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### Selection Guidelines

Tubing life performance is just one of many factors present in your pumping applications. The charts in this section will assist you in selecting tubing for your pumping application.

Tubing life is shown in hours at various motor speeds while continuously pumping water at 21°C (70°F) and 0 psig (0 bar). Masterflex® tubing life data is calculated from time to failure or reduction to 50% flow rate, whichever comes first.

In general:

- The Norprene® and PharMed® BPT tubing formulations offer the best tubing life in all applications where the fluid being pumped is chemically compatible
- High-performance precision tubing has a 20 to 30% increased tubing life over Precision tubing
- High-pressure Norprene and PharMed BPT have the best life in pressure applications
- Peroxide-cured silicone tubing offers up to 40% more tubing life. Platinum-cured silicone tubing offers better biocompatibility and fewer extractables. BioPharm Plus platinum-cured silicone tubing lasts up to five times longer than other platinum-cured silicone tubings.

#### Other factors to consider when determining the best tubing for your application:

- |                       |                       |
|-----------------------|-----------------------|
| • Fluid compatibility | • Duty cycle          |
| • Fluid temperature   | • Maintenance periods |
| • System pressure     | • Tubing purity       |
| • Motor rpm           | • Viscosity           |
| • Clarity of tubing   |                       |

#### Once tubing has been selected:

1. Test it in your application.
2. Monitor tubing life in duty cycle, look for signs of tubing fatigue (e.g. small pinhole leaks, abrasion, etc.).
3. Set up maintenance schedule to anticipate tubing failure.

Monitor the time tubing is in the pump. Advance it 8 to 12 inches on a daily, weekly, monthly, or quarterly basis, depending on your experience with your maintenance schedule.

### Testing Parameters

The charts found on pages TD-21-27 indicate the average life of Masterflex tubing used in our Standard-style pump heads unless otherwise noted. The tubing life is shown in hours at various motor speeds while continuously pumping water at 21°C (70°F) and 0 psig (0 bar). This data has been collected from years of testing Masterflex peristaltic pumps. Masterflex tubing life data is calculated from time to failure or reduction to 50% flow rate, whichever comes first.

These charts are best used as a general comparison only. It is not guaranteed that you will achieve the results shown. Generally, the life of all types of tubing is adversely affected by temperature, pump motor rpm, chemical compatibility, and pressure.



Tubing performance data presented in this catalog is the result of years of rigorous testing under actual application conditions.

# Tips for Dispensing Applications

Masterflex® digital pump drives are ideal for laboratory and process dispensing applications. Accuracies of  $\pm 0.5\%$  and better are achievable with careful pump system selection and by following some simple guidelines.

## Dispensing Benefits of Masterflex® Tubing Pumps

- Variety of available tubing formulations ensures chemical and biocompatibility with your fluid
- A continuous piece of tubing from inlet to outlet minimizes obstructions and interruptions in the fluid path
- Gentle pumping action is ideal for shear-sensitive fluids and fluids containing proteins and other large molecules
- Wide range of flow rates provides flexibility in volume and time of dispense
- Simple and reliable calibration ensures accuracy and repeatability
- Nonsiphoning; prevents backflow and enhances dispensing accuracy
- Multichannel capability with synchronous or independently controlled channels

## Pump Head Selection

Masterflex Standard, Easy-Load®-series, and High-performance pump heads all deliver excellent results in dispensing applications.

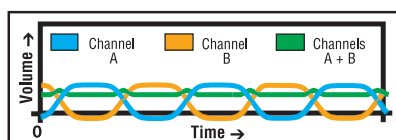
## Multichannel Options

Multichannel options include either stacking single-channel heads on a single drive or using a multichannel pump head.

Stacking multiple Easy-Load-series single-channel pump heads offers the advantage of reduced pulsation due to the offset rollers. Uniting the flow channels from two stacked heads into a single output line will greatly reduce pulsation (a measured reduction of up to 95%).

### Reduced Pulsation

Minimal pulsation is essential to ensuring accuracy in peristaltic dispensing. Pulsation causes variations in flow rate and splashing and frothing in the receiving vessel. Combining the split-channel tubing configuration with the offset rollers of two stacked Easy-Load® II pump heads merges a pulse from one channel with a trough from the other. The reduced pulsation is measured at the outlet and shown in the graph above.



Cartridge heads are popular for their small size and versatility. Mount up to 12 cartridges on a single pump head—ideal for applications requiring very low flow rates.

Newer options for multichannel applications include the dual-channel P/S® Easy-Load II pump heads (77202-50 and -60), and the P/S four- and eight-channel multichannel heads that deliver synchronous flow from up to 32 channels.

## Tubing Selection

### Chemical Compatibility

Refer to the chemical compatibility charts specific to pump tubing on pages TD-12-13. These charts are compiled from actual test data in peristaltic pumps.

### Temperature Sensitivity

The friction caused by the rollers moving over the tubing will generate measurable heat. This heat generation can affect the mechanical properties of the tubing and result in slight variations in performance. PVC-based formulations show the most pronounced temperature sensitivity. Due to minimal temperature sensitivity, recommended formulations for dispensing applications are BioPharm silicone, PharMed® BPT, PharmaPure®, Norprene®, and Gore™ STA-PURE®. STA-PURE tubing has characteristics that make it ideal for dispensing: superior shape memory throughout its life in the pump, little cross-sectional distortion over time, and minimal variation in flow over time. This superior shape memory is sufficient to offset the need for an initial break-in period.

## Size/Flow Range

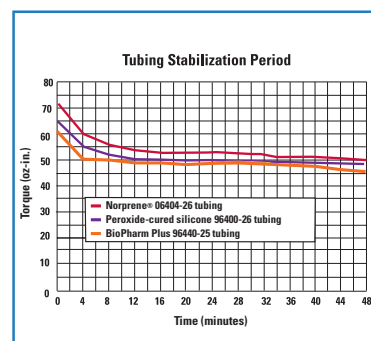
Size your tubing so that you are operating at the middle of the tubing's flow range (volume per unit time). This will give you maximum flexibility to make adjustments without approaching either the upper or lower limit of the tubing flow range.

## Loading the Tubing in the Pump Head

You will realize optimal performance, and best pumping life, if you are careful not to impart any twist or torsion to the tubing when loading. Tubing has a natural curvature—follow that curvature when laying the tubing across rollers or onto occlusion bed.

## Tubing Break-In Period

Peristaltic pump tubing shows a distinct increase in flow stability after the first few minutes of pumping. During this break-in period the tubing adapts to the repeated compression of the rollers. For tubing in the P/S® sizes the break-in period is 10 to 15 minutes; for I/P® tubing sizes, 15 to 20 minutes.



## Drive Selection

Masterflex® offers digital drives with features designed for dispensing applications. Drives are available in console, modular, and modular washdown configurations.

## Dispense Features

**Dispense by volume**—lets you program the volume to be dispensed for either single or multiple cycles

**Copy**—lets you program the number of dispense cycles or repeats

**Dispense interval**—an adjustable time delay between cycles gives you ample time to reposition the tubing or filling accessory, or to switch target vessels

**Cumulative volume**—displays the total volume dispensed over multiple cycles (available on the P/S and I/P digital process console drives; 07575-00 and 77420-00)

**Dispense by weight**—requires an RS-232 balance-compatible interface (available on the 07750-series P/S computer-compatible drive and on the P/S Digi-Staltic® modular dispensing pump 77310-00/77340-00)

**Anti-drip feature**—briefly reverses the rollers at the end of the dispense cycle, further ensuring accuracy (available on the P/S Digi-Staltic® modular dispensing pump)

## Remote Control

Remote control options enable easy integration of pumps into automated systems and also enhance user comfort in repetitive dispensing applications. Controllable functions include start/stop, reverse, prime, dispense or copy, and speed. Drives are available with analog (DC voltage, current, or contact closure) and/or digital (RS-232) interfaces. Control accessories include foot switches and dispensing wands for momentary start/stop and a full-function handheld remote controller for selected drives.

## Calibration

Proper calibration is essential to dispensing accuracy. Follow the directions in the drive operating manual and perform no more than two or three successive calibrations. Masterflex digital dispensing drives store one calibration value per tubing size and will hold that value in memory until the pump is recalibrated for that particular tubing size. Calibration conditions should be identical to the actual dispensing conditions. Backpressure, fluid viscosity, and temperature should not vary from calibration throughout dispensing. Remember to break in the tubing for the described period (see above) before calibration.

## Pumping Abrasive Fluids

Masterflex® tubing pumps are well suited for pumping abrasive slurries for several reasons. The peristaltic pumping action is gentle on the fluid, reducing tubing wear. The only part of the pump the fluid comes in contact with is a smooth piece of tubing; there are no fittings or valves that particles may clog. Abrasive materials shorten the life of any pump, but with peristaltic pumps the tubing is quickly and inexpensively replaced.

Follow these suggestions to get the maximum performance from your peristaltic tubing pump:

### 1. Choose abrasion-resistant tubing.

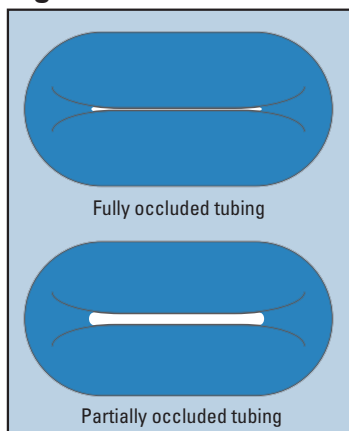
Norprene® and PharMed® BPT have good abrasion resistance. Tygon® is fair with abrasives, while C-FLEX®, silicone, and Viton® are moderately resistant to wear from abrasive materials.

### 2. Use an adjustable-occlusion pump head.

The standard occlusion for all Masterflex® fixed-occlusion pump heads is shown in Figure A. Abrasive materials, especially hard particles, are pressed into the tubing wall and can cause a great amount of wear. Using an adjustable-occlusion pump head allows you to reduce the amount that the tubing is

squeezed (Figure A); the result is less wear on the tubing. By increasing the occlusion to prime the tubing and then reducing it to pump, you'll get maximum performance from your pump with the least amount of wear on the tubing.

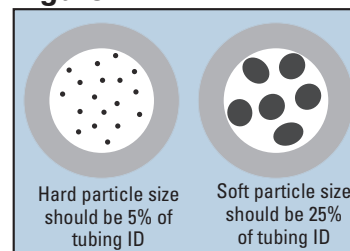
Figure A



3. **Select a larger tubing size.** This will reduce the rate that particles come into contact with the tubing wall. Soft particles should have an ID less than 25% of the ID of the tubing. Hard particles should be even smaller in relation to the ID of the tubing (less than 5%). Maintaining these ratios will reduce the rate that the tubing is being worn from the inside (Figure B).

4. **Slow down the speed of the drive.** This will cause a more gentle pumping action and increase the life of your tubing. Since many slurries are also viscous, slowing down the drive speed will also increase the efficiency of the pump.

Figure B



## Viscous Fluid Behavior

Effective viscosity can be better understood by looking at the behavior of viscous fluids at different shear rates. There are a number of types of viscous fluid behavior.

