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Masterflex® Tubing and General Technical Data

Table of Contents

Masterflex® Performance Data

General Technical Data

Testing Parameters

The charts found on pages 172–180 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.

Tubing Selection Guidelines

Tubing life performance is just one of many factors present in your pumping applications. The charts in this section and the information on pages 19–31 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®, PharMed® BPT, and PharmaPure® 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 and is the recommended formulation for high-accuracy dispensing applications (see pages 188–189).

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

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

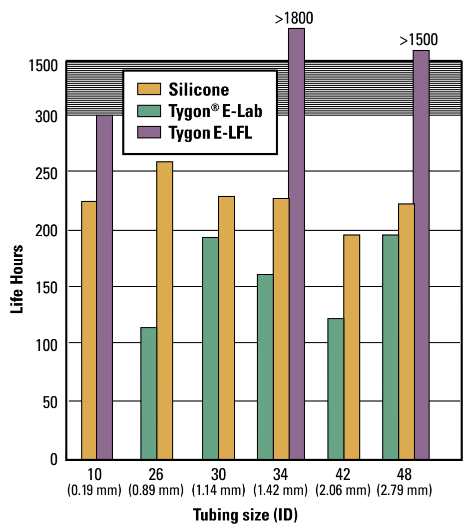
Once tubing has been selected:

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.

C/L® Microbore Tubing Life Data

This graph shows average tubing life, by tubing size, of C/L® silicone and C/L® Tygon® while pumping water through a C/L® variable-speed pump 77120-series at 21°C (70°F) with 0 psig at 300 rpm.



L/S® Precision and High-Performance Precision 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-two different material formulations are available.

To order the correct tubing:

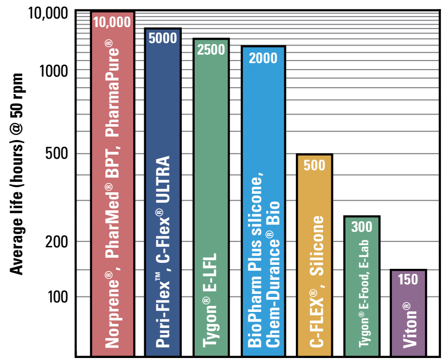
1. Consider all the aspects of your application: flow rate, pressure, etc.
2. Review the chemical compatibility data on pages 30–31, as well as specific information about individual tubing materials on pages 22–29.
3. Use the "Tubing Material Life Comparison" graph and table at right to select the tubing 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 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 191 to select the best tubing size.

Tubing Material Life Comparison

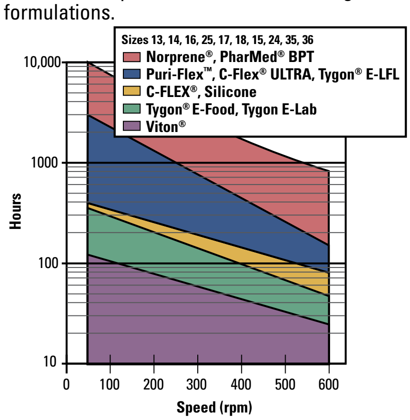


The graph above displays the average tubing life in hours of Masterflex® L/S® 16 tubing. This tubing was tested in a Masterflex® Standard pump head continuously pumping water at 21°C (70°F) and 0 psig (0 bar). Tubing life is calculated to time of failure or of 50% reduction in flow rate, whichever comes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

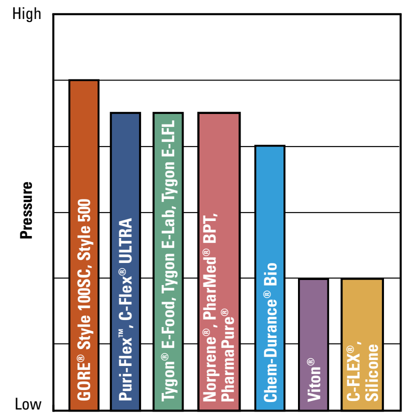
Tubing class	L/S® 16		I/P® 73		B/T® 91	
Drive rpm	50	600	50	600	50	321
Norprene®, PharMed® BPT, PharmaPure®	10,000	1000	4000	800	3000	600
Puri-Flex™, C-Flex® ULTRA	5000	1000	3000	500	500	100
Tygon® E-LFL	2500	600	800	400	600	200
C-FLEX®, Silicone	500	100	400	80	250	100
Tygon® E-Food	320	80	—	125	—	—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

L/S® Precision Tubing Life Characteristics

The graph below shows average tubing life vs motor rpm for selected L/S® tubing formulations.

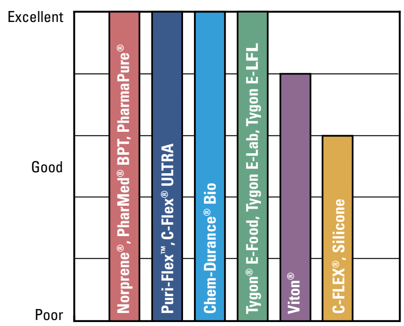


Pressure Guidelines



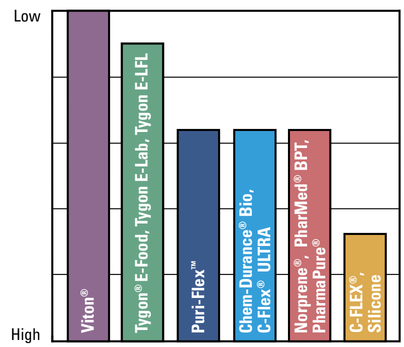
All tubing types accept pressure, but the firmer formulations accept more pressure than the softer types of tubing.

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® L/S® High-Performance precision tubing (L/S® 15, L/S® 24, L/S® 35, and L/S® 36) is less permeable than Precision tubing sizes. See pages 20–23 for tubing permeability to various gases.

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!

See pages 68–73 for L/S® pump tubing ordering information.

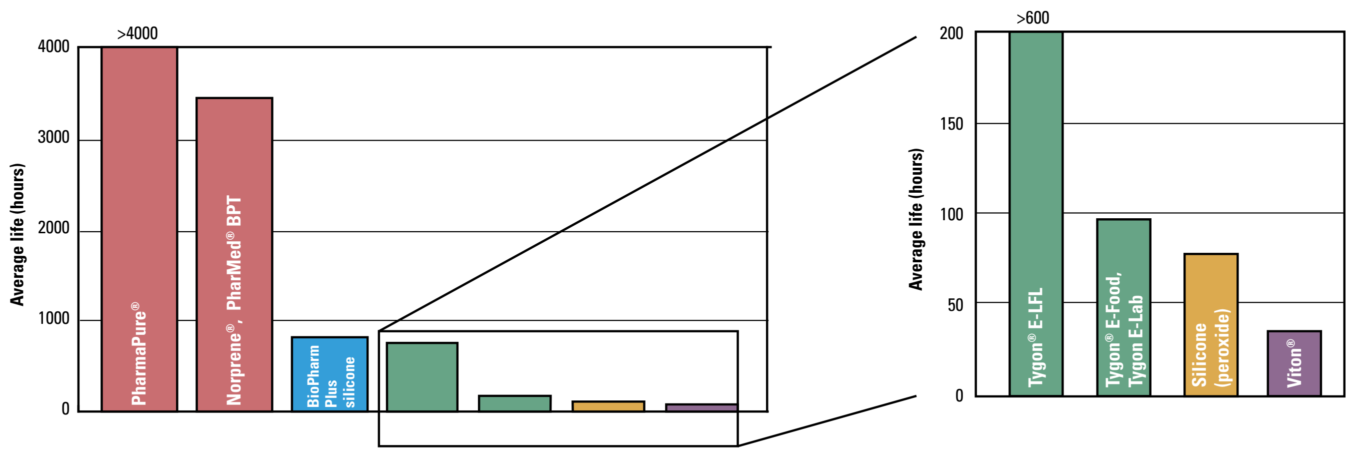
L/S® Precision and High-Performance Precision Pump Tubing

Performance Data for PharmaPure®, Norprene®, PharMed® BPT, BioPharm Plus Silicone, Silicone, Tygon®, and Viton® Tubing Formulations

See pages 68–73
for L/S® pump tubing ordering information.

