

## I/P® HIGH-PERFORMANCE PUMP HEADS

### FEATURES/BENEFITS

- ▶ For higher volume fluid transfer applications
- ▶ Deliver flow rates from 0.01 to 19 LPM
- ▶ Highest flow rates of any I/P pump head
- ▶ Ideal for viscous fluid transfer
- ▶ C-shaped—allows tubing to enter and exit the same side of pump head
- ▶ Easy to load: accepts Masterflex® I/P High-Performance Precision tubing
- ▶ Tubing enables better pressure generation and suction lift
- ▶ Adjustable tubing retention prevents tubing movement in head
- ▶ Compatible with all Masterflex I/P drives that accept two or more pump heads
- ▶ Model 77600-82 is ATEX Zone 2 rated EEx II 3 G c IIC T6; NEC rated for Class I Division 2, Groups A, B, C, D T6



I/P high-performance pump head 77600-62

### SELECTION CRITERIA

1. Flow rate desired.
2. Tubing size desired.
3. Compatibility with drives.

Includes 50.8 cm (20") of silicone tubing and single-channel mounting hardware.

See specifications for more information.

**Order tubing and drives separately.**

### COMPATIBILITY WITH DRIVES

- ▶ Mount pumps on all Masterflex I/P drives

### PUMP HOUSING SPECIFICATIONS

- ▶ Stainless steel rotor plates/shaft, rollers, and bearings
- ▶ Thermoset polyester occlusion bed

### MULTICHANNEL CAPABILITIES

- ▶ I/P High-performance pump heads are not designed to be stacked

### ROLLER/ROTOR SPECIFICATIONS

- ▶ Stainless steel with PTFE shielded ball bearing
- ▶ Operating temperature: 0 to 40°C (32 to 104°F)
- ▶ Storage temperature: -40 to 60°C (-40 to 140°F)
- ▶ Humidity: 5 to 95% (noncondensing)



I/P high-performance pump head 77600-62 mounted on I/P process drive 77411-00



**2** year warranty

### ORDERING INFORMATION

Pump tubing size	Flow rates (at 1 to 650 rpm)	Polyester and SS housing, SS rotor	ATEX-approved; Polyester and SS housing, SS rotor
I/P 70	0.01 to 8 LPM		
I/P 88	0.02 to 17 LPM	<a href="#">HL-77600-62</a>	<a href="#">HL-77600-82</a>
I/P 89	0.03 to 19 LPM		

### I/P PUMP TUBING FLOW RATE INFORMATION

Order Masterflex I/P High-performance Precision pump tubing separately on page 128.

Tubing cross sections	I/P High-performance Precision tubing		
	I/P 70	I/P 88	I/P 89
Flow rate—mL/rev	12.3	26.2	29.2
Flow rate @ 650 rpm	8 LPM (2.1 GPM)	17 LPM (4.5 GPM)	19 LPM (5.0 GPM)
Max pressure†	2.7 bar (40 psi)	2.4 bar (35 psi)	1.4 bar (20 psi)
Max vacuum†	660 mm Hg (26" Hg)		610 mm Hg (24" Hg)
Suction lift	8.8 m H <sub>2</sub> O (29 ft H <sub>2</sub> O)		8.2 m H <sub>2</sub> O (27 ft H <sub>2</sub> O)

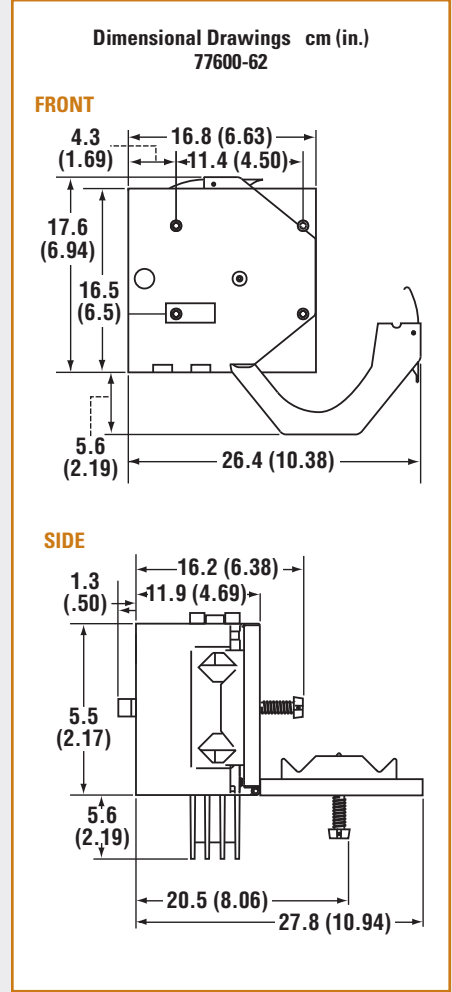
†Actual performance varies depending upon tubing materials—see pages 20–24 and 172–192 for more information.

### NOTES

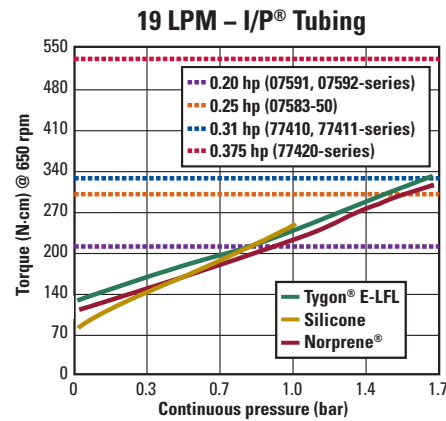
Use only Masterflex pump tubing with Masterflex pumps to ensure optimal performance. Use of other tubing may void applicable warranties.

## SPECIFICATIONS for I/P High-Performance Pump Head

Catalog number	<a href="#">HL-77600-62</a> and <a href="#">HL-77600-82</a>	
<b>Performance Specifications</b>		
Flow capacity	0.01 to 19 LPM (0.002 to 5.0 GPM)	
Max rpm	650	
Number of rollers	3	
Max pressure	2.7 bar (40 psi)	
Max vacuum	660 mm Hg (26" Hg)	
Max suction lift	8.8 m H <sub>2</sub> O (29 ft H <sub>2</sub> O)	
<b>Torque Specifications [pumping water at 0 bar (0 psi), 21°C (70°F)]</b>		
Norprene®, PharMed® BPT	Starting torque	658 N-cm (930 oz-in)
	Running torque	134 N-cm (190 oz-in)
Tygon®, Viton®	Starting torque	467 N-cm (660 oz-in)
	Running torque	130 N-cm (185 oz-in)
C-FLEX®, Silicone	Starting torque	357 N-cm (480 oz-in)
	Running torque	109 N-cm (155 oz-in)
<b>Physical Specifications</b>		
Roller/rotor assembly materials	Stainless steel	
Occlusion bed materials	Thermoset polyester	
Operating temperature	0 to 40°C (32 to 104°F)	
Shipping weight	3.2 kg (7 lb)	



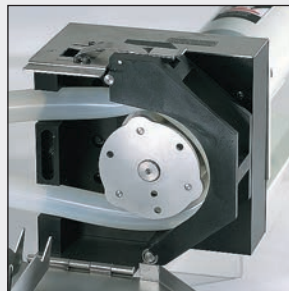
## DRIVE TORQUE REQUIREMENTS TO OBTAIN 19 LPM



## HOW TO LOAD YOUR PUMP HEAD



1. Rotate tubing retainer knob counterclockwise to release retainer, then open cover. Lift latch to open occlusion bed.



2. Insert tubing into bed with both ends of the tubing extending through notches as shown.



3. Press occlusion bed against the tubing and snap the latch closed. Pull the tubing snug around the rotor, close the cover, and rotate the tubing retainer knob clockwise until the tube no longer moves.

### Watch the VIDEO!

For a video demonstration on how to load your I/P High-Performance Pump Head, go to . . . [Masterflex.com/video](http://Masterflex.com/video)



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## I/P® HIGH-PERFORMANCE PRECISION PUMP TUBING

Our High-Performance Precision pump tubing features a thicker wall compared to our Precision pump tubing, making it the best choice for applications involving pressure, suction lift, viscous fluids, or long tubing life.

### SPECIFICATIONS

Pump tubing cross sections	I/P High-performance Precision pump tubing		
			
	I/P 70	I/P 88	I/P 89
Inside diameter (nominal)	9.5 mm (0.37")	12.7 mm (0.5")	15.88 mm (0.62")
Hose barb size (nominal)	9.5 mm (3/8")	12.7 mm (1/2")	15.88 mm (5/8")
Flow range (approximate) <sup>†</sup> with 1 to 650 rpm drive	0.01 to 8 LPM (0.002 to 2.1 GPM)	0.02 to 17 LPM (0.005 to 4.5 GPM)	0.03 to 19 LPM (0.007 to 5.0 GPM)
Maximum pressure <sup>‡</sup>	2.7 bar (40 psi)	2.4 bar (35 psi)	1.4 bar (20 psi)
Maximum vacuum <sup>‡</sup>	660 mm Hg (26" Hg)	660 mm Hg (26" Hg)	610 mm Hg (24" Hg)
Suction lift <sup>‡</sup>	8.8 m H <sub>2</sub> O (29 ft H <sub>2</sub> O)	8.8 m H <sub>2</sub> O (29 ft H <sub>2</sub> O)	8.2 m H <sub>2</sub> O (27 ft H <sub>2</sub> O)

<sup>†</sup>Determined under the following conditions: 0 psi at inlet, 0.5 psi at outlet; water temperature at 22°C (72°F).

<sup>‡</sup>Actual performance varies depending on tubing formulation—values shown are for firm tubing.