### 1. Newtonian fluids

Viscosity is constant with change in shear rate or agitation. Forces to cause motion increase proportionately as speed increases. Fluids showing Newtonian behavior include water, mineral oils, syrup, hydrocarbons, and resins.

### 2. Thixotropic fluids

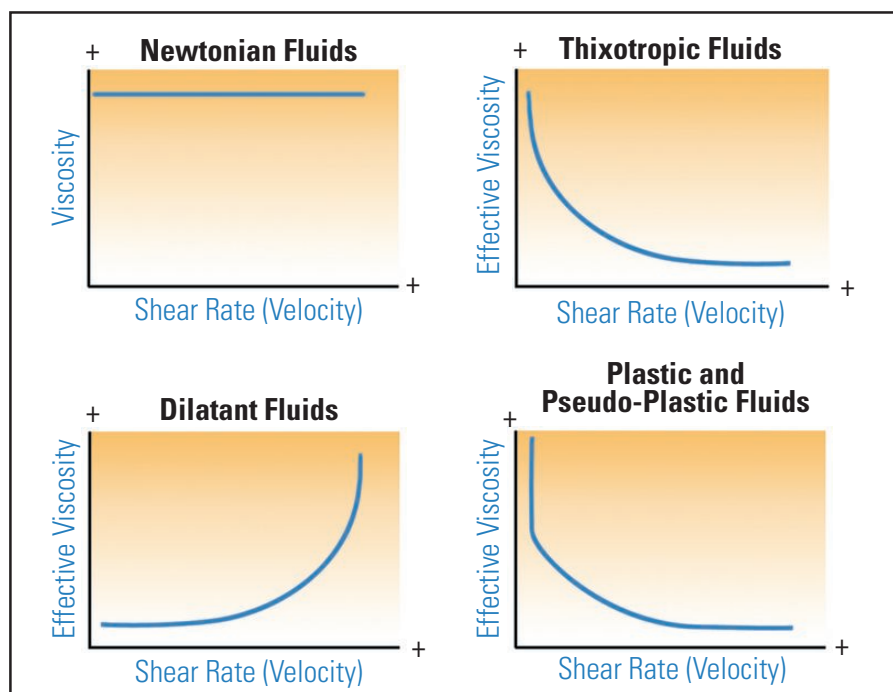
Viscosity decreases as shear rate or agitation increases. The forces to cause motion are relatively lower as speed increases. Examples are soaps, tars, vegetable oils, shortening, glue, inks, peanut butter, and some slurries.

### 3. Dilatant fluids

Viscosity increases as shear rate increases. Forces to cause motion may greatly increase as speed increases. Some liquids showing dilatant behavior are slurries, clay, and candy compounds.

### 4. Plastic and pseudo-plastic fluids

Viscosity decreases as shear rate increases, but initial viscosity may not be great enough to prevent start of flow in a typical pumping system. Typical plastic fluids are gels, latex paints, lotions, and shortening.



# MASTERFLEX® Peristaltic Pumps— Ideal for Pumping Viscous Fluids

To maximize the pumping efficiency of viscous fluid, follow these steps.

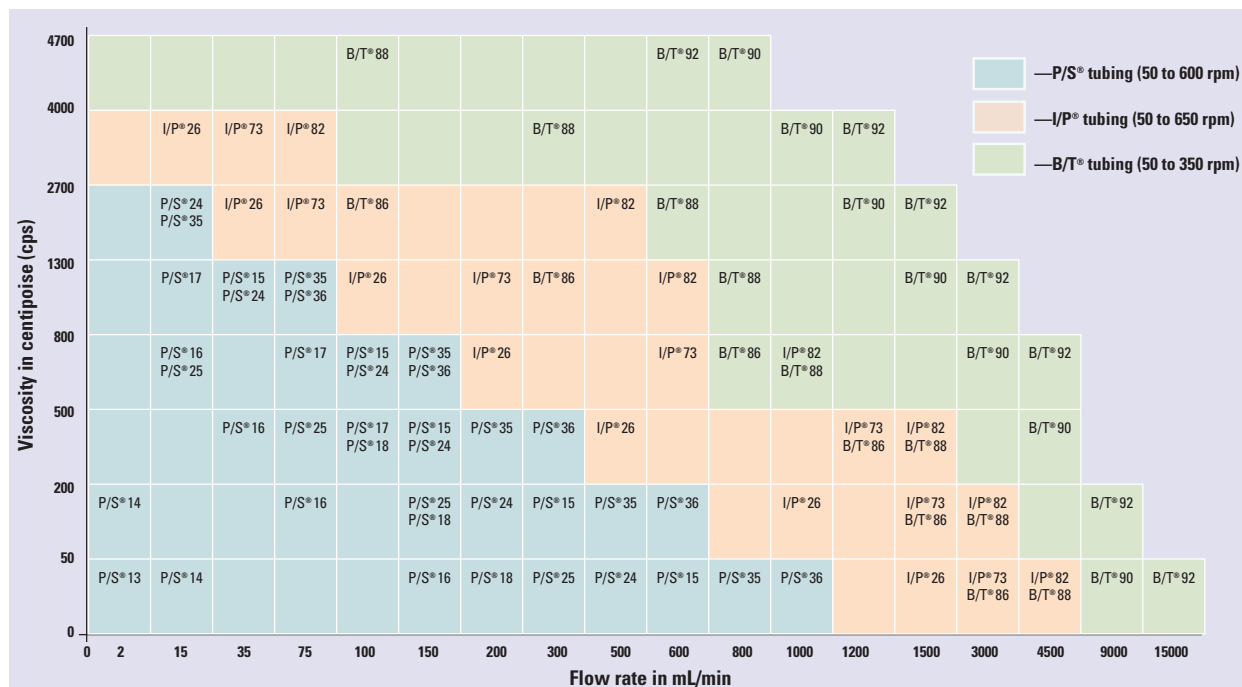
- 1. Slow down the speed of your pump.**  
Increasing the speed beyond a certain point will not have any effect on flow rate. The maximum efficient speed of the pump decreases as viscosity increases and tubing size decreases.
- 2. Choose a larger size tubing** than required to pump water. The table below will help you choose the best size.
- 3. Choose a firm tubing** such as Norprene®, PharMed® BPT, Viton®, or Tygon® LFL. Performance will be better because the tubing returns to its original shape quickly after pump head occlusion.

For P/S®, I/P®, and B/T® sizes, choose High-performance precision tubing—the thicker wall also returns more quickly to its original shape than precision tubing. The quicker return allows liquid to be pulled into the tubing with greater force.

- 4. Select a tubing with a smooth bore.**  
A smooth bore will decrease frictional forces. Tygon, Tygon LFL, silicone, or BioPharm silicone formulations are good choices.
- 5. Decrease the viscosity of your fluid.**  
Heat your fluid if possible; viscosity usually decreases with temperature.



## Tubing Selection Guide for Pumping Viscous Fluids



### How to use this graph

**Example:** You have a 800 centipoise fluid that you wish to pump at 150 mL/min. Find 150 mL/min on the “flow rate” axis of the graph above and find 800 centipoise on the “viscosity” axis. Follow the two points to where they meet. The graph shows that P/S\* 35 and P/S\* 36 tubing will produce the desired flow rate. These tubing sizes will also work for all lower viscosities and lower flow rates.

**Considerations:** All viscosity test data was obtained using firm tubing materials such as Norprene®, PharMed® BPT, Viton®, and Tygon® because these formulations perform the best in high-viscosity applications. Tests were performed with fluids at 21°C (0°F) and 0 psig (0 bar) of back pressure. The graph assumes Newtonian fluid behavior and is best used as a general guideline only; it is not a guarantee that you will achieve the results shown.

### Pulse Dampener

Virtually eliminates pulsation in your output flow. Features a polyethylene body and includes five pairs of fittings and PTFE pipe-thread tape.

- Accepted tubing: All P/S\* sizes and I/P\* 26
- Fittings included (tubing ID x NPT(M) thread):  
1/16" x 1/8", 1/8" x 1/8" PP fittings; 3/16" x 1/8", 1/4" x 1/8" and 3/8" x 1/8" HDPE fittings
- Dampener connections: 1/8" NPT(F)
- Volume, dead: 190 mL; internal: 60 to 180 mL
- Max. pressure: 60 psi (4.3 bar) at 21°C (70°F)

07596-20 Pulse dampener



# P/S® Precision and High-Performance Pump Tubing

- Tubing Life
- Pressure Guidelines
- Vacuum/Suction Lift
- Gas Permeability

Ensure top performance with your Masterflex® pump head by using precision-extruded Masterflex tubing to deliver accurate flow rates. Twenty-one different material formulations are available.

To order the correct tubing:

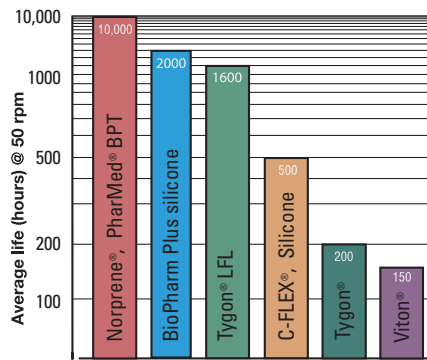
1. Consider all the aspects of your application: flow rate, pressure, etc.
2. Review the chemical compatibility data on pages TD-12–13, as well as specific information about individual tubing materials on pages TD-8–11.
3. Use the “Tubing Material Life Comparison” graph and table at right to select the tubing with the longest life.

If your application requires the generation of high pressure or a strong vacuum/suction lift, refer to the “Pressure Guidelines” and “Vacuum/Suction Lift” graphs at right. These graphs can assist you in determining which tubing will pressurize most rapidly or develop the strongest vacuum/suction lift in your application.

If your application requires pumping air-sensitive gases or liquids, refer to the “Gas Permeability” graph below right to choose the tubing with the lowest permeability.

If you are pumping a viscous fluid, refer to the “Tubing Selection Guide for Pumping Viscous Fluids” graph on page TD-19 to select the best tubing size.

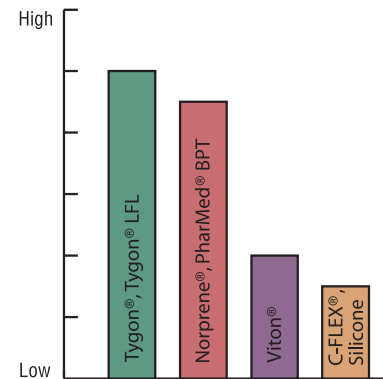
## Tubing Material Life Comparison



The graph above displays the average tubing life in hours of Masterflex P/S 16 tubing. This tubing was tested in a Masterflex Standard pump head continuously pumping water at 21°C (70°F) and 0 psig (0 bar). Tubing life is calculated to time of failure or of 50% reduction in flow rate, whichever comes first. Reduce drive speeds to extend tubing life. Average tubing life for P/S® 16, I/P® 73, and B/T® 90 tubing at various speeds are listed in the table below.