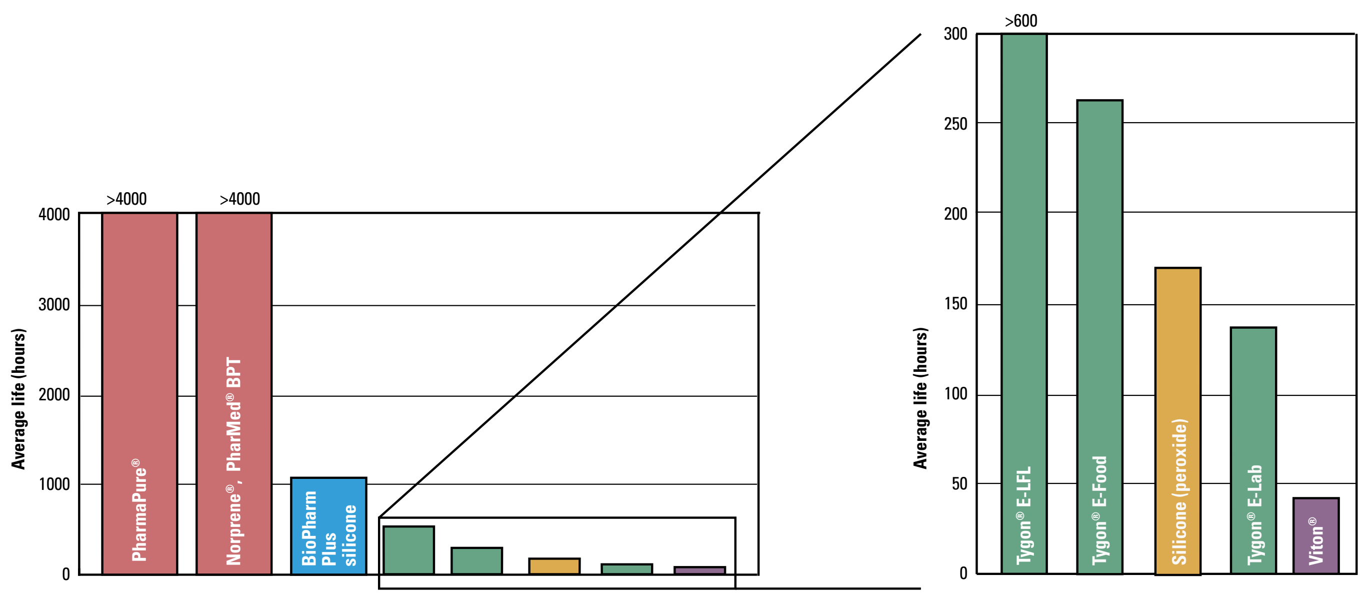
L/S® Precision Tubing

Precision tubing (L/S® 13, L/S® 14, L/S® 16, L/S® 25, L/S® 17, and L/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.



L/S® High-Performance Precision Tubing

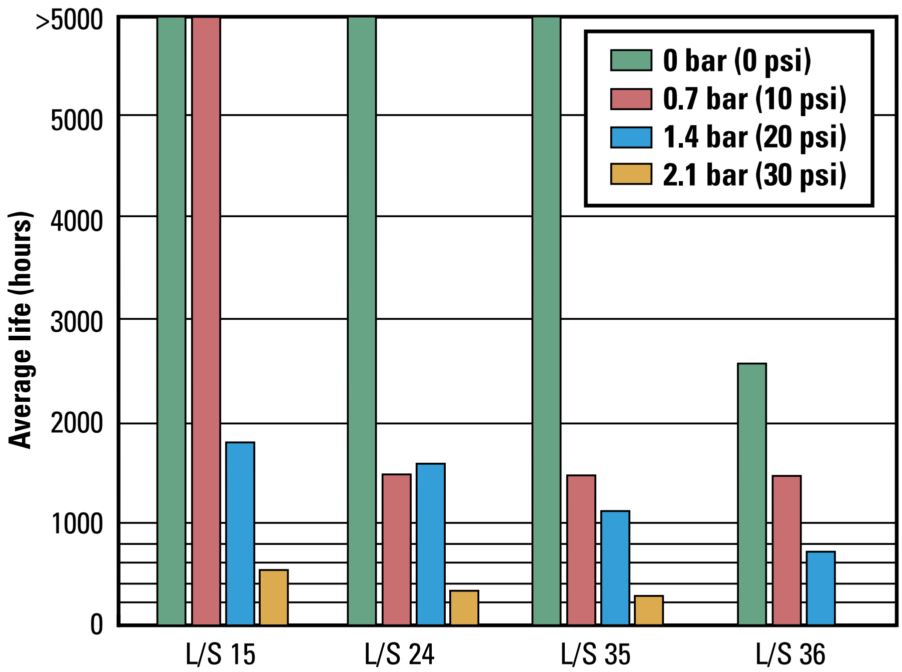
High-performance precision tubing (L/S® 15, L/S® 24, L/S® 35, and L/S® 36) improves pressure generation, suction lift, tubing life, and the ability to pump viscous fluids. The graph below shows average tubing life while pumping water through an Easy-Load® II pump head at 21°C (70°F), 0 psi, 600 rpm.



PERFORMANCE DATA FOR NORPRENE® AND PHARMED® BPT TUBING FORMULATIONS L/S® HIGH-PERFORMANCE PUMP HEAD PUMPING WATER AT 21°C (70°F)

L/S® HIGH-PERFORMANCE PRECISION TUBING

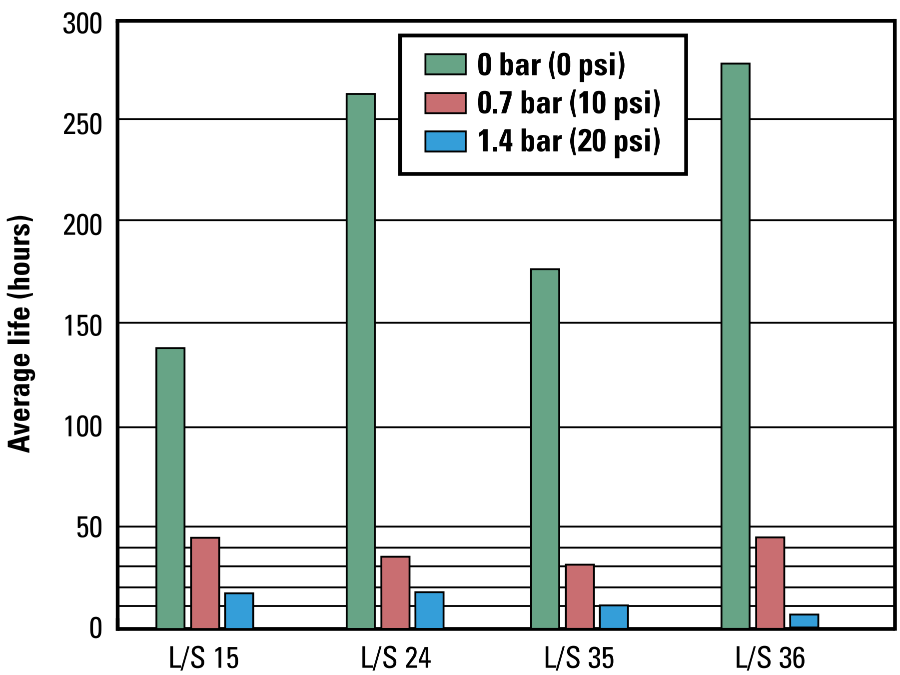
High-performance precision tubing (L/S® 15, L/S® 24, L/S® 35, and L/S® 36) improves pressure generation, suction lift, tubing life, and the ability to pump viscous fluids. The graph at right shows average tubing life while pumping water through a High-Performance pump head at 21°C (70°F), 600 rpm.



