fructose Corn Syrup at 5,000 cps, 1.32 SG and 38°F

The duty will be 100 gpm @ 250 psi and the NIPA will be 10 psia

The pressure of this duty point exceeds the maximum of any of our FLII pumps; therefore, we will select a FKL pump for this application. Look at the composite curve (Figure 32) and select a model. See page 72 for more explanation.

Figure 32

The model that will work best is the FKL 250. The FKL 150 is above the duty point, but the speed required is too high.

This duty will not require a viscosity or temperature adjustment.

Calculate the pump speed, horsepower and application torque. The speed can be calculated by dividing the flow rate by the displacement, or it can be found by reading the zero slip line on the slip chart.
For example 2, the FKL 250 requires 179 rpm to deliver 5,000 cps product at 100 gpm against 250 psi.

\[ \text{BHp} = \text{WHp} + \text{VHp} \]

\[ \text{BHp} = 17.5 + 5.0 \]

\[ \text{BHp} = 22.5 \]

\[ T = \frac{\text{BHp} \times 63,025}{\text{speed}} \]

\[ T = \frac{22.5 \times 63,025}{179} \]

\[ T = 7,922 \text{ in-lbs} \]

Check the NIPR of the pump using the NIPR curve Figure 33.

The NIPA of 10 psi will be more than the 5.3 psi required for the FKL 250. The final selection would be a FKL 250, running at 179 rpm with a 25 hp drive and having a torque of 7,922 in-lbs.
Example 3
Pie filling at 200 cps, 1.2 SG and 90°F

The duty will be 50 gpm @ 75 psi and the NIPA will be 10 psia

This is a simple application with a low duty point pressure and plenty of NIPA; therefore, we will select a FLII pump. Look at the composite curve (Figure 35) and select a model. See page 72 for more explanation.

The FLII 100S is above the duty point. We will not select the FLII 75L for this application, because we are trying to keep the pump speed below the 400 – 500 rpm range.

This duty will require a viscosity adjustment, but will not require a high temperature adjustment.
Following the viscosity adjustment procedure for the FLII pump (pages 58-61), we determine the slip curve will be read on the 10 psi line.

The NIPA for the application is 10 psia, which is more than adequate for the FLII 100S.
Calculate the pump speed, horsepower and application torque.

For example 3, the FLII 100S requires 390 rpm to deliver 200 cps product at 50 gpm against 75 psi.

\[ \text{BHp} = \text{WHp} = \text{VHp} \]
\[ \text{BHp} = 4.2 + 1.2 \]
\[ \text{BHp} = 5.4 \]

\[ T = (\text{BHp} \times 63,025) / \text{speed} \]
\[ T = (5.4 \times 63,025) / 390 \]
\[ T = 873 \text{ in-lbs} \]

The final selection would be a FLII 100S, running at 390 rpm with a 7.5 Hp drive and having a torque of 873 in-lbs.
Example 4
Vegetable Oil at 3 cps, 0.98 SG and 275°F

The duty will be 100 gpm @ 80 psi and the NIPA will be 10 psia

This is a simple application with a low duty point pressure and plenty of NIPA; therefore, we will select a FLII pump. Look at the composite curve (Figure 38) and select a model. See page 72 for more explanation.

The FLII 130S falls above the duty point and will fall within the preferred speed range.

Figure 38
This duty will require a small viscosity adjustment and a high temperature adjustment.

Following the viscosity adjustment procedure for the FLII pump (pages 58-61), we determine the slip curve will be read on the 62 psi line.

Use the High Temperature Rotor Correction curve (Figure 40) to determine the speed adjustment. We will add 27 rpm to the speed, to compensate for the high temperature rotors.
The NIPA for the application is 10 psia, which is more than adequate for the FLII 130S. Calculate the pump speed, horsepower and application torque.

For example 4, the FLII 130S requires 360 rpm to deliver 3 cps product at 100 gpm against 80 psi. We then need to add 27 rpm to the 360 rpm.

\[ BHp = WHp + VHp \]
\[ BHp = 10.0 + 1.5 \]
\[ BHp = 11.5 \]

\[ T = \frac{(BHp \times 63,025)}{\text{speed}} \]
\[ T = \frac{(11.5 \times 63,025)}{387} \]
\[ T = 2,085 \text{ in-lbs} \]

The final selection would be a FLII 130S, running at 387 rpm with a 15 Hp drive and having a torque of 2,085 in-lbs.