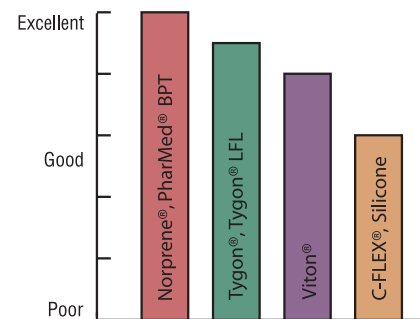
Tubing class	P/S® 16		I/P® 73		B/T® 90	
	Drive rpm	50	600	50	600	50
Norprene® PharMed® BPT	10,000	1000	4000	800	2000	400
Tygon® LFL	1600	700	800	400	500	130
C-FLEX®, Silicone	500	100	400	80	250	100
Tygon®	200	50	180	35	100	30
Viton®	150	30	120	25	—	—

## Pressure Guidelines



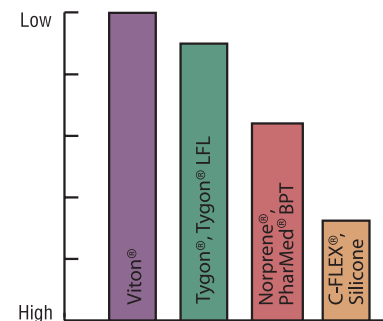
All tubing types accept pressure, but the firmer formulations accept more pressure than the softer types of tubing.

## Vacuum/Suction Lift



Vacuum/suction lift capability depends greatly on the tubing’s ability to maintain its shape. Thus, a firmer tubing type in the smallest possible bore size will generate a stronger vacuum for your application. Higher drive speeds are required to generate the strongest possible vacuum with some tubing sizes.

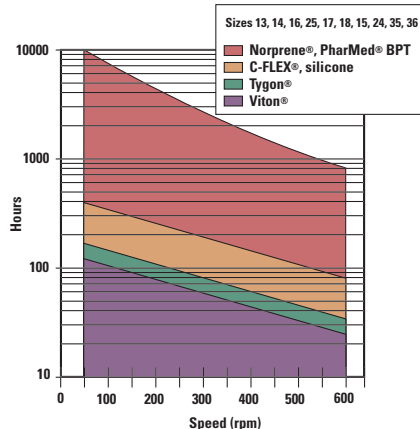
## Gas Permeability



To minimize permeation of gases through the tubing wall, use firm tubing. Masterflex P/S High-performance precision tubing (P/S 15, P/S 24, P/S 35, and P/S 36) is less permeable than Precision tubing sizes. See pages TD-12–13 for tubing permeability to various gases.

## P/S® Precision Tubing Life Characteristics

The graph at right shows average tubing life vs motor rpm for selected P/S tubing formulations.

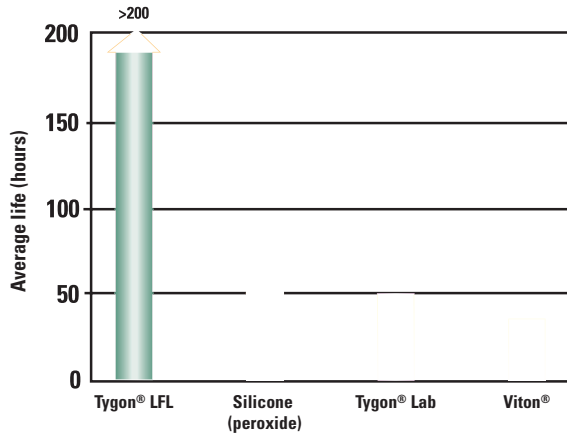


# P/S® Precision and High-Performance Pump Tubing (cont.)

## Performance Data for Tygon®, Silicone, and Viton® Tubing Formulations

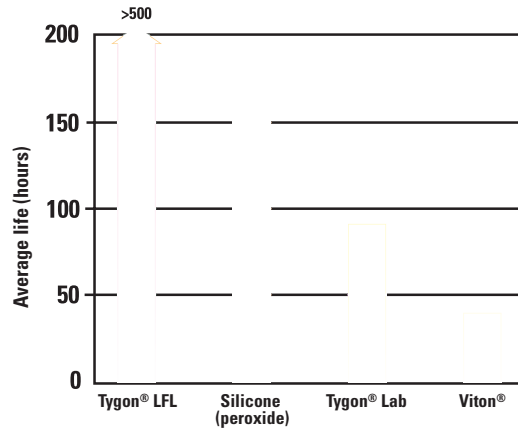
### P/S® Precision Tubing

Precision tubing (P/S 13, P/S 14, P/S 16, P/S 25, P/S 17, and P/S 18) is made to tight tolerances that ensure accurate flow rates and long tubing life. The graph below shows average tubing life while pumping water through an Easy-Load® II pump head at 21°C (70°F), 0 psi, 600 rpm.



### P/S® High-Performance Precision Tubing

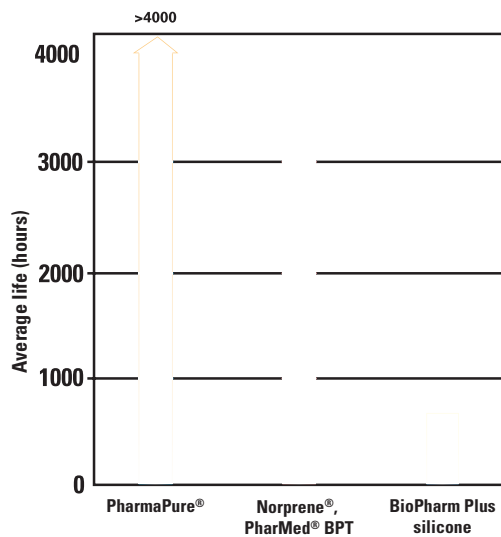
High-performance precision tubing (P/S 15, P/S 24, P/S 35, and P/S 36) improves pressure generation, suction lift, tubing life, and the ability to pump viscous fluids. The graph below shows average tubing life while pumping water through an Easy-Load II pump head at 21°C (70°F), 0 psi, 600 rpm.



## Performance Data for PharmaPure®, Norprene®, PharMed® BPT, and BioPharm Plus Tubing Formulations

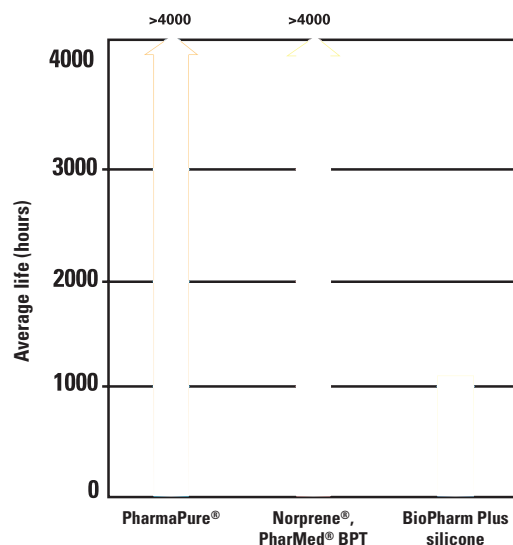
### P/S® Precision Tubing

Precision tubing (P/S 13, P/S 14, P/S 16, P/S 25, P/S 17, and P/S 18) is made to tight tolerances that ensure accurate flow rates and long tubing life. The graph below shows average tubing life while pumping water through an Easy-Load II pump head at 21°C (70°F), 0 psi, 600 rpm.



### P/S® High-Performance Precision Tubing

High-performance precision tubing (P/S 15, P/S 24, P/S 35, and P/S 36) improves pressure generation, suction lift, tubing life, and the ability to pump viscous fluids. The graph below shows average tubing life while pumping water through an Easy-Load II pump head at 21°C (70°F), 0 psi, 600 rpm.

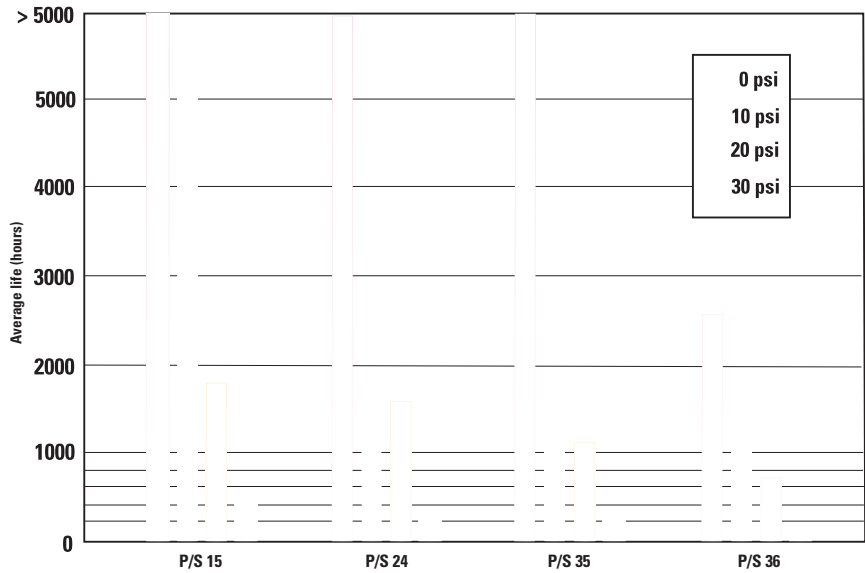


# P/S® Precision and High-Performance Pump Tubing (cont.)

## Performance Data for Norprene® and PharMed® BPT Tubing Formulations

### P/S® High-Performance Precision Tubing

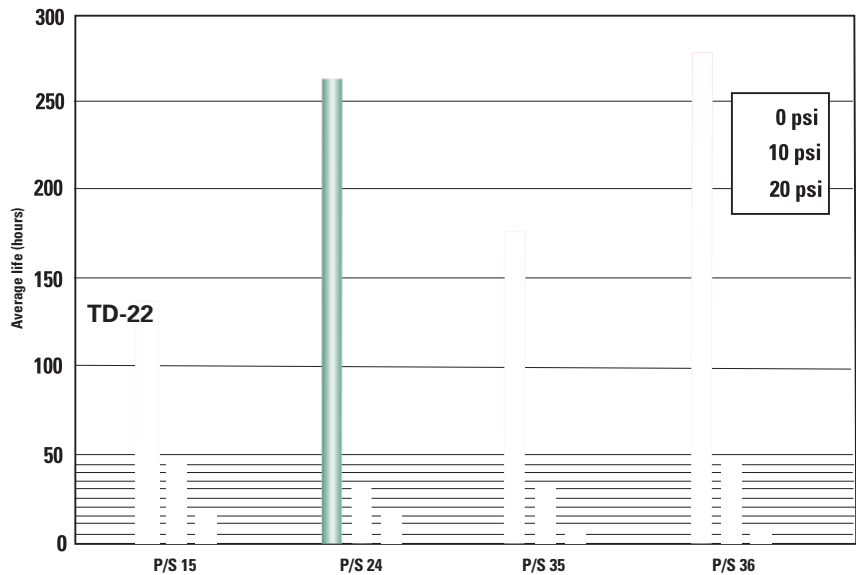
High-performance precision tubing (P/S® 15, P/S® 24, P/S® 35, and P/S® 36) improves pressure generation, suction lift, tubing life, and the ability to pump viscous fluids. The graph at right shows average tubing life while pumping water through a High-Performance pump head at 21°C (70°F), 600 rpm.