PERFORMANCE DATA FOR SILICONE (PEROXIDE-CURED) TUBING FORMULATION L/S® HIGH-PERFORMANCE PUMP HEAD PUMPING WATER AT 21°C (70°F)

L/S® HIGH-PERFORMANCE PRECISION TUBING

High-performance precision tubing (L/S® 15, L/S® 24, L/S® 35, and L/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.



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!

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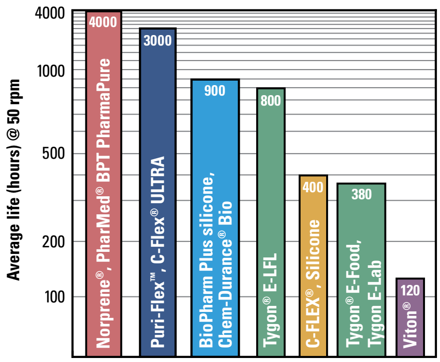
Call or go online to request your FREE test kit today!

Where to Order Tubing

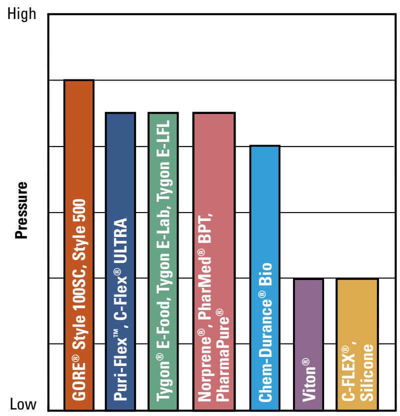
Tubing Material Life Comparison



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.

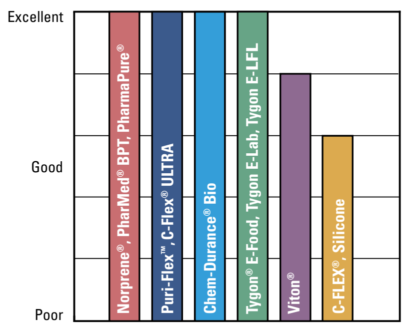
Tubing class	L/S® 16		I/P® 73		B/T® 91	
Drive rpm	50	600	50	600	50	321
Norprene®, PharMed® BPT, PharmaPure®	10,000	1000	4000	800	3000	600
Puri-Flex™, C-Flex® ULTRA	5000	1000	3000	500	500	100
Tygon® E-LFL	2500	600	800	400	600	200
C-FLEX®, Silicone	500	100	400	80	250	100
Tygon® E-Food	320	80	—	125	—	—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

Pressure Guidelines



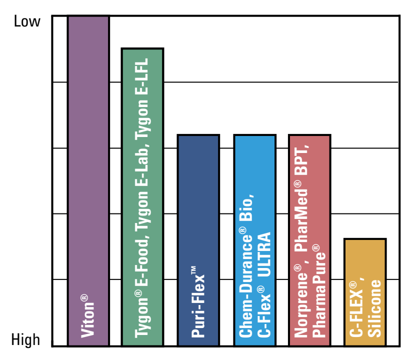
All tubing types accept pressure, but the firmer formulations accept more pressure than the softer types of tubing.

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



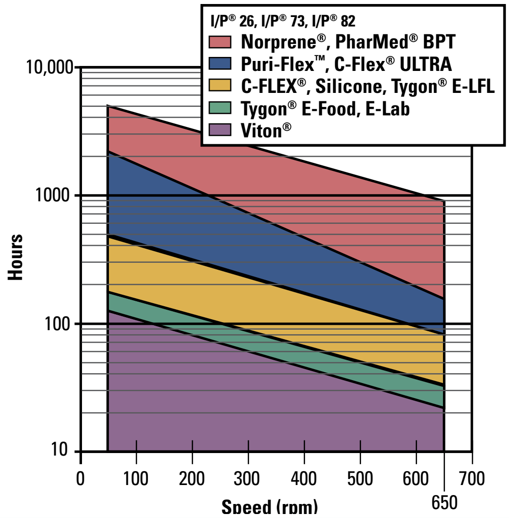
To minimize permeation of gases through the tubing wall, use firm tubing. Masterflex® I/P® High-Performance precision tubing (I/P® 70, I/P® 88, and I/P® 89) is less permeable than Precision tubing sizes. See pages 20–23 for tubing permeability to various gases.

I/P® Precision Tubing Life Characteristics

Like the L/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).

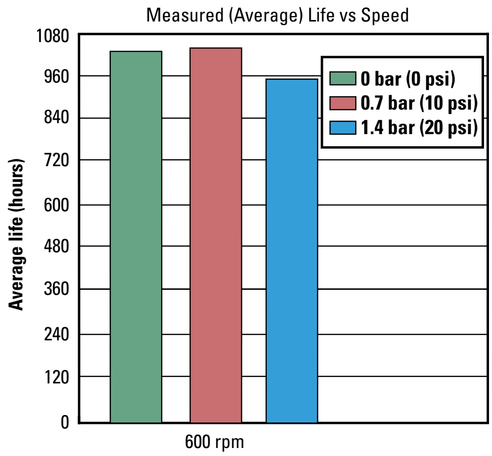
For example, using this graph it can be determined that the expected average life of Masterflex® I/P® 73 silicone tubing at 300 rpm is about 200 hours.



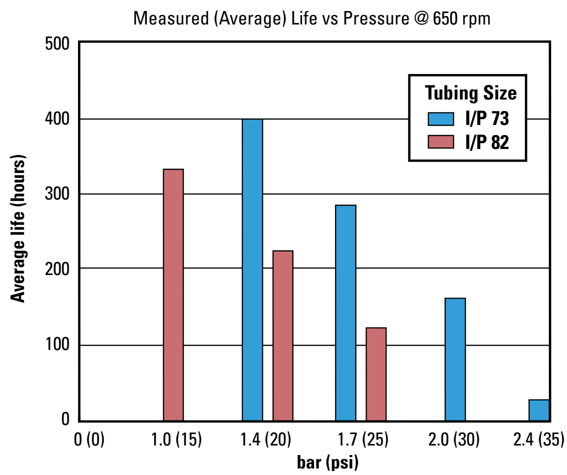
Notes

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.

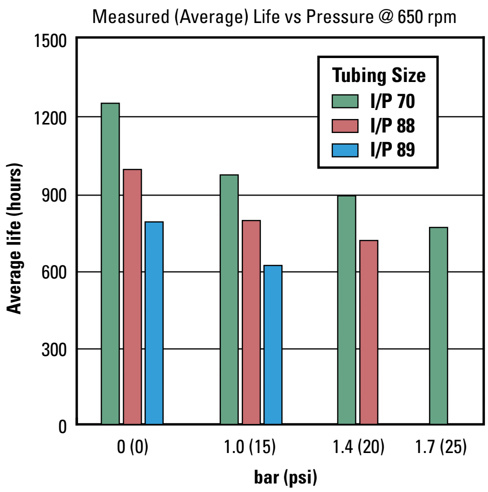
Norprene®, PharMed® BPT I/P® 73 Tubing in I/P® Standard Head (07019-series)



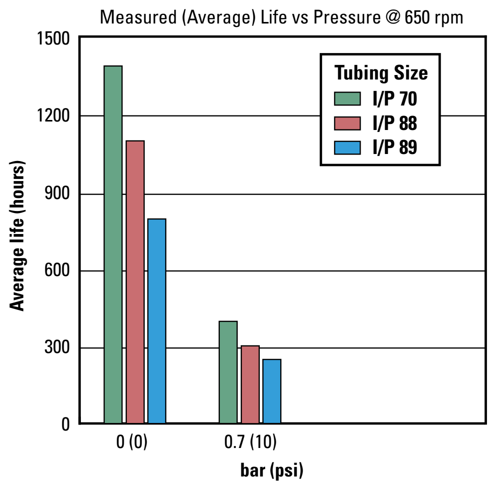
Norprene® in I/P® Easy-Load® Pump Head (77601-series)



Norprene®, PharMed® BPT in I/P® High-Performance Pump Head (77600-62)