### ORDERING INFORMATION

Pump tubing formulation	I/P Pump Head Compatibility			
	High-Performance	I/P 70	I/P 88	I/P 89
Silicone (platinum-cured)	✓	—	<a href="#">HL-96510-88</a> 3.0 m (10 ft)/pk	<a href="#">HL-96510-89</a> 3.0 m (10 ft)/pk
 BioPharm silicone (platinum-cured)	✓	<a href="#">HL-96421-70</a> 3.0 m (10 ft)/pk	<a href="#">HL-96421-88</a> 3.0 m (10 ft)/pk	<a href="#">HL-96421-89</a> 3.0 m (10 ft)/pk
 BioPharm Plus silicone (platinum-cured)	✓	<a href="#">HL-96441-70</a> 3.0 m (10 ft)/pk	<a href="#">HL-96441-88</a> 3.0 m (10 ft)/pk	<a href="#">HL-96441-89</a> 3.0 m (10 ft)/pk
 Puri-Flex™	✓	<a href="#">HL-96419-70</a> 3.0 m (10 ft)/pk	<a href="#">HL-96419-88</a> 3.0 m (10 ft)/pk	<a href="#">HL-96419-89</a> 3.0 m (10 ft)/pk
 C-Flex®	✓	<a href="#">HL-06424-70</a> 3.0 m (10 ft)/pk	<a href="#">HL-06424-88</a> 3.0 m (10 ft)/pk	<a href="#">HL-06424-89</a> 3.0 m (10 ft)/pk
 PharMed® BPT	✓	<a href="#">HL-06508-70</a> 7.6 m (25 ft)/pk	<a href="#">HL-06508-88</a> 7.6 m (25 ft)/pk	—
 Chem-Durance® Bio	✓	<a href="#">HL-06442-70</a> 7.6 m (25 ft)/pk	<a href="#">HL-06442-88</a> 7.6 m (25 ft)/pk	<a href="#">HL-06442-89</a> 7.6 m (25 ft)/pk
 Tygon® E-LFL <b>NEW</b>	✓	<a href="#">HL-06440-70</a> 7.6 m (25 ft)/pk	<a href="#">HL-06440-88</a> 7.6 m (25 ft)/pk	<a href="#">HL-06440-89</a> 7.6 m (25 ft)/pk
 Tygon® E-Food (B44-4X) <b>NEW</b>	✓	<a href="#">HL-06418-70</a> 15.2 m (50 ft)/pk	<a href="#">HL-06418-88</a> 15.2 m (50 ft)/pk	<a href="#">HL-06418-89</a> 15.2 m (50 ft)/pk
 Tygon® E-Lab (E-3603) <b>NEW</b>	✓	<a href="#">HL-06509-70</a> 15.2 m (50 ft)/pk	<a href="#">HL-06509-88</a> 15.2 m (50 ft)/pk	<a href="#">HL-06509-89</a> 15.2 m (50 ft)/pk
 Norprene® (A 60 G)	✓	<a href="#">HL-06404-70</a> 7.6 m (25 ft)/pk	<a href="#">HL-06404-88</a> 7.6 m (25 ft)/pk	<a href="#">HL-06404-89</a> 7.6 m (25 ft)/pk
 Norprene® Food (A 60 F)	✓	—	<a href="#">HL-06402-88</a> 7.6 m (25 ft)/pk	<a href="#">HL-06402-89</a> 7.6 m (25 ft)/pk
 GORE® Style 100SC	✓	—	<a href="#">HL-96190-88</a> 61 cm (24")/pk	<a href="#">HL-96190-89</a> 61 cm (24")/pk
 GORE® Style 500	✓	—	<a href="#">HL-96191-88</a> 61 cm (24")/pk	<a href="#">HL-96191-89</a> 61 cm (24")/pk
 GORE® Style 400	✓	—	<a href="#">HL-06439-88</a> 61 cm (24")/pk	—

## I/P® SANITARY PUMP TUBING ASSEMBLIES

### FEATURES/BENEFITS

- ▶ Ideal for biotech, pharmaceutical, food, beverage, and dairy processing applications
- ▶ Pre-molded tubing ends with ½" mini-connection for bacteria-free fluid transfer
- ▶ Sanitary tubing is less thermally conductive than metallic tubing systems and not subject to galvanic action, RFI, or EMI

### HOW TO CONNECT TUBING

- ▶ Each length of tubing features pre-molded ends with ½" mini-connection. One end has molded-in gasket to ensure quality seal
- ▶ Pre-molded ends allow quick connection to an adapter or to additional length of sanitary tubing
- ▶ Join ½" mini-connection to another ½" mini-connection, adapter, or to system with a push/pull clamp. Clamped connection withstands greater pressures than tubing.

### HOW TO ORDER

1. Order your desired tubing formulation and length. Choose tubing size based on flow range (see chart on pages 126 and 128).
2. Order PVDF push/pull clamp (separately below).
3. Order silicone or Viton® gaskets as needed to connect to your system or to adapters.
4. Select sanitary adapters as needed.

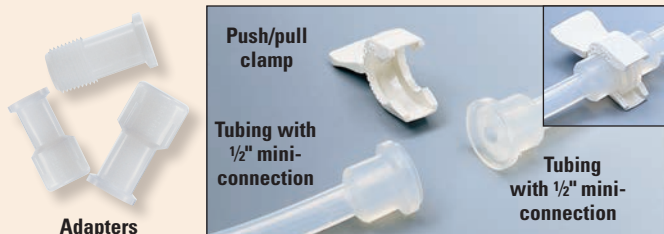


I/P PharMed® BPT sanitary tubing features pre-molded ends with ½" mini-connection

### ORDERING INFORMATION

Tubing size	Platinum-cured silicone (96410-series) 1.5-m (5-ft) length	Platinum-cured silicone (96410-series) 3-m (10-ft) length	PharMed® BPT (06508-series) 1.5-m (5-ft) length	PharMed® BPT (06508-series) 3-m (10-ft) length
	Catalog number	Catalog number	Catalog number	Catalog number
<b>I/P Precision sanitary pump tubing</b>				
I/P 26	<a href="#">HL-96100-26</a>	<a href="#">HL-96101-26</a>	<a href="#">HL-96112-26</a>	<a href="#">HL-96113-26</a>
I/P 73	<a href="#">HL-96100-73</a>	<a href="#">HL-96101-73</a>	<a href="#">HL-96112-73</a>	<a href="#">HL-96113-73</a>
I/P 82	<a href="#">HL-96100-82</a>	<a href="#">HL-96101-82</a>	<a href="#">HL-96112-82</a>	<a href="#">HL-96113-82</a>
<b>I/P High-performance Precision sanitary pump tubing</b>				
I/P 70	—	—	<a href="#">HL-96112-70</a>	<a href="#">HL-96113-70</a>
I/P 88	—	—	<a href="#">HL-96112-88</a>	<a href="#">HL-96113-88</a>
I/P 89	—	—	<a href="#">HL-96112-89</a>	<a href="#">HL-96113-89</a>

### ACCESSORIES FOR I/P SANITARY PUMP TUBING



**HL-31201-88 Push/pull clamp**, PVDF. For quick joining of two ½" mini connections.

**Gaskets.** Order gaskets to join ½" mini connection without molded-in gasket to another ½" mini connection without molded-in gasket or to an adapter (sold separately below).

**HL-30548-00 Silicone gasket** for use with sanitary silicone (platinum-cured) tubing. Pack of 10.

**HL-30548-20 Viton® gasket** for use with sanitary PharMed® BPT tubing. Pack of 10.

### ADAPTER ORDERING INFORMATION

Adapter connections	Polypropylene	PVDF
	Catalog number	Catalog number
½" mini to ¼" NPT(M)	<a href="#">HL-31200-01</a>	<a href="#">HL-31201-01</a>
½" mini to ¼" NPT(F)	<a href="#">HL-31200-11</a>	<a href="#">HL-31201-11</a>
½" mini to ¼" hose barb	<a href="#">HL-31805-25</a>	<a href="#">HL-31808-25</a>
½" mini to ⅜" NPT(M)	<a href="#">HL-31200-02</a>	<a href="#">HL-31201-02</a>
½" mini to ⅜" NPT(F)	<a href="#">HL-31200-12</a>	<a href="#">HL-31201-12</a>
½" mini to ⅜" hose barb	<a href="#">HL-31805-26</a>	<a href="#">HL-31808-26</a>
½" mini to ½" NPT(M)	<a href="#">HL-31200-03</a>	<a href="#">HL-31201-03</a>
½" mini to ½" NPT(F)	<a href="#">HL-31200-13</a>	<a href="#">HL-31201-13</a>
½" mini to 1" Iadish	<a href="#">HL-31805-05</a>	<a href="#">HL-31201-40</a>
½" mini to female luer lock	<a href="#">HL-31200-50</a>	<a href="#">HL-31201-50</a>

### NOTES

- ▶ Consider all aspects of your application: flow rate, pressure, viscosity, etc.
- ▶ If your application requires the generation of high pressure, a strong vacuum/suction lift, or involves viscous fluids, consider using High-performance Precision tubing.

**Note:** Use High-performance Precision tubing only with the High-performance pump head.

- ▶ Norprene®, PharMed® BPT, and Tygon® are the firmest formulations we offer; C-FLEX® and silicone are the softest. Firm tubing has better pressure generation, stronger vacuum/suction lift, and lower gas permeability.
- ▶ Review the tubing compatibility charts on pages 30–31 and specific information on tubing materials on pages 20–24.
- ▶ Always test tubing before extended use: see page 31 for tubing testing procedures.

## I/P® SPOOLED PUMP TUBING

- ▶ Continuous lengths of tubing are convenient and cost-effective
- ▶ Spools contain up to 121.9 m (400 ft) of continuous pump tubing, depending on size
- ▶ Eliminate waste by cutting to the exact length needed for your application
- ▶ Save space and shipping costs by buying in bulk
- ▶ Good choice for applications requiring long, continuous runs of tubing, or which use odd-size lengths that generate scrap when using standard 7.6- or 15.2-m (25- or 50-ft) coils

### TECHNICAL INFO

For technical information about our Masterflex® pump tubing formulations, go to pages 20–31.

**Save Money and Reduce Downtime!**



96403-26

**SEE PAGE 73**

Order L/S® spooled and bulk tubing on page 73.