## Performance Data for Silicone (Peroxide-Cured) Tubing Formulation

### P/S® High-Performance Precision Tubing

High-performance precision tubing (P/S® 15, P/S® 24, P/S® 35, and P/S® 36) improves pressure generation, suction lift, tubing life, and the ability to pump viscous fluids. The graph at right shows average tubing life while pumping water through a High-Performance pump head at 21°C (70°F), 600 rpm.



# B/T® Precision and High-Performance Pump Tubing

- Tubing Life
- Pressure Guidelines
- Vacuum/Suction Lift
- Gas Permeability

Ensure top performance with your Masterflex® pump head by using precision-extruded Masterflex tubing to deliver accurate flow rates. Nine different material formulations are available for B/T pumps.

To order the correct tubing:

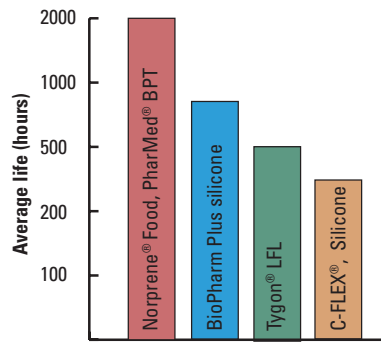
1. Consider all the aspects of your application: flow rate, pressure, etc.
2. Review the chemical compatibility data on pages TD-12–13, as well as specific information about individual tubing materials on pages TD-8–11.
3. Use the “Tubing Material Life Comparison” graph and table at right to select the tubing with the longest life.

If your specific application requires the generation of high pressure or a strong vacuum/suction lift, refer to the “Pressure Guidelines” and “Vacuum/Suction Lift” graphs at right. These graphs help you determine which tubing will pressurize the most rapidly or develop the strongest vacuum/suction lift in your particular application.

If your application requires pumping air-sensitive gases or liquids, refer to the “Gas Permeability” graph below right to choose the tubing with the lowest permeability.

If you are pumping a viscous fluid, refer to the “Tubing Selection Guide for Pumping Viscous Fluids” graph on TD-19 to select the best tubing size.

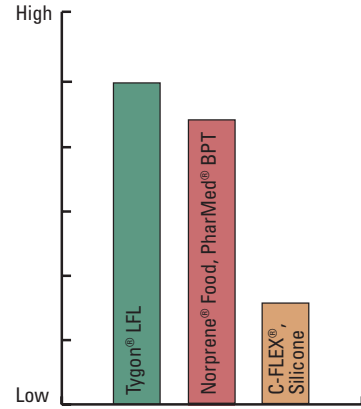
## Tubing Material Life Comparison



The graph above displays the average tubing life in hours of Masterflex® B/T® 90 tubing. This tubing was tested in a Masterflex® Standard pump head continuously pumping water at 21°C (70°F) and 0 psig (0 bar). Tubing life is calculated to time of failure or of 50% reduction in flow rate, whichever comes first. Reduce drive speeds to extend tubing life. Average tubing life for P/S® 16, I/P® 73, and B/T® 90 tubing at various rpm are listed in the table below.

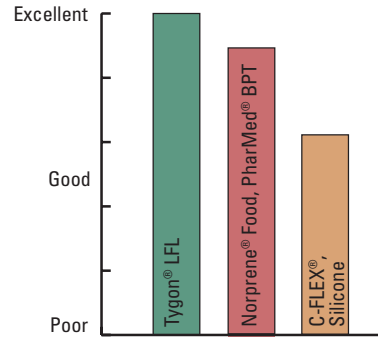
Tubing class	P/S® 16		I/P® 73		B/T® 90	
	50	600	50	600	50	350
Norprene®, PharMed® BPT	10,000	1000	4000	800	2000	400
Tygon® LFL	1600	700	800	400	500	130
C-FLEX®, Silicone	500	100	400	80	250	100
Tygon®	200	50	180	35	100	30
Viton®	150	30	120	25	—	—

## Pressure Guidelines



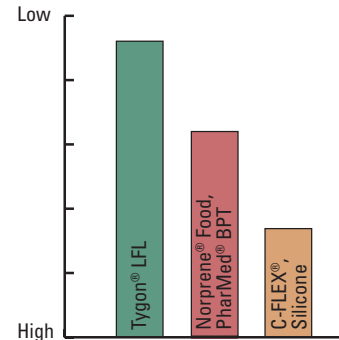
All tubing types accept pressure, but the firmer formulations accept more pressure than the softer types of tubing.

## Vacuum/Suction Lift



Vacuum/suction lift capability depends greatly on the tubing’s ability to maintain its shape. Thus, a firmer tubing type in the smallest possible bore size will generate a stronger vacuum for your application. Higher drive speeds are required to generate the strongest possible vacuum with some tubing sizes.

## Gas Permeability

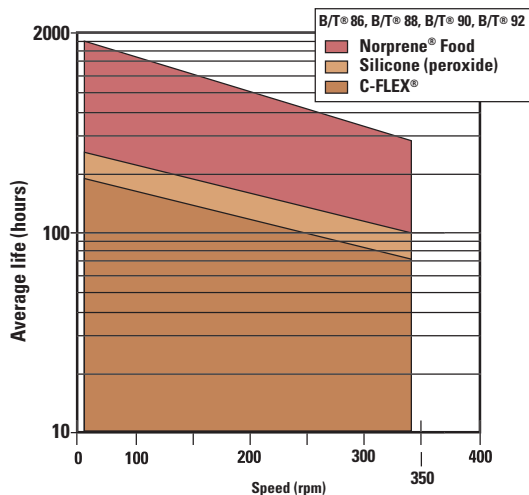


To minimize permeation of gases through the tubing wall, use firm tubing. Masterflex B/T High-performance precision tubing (B/T 86, B/T 90) is less permeable than Precision tubing sizes. See pages TD-20–23 for tubing permeability to various gases.

## B/T® Precision Tubing Life Characteristics

Like the P/S® and I/P® tubing sizes, B/T sizes B/T 86, B/T 88, B/T 90, and B/T 92 offer all the characteristics of the smaller size tubing styles at flow ranges up to 45 LPM (12 GPM). The graph below shows average tubing life while pumping water through a Rapid-Load® pump head at 21°C (70°F).

For example, using this graph it can be determined that the expected average life of Masterflex® Norprene® Food tubing at 100 rpm is over 1000 hours.



### More info

Use only Masterflex® tubing with Masterflex® pumps to ensure optimal performance. Use of other tubing may void applicable warranties.

## Selection Guidelines

Tubing life performance is just one of many factors present in your pumping applications. These reference graphs are designed to help you select tubing for your pumping application.

In general:

- The Norprene®, PharMed® BPT, and PharmaPure® tubing materials offer the best tubing life in all applications where the fluid being pumped is chemically compatible.
- Peroxide-cured silicone tubing offers up to 40% more tubing life. Platinum-cured silicone tubing offers better chemical compatibility. Biopharm Plus silicone tubing lasts up to five times longer than other platinum silicone tubings.
- Thicker-walled tubing has a 20 to 30% increased life over thinner-walled tubing.

- High-Pressure Norprene and PharMed BPT have the best life in pressure applications.

Other factors to consider when determining the best tubing for your application include:

- Chemical compatibility
- Fluid temperature
- System pressure
- Motor rpm
- Duty cycle
- Maintenance periods
- Clarity of tubing
- Viscosity
- Tubing purity

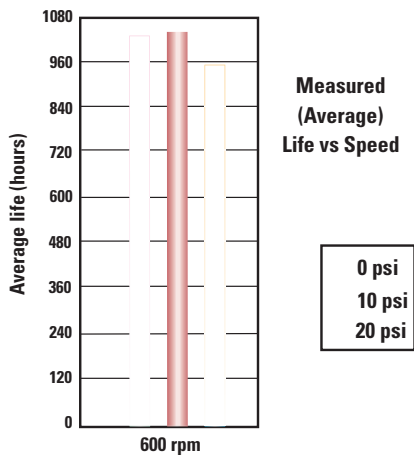
## Testing Parameters

These graphs indicate the average life of Masterflex® tubing used in our Standard pump heads. Tubing life is shown in hours at various motor speeds while continuously pumping water at 21°C (70°F) and 0 psig (0 bar). This data has been collected from years of testing Masterflex peristaltic pumps, and is calculated from time to failure or reduction to 50% flow rate, whichever comes first.

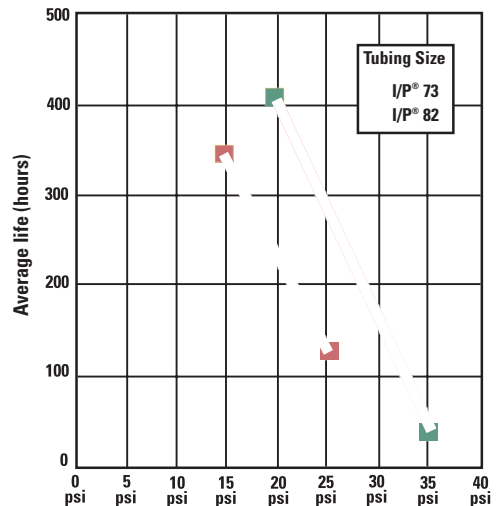
These graphs are best used as a general comparison only. It is not guaranteed that you will achieve the results shown. Generally, the life of all tubing types is adversely affected by temperature, pump motor rpm, chemical compatibility and pressure.

## Performance Data for Norprene®, PharMed® BPT, and Silicone Tubing Formulations

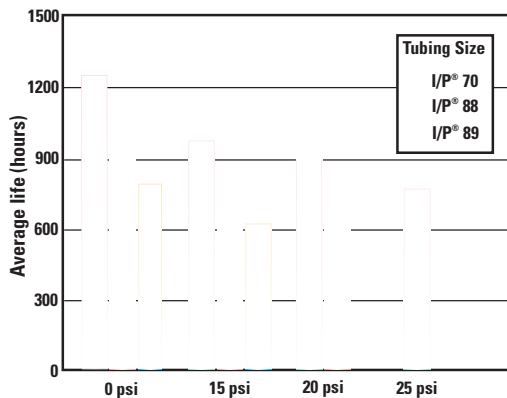
**Norprene®, PharMed® BPT Tubing, size I/P 73**  
using Standard Pump Head (07019-series) @ 650 rpm



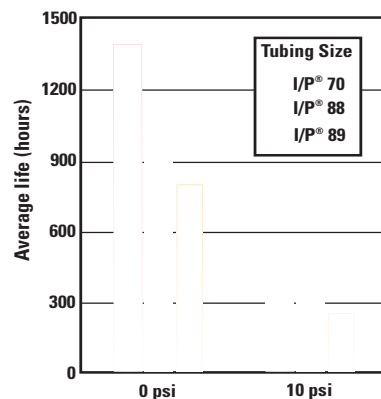
**Norprene® Tubing**  
using Easy-Load® Pump Head (77601-series) @ 650 rpm