Figure 41

Model: FLII 130S
Displacement: 0.465 gal/rev
Standard Port Size: 3"X3"
FKL 25-400 Dimensional Drawing with Straps

Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
FKL 50-250 Rectangular Inlet Vertical Mount Dimensional Drawing

Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
FKL 50 - 400 Rectangular Inlet Dimensional Drawing

DIMENSIONS IN MILLIMETERS (INCHES)

<table>
<thead>
<tr>
<th>PUMP MODEL</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>K</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>FKL 50</td>
<td>305</td>
<td>87</td>
<td>171</td>
<td>88</td>
<td>2.73</td>
<td>16</td>
<td>79</td>
<td>46</td>
<td>15.5</td>
<td>44</td>
<td>175</td>
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<td>FKL 75</td>
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<td>98</td>
<td>167</td>
<td>90</td>
<td>3</td>
<td>13</td>
<td>120</td>
<td>100</td>
<td>10</td>
<td>57</td>
<td>56</td>
</tr>
<tr>
<td>FKL 150</td>
<td>387</td>
<td>98</td>
<td>167</td>
<td>90</td>
<td>3</td>
<td>13</td>
<td>120</td>
<td>100</td>
<td>10</td>
<td>57</td>
<td>56</td>
</tr>
<tr>
<td>FKL 400</td>
<td>467</td>
<td>98</td>
<td>167</td>
<td>90</td>
<td>3</td>
<td>13</td>
<td>120</td>
<td>100</td>
<td>10</td>
<td>57</td>
<td>56</td>
</tr>
</tbody>
</table>

FKL 400

FKL 250

FKL 75

FKL 50

FKL 150
FKL 600 Dimensional Drawing

Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
### FKL Single Mechanical Seal

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Rotating seal o-ring</td>
</tr>
<tr>
<td>55</td>
<td>Rotating seal ring</td>
</tr>
<tr>
<td>56</td>
<td>Seal retaining ring</td>
</tr>
<tr>
<td>57</td>
<td>Single seal insert</td>
</tr>
<tr>
<td>58</td>
<td>Outer seal spring</td>
</tr>
<tr>
<td>59</td>
<td>Inner stationary seal ring</td>
</tr>
<tr>
<td>60</td>
<td>Seal housing screw</td>
</tr>
<tr>
<td>61</td>
<td>Outer stationary seal o-ring</td>
</tr>
<tr>
<td>62</td>
<td>Seal housing</td>
</tr>
<tr>
<td>64</td>
<td>Inner stationary seal o-ring</td>
</tr>
<tr>
<td>65</td>
<td>Inner seal spring</td>
</tr>
<tr>
<td>66</td>
<td>Seal pin</td>
</tr>
</tbody>
</table>

The diagram illustrates the parts of the FKL Single Mechanical Seal, with numbers corresponding to the item numbers in the table. The image also includes an exploded view of the seal components.
# FKL Double Mechanical Seal

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Rotating seal o-ring</td>
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<td>55</td>
<td>Rotating seal ring</td>
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<tr>
<td>56</td>
<td>Seal retaining ring</td>
</tr>
<tr>
<td>58</td>
<td>Outer seal spring</td>
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<tr>
<td>59</td>
<td>Inner stationary seal ring</td>
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<tr>
<td>60</td>
<td>Seal housing screw</td>
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<tr>
<td>61</td>
<td>Outer stationary seal o-ring</td>
</tr>
<tr>
<td>62</td>
<td>Seal housing</td>
</tr>
<tr>
<td>64</td>
<td>Inner stationary seal o-ring</td>
</tr>
<tr>
<td>65</td>
<td>Inner seal spring</td>
</tr>
<tr>
<td>66</td>
<td>Seal pin</td>
</tr>
<tr>
<td>67</td>
<td>Outer stationary seal ring</td>
</tr>
<tr>
<td>68</td>
<td>Water pipe</td>
</tr>
<tr>
<td>69</td>
<td>Small seal housing o-ring</td>
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FKL Aseptic Double Mechanical Seal