### ORDERING INFORMATION

Tubing size	Peroxide-cured silicone (96400-series)		Platinum-cured silicone (96410-series)		PharMed® BPT (06508-series)		BioPharm Silicone (96420-series)		C-Flex® (06424-series)	
	m (ft)	Catalog number	m (ft)	Catalog number	m (ft)	Catalog number	m (ft)	Catalog number	m (ft)	Catalog number
I/P 26	—	—	61.0 (200)	<a href="#">HL-96403-26</a>	61.0 (200)	—	121.9 (400)	<a href="#">HL-96423-26</a>	121.9 (400)	<a href="#">HL-06427-26</a>
I/P 73	45.7 (150)	<a href="#">HL-96402-73</a>	45.7 (150)	<a href="#">HL-96403-73</a>	45.7 (150)	<a href="#">HL-95687-73</a>	30.5 (100)	<a href="#">HL-96423-73</a>	30.5 (100)	<a href="#">HL-06427-73</a>
I/P 82	30.5 (100)	<a href="#">HL-96402-82</a>	30.5 (100)	<a href="#">HL-96403-82</a>	30.5 (100)	<a href="#">HL-95687-82</a>	—	—	30.5 (100)	<a href="#">HL-06427-82</a>
I/P 88	—	—	—	—	—	—	30.5 (100)	<a href="#">HL-96423-88</a>	—	—
I/P 89	—	—	—	—	—	—	30.5 (100)	<a href="#">HL-96423-89</a>	—	—

## I/P® BULK-PACKED PUMP TUBING

- ▶ Save money and always have enough tubing on hand
- ▶ Tubing coils are individually bagged and sealed to prevent contamination
- ▶ Use as many or as few as you need, and store the rest
- ▶ Save money by buying and shipping in bulk
- ▶ Bulk packs contain ten individually bagged, sealed 7.6-m (25-ft) coils of tubing, all from a single manufacturing lot

### ORDERING INFORMATION

Tubing size	Number of 7.6-m (25-ft) bags per box	Platinum-cured silicone (96410-series)	PharMed® BPT (06508-series)	C-Flex® (06424-series)
		Catalog number	Catalog number	Catalog number
I/P 26	10	<a href="#">HL-96404-26</a>	—	<a href="#">HL-06436-26</a>
I/P 73	10	<a href="#">HL-96404-73</a>	—	<a href="#">HL-06436-73</a>
I/P 82	10	<a href="#">HL-96404-82</a>	<a href="#">HL-95691-82</a>	<a href="#">HL-06436-82</a>



**Bulk packs offer individually sealed bags of tubing at a lower price per pack than individual packs—so you save money!**

## PURE-FIT® TC TUBING CLAMPS

Install easily over existing tubing lines or assemblies



- ▶ Smooth contours eliminate risk of puncture or rupture
- ▶ Fully sterilizable
- ▶ Meet USP Class IV criteria

The Pure-Fit TC clamp has a press-down locking mechanism that provides complete fluid stoppage. Its side-release mechanism ensures against unwanted opening. The open design can be installed over existing fittings or finished tubing assemblies, eliminating costly downtime. Available sizes handle two tubing ranges.

Available in polypropylene (PP) or PVDF. Sterilize PP by gamma irradiation only; PVDF may be sterilized by gamma irradiation or autoclaving. Sold in pack of 10.

Catalog number	Fits Masterflex® tubing sizes	Material
<a href="#">HL-06822-01</a>	L/S® 13, 14, 15, 16, 17, 25	Polypropylene
<a href="#">HL-06822-03</a>		PVDF
<a href="#">HL-06822-11</a>	L/S 18, 24, 35, 36; I/P® 26, 70, 73, 82	Polypropylene
<a href="#">HL-06822-13</a>		PVDF

## I/P® PROCESS PUMP

### APPLICATIONS

- ▶ Media transfer
- ▶ Filling/emptying large carboys and bags
- ▶ Pumping dyes and pigments
- ▶ Pumping fermentation chemicals
- ▶ Sewage and sludge sampling

### BENEFITS

- ▶ Brushless, maintenance-free motor
- ▶ Light enough to carry with one hand
- ▶ Displays percent speed from 5 to 100% for repeatable control
- ▶ Sealed, IP55-rated housing sprays or wipes down for easy cleaning
- ▶ Powerful enough to drive two Easy-Load® pump heads for twice the flow rate

### FEATURES

- ▶ ½-hp, continuous-duty brushless drive
- ▶ ±0.25% PWM speed control accuracy
- ▶ Precise, three-turn speed control
- ▶ Sealed membrane keypad



77963-10

### SPECIFICATIONS & ORDERING INFORMATION



Catalog number	Flow range† (LPM)	Pump head included	Tubing included	Tubing sizes accepted	Drive included	Drive speed range (rpm)	Drive IP rating	Power (50/60 Hz)
<a href="#">HL-77963-10</a>	0.4 to 8.0	I/P Easy-Load® 77601-10	C-Flex® ULTRA I/P 73 06434-73; 3 m (10 ft)	I/P 26, I/P 73, I/P 82	77410-10	33 to 650	IP55	90 to 130 VAC, 4.5 A; and 220 to 260 VAC, 2.6 A
<a href="#">HL-77963-20</a>	0.7 to 17.0	I/P High-Performance 77600-62	Tygon® E-LFL I/P 88 06440-88; 1 m (3 ft)	I/P 70, I/P 88, I/P 89				

†Flow range with included tubing; extend the flow range of these systems with additional sizes of tubing; order on pages 126–130.

[HL-17050-01](#) NIST-traceable calibration for peristaltic pump drive.

## I/P® PROCESS PUMPS WITH REMOTE CAPABILITY

### APPLICATIONS

- ▶ Purification/filtration/media transfer
- ▶ Automated process
- ▶ Food and pharma process pump
- ▶ Pumping anti-foaming agents
- ▶ Chemical feed and metering
- ▶ Wastewater process pump

### BENEFITS

- ▶ Remote control capability via fluid-resistant I/O connector on back of drive (requires 77300-32 remote cable kit—order separately)
- ▶ Analog outputs include “pump ready” signal (order 77300-32 remote cable kit below)
- ▶ Displays percent speed from 5 to 100% for precise, repeatable control
- ▶ Sealed, IP55-rated housing sprays or wipes down for easy cleaning
- ▶ Brushless, maintenance-free motor

### FEATURES

- ▶ ½-hp, continuous-duty brushless drive
- ▶ ±0.25% PWM speed control accuracy
- ▶ Sealed membrane keypad



77965-10

### SPECIFICATIONS & ORDERING INFORMATION



Catalog number	Flow range† (LPM)	Pump head included	Tubing included	Tubing sizes accepted	Drive included	Drive speed range (rpm)	Drive IP rating	Power (50/60 Hz)
<a href="#">HL-77965-00</a>	0.4 to 8.0	I/P Easy-Load® 77601-10	C-Flex® ULTRA I/P 73 06434-73; 3 m (10 ft)	I/P 26, I/P 73, I/P 82	77411-00	33 to 650	IP55	90 to 130 VAC, 4.5 A; and 220 to 260 VAC, 2.6 A
<a href="#">HL-77965-10</a>	0.7 to 17.0	I/P High-Performance 77600-62	Tygon® E-LFL I/P 88 06440-88; 1 m (3 ft)	I/P 70, I/P 88, I/P 89				

†Flow range with included tubing; extend the flow range of these systems with additional sizes of tubing; order on pages 126–130.

[HL-07595-43](#) Washdown foot switch.

[HL-17050-01](#) NIST-traceable calibration for peristaltic pump drive.

[HL-77300-32](#) Remote cable kit.

## I/P® PRECISION AND HIGH-PERFORMANCE PRECISION 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. Nineteen 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 30–31, as well as specific information about individual tubing materials on pages 22–29.
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 help you determine which tubing will pressurize the 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 191 to select the best tubing size.

### FREE TUBING TEST KIT!

Our FREE Tubing Test Kit is a simple way to test your chemicals against different tubing formulations. Kit contains samples of different pump tubing formulations, formulation descriptions, a selection guide, instructions on how to test your tubing, and complete ordering information. Call today! Request item HL-00101-10.

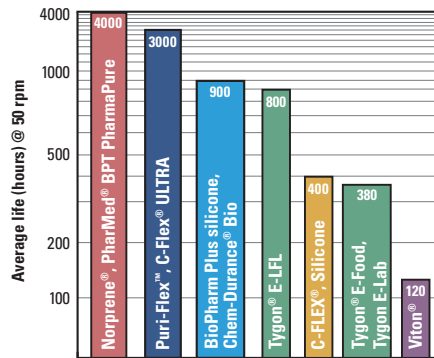
**Call or go online to request your FREE test kit today!**



### WHERE TO ORDER TUBING

C/L® TUBING ..... 34, 36  
 L/S® TUBING ..... 68–73  
 I/P® TUBING ..... 126–130  
 B/T® TUBING ..... 153

### TUBING MATERIAL LIFE COMPARISON

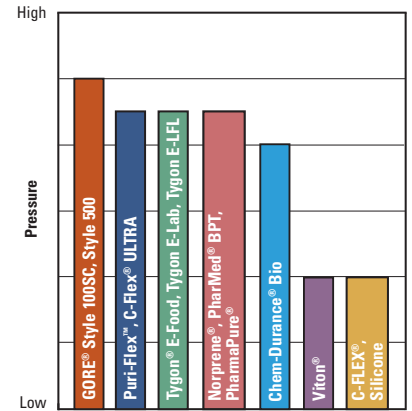


The graph above displays the average tubing life in hours of Masterflex® I/P® 73 tubing. This tubing was tested in a Masterflex® Standard pump head continuously pumping water at 21°C (70°F) and 0 bar (0 psig). Tubing life is calculated to time of failure or of 50% reduction in flow rate, whichever comes first. Reduce drive speeds to extend tubing life. Average tubing life for L/S® 16, I/P® 73, and B/T® 91 tubing at various speeds are listed in the table below.