**Norprene®, PharMed® BPT Tubing**  
using High-Performance Pump Head (77600-62) @ 650 rpm



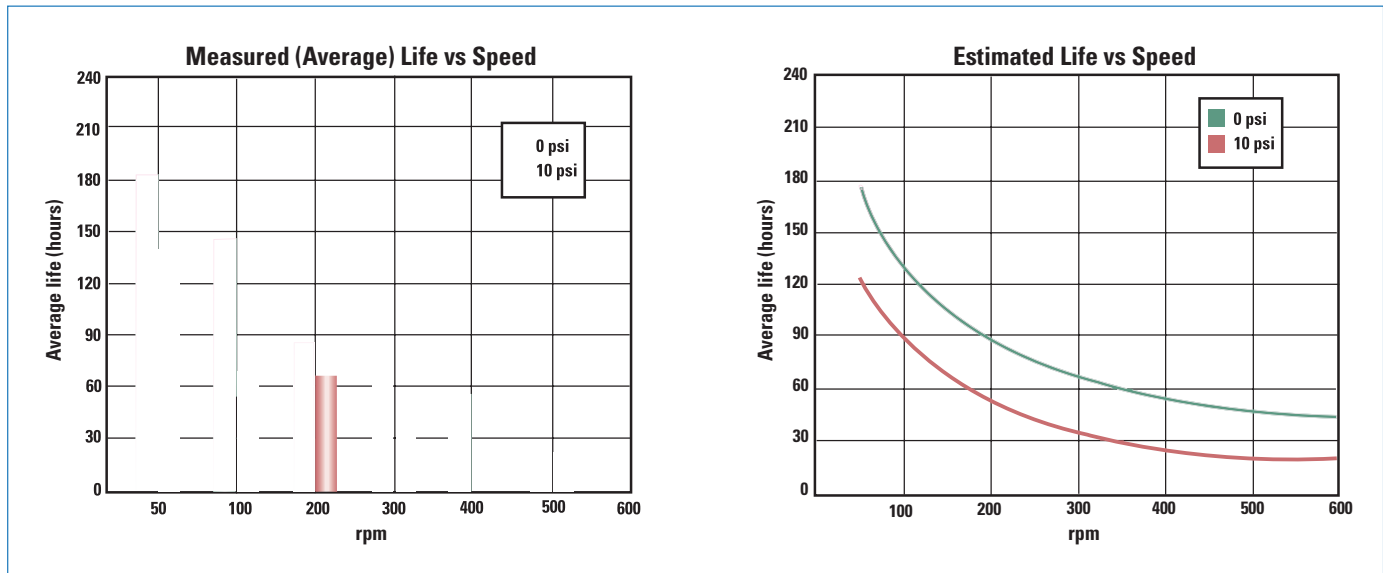
**Peroxide-Cured Silicone Tubing**  
using High-Performance Pump Head (77600-62) @ 650 rpm



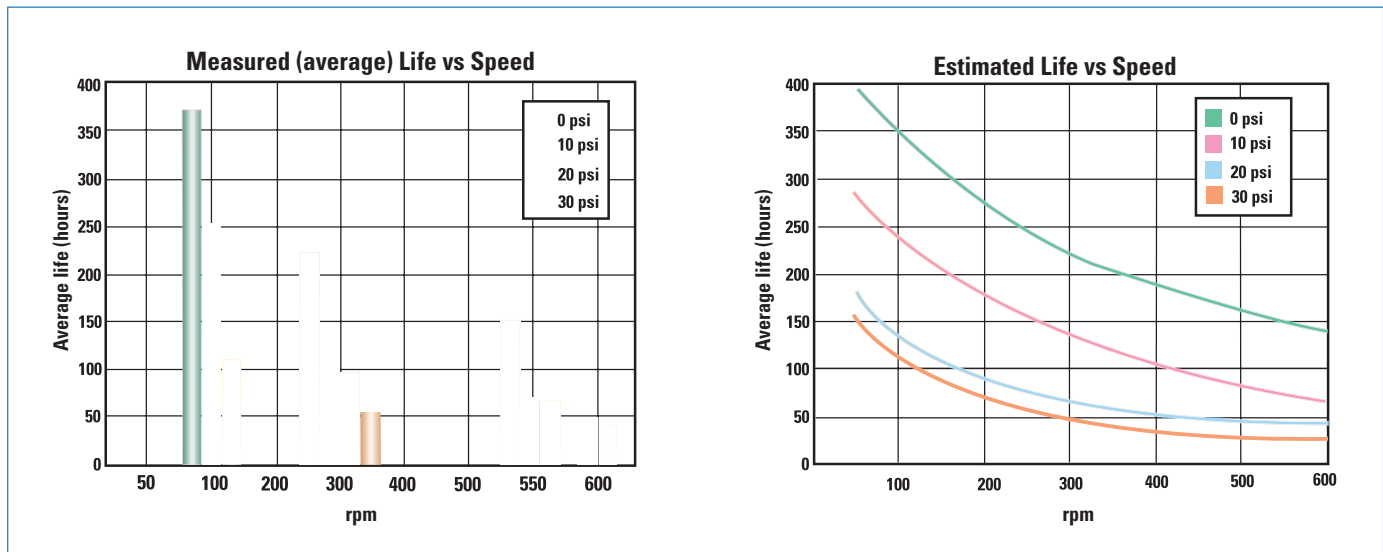


# I/P® Precision and High-Performance Pump Tubing (cont.)

## Performance Data for Silicone (Peroxide-Cured) Tubing, size I/P 73, using Standard Head (07019-series)



## Performance Data for Tygon® Tubing, size I/P 73, using Standard Head (07019-series)



# B/T® Precision and High-Performance Pump Tubing

- Tubing Life
- Pressure Guidelines
- Vacuum/Suction Lift
- Gas Permeability

Ensure top performance with your Masterflex® pump head by using precision-extruded Masterflex tubing to deliver accurate flow rates. Nine different material formulations are available for B/T pumps.

To order the correct tubing:

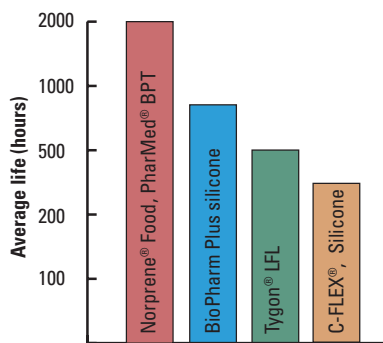
1. Consider all the aspects of your application: flow rate, pressure, etc.
2. Review the chemical compatibility data on pages TD-12–13, as well as specific information about individual tubing materials on pages TD-8–11.
3. Use the “Tubing Material Life Comparison” graph and table at right to select the tubing with the longest life.

If your specific application requires the generation of high pressure or a strong vacuum/suction lift, refer to the “Pressure Guidelines” and “Vacuum/Suction Lift” graphs at right. These graphs help you determine which tubing will pressurize the most rapidly or develop the strongest vacuum/suction lift in your particular application.

If your application requires pumping air-sensitive gases or liquids, refer to the “Gas Permeability” graph below right to choose the tubing with the lowest permeability.

If you are pumping a viscous fluid, refer to the “Tubing Selection Guide for Pumping Viscous Fluids” graph on TD-19 to select the best tubing size.

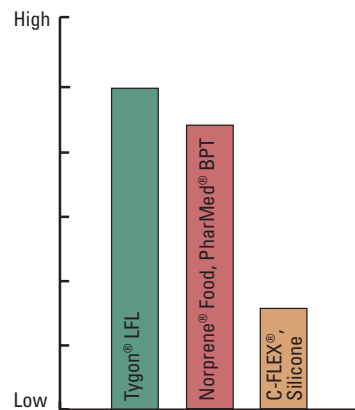
## Tubing Material Life Comparison



The graph above displays the average tubing life in hours of Masterflex® B/T® 90 tubing. This tubing was tested in a Masterflex® Standard pump head continuously pumping water at 21°C (70°F) and 0 psig (0 bar). Tubing life is calculated to time of failure or of 50% reduction in flow rate, whichever comes first. Reduce drive speeds to extend tubing life. Average tubing life for P/S® 16, I/P® 73, and B/T® 90 tubing at various rpm are listed in the table below.

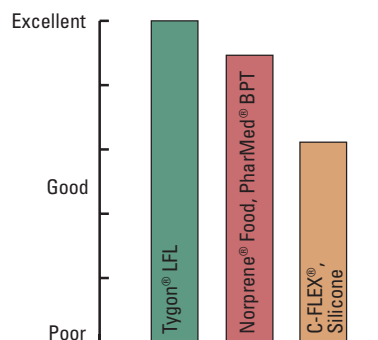
Tubing class	P/S® 16		I/P® 73		B/T® 90	
	50	600	50	600	50	350
Norprene®, PharMed® BPT	10,000	1000	4000	800	2000	400
Tygon® LFL	1600	700	800	400	500	130
C-FLEX®, Silicone	500	100	400	80	250	100
Tygon®	200	50	180	35	100	30
Viton®	150	30	120	25	—	—

## Pressure Guidelines



All tubing types accept pressure, but the firmer formulations accept more pressure than the softer types of tubing.

## Vacuum/Suction Lift

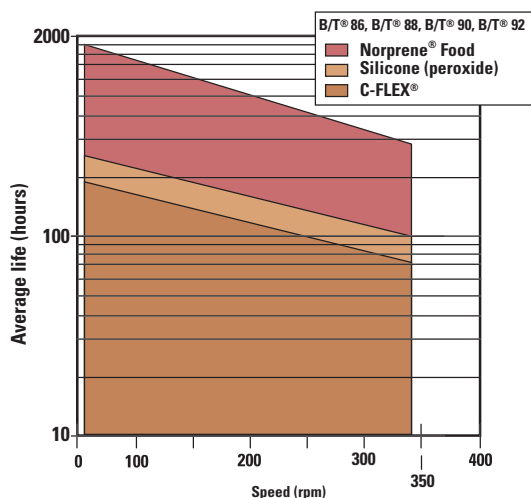


Vacuum/suction lift capability depends greatly on the tubing’s ability to maintain its shape. Thus, a firmer tubing type in the smallest possible bore size will generate a stronger vacuum for your application. Higher drive speeds are required to generate the strongest possible vacuum with some tubing sizes.

## B/T® Precision Tubing Life Characteristics

Like the P/S® and I/P® tubing sizes, B/T sizes B/T 86, B/T 88, B/T 90, and B/T 92 offer all the characteristics of the smaller size tubing styles at flow ranges up to 45 LPM (12 GPM). The graph below shows average tubing life while pumping water through a Rapid-Load® pump head at 21°C (70°F).

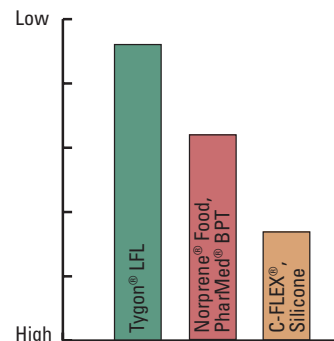
For example, using this graph it can be determined that the expected average life of Masterflex® Norprene® Food tubing at 100 rpm is over 1000 hours.



### More info

Use only Masterflex® tubing with Masterflex® pumps to ensure optimal performance. Use of other tubing may void applicable warranties.

## Gas Permeability



To minimize permeation of gases through the tubing wall, use firm tubing. Masterflex B/T High-performance precision tubing (B/T 86, B/T 90) is less permeable than Precision tubing sizes. See pages TD-20–23 for tubing permeability to various gases.