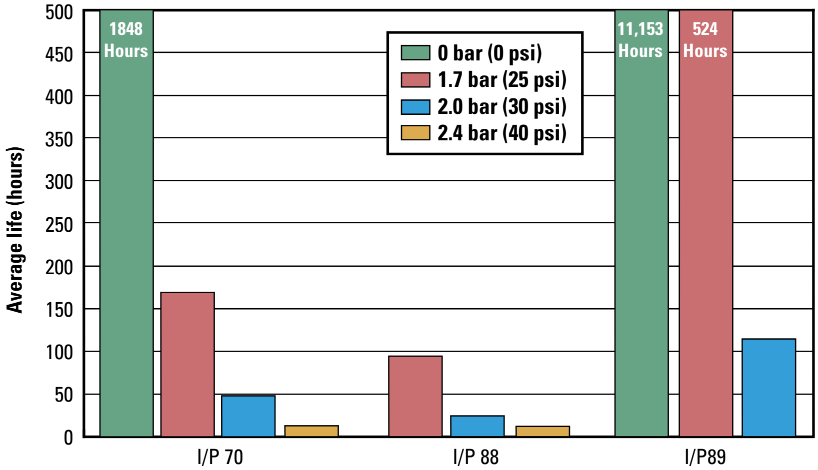
Peroxide-Cured Silicone in I/P® High-Performance Pump Head (77600-62)



I/P® Precision and High-Performance Precision Pump Tubing

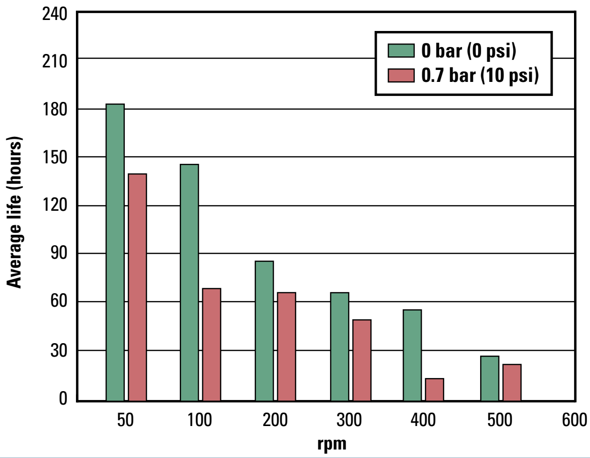
Chem-Durance® Bio in I/P® High-Performance Pump Head (77600-62)

Measured (Average) Life vs Pressure @ 100 rpm

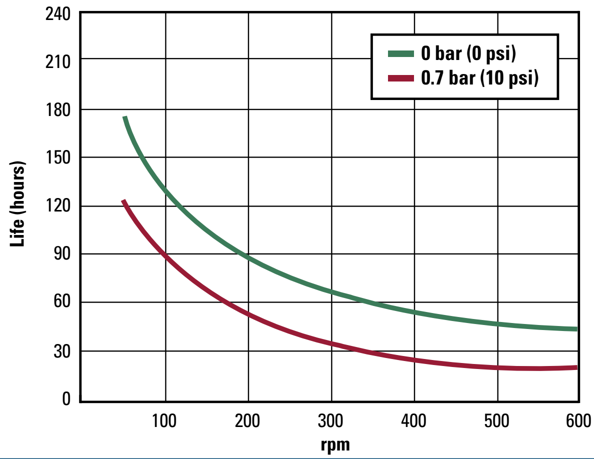


Performance Data for I/P® 73 Silicone (Peroxide-Cured) Tubing using an I/P® Standard Head (07019-series)

Measured (Average) Life vs Speed

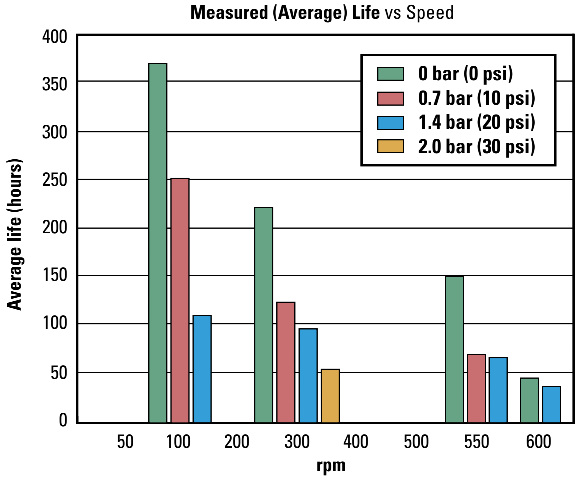


Estimated Life vs Speed

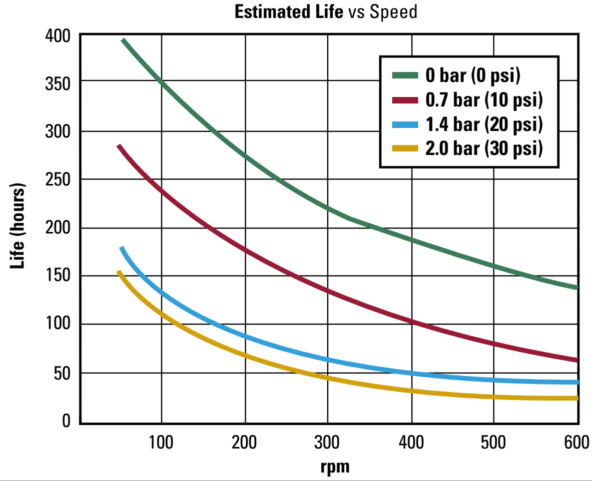


Performance Data for I/P® 73 Tygon® E-LFL Tubing using an I/P® Standard Head (07019-series)

Measured (Average) Life vs Speed



Estimated Life vs Speed



B/T® PerfectPosition™ 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. Ten 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 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.

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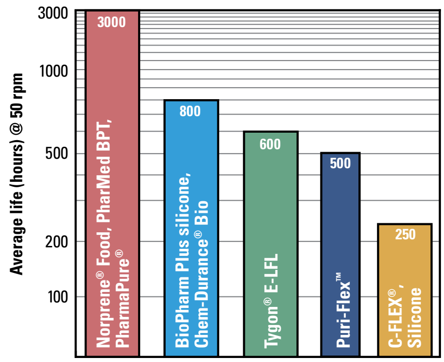
Call or go online to request your FREE test kit today!

Where to Order Tubing

Tubing Material Life Comparison



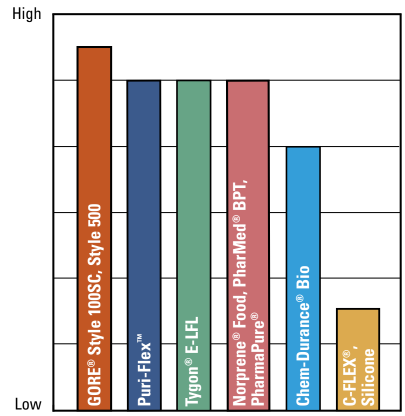
The graph above displays the average tubing life in hours of Masterflex® B/T® 91 tubing. This tubing was tested in a Masterflex® RapidLoad® pump head continuously pumping water at 21°C (70°F) and 0 psig (0 bar). Tubing life is calculated to time of failure or of 50% reduction in flow rate, whichever comes first. Reduce drive speeds to extend tubing life. Average tubing life for L/S® 16, I/P® 73, and B/T® 91 tubing at various rpm 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	—	—
Viton®	150	30	120	25	—	—

Notes

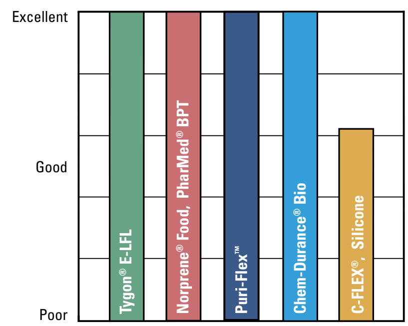
Use only Masterflex® tubing with Masterflex® pumps to ensure optimal performance. Use of other tubing may void applicable warranties.