Tubing class	L/S® 16		I/P® 73		B/T® 91		
	Drive rpm	50	600	50	600	50	321
Norprene®, PharMed® BPT, PharmaPure®		10,000	1000	4000	800	3000	600
Puri-Flex™, C-Flex® ULTRA		5000	1000	3000	500	500	100
Tygon® E-LFL		2500	600	800	400	600	200
C-FLEX®, Silicone		500	100	400	80	250	100
Tygon® E-Food		320	80	—	125	—	—
Tygon® E-Lab		320	80	180	380	100	30
Viton®		150	30	120	25	—	—

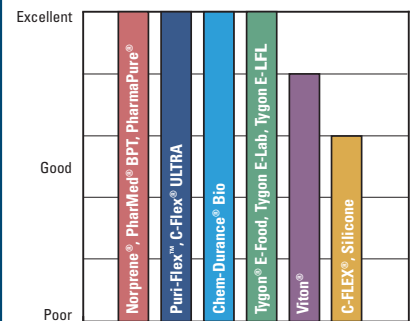


### PRESSURE GUIDELINES



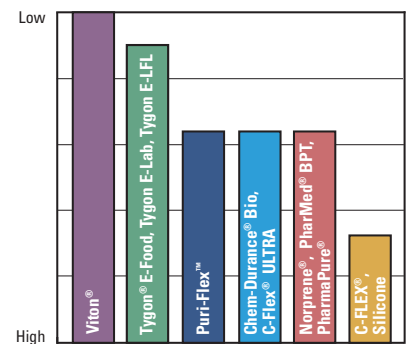
All tubing types accept pressure, but the firmer formulations accept more pressure than the softer types of tubing.

### VACUUM/SUCTION LIFT

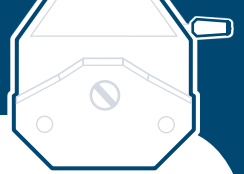


Vacuum/suction lift capability depends greatly on the tubing’s ability to maintain its shape. Thus, a firmer tubing type in the smallest possible bore size will generate a stronger vacuum for your application. Higher drive speeds are required to generate the strongest possible vacuum with some tubing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

### GAS PERMEABILITY



To minimize permeation of gases through the tubing wall, use firm tubing. Masterflex® I/P® High-Performance precision tubing (I/P® 70, I/P® 88, and I/P® 89) is less permeable than Precision tubing sizes. See pages 20–23 for tubing permeability to various gases.

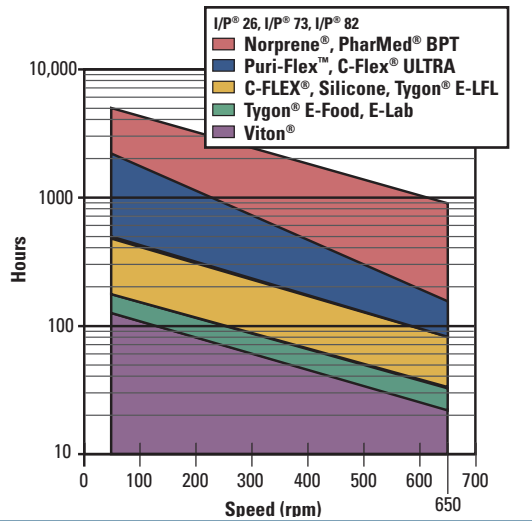


## I/P® PRECISION TUBING LIFE CHARACTERISTICS

Like the I/S® tubing sizes, I/P® sizes I/P® 26, I/P® 73, I/P® 82, I/P® 70, I/P® 88, and I/P® 89 offer excellent pressure generation, suction lift, tubing life, and the ability to pump viscous fluids—all at higher flow rates. This tubing is ideal for industrial applications that require flow rates up to 19 LPM (5.0 GPM).

The graph at right shows average tubing life while pumping water through a Standard pump head at 21°C (70°F).

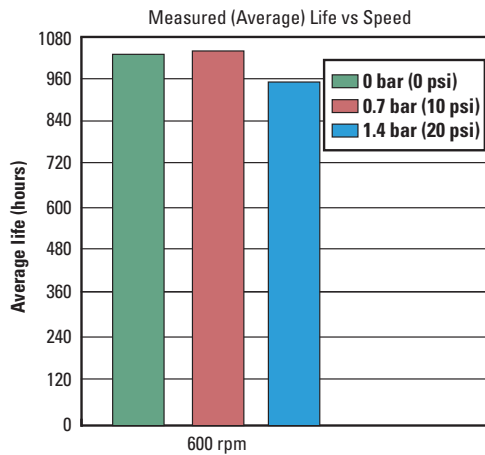
For example, using this graph it can be determined that the expected average life of Masterflex® I/P® 73 silicone tubing at 300 rpm is about 200 hours.



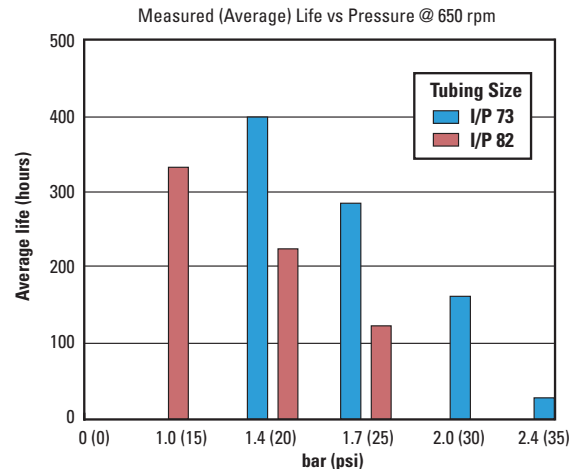
## NOTES

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.

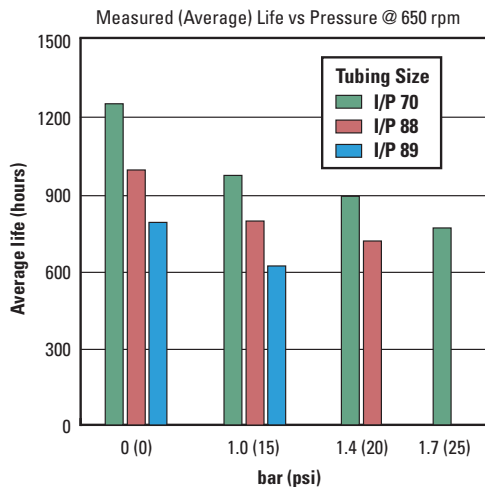
### NORPRENE®, PHARMED® BPT I/P® 73 TUBING IN I/P® STANDARD HEAD (07019-series)



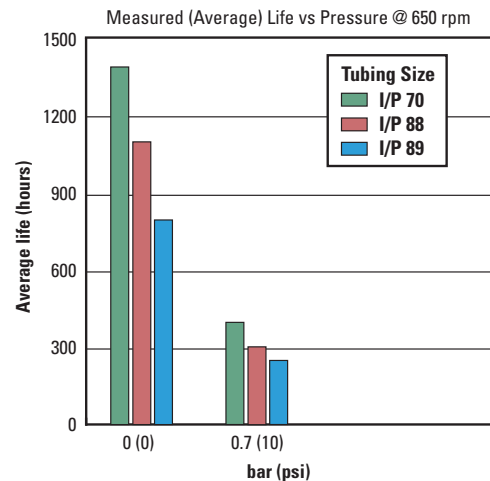
### NORPRENE® IN I/P® EASY-LOAD® PUMP HEAD (77601-series)