# B/T® Precision and High-Performance Pump Tubing (cont.)

## Selection Guidelines

Tubing life performance is just one of many factors present in your pumping applications. These reference graphs are designed to help you select tubing for your pumping application.

In general:

- Norprene and PharMed BPT, and PharmaPure® tubing materials offer the best tubing life in all applications where the fluid being pumped is chemically compatible.
- Peroxide-cured silicone tubing offers up to 40% more tubing life. Platinum-cured silicone tubing offers better chemical compatibility. Biopharm Plus silicone tubing lasts up to five times longer than other platinum silicone tubings.

- Thicker-walled tubing has a 20 to 30% increased life over thinner-walled tubing.
- Norprene and PharMed BPT have the best life in pressure applications.

Other factors to consider when determining the best tubing for your application include:

- Fluid compatibility
- Fluid temperature
- System pressure
- Motor rpm
- Duty cycle
- Maintenance periods
- Clarity of tubing
- Tubing purity
- Viscosity

## Testing Parameters

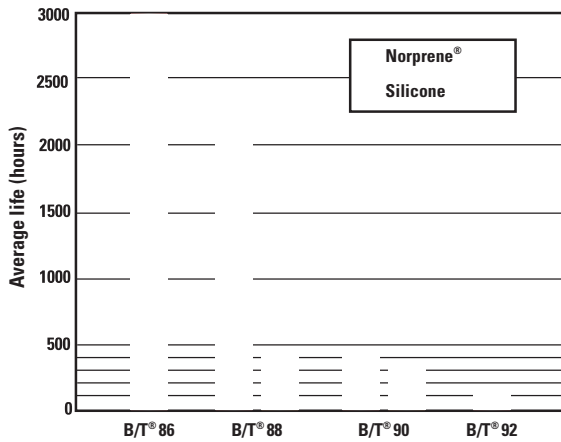
Once tubing has been selected:

1. Test it in your application.
2. Monitor tubing life in duty cycle, look for signs of tubing fatigue (i.e., small pin-hole leaks, abrasion, etc.).
3. Set up maintenance schedule to anticipate tubing failure.

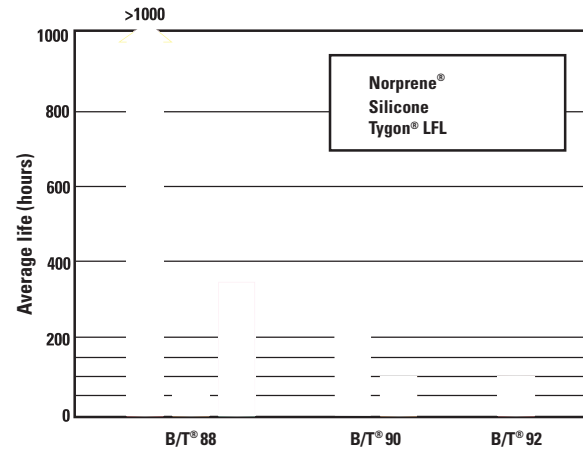
Monitor the time tubing is in the pump. Advance it 12 to 18 inches on a daily, weekly, monthly or quarterly basis, depending on your experience with your maintenance schedule.

## Performance Data for Norprene®, Silicone, and Tygon® LFL Tubing Formulations

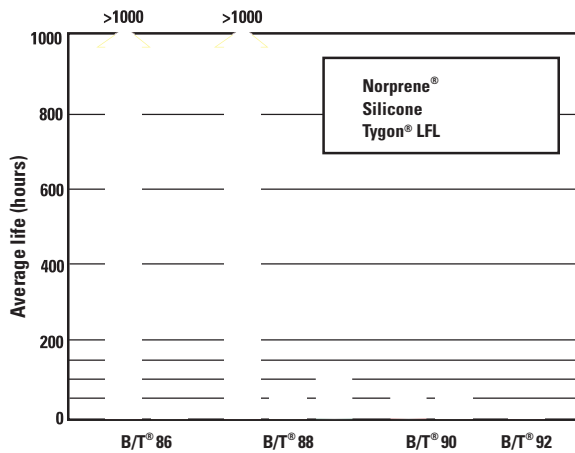
Tubing Life at 0 psi, 350 rpm



Tubing Life at 10 psi, 350 rpm

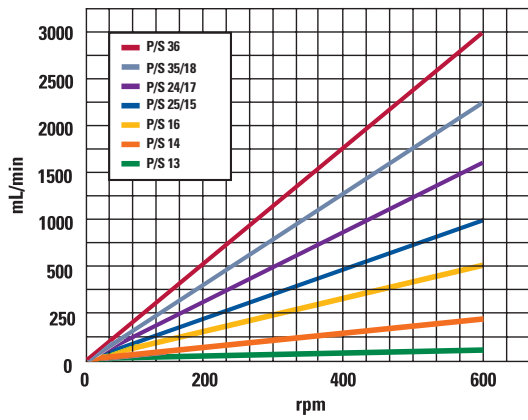


Tubing Life at 20 psi, 350 rpm

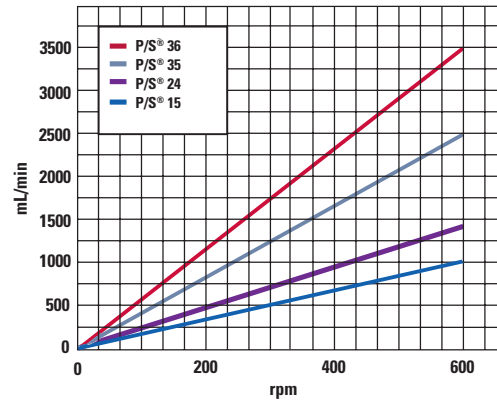


# MASTERFLEX® Tubing Pump Flow Performance

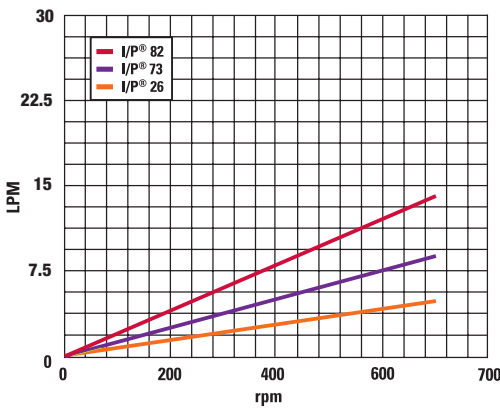
**P/S® Easy-Load® II (77200- and 77201-series) and Easy-Load 3 Pump Head (77800-series)**



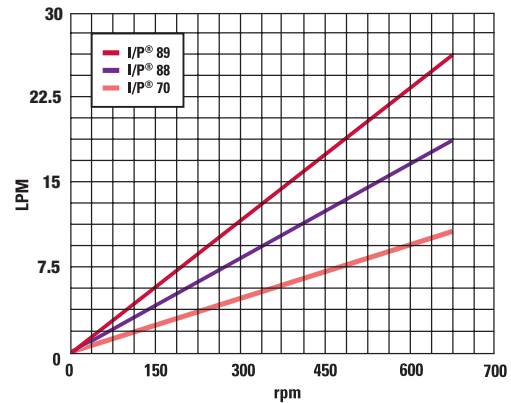
**P/S® High-Performance Pump Head (77250-62)**



**I/P® Easy-Load Pump Head (77601-series)**



**I/P® High-Performance Pump Head (77600-62)**



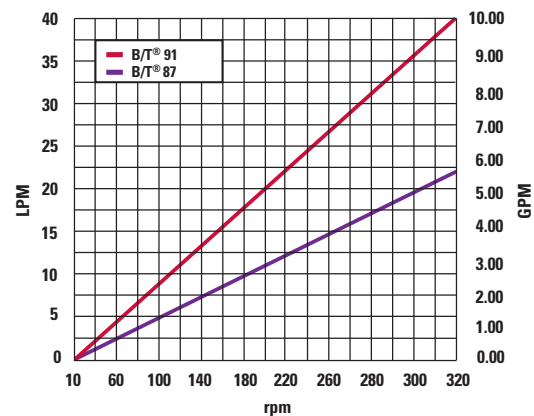
## Flow Rates

Masterflex® offers a wide range of pump systems and tubing sizes. These graphs are designed to help you select a size for your application.

Pressure, in general, does not affect the flow rate of the pump head and tubing combination in water applications, unless the pressure exceeds the rating for continuous duty operation. At pressures above this rating to the maximum, the flow rates will drop off.

The exact flow rates will vary from application to application depending on the tubing material and occlusion.

**B/T® Rapid-Load® Pump Head**



# Pump Head Torque Requirements

## How to Use These Tables

Use this guide to help you select the number of pump heads and tubing formulations that can be used with your drives.

To define your torque needs:

1. Consider the following:

- Discharge pressure (increase necessary torque)
- Tubing material (firm or soft)

2. Multiply by the number of pump heads you would like to use (to run two heads with the same size and formulation of tubing, multiply the value from the table by 1.8). See example at right.

3. See drive specifications for maximum torque limits. (Consider starting torque when selecting a drive.) The torque of the drive must exceed the starting torque value for the pump head/tubing combination. Note: starting torque is equal to approximately three times (3x) maximum running torque.

4. Several factors influence starting torque:

- New or used tubing
- Tubing formulation
- Length of time tubing has been in closed pump head without running
- Temperature

## EXAMPLE:

Using one Easy-Load® II pump head with P/S® 15 Norprene® tubing requires a drive capable of supplying at least 8.28 kg-cm (115 oz-in) of starting torque.

When using two Easy-Load II pump heads with P/S 15 Norprene tubing, you will need a drive capable of supplying 14.9 kg-cm (207 oz-in) of starting torque.

## Starting torque using P/S® and I/P® Standard pump head at 0 bar (0 psi) and 21°C (70°F)

Tubing size	C-FLEX®/ silicone		BioPharm Plus silicone		Viton®		Tygon® Lab		Tygon® LFL		Tygon® Food/ Tygon Fuel & Lubricant		Tygon® Chemical*		Norprene®/ PharMed® BPT		PharmaPure®		Style 100 RF Silicone	
	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in
<b>P/S® Precision pump tubing</b>																				
P/S 13	0.79	11	0.94	13	1.15	16	2.30	32	1.73	24	4.32	60	2.52	35	2.02	28	2.74	38	NA	NA
P/S 14	1.01	14	1.15	16	1.37	19	5.04	70	2.30	32	8.64	120	6.48	90	2.59	36	4.68	65	8.28	115
P/S 16	1.87	26	1.87	26	1.58	22	7.20	100	5.40	75	8.28	115	6.84	95	5.40	75	5.76	80	9.00	125
P/S 17	2.74	38	3.46	48	4.68	65	10.80	150	7.92	110	12.96	180	13.82	192	11.88	165	11.16	155	23.04	320
P/S 18	4.32	60	3.96	55	6.12	85	9.36	130	7.20	100	18.43	256	16.13	224	17.28	240	16.13	224	31.10	432
<b>P/S® High-performance precision pump tubing</b>																				
P/S 15	2.45	34	3.60	50	2.16	30	10.80	150	7.20	100	23.04	320	—	—	9.36	130	9.36	130	9.36	130
P/S 24	4.32	60	10.08	140	6.62	92	12.96	180	10.08	140	32.25	448	13.82	192	13.82	192	14.40	200	12.24	170
P/S 35	4.25	59	5.18	72	11.52	160	15.41	214	11.52	160	31.10	432	NR	NR	15.55	216	NR	NR	12.67	176
P/S 36	5.04	70	7.92	110	14.97	208	14.25	198	11.52	160	NR	NR	NR	NR	17.28	240	NR	NR	NA	NA
<b>I/P® Precision pump tubing</b>																				
I/P 73	9.22	128	12.67	176	14.04	195	23.04	320	14.97	208	55.87	776	32.25	448	21.89	304	23.04	320	23.04	320
I/P 82	7.92	110	20.73	288	NA	NA	34.56	480	13.82	192	69.11	960	NR	NR	23.04	320	46.08	640	46.08	640

\* Note: Tygon® Chemical is not recommended for use with a polycarbonate Standard pump head. It is recommended for use with a PPS Standard pump head.