Pressure Guidelines



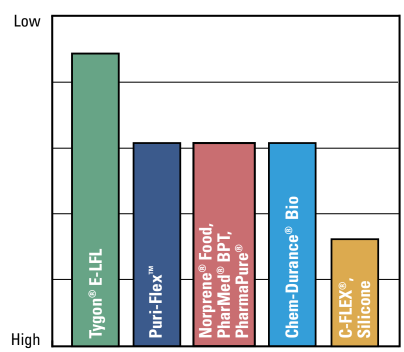
All tubing types accept pressure, but the firmer formulations accept more pressure than the softer types of tubing.

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.

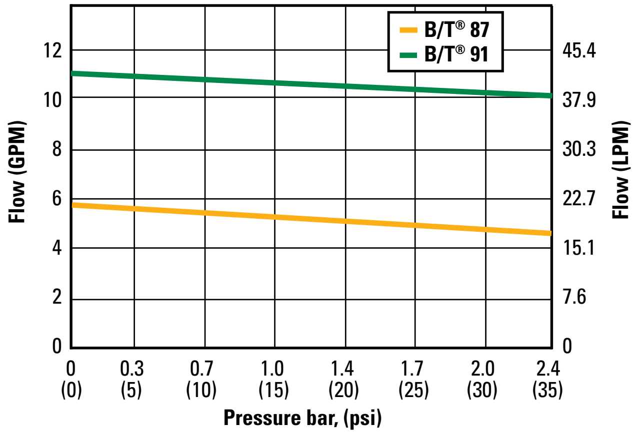
Gas Permeability



To minimize permeation of gases through the tubing wall, use firm tubing. See pages 20–23 for tubing permeability to various gases.

B/T® PerfectPosition™ Pump Tubing

Flow Performance*

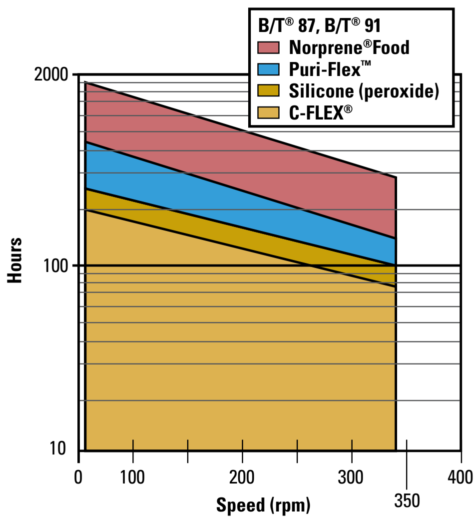


*Flow curves based on 77111- series B/T® pumps

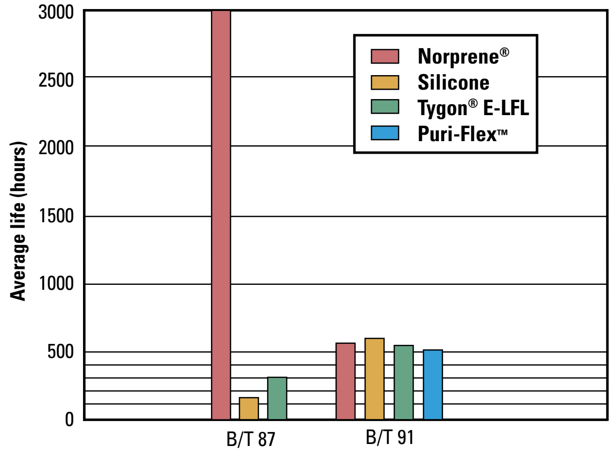
B/T® PerfectPosition™ Tubing Life Characteristics

Like the L/S® and I/P® tubing sizes, B/T® sizes B/T® 87 and B/T® 91 offer all the characteristics of the smaller size tubing styles at flow ranges up to 37 LPM (9.8 GPM). The graph below shows average tubing life while pumping water through a Rapid-Load® pump head at 21°C (70°F).

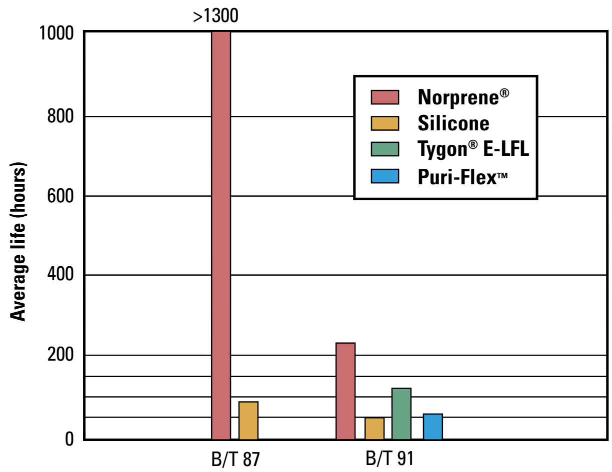
For example, using this graph it can be determined that the expected average life of Masterflex® Norprene® Food tubing at 100 rpm is over 1000 hours.



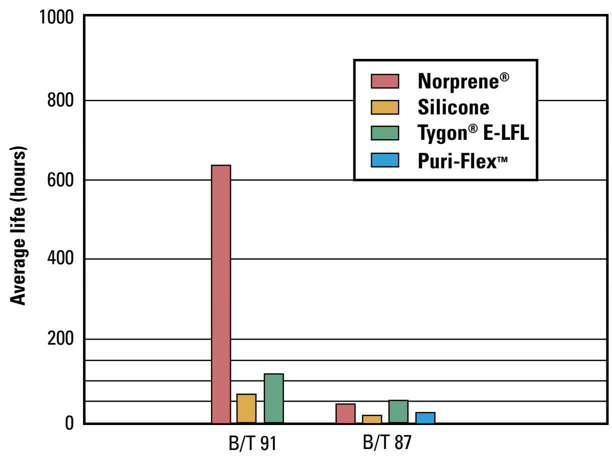
Tubing Life @ 0 bar (0 psi), 321 rpm



Tubing Life @ 0.7 bar (10 psi), 321 rpm



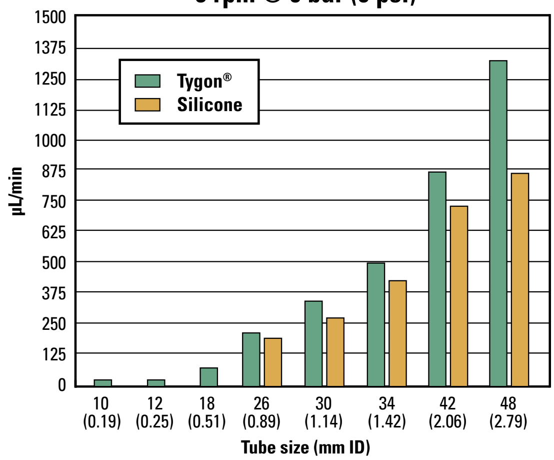
Tubing Life @ 1.4 bar (20 psi), 321 rpm



MASTERFLEX® TUBING PUMP FLOW PERFORMANCE

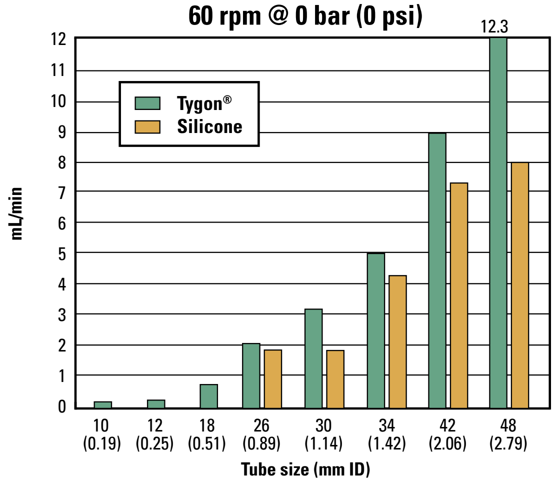
C/L® PUMP (77120-32, -52)

6 rpm @ 0 bar (0 psi)