### NORPRENE®, PHARMED® BPT IN I/P® HIGH-PERFORMANCE PUMP HEAD (77600-62)

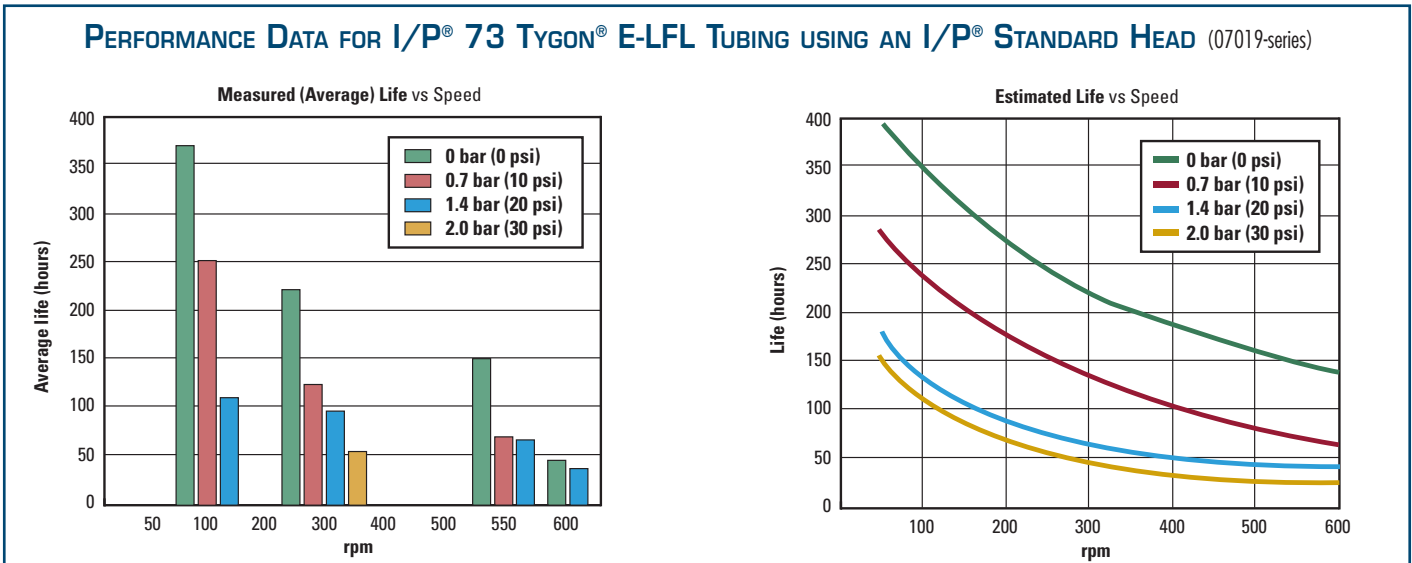
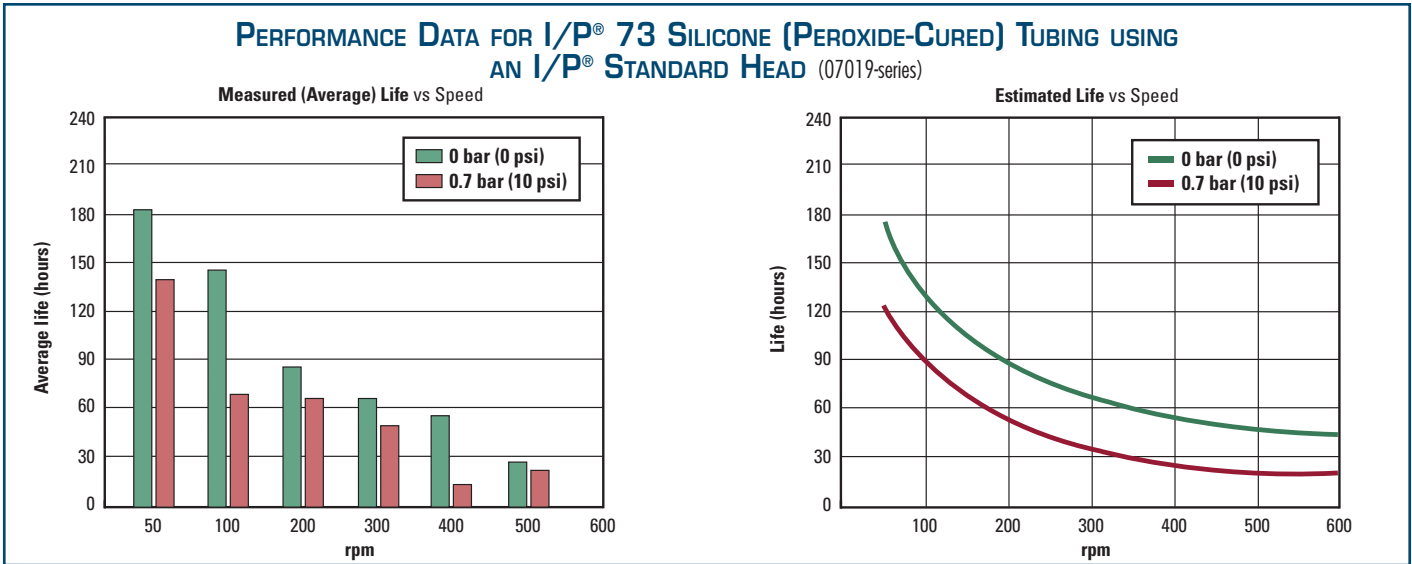
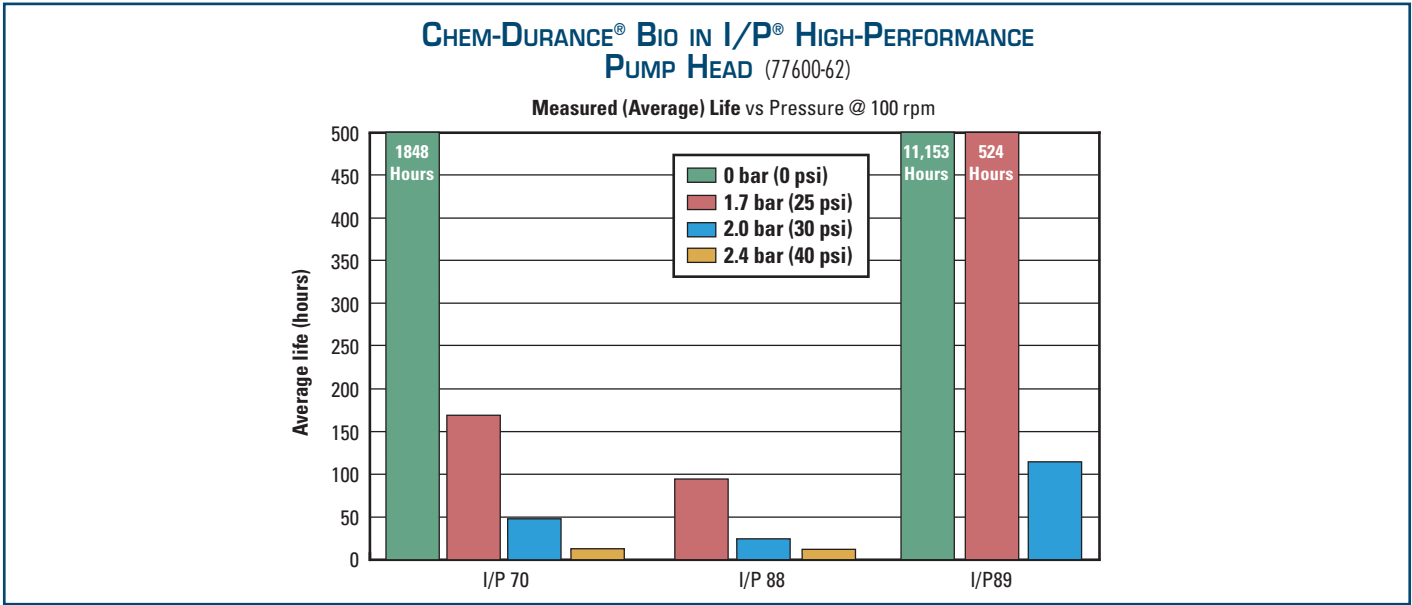


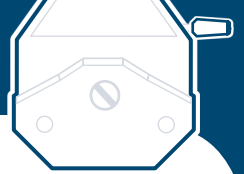
### PEROXIDE-CURED SILICONE IN I/P® HIGH-PERFORMANCE PUMP HEAD (77600-62)



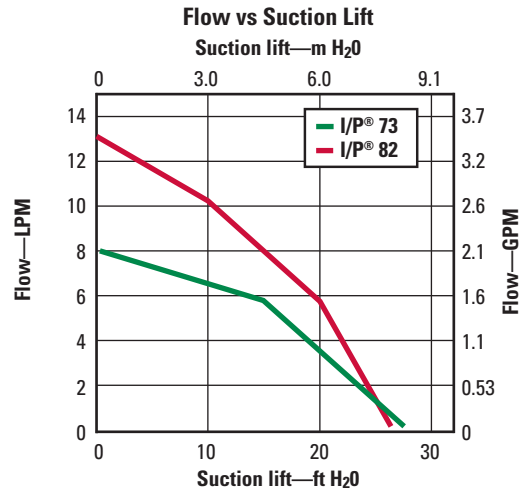
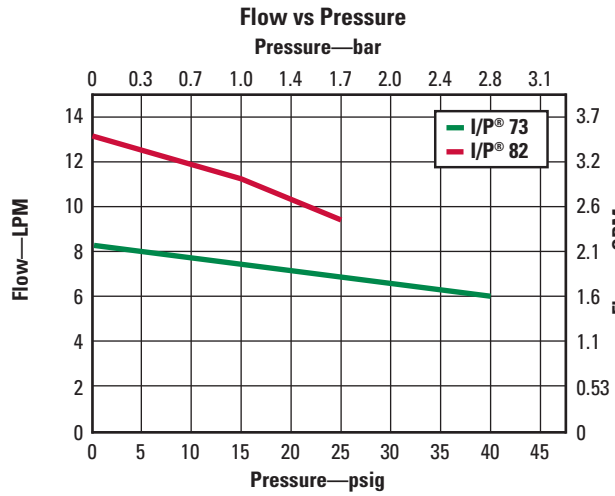


## I/P® PRECISION AND HIGH-PERFORMANCE PRECISION PUMP TUBING

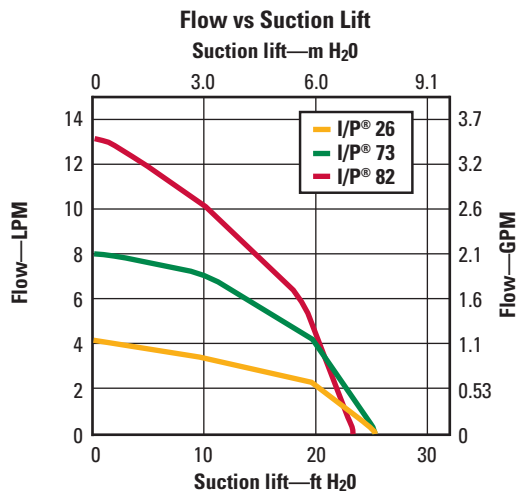
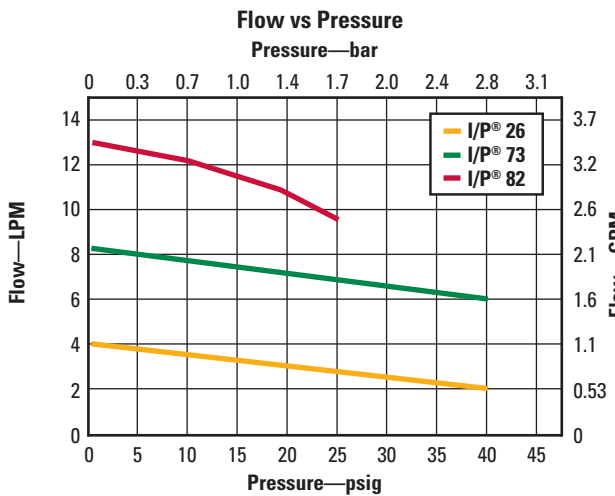