## Starting torque using P/S® and I/P® Easy-Load® and Easy-Load® II pump heads at 0 bar (0 psi) and 21°C (70°F)

Tubing size	C-FLEX®/ silicone		BioPharm Plus silicone		Viton®		Tygon® Lab		Tygon® LFL		Tygon® Food/ Tygon Fuel & Lubricant		Tygon® Chemical		Norprene®/ PharMed® BPT		PharmaPure®		Style 100 RF Silicone	
	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in
<b>P/S® Precision pump tubing</b>																				
P/S 13	0.79	11	0.94	13	1.22	17	2.16	30	1.22	17	5.76	80	1.73	24	1.44	20	2.09	29	NA	NA
P/S 14	1.15	16	1.30	18	1.66	23	3.24	45	1.94	27	6.48	90	3.60	50	2.88	40	2.81	39	2.52	35
P/S 16	1.15	16	1.37	19	2.52	35	4.32	60	2.88	40	6.48	90	4.68	65	3.24	45	6.48	90	6.48	90
P/S 25	2.16	30	4.68	65	2.16	30	6.12	85	3.60	50	5.40	75	6.48	90	3.60	50	5.18	72	9.36	130
P/S 17	2.52	35	3.67	51	3.60	50	5.76	80	5.40	75	8.64	120	4.68	65	8.64	120	7.20	100	4.32	60
P/S 18	3.60	50	3.96	55	5.40	75	7.20	100	3.60	50	8.64	120	5.40	75	8.64	120	9.36	130	7.20	100
<b>P/S® High-performance precision pump tubing</b>																				
P/S 15	4.68	65	5.04	70	4.68	65	9.00	125	6.84	95	20.16	280	—	—	8.28	115	7.92	110	7.20	100
P/S 24	3.96	55	5.04	70	7.56	105	9.72	135	7.20	100	21.24	295	19.58	272	8.64	120	11.52	160	5.04	70
P/S 35	5.76	80	6.12	85	7.92	110	10.08	140	7.20	100	19.58	272	NR	NR	12.67	176	NR	NR	9.36	130
P/S 36	5.04	70	7.92	110	7.20	100	11.52	160	10.80	150	21.89	304	NR	NR	11.16	155	NR	NR	NA	NA
<b>I/P® Precision pump tubing</b>																				
I/P 26	11.52	160	11.52	160	—	—	20.73	288	14.97	208	25.34	352	33.41	464	18.43	256	23.04	320	12.96	180
I/P 73	17.28	240	17.28	240	19.60	272	32.25	448	18.43	256	49.17	683	28.80	400	32.25	448	25.34	352	19.58	272
I/P 82	18.43	256	19.58	272	NA	NA	31.10	432	23.04	320	48.38	672	40.32	560	28.80	400	34.56	480	34.56	480

NA=Not available or applicable

NR= Not recommended for use in this pump head

Continued on next page

# Pump Head Torque Requirements (cont.)

## How to Use This Table

Use this guide to help you select the number of pump heads and tubing formulations that can be used with your drives.

To define your torque needs:

1. Consider the following:
  - Discharge pressure (increase necessary torque)
  - Tubing material (firm or soft)
2. Multiply by the number of pump heads you would like to use (to run two heads with the same size and formulation of tubing, multiply the value from the table by 1.8). See example at right.
3. See drive specifications for maximum torque limits. (Consider starting torque when selecting a drive.) The torque of the drive must exceed the starting torque value for the pump head/tubing combination. Note: starting torque is equal to approximately three times (3x) maximum running torque.
4. Several factors influence starting torque:
  - New or used tubing
  - Tubing formulation
  - Length of time tubing has been in closed pump head without running
  - Temperature

### EXAMPLE:

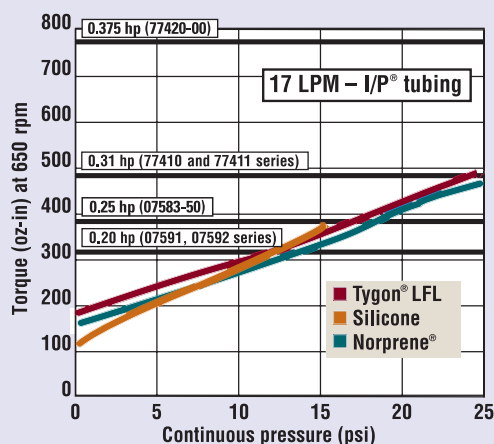
Using one High-Performance pump head with P/S® 15 Norprene® tubing requires a drive capable of supplying at least 10.8 kg-cm (150 oz-in) of starting torque.

## Starting torque using P/S® and I/P® High-Performance pump head at 0 bar (0 psi) and 21°C (70°F)

Tubing size	C-FLEX®/silicone		BioPharm Plus silicone		Viton®		Tygon® Lab		Tygon® LFL		Tygon® Food / Tygon® Fuel & Lubricant		Tygon® Chemical		Norprene®/PharMed® BPT		PharmePure®		Style 100 RF Silicone		
	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	kg-cm	oz-in	
<b>P/S® High-pressure pump tubing</b>																					
P/S 15HP*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	43.77	608	NA	NA	NA	NA
P/S 16HP*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	50.68	704	NA	NA	NA	NA
<b>P/S® High-performance precision pump tubing</b>																					
P/S 15	3.60	50	5.76	80	7.20	100	12.96	180	8.64	120	27.65	384	NR	NR	10.80	150	NR	NR	12.60	175	
P/S 24	3.60	50	6.48	90	9.36	130	12.24	170	7.92	110	28.80	400	NR	NR	12.24	170	NR	NR	18.43	256	
P/S 35	5.40	75	6.62	92	8.64	120	16.13	224	10.08	140	NR	NR	NR	NR	12.67	176	NR	NR	23.04	320	
P/S 36	5.40	75	7.92	110	10.80	150	14.97	208	11.52	160	NR	NR	NR	NR	13.82	192	NR	NR	NA	NA	
<b>I/P® High-performance precision pump tubing</b>																					
I/P 70†	23.04	320	25.34	352	NA	NA	34.56	480	32.25	448	NR	NR	NR	NR	50.68	704	NR	NR	24.19	336	
I/P 88†	18.43	256	24.19	336	NA	NA	—	—	26.49	368	NR	NR	NR	NR	43.77	608	NR	NR	34.56	480	
I/P 89†	16.13	224	18.43	256	NA	NA	36.86	512	26.49	368	NR	NR	NR	NR	46.08	640	NR	NR	41.47	576	

\*Can only be used and started on a 100 rpm drive †Starting torque based on notch #1.  
 NA = Not available or applicable NR= Not recommended for use in this pump head

## Drive torque requirements to obtain 17 LPM with I/P® High-Performance pump heads



Choose your drive based on desired flow rate, pressure in your application, and type of tubing used. For example, if you need 17 LPM at 20 psi and are using Norprene® tubing, you need a drive that supplies 0.25 hp (07583-50).

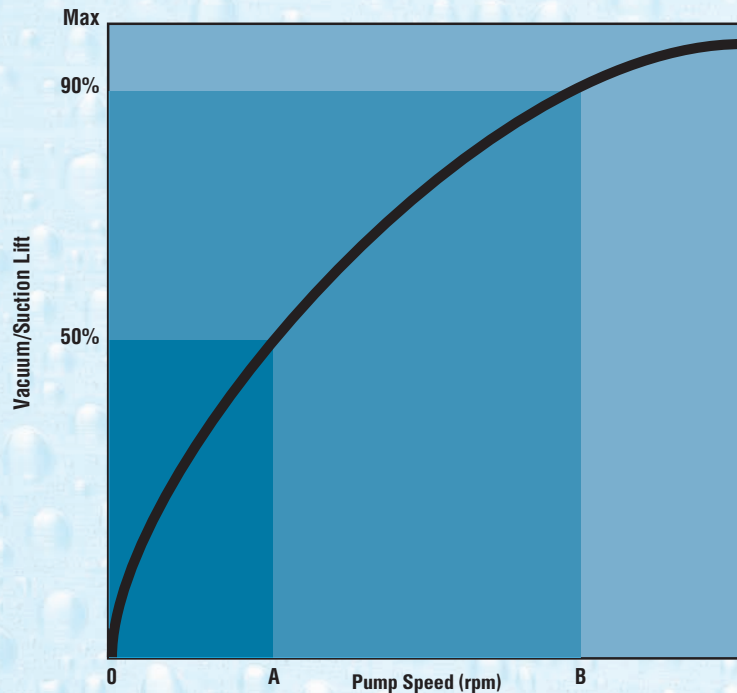


High-Performance pump head 77600-62

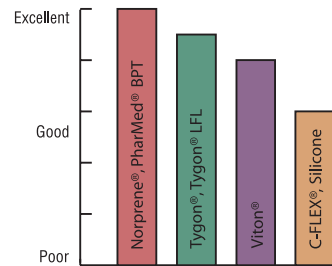
# MASTERFLEX® Vacuum/Suction Lift Data

Masterflex® pumps offer excellent vacuum/suction lift. To achieve maximum lift, choose your tubing size and material carefully. The lower the ID-to-wall ratio, the better the vacuum performance. The stiffer the wall material, the better the vacuum level. In general, Norprene®/PharMed® BPT materials enable you to generate the highest level of vacuum before collapsing, and give you the longest life in a fluidless application; adjustable occlusion pump heads generate the best level of vacuum.

The easy-to-use graph and table below can help you determine the speed required to achieve the vacuum level required. All of the vacuum tests were conducted with either the Standard, High-Performance, or Rapid-Load® pump heads, depending on tubing size. The rated vacuum was generated after running for two minutes.



## Vacuum/Suction Lift



Vacuum/suction lift capability depends greatly on the tubing's ability to maintain its shape. Thus, a firmer tubing type in the smallest possible bore size will generate a stronger vacuum for your application. Higher drive speeds are required to generate the strongest possible vacuum with some tubing sizes.

### Example 1

To generate a 13 in. Hg vacuum (almost 50%) using P/S® 13 silicone tubing, the motor speed must be at least 5 rpm. The pump system will generate the vacuum in about 30 to 60 seconds, depending on the length of the tubing system that needs to be evacuated.