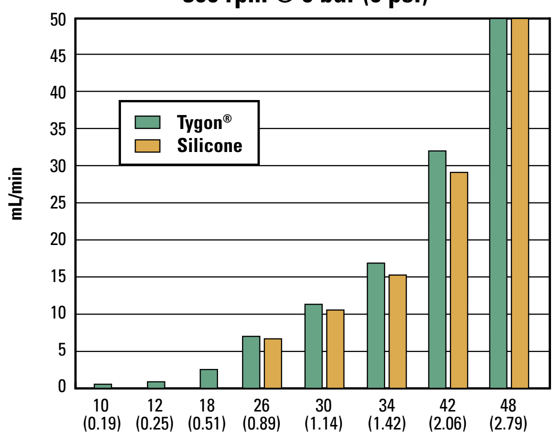
C/L® PUMP (77120-42, -62)

60 rpm @ 0 bar (0 psi)



C/L® PUMP (77122-24, -26)

300 rpm @ 0 bar (0 psi)



FLOW RATES

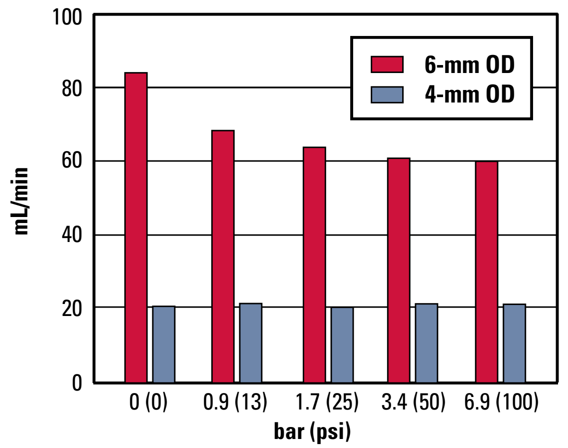
Masterflex® offers a wide range of pump systems and tubing sizes. These graphs are designed to help you select a size for your application.

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.

L/S® PTFE TUBING PUMP (77390-series)

Flow measurements taken at one hour running;
pumping water @ 21°C (70°F), 300 rpm

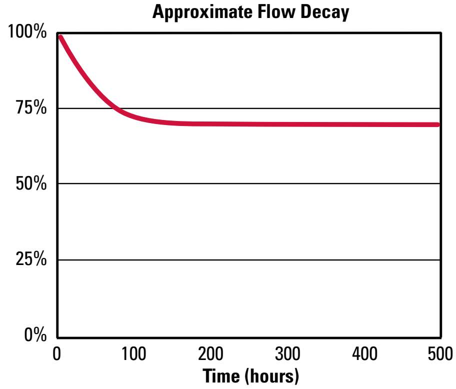


TUBING MEAN TIME TO FAILURE (MTTF)

L/S® PTFE Pump 77390-00 @ 300 rpm, 0 psi

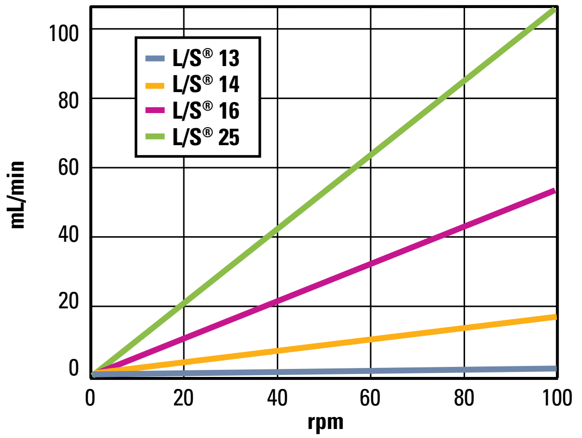
Parametric: 500 hours at 100 rpm
Catastrophic: 1500 hours at 100 rpm

Approximate Flow Decay

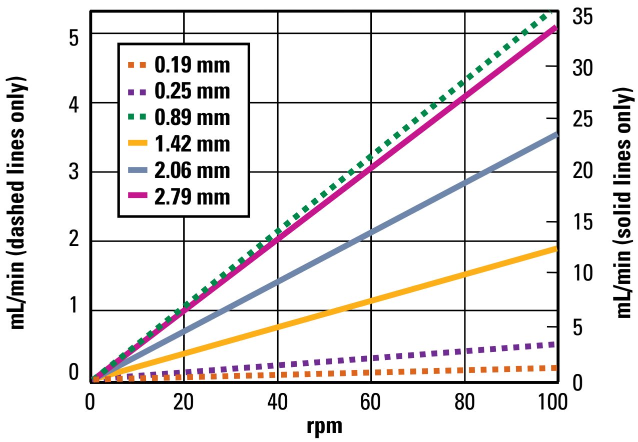


Masterflex® Tubing Pump Flow Performance

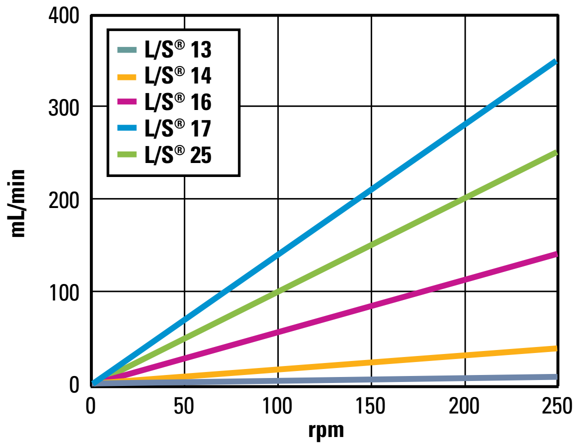
L/S® Compact Tubing Pump
(77240-series)



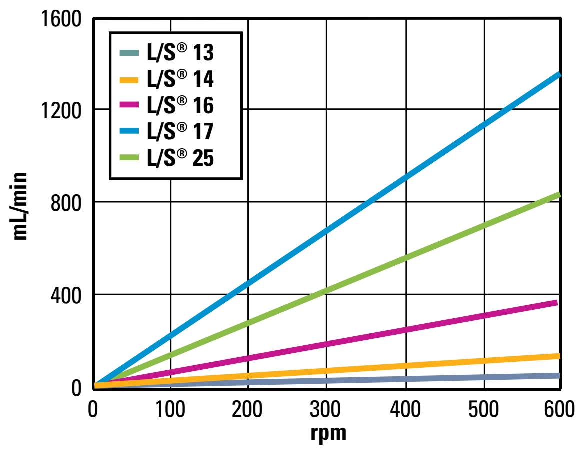
L/S® Multichannel (07534-series) with Microbore Tubing



L/S® Cartridge Pump Head
(07519-series) 6-roller

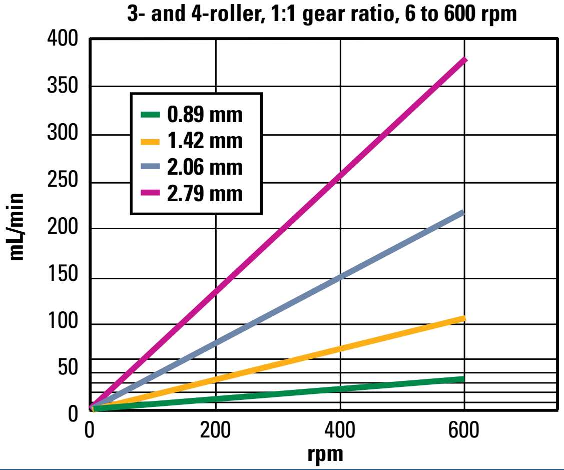


L/S® Cartridge Pump Head
(07519-series) 4-roller



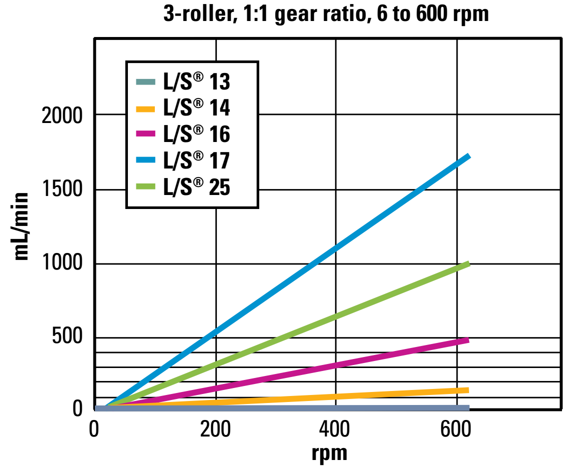
L/S® Cartridge Pump Head (07519-series) with Microbore Tubing