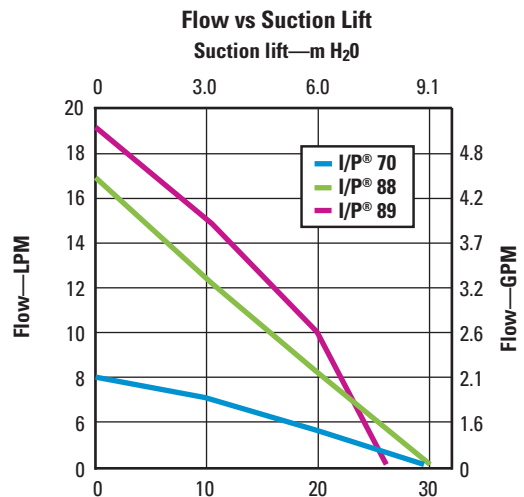
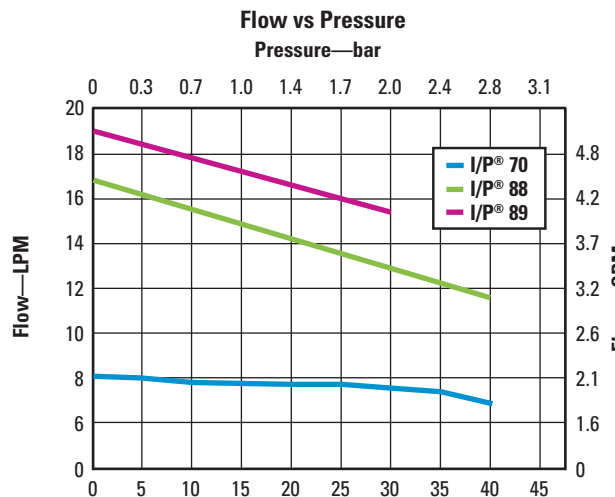
## I/P® STANDARD PUMP HEAD



## 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.

## 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 1.9). 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 for drives of 75 W (1/10 hp) or greater.

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
- ▶ Pressure

### EXAMPLE

Using one Easy-Load® II pump head with L/S® 15 Norprene® tubing requires a drive capable of supplying at least 81.1 N-cm (115 oz-in.) of starting torque.

When using two Easy-Load® II pump heads with L/S® 15 Norprene® tubing, you will need a drive capable of supplying 154 N-cm (218 oz-in.) of starting torque.

### STARTING TORQUE USING THE L/S® AND I/P® STANDARD PUMP HEAD

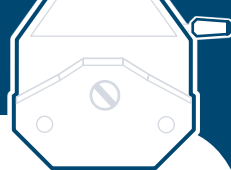
Tubing size	C-FLEX® / Silicone		BioPharm Plus silicone		Viton®		Tygon® E-Lab		Tygon® E-LFL		Tygon® E-Food / Tygon® Fuel & Lubricant		Tygon® Chemical		Chem-Durance® Bio		Norprene® / Puri-Flex™ / PharMed® BPT / C-Flex® ULTRA		PharmaPure®		GORE® Style 100SC	
	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in
<b>L/S® Precision pump tubing</b>																						
L/S 13	7.7	11	9.2	13	11.3	16	22.5	32	17	24	42.3	60	—	—	—	—	19.8	28	—	—	NA	NA
L/S 14	9.9	14	11.3	16	13.4	19	49.4	70	22.5	32	84.7	120	—	—	—	—	25.3	36	—	—	81.1	115
L/S 16	18.3	26	18.3	26	15.5	22	70.6	100	51.5	73	81.1	115	—	—	—	—	52.9	75	—	—	88.2	125
L/S 17	26.9	38	33.9	48	45.9	65	105.8	150	77.6	75	127	180	—	—	—	—	116.4	165	—	—	226	320
L/S 18	42.3	60	38.8	55	60	85	91.7	130	70.6	90	180.6	256	—	—	—	—	169.3	240	—	—	305	432
<b>L/S® High-performance Precision pump tubing</b>																						
L/S 15	24	34	35.3	50	21.2	30	105.8	150	70.6	115	225.8	320	—	—	—	—	91.7	130	—	—	91.7	130
L/S 24	42.3	60	98.8	140	64.9	92	127	180	98.8	140	316.1	448	—	—	—	—	135.4	192	—	—	120	170
L/S 35	41.7	59	50.8	72	113	160	151	214	113	160	304.8	432	—	—	—	—	152.4	216	—	—	124.2	176
L/S 36	49.4	70	77.6	110	147	208	140	198	113	160	—	—	—	—	—	—	169.3	240	—	—	NA	NA
<b>I/P® Precision pump tubing</b>																						
I/P 73	90.4	128	124.2	176	137.6	195	225.8	320	147	208	548	776	—	—	—	—	214.5	304	—	—	226	320
I/P 82	77.6	110	203.4	288	NA	NA	338.7	480	135.4	192	678	960	—	—	—	—	225.8	320	—	—	452	640

### STARTING TORQUE USING L/S® AND I/P® EASY-LOAD® AND EASY-LOAD® II PUMP HEADS

Tubing size	C-FLEX® / Silicone		BioPharm Plus silicone		Viton®		Tygon® E-Lab		Tygon® E-LFL		Tygon® E-Food / Tygon® Fuel & Lubricant		Tygon® Chemical		Chem-Durance® Bio		Norprene® / Puri-Flex™ / PharMed® BPT / C-Flex® ULTRA		PharmaPure®		GORE® Style 100SC	
	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in
<b>L/S® Precision pump tubing</b>																						
L/S 13	7.7	11	9.2	13	12	17	21.2	30	12	17	56.4	80	17	24	21.2	30	14.1	20	20.5	29	NA	NA
L/S 14	11.3	16	12.7	18	16.3	23	31.8	45	19	27	63.5	90	35.3	50	35.3	50	28.2	40	27.5	39	24.7	35
L/S 16	11.3	16	13.4	19	24.7	35	38.8	55	42.4	60	63.5	90	45.9	65	56.4	80	31.8	45	63.5	90	63.5	90
L/S 25	21.2	30	45.9	65	21.2	30	60	85	35.3	50	52.9	75	63.5	90	84.7	120	35.3	50	50.8	72	91.7	130
L/S 17	24.7	35	36	51	35.3	50	56.4	80	61.4	87	84.7	120	45.9	65	84.7	120	84.7	120	70.6	100	42.3	60
L/S 18	35.3	50	38.8	55	52.9	75	70.6	100	35.3	50	84.7	120	52.9	75	113	160	84.7	120	91.7	130	70.6	100
<b>L/S® High-performance Precision pump tubing</b>																						
L/S 15	45.9	65	49.4	70	45.9	65	88.2	125	77.6	110	197.6	280	—	—	113	160	81.1	115	77.6	110	70.6	100
L/S 24	38.8	55	49.4	70	74.1	105	95.3	135	70.6	100	208.2	295	192	272	119.9	170	84.7	120	113	160	49.4	70
L/S 35	56.4	80	60	85	77.6	110	98.8	140	70.6	100	192	272	—	—	124.1	176	124.2	176	—	—	91.7	130
L/S 36	49.4	70	77.6	110	70.6	100	113	160	105.8	150	214.5	304	—	—	135.3	192	109.4	155	—	—	NA	NA
<b>I/P® Precision pump tubing</b>																						
I/P 76	113	160	113	160	—	—	203.2	288	147	208	248.3	352	327.4	464	—	—	180.6	256	226	320	127	180
I/P 73	169.3	240	169.3	240	192	272	316.1	448	180.6	256	481.9	683	282.2	400	304.6	432	316.1	448	248.3	352	192	272
I/P 82	180.6	256	192	272	NA	NA	304.8	432	225.8	320	474.1	672	395.1	560	429.3	608	282.2	400	338.7	480	338.7	480

NA = Not available or applicable

— Not recommended



## 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. 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.

3. Several factors influence starting torque:

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

### EXAMPLE

Using one High-Performance pump head with L/S® 15 Norprene® tubing requires a drive capable of supplying at least 105.8 N-cm (150 oz-in) of starting torque.

## STARTING TORQUE USING THE L/S® AND I/P® HIGH-PERFORMANCE PUMP HEADS

Tubing size	C-FLEX® / Silicone		BioPharm Plus silicone		Viton®		Tygon® E-Lab		Tygon® E-LFL		Tygon® E-Food / Tygon® Fuel & Lubricant		Tygon® Chemical		Chem-Durance® Bio		Norprene® / Puri-Flex™ / PharMed® BPT / C-Flex® ULTRA		PharmaPure®		GORE® Style 100SC		
	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	N-cm	oz-in	
<b>L/S® High-pressure pump tubing</b>																							
L/S 15HP†	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	428.9	608	NA	NA	NA	NA
L/S 16HP†	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	496.7	704	NA	NA	NA	NA
<b>L/S® High-performance Precision pump tubing</b>																							
L/S 15	35.3	50	56.4	80	70.6	100	127	180	84.7	120	271	384	—	—	—	—	105.8	150	—	—	123.5	175	
L/S 24	35.3	50	63.5	90	91.7	130	120	170	77.6	110	282.2	400	—	—	—	—	120	170	—	—	180.5	256	
L/S 35	52.9	75	64.9	92	84.7	120	158.1	224	98.8	140	—	—	—	—	—	—	124.2	176	—	—	225.8	320	
L/S 36	52.9	75	77.6	110	105.8	150	146.7	208	112.9	160	—	—	—	—	—	—	135.4	192	—	—	NA	NA	
<b>I/P® High-performance Precision pump tubing</b>																							
I/P 26‡	226	320	248.3	352	NA	NA	338.7	480	316.1	448	—	—	—	—	485.8	688	496.7	704	—	—	237.1	336	
I/P 73‡	180.6	256	237.1	336	NA	NA	—	—	259.6	368	—	—	—	—	575.3	816	428.9	608	—	—	338.7	480	
I/P 82‡	158.1	224	180.6	256	NA	NA	361.2	432	259.6	368	—	—	—	—	564.5	800	451.6	640	—	—	406.4	576	

† Can only be used and started on a 100 rpm drive

‡ Starting torque based on notch #1.