### Example 2

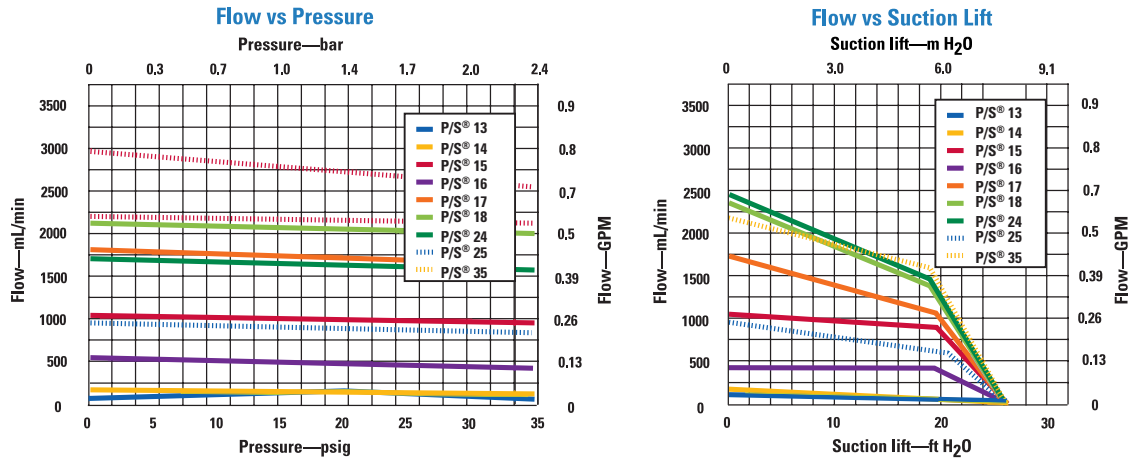
To develop a suction lift of 8.8 m (29 ft) H<sub>2</sub>O with P/S® 15 Norprene® tubing, the motor speed needs to be >50 rpm. At 50 rpm it will take approximately 2 to 3 minutes to prime the pump.

## Specifications for Masterflex® Precision and High-Performance Pump Tubing

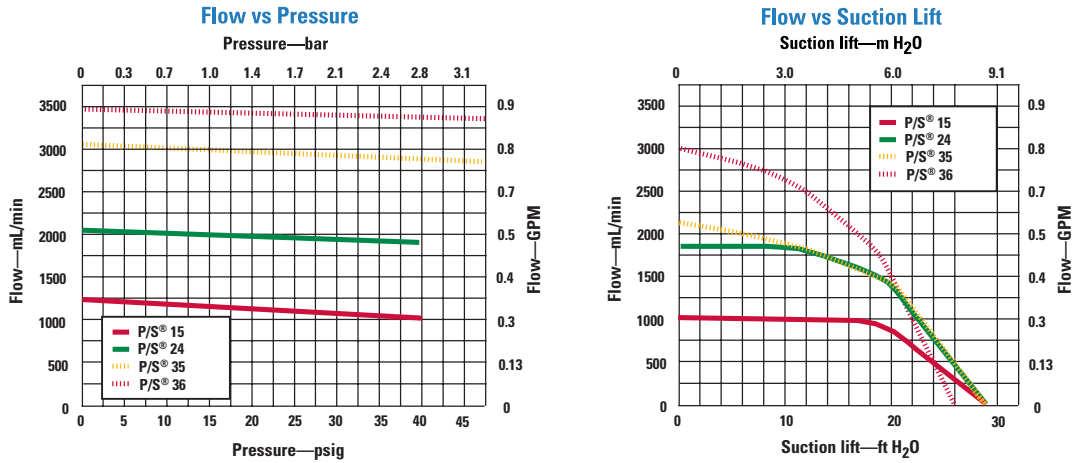
Tubing size	C-FLEX®/Silicone				Tygon®/Tygon® LFL				Norprene®/PharMed® BPT				Viton®			
	Max vac. mm (in.) Hg	Suction m (ft) H <sub>2</sub> O	Pump speed (rpm)		Max vac. mm (in.) Hg	Suction m (ft) H <sub>2</sub> O	Pump speed (rpm)		Max vac. mm (in.) Hg	Suction m (ft) H <sub>2</sub> O	Pump speed (rpm)		Max vac. mm (in.) Hg	Suction m (ft) H <sub>2</sub> O	Pump speed (rpm)	
			A	B			A	B			A	B			A	B
P/S®13	560 (24)	7.6 (25)	5	50	560 (24)	7.6 (25)	5	20	560 (24)	7.6 (25)	5	20	560 (24)	7.6 (25)	5	50
P/S®14	560 (24)	7.6 (25)	5	50	560 (24)	7.6 (25)	5	20	560 (24)	7.6 (25)	5	20	560 (24)	7.6 (25)	5	50
P/S®16	560 (24)	7.6 (25)	5	50	560 (24)	7.6 (25)	5	20	560 (24)	7.6 (25)	5	20	560 (24)	7.6 (25)	5	50
P/S®25	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	5	50	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	25	50
P/S®17	313 (12)	4.3 (14)	10	150	313 (12)	4.9 (16)	5	50	403 (16)	5.5 (18)	10	200	403 (16)	5.5 (18)	25	200
P/S®18	313 (12)	4.3 (14)	10	150	313 (12)	4.9 (16)	10	100	403 (16)	5.5 (18)	10	200	403 (16)	5.5 (18)	25	200
P/S®15	560 (24)	7.6 (25)	10	75	560 (24)	7.6 (25)	5	50	560 (24)	7.6 (25)	5	50	560 (24)	7.6 (25)	10	100
P/S®24	560 (24)	7.6 (25)	10	150	560 (24)	7.6 (25)	10	75	560 (24)	7.6 (25)	10	100	560 (24)	7.6 (25)	10	200
P/S®35	493 (19)	6.7 (22)	50	300	515 (20)	7.3 (24)	50	300	560 (24)	7.6 (25)	50	300	560 (24)	7.6 (25)	50	300
P/S®36	493 (19)	6.7 (22)	50	300	515 (20)	7.3 (24)	50	300	560 (24)	7.6 (25)	50	500	560 (24)	7.6 (25)	50	300
I/P®26	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	10	50	515 (20)	7.3 (24)	10	50
I/P®73	560 (24)	7.6 (25)	25	50	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	10	50	515 (20)	7.3 (24)	25	50
I/P®82	515 (20)	7.0 (23)	50	200	493 (19)	7.0 (23)	10	50	560 (24)	7.6 (25)	50	200	—	—	—	—
I/P®70	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	10	50	—	—	—	—
I/P®88	470 (18)	6.4 (21)	25	50	560 (24)	7.6 (25)	10	50	560 (24)	7.6 (25)	10	50	—	—	—	—
I/P®89	314 (12)	4.3 (14)	50	200	314 (12)	4.9 (16)	10	50	515 (20)	7.0 (23)	10	50	—	—	—	—
B/T®86	560 (24)	7.6 (25)	20	40	515 (20)	7.0 (23)	20	40	560 (24)	7.6 (25)	20	40	—	—	—	—
B/T®88	515 (20)	7.0 (23)	20	40	515 (20)	7.0 (23)	20	40	560 (24)	7.6 (25)	20	40	—	—	—	—
B/T®90	470 (18)	6.4 (21)	20	40	515 (20)	7.0 (23)	20	40	560 (24)	7.6 (25)	20	40	—	—	—	—
B/T®92	470 (18)	6.4 (21)	20	40	515 (20)	7.0 (23)	20	40	560 (24)	7.6 (25)	20	40	—	—	—	—

# Pump Head Flow Curves

## P/S® Easy-Load® Pump Head



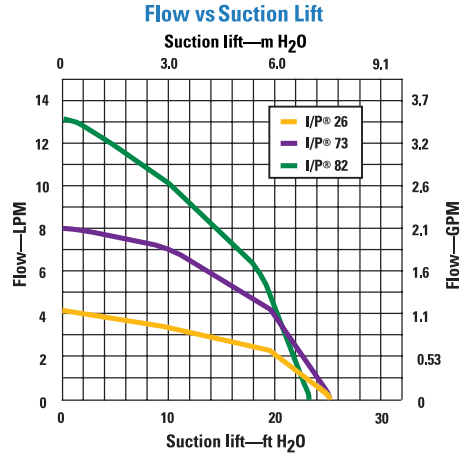
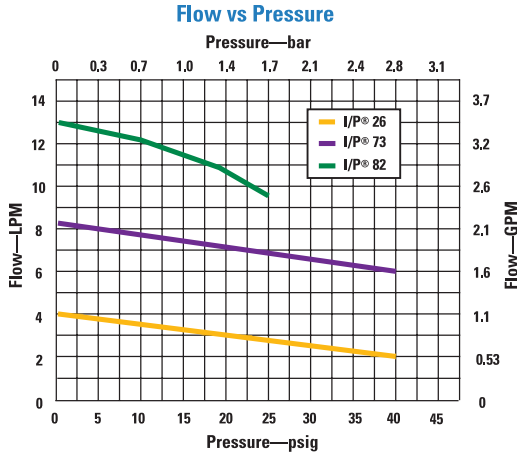
## P/S High-Performance Pump Head



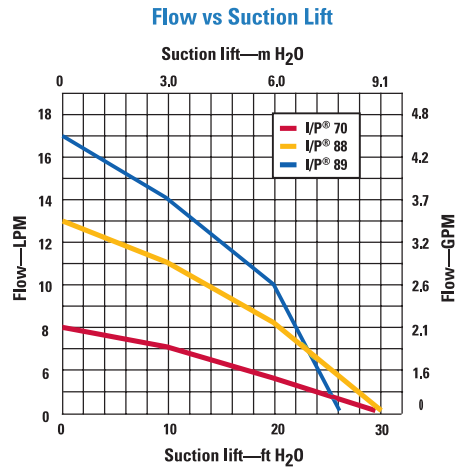
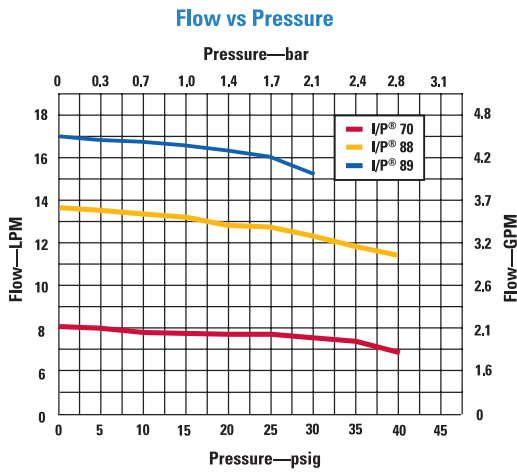
**NOTE:** Pressure curves developed with zero to one foot suction lift. Suction lift curves developed with zero discharge pressure. Pump speed: 600 rpm. Fluid: water at ambient temperature.

# Pump Head Flow Curves (cont.)

## I/P® Easy-Load® Pump Head



## I/P® High-Performance Pump Head



**NOTE:** Pressure curves developed with zero to one foot suction lift. Suction lift curves developed with zero discharge pressure. Pump speed: 650 rpm. Fluid: water at ambient temperature.