3- and 4-roller, 1:1 gear ratio, 6 to 600 rpm



L/S® Cartridge Pump Head
(07519-series)

3-roller, 1:1 gear ratio, 6 to 600 rpm



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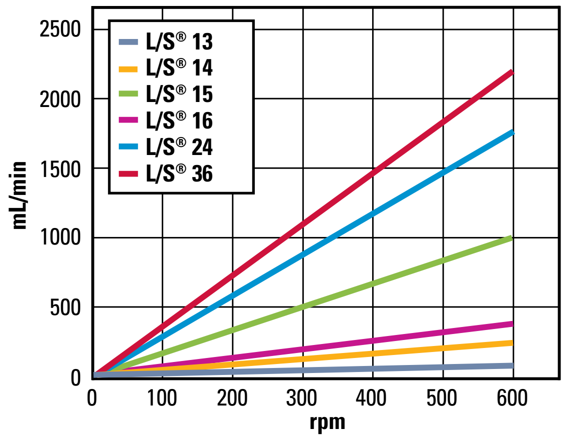
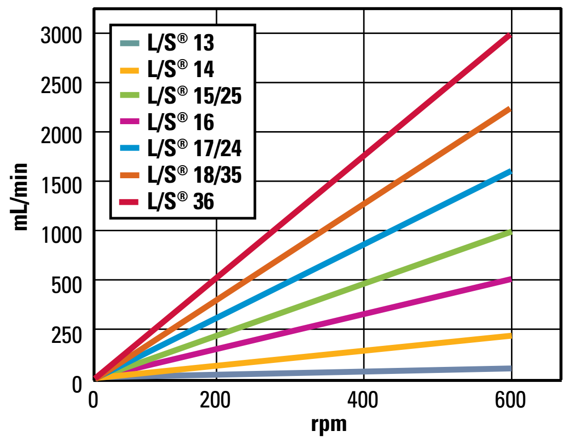
Canada 800-363-5900 • India 91-22-6139-4444 • UK 0500-345-300

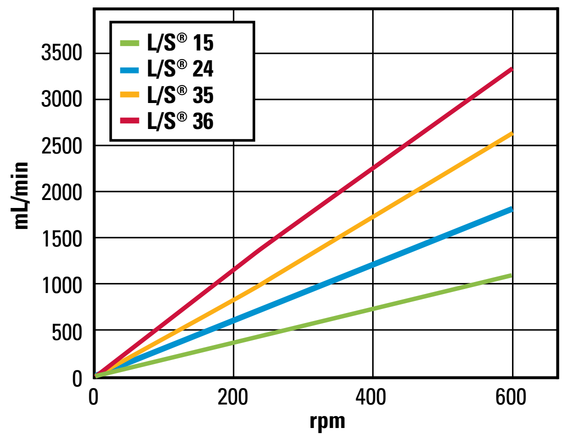
L/S® Multichannel
(07535-, 07536-series)



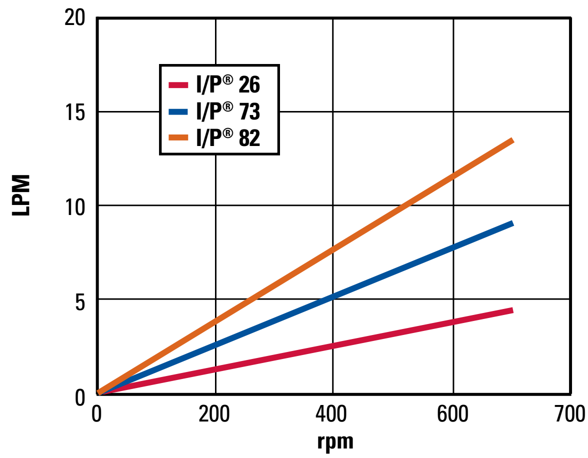
L/S® Standard (070XX-series), Easy-Load® (07518-series), Easy-Load® II (77200-, 77201-series), and Easy-Load® 3 (77800-series)



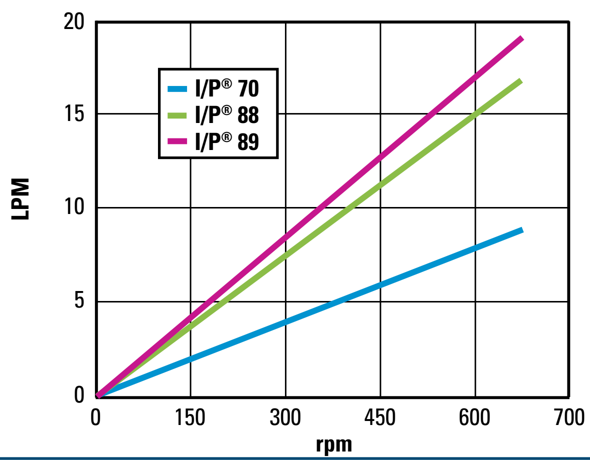
L/S® High-Performance Pump Head
(77250-62, -82)



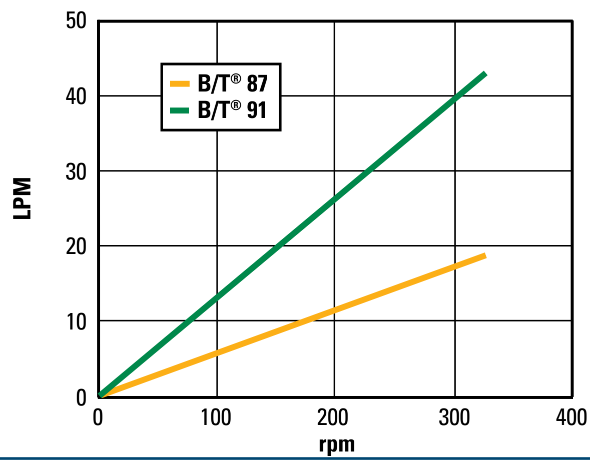
I/P® Standard (07019-series) and Easy-Load® (77601-series)



I/P® High-Performance Pump Head
(77600-62, -82)



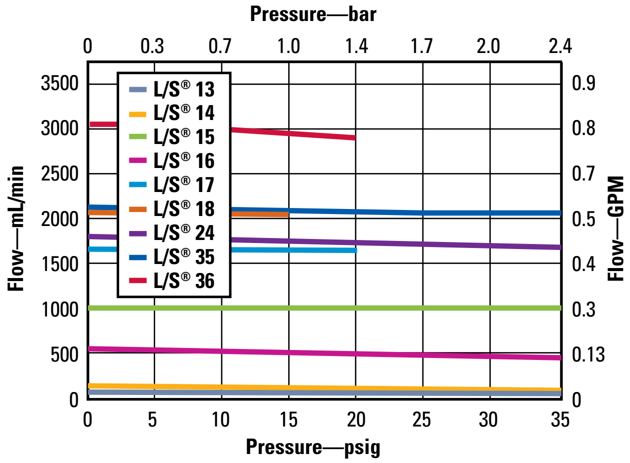
B/T® Pump Head
(77111-series)