NA = Not available or applicable

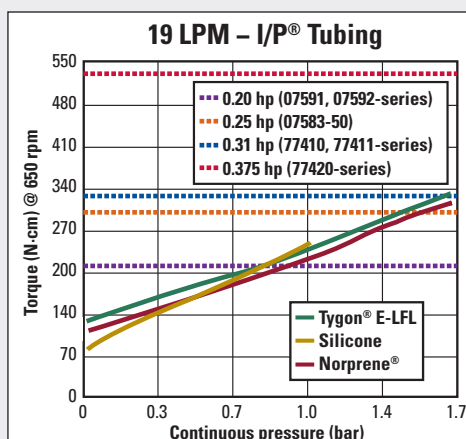
— Not recommended

## TORQUE SPECIFICATIONS FOR L/S® PTFE-DIAPHRAGM PUMP HEAD

Catalog number	HL-07090-62		HL-07090-42	
Discharge pressure	0 bar (0 psi)		5.2 bar (75 psi)	
Start	56.8 N-cm (80 oz-in)		127.4 N-cm (180 oz-in)	
Average	21.2 N-cm (30 oz-in)		24.5 N-cm (35 oz-in)	
Peak	31.8 N-cm (45 oz-in)		63.5 N-cm (90 oz-in)	

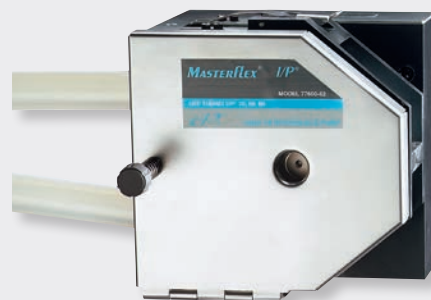


## DRIVE TORQUE REQUIREMENTS TO OBTAIN 19 LPM WITH I/P® HIGH-PERFORMANCE PUMP HEADS



Choose your drive based on desired flow rate, pressure in your application, and type of tubing used. For example, if you need 19 LPM at 1.4 bar and are using Norprene® tubing, you need a drive that supplies 0.25 hp (07583-50).

Some flow rate/pressure combinations are not possible with all drives. High-performance pump head is designed exclusively for use with High-performance Precision tubing.



High-Performance pump head 77600-62. Order on pages 126–127.

## 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

Three types of pump head adapt easily to multichannel applications: stackable single-channel heads, multichannel heads, and cartridge heads. Multichannel and cartridge heads provide for the maximum number of tubing channels within a relatively small space.

#### Stackable Single-Channel Pump Heads

You can add or remove stackable single-channel heads as needed for different applications. Stackable pump heads are therefore popular for applications that require the flexibility to frequently reconfigure the pump design. Stackable heads are preferred for larger tubing sizes, and when the application involves high suction lift and/or discharge pressure.

Two or four stacked heads can typically be mounted on a drive depending on the drive's speed range and horsepower. The dual channel Masterflex® L/S® Easy-Load® II pump head can give you up to 8 channels with four heads stacked on a single drive.

#### Multichannel Pump Heads

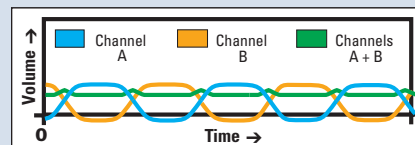
Multichannel heads are a second option for multiple channel applications. These heads combine many of the best features of both cartridge heads and stacked single-channel heads.

These heads offer relatively low pulsation flow from two, four, or eight channels with no cartridges. They are also stackable for up to 32 channels depending on tubing size and formulation and drive power. Between-channel flow is synchronous with no adjustment of occlusion. These features give multichannel heads the configuration flexibility of stacked single-channel heads, as well as the synchronous flow and channel capacity of cartridge heads.

Masterflex® L/S® multichannel pump heads are available for microbore tubing and for Masterflex® L/S® tubing sizes.

### 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 at right.



### Cartridge Pump Heads

Cartridge pump heads accept a predetermined maximum number of channels—any number of these channels can be used, up to the capability of the head and the drive. Masterflex® L/S® cartridge heads can be mounted on most Masterflex® L/S® drives. Up to 12 individual channels mount on a single head with flow rates as low as 0.0005 mL/min per channel.

Cartridge pumps have long rollers that provide synchronous fluid delivery between the cartridges. These pump heads also have a higher number of rollers than single-channel heads, which results in lower pulsation flow and higher accuracy at low volumes and low flow rates. These pumps are recommended for low volume/low flow rate fluid transfer applications.

Cartridge heads with adjustable occlusion offer the highest between-channel accuracy of all pump head types. Fine adjustments to the occlusion in individual channels can effectively compensate for any minor variations in tubing dimensions that lead to slight variations in flow.

### Accuracy

Cartridge and multichannel pump heads are popular for accurate sampling, dispensing, and metering of fluids. The synchronous rollers provide coordinated fluid delivery between each channel in the pump head. Multichannel heads deliver between-channel flow accuracies in the range of 1.5 to 2% (depending on tubing formulation). With adjustable occlusion, cartridge pump heads can deliver flow accuracies of <1% between channels. Precise dispensing and metering require this high level of performance and accuracy.

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**APPLICATION SPECIALISTS**

**CHALLENGE:** A pharmaceutical manufacturer needed to dispense volumes of 300 mL in 15 seconds or less repeating three times per minute; and 20 mL in 2 seconds or less repeating 20 times per minute. The desired accuracy target for both applications was  $\pm 1.5\%$ . The efficiency of simultaneously pumping multiple channels was critical.

**OUR SOLUTION:** The manufacturer now uses a Masterflex® L/S® digital drive 07522-20 (see pages 88–89) with an L/S four-channel pump head 07536-04 (see pages 54–55). Size L/S 15 two-stop BioPharm Plus silicone tubing (96116-15) met the smaller flow requirement; while size L/S 35 two-stop BioPharm Plus silicone tubing (96116-35) met the larger flow requirement. BioPharm Plus silicone tubing is recommended for high-accuracy dispensing applications due to its exceptional flow stability over time. Careful calibration of the drive and the synchronous multichannel flow capability of the pump head enabled the manufacturer to meet the accuracy target.



## TUBING SELECTION

### Chemical Compatibility

Refer to the chemical compatibility charts specific to pump tubing on pages 30–31. 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 Plus silicone, PharMed® BPT, PharmaPure®, Norprene®, and GORE® Style 100SC. BioPharm Plus 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

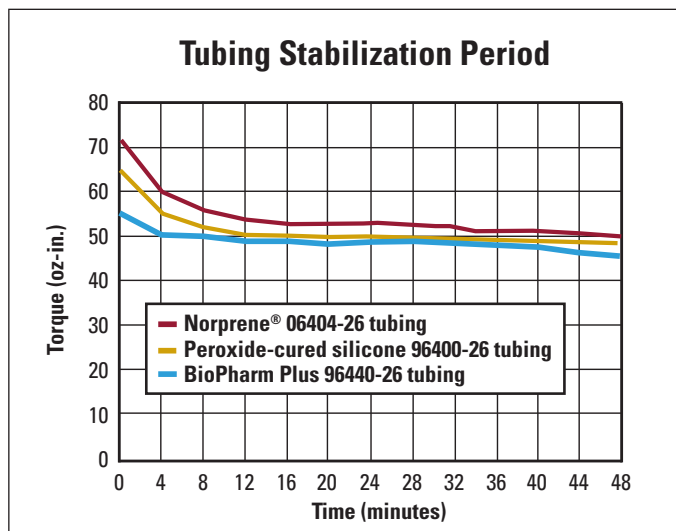
Size your tubing so that you are operating at the middle of the tubing's flow range (volume per unit time). This will give you maximum flexibility to make adjustments without approaching either the upper or lower limit of the tubing flow range.

### 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 L/S® sizes the break-in period is 10 to 15 minutes; for I/P® tubing sizes 12 to 18 minutes.



### Tubing Dimensions and Tolerances

Masterflex drives, pump heads, and pump tubing have all been co-designed, and are continually being monitored and refined, to deliver best performance when used together in complete pump systems. The exact dimensions and manufacturing tolerances of the tubing have direct impacts on maximizing tubing life and dispensing accuracy.

The flow rate for a given size of tubing is derived from the volume pumped per each revolution of the rollers. Volume pumped per revolution is directly proportional to the inside diameter of the tubing. Even slight variations in inside diameter can have significant impact on flow accuracy. Variations in the outside diameter of the tubing can result in the tubing not being properly retained in the pump head and being either over- or under-occluded. These

problems can also impact accuracy as well as tubing life. Masterflex pump tubing is manufactured to very precise tolerances and monitored and tested to verify those tolerances. To realize the maximum accuracy and repeatability from your Masterflex pump drive, we strongly recommend that you use only Masterflex pump tubing.

### Regulatory Classifications for Tubing

Several Masterflex tubing formulations comply with industry-critical regulations. Relevant classifications include those specified by the United States Pharmacopoeia (USP), European Pharmacopoeia (EP), US Food and Drug Administration (FDA), U.S. Department of Agriculture (USDA) and National Sanitation Foundation (NSF).

Upon request, Cole-Parmer will provide you with a certificate validating that the tubing is in compliance with a particular regulation. This documentation will ensure that you can demonstrate compliance with your individual protocols.