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>54</td>
<td>Rotating seal o-ring</td>
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<tr>
<td>55</td>
<td>Aseptic rotating seal ring</td>
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<tr>
<td>56</td>
<td>Seal retaining ring</td>
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<tr>
<td>58</td>
<td>Outer seal spring</td>
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<td>59</td>
<td>Inner stationary seal ring</td>
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<tr>
<td>60</td>
<td>Seal housing screw</td>
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<tr>
<td>61</td>
<td>Outer stationary seal o-ring</td>
</tr>
<tr>
<td>62</td>
<td>Aseptic seal housing</td>
</tr>
<tr>
<td>63</td>
<td>Seal housing o-ring</td>
</tr>
<tr>
<td>64</td>
<td>Inner stationary seal o-ring</td>
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<tr>
<td>65</td>
<td>Inner seal spring</td>
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<tr>
<td>66</td>
<td>Seal pin</td>
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<tr>
<td>67</td>
<td>Outer stationary seal ring</td>
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<td>68</td>
<td>Water pipe</td>
</tr>
<tr>
<td>69</td>
<td>Small seal housing o-ring</td>
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</table>
FKL Single O-ring Seal

**Item No. Description**

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>60</td>
<td>Seal housing screw</td>
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<tr>
<td>64</td>
<td>Inner stationary seal o-ring</td>
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<tr>
<td>70</td>
<td>Seal o-ring</td>
</tr>
<tr>
<td>71</td>
<td>Seal housing</td>
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IL-0537
9/1200
FKL Double O-ring Seal

<table>
<thead>
<tr>
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<td>68</td>
<td>Water pipe</td>
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<tr>
<td>69</td>
<td>Small seal housing o-ring</td>
</tr>
<tr>
<td>70</td>
<td>Seal o-ring</td>
</tr>
<tr>
<td>72</td>
<td>Seal housing</td>
</tr>
</tbody>
</table>
FL II 15 Dimensional Pump Assembly

3/4" INLET/OUTLET PORT
Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
# FL II Vertical Dimensional Pump Assembly

<table>
<thead>
<tr>
<th>PUMP MODEL</th>
<th>INLET &amp; OUTLET</th>
<th>DIMENSIONS IN MILLIMETERS (INCHES)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>15</td>
<td>3/4&quot;</td>
<td>230 (9.06&quot;)</td>
</tr>
<tr>
<td>1&quot;</td>
<td>262 (10.32&quot;)</td>
<td>25</td>
</tr>
<tr>
<td>1-1/2&quot;</td>
<td>294 (11.57&quot;)</td>
<td>25</td>
</tr>
<tr>
<td>2&quot;</td>
<td>341 (13.44&quot;)</td>
<td>25</td>
</tr>
<tr>
<td>2-1/2&quot;</td>
<td>326 (12.84&quot;)</td>
<td>25</td>
</tr>
<tr>
<td>3&quot;</td>
<td>341 (13.44&quot;)</td>
<td>25</td>
</tr>
</tbody>
</table>

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Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
FL II 130 Dimensional Pump Assembly

Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
Due to Fristam Pumps’ commitment to continuous improvement, specifications are subject to change without notice.
Due to Fristam Pumps commitment to continuous improvement, specifications are subject to change without notice.
FL II Single Mechanical Seal

DESCRIPTION

5  ROTOR NUT O-RING
12  ROTOR O-RING
13  STATIONARY SEAL O-RING
33  SEAL WAVE SPRING
14  STATIONARY SEAL
16  GAPPING SPACER O-RING
  3  GAPPING SPACER
18  ROTATING SEAL

* gapping spacer is not included in seal kits
FL II Double Mechanical Seal

DESCRIPTION

5. ROTOR NUT O-RING
12. ROTOR O-RING
13. FRONT STATIONARY SEAL O-RING
3. GAPPING SPACER
16. GAPPING SPACER O-RING
33. FRONT SEAL SPRING
14. FRONT STATIONARY SEAL
18. ROTATING SEAL
20. REAR STATIONARY SEAL
19. REAR SEAL SPRING
21. REAR STATIONARY SEAL O-RING
32. SEAL FLUSH HOUSING O-RING
37. SEAL FLUSH HOUSING

* gapping spacer is not included in seal kits