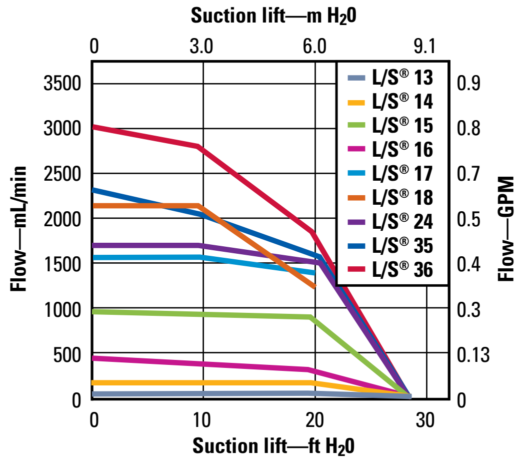
PUMP HEAD FLOW CURVES

L/S® STANDARD PUMP HEAD

Flow vs Pressure

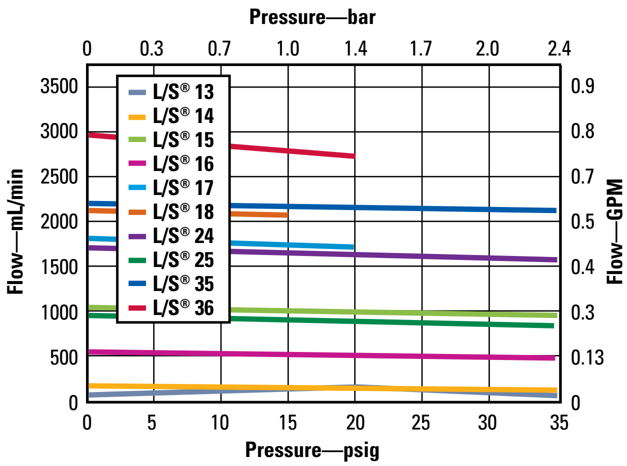


Flow vs Suction Lift

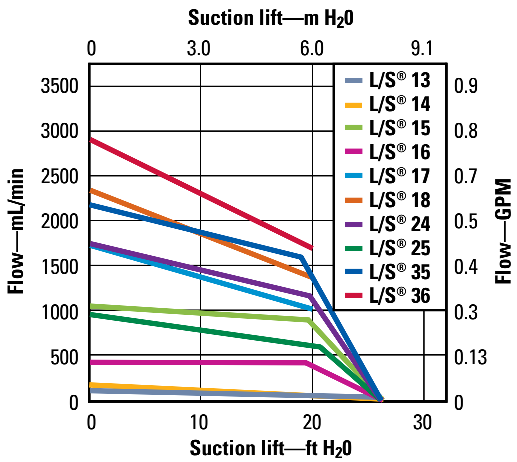


L/S® EASY-LOAD®, EASY-LOAD® II, AND EASY-LOAD® 3 PUMP HEAD

Flow vs Pressure

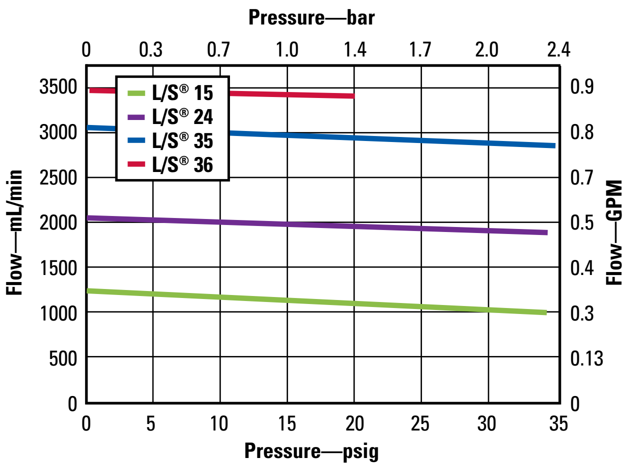


Flow vs Suction Lift

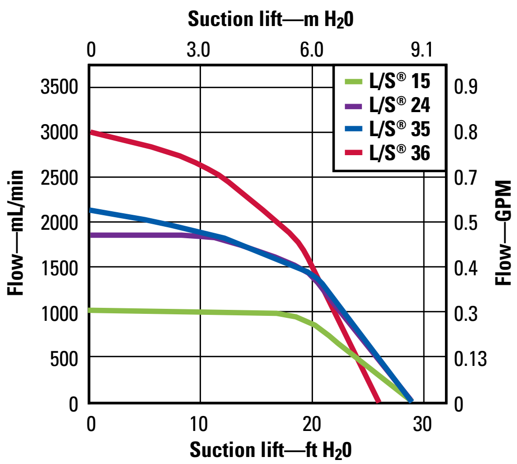


L/S® HIGH-PERFORMANCE PUMP HEAD

Flow vs Pressure



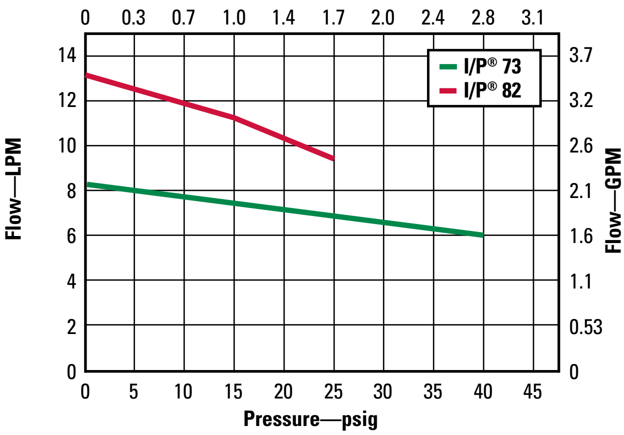
Flow vs Suction Lift



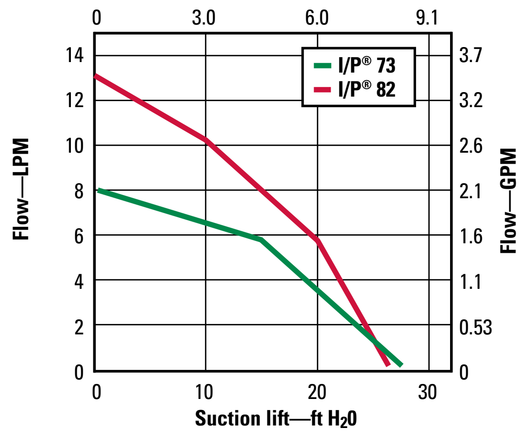
Note: Pressure curves developed with zero to one foot suction lift. Suction lift curves developed with zero discharge pressure. Pump speed: 650 rpm. Fluid: water at ambient temperature.

I/P® Standard Pump Head

Flow vs Pressure

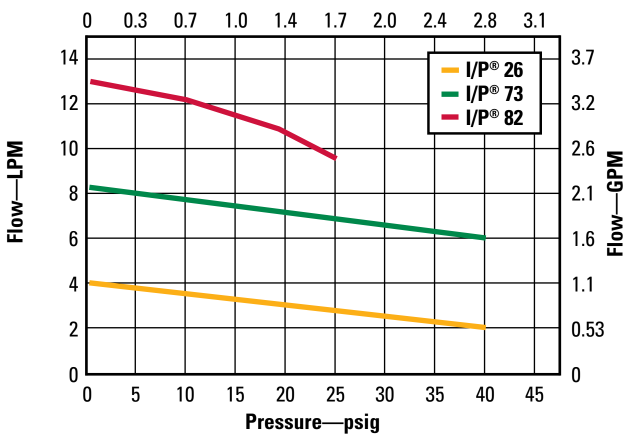


Flow vs Suction Lift

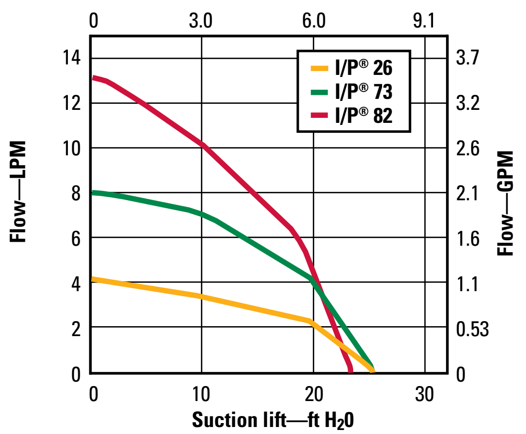


I/P® Easy-Load® Pump Head

Flow vs Pressure