## DRIVE SELECTION

Masterflex systems offer 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
- Dispense by time—allows you to run the pump at a programmed flow rate for a specified period of time
- 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
- Batch count—this feature allows you to program a defined number of batches; as the pump operates, the number of batches completed is displayed alongside the programmed total
- Cumulative volume—displays the total volume dispensed over multiple cycles
- Dispense by weight—requires an RS-232 or balance-compatible interface (available on the L/S 07551-00 and -10 Computer-Compatible drive and on the L/S Digi-Staltic® modular dispensing pump)
- Antidrip feature—briefly reverses the rollers at the end of the dispense cycle, further ensuring accuracy (available on the L/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, USB) 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.
- 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 A

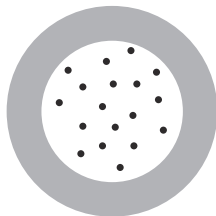


Fully occluded tubing

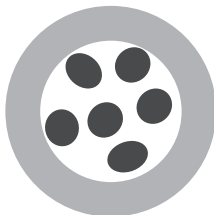


Partially occluded tubing

FIGURE B



Hard particle size should be 5% of tubing ID



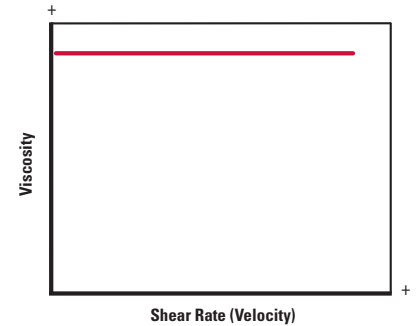
Soft particle size should be 25% of tubing ID

## 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.

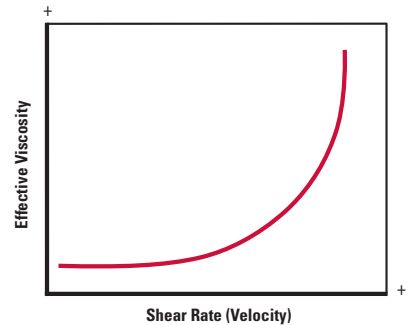
### NEWTONIAN FLUIDS

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.



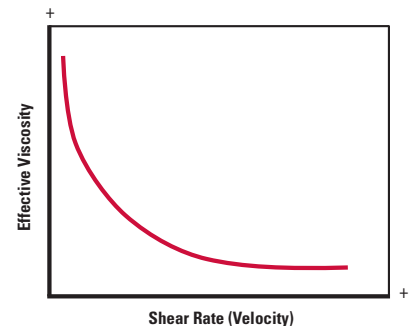
### DILATANT FLUIDS

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.



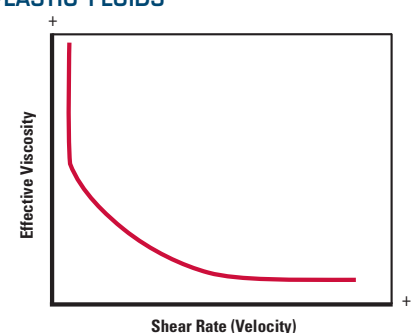
### THIXOTROPIC FLUIDS

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.



### PLASTIC/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.





## TUBING SELECTION FOR PUMPING VISCOUS FLUIDS

### TO MAXIMIZE THE PUMPING EFFICIENCY OF VISCOUS FLUIDS, 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 Chem-Durance® Bio, GORE® Style 100SC and Style 500, Norprene®, PharmaPure®, PharMed® BPT, and Tygon® E-LFL. Performance will be better because the tubing returns to its original shape quickly after pump head occlusion. For L/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. BioPharm, BioPharm Plus, Tygon® E-Lab, Tygon® E-LFL, or silicone formulations are good choices.
5. Decrease the viscosity of your fluid. Heat your fluid if possible; viscosity usually decreases with temperature.

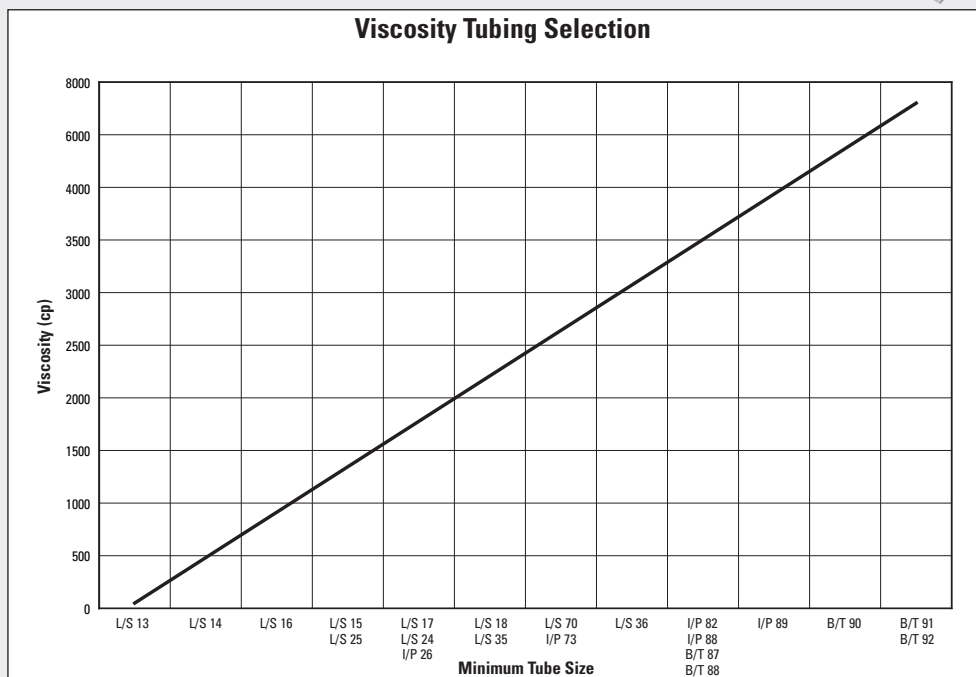


### TUBING SELECTION GUIDE FOR PUMPING VISCOUS FLUIDS

#### How to use this graph:

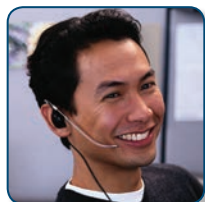
Example: You have an 800 centipoise fluid that you wish to pump and you need to determine what the minimum tubing size you need to pump this viscous fluid. Look at the Viscosity axis on the left hand side of the graph and find 800 centipoise. Follow this over until it meets the line. At the intersection of the line and 800 centipoise, follow this down to the Minimum Tube Size axis to see which tubing range it falls within. In this scenario the 800 centipoise falls in the range of the L/S 16 tubing size. Therefore, the minimum tube size needed to pump 800 centipoise is L/S size 16. All viscosities below 800 centipoise can be used with an L/S size 16 tube as well.

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 viscous fluid applications. Tests were performed with fluids at 21°C (70°F) and 0 bar (0 psig) of back pressure. This graph is best used as a general guideline only, and is not a guarantee that you will achieve the results shown.



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**APPLICATION SPECIALISTS**

**CHALLENGE:** An adhesives manufacturer needed to dose different types and different volumes of viscous rapid-drying glue. Pumps with valves and moving parts were prone to getting stuck or would have to be cleaned very thoroughly at the end of a session. In some cases, pumps were damaged beyond recovery.

**OUR SOLUTION:** We recommended L/S® 24 high-performance precision (thicker-walled) platinum-cured silicone tubing. Silicone is the only tubing that can be used more than once. The rapid-drying glue can actually be stored in the silicone tubing for several days if the outlet of the tubing is closed.

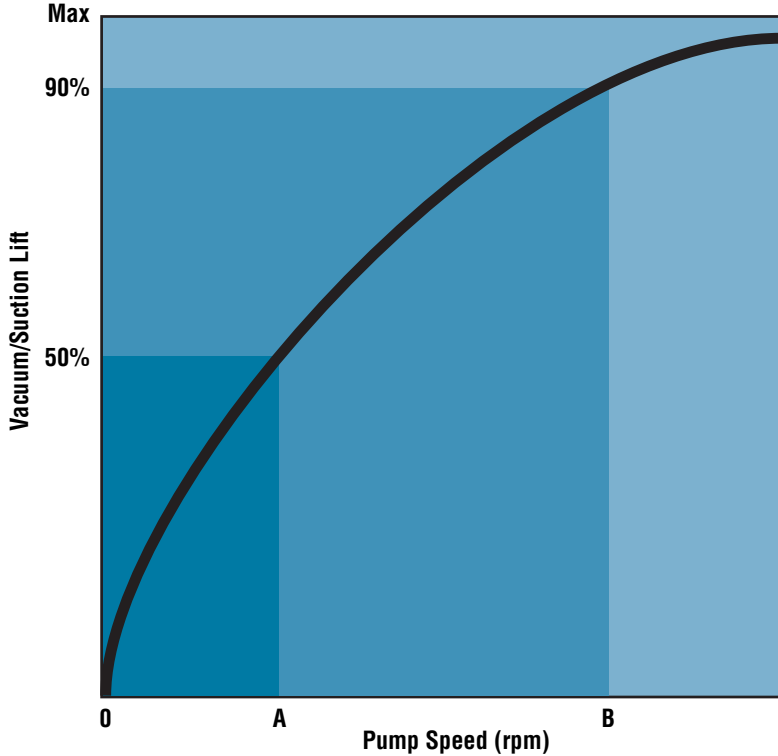
The manufacturer now uses an L/S® standard digital drive 07522-20 (see pages 88–89) and Easy-Load® II pump head 77200-62 (see pages 44–45) to dose 20 and 50 mL of rapid-drying glue with a viscosity of approximately 1200 cp. Oversizing the tubing allows the pump to run at speeds under 200 rpm; facilitating pumping of the viscous glue.



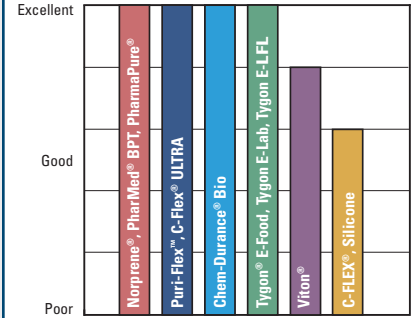
## MASTERFLEX® VACUUM/SUCTION LIFT DATA

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 L/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 L/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.

### VACUUM/SUCTION LIFT SPECIFICATIONS

Masterflex® Precision and High-Performance Precision pump tubing																
Tubing size	C-FLEX®/Silicone				Tygon®/Tygon® E-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
L/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
L/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
L/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
L/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
L/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
L/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
L/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
L/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
L/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
L/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® 87	538 (22)	7.3 (24)	20	40	515 (20)	7.0 (23)	20	40	560 (24)	7.6 (25)	20	40	—	—	—	—
B/T® 91	470 (18)	6.4 (21)	20	40	515 (20)	7.0 (23)	20	40	560 (24)	7.6 (25)	20	40	—	—	—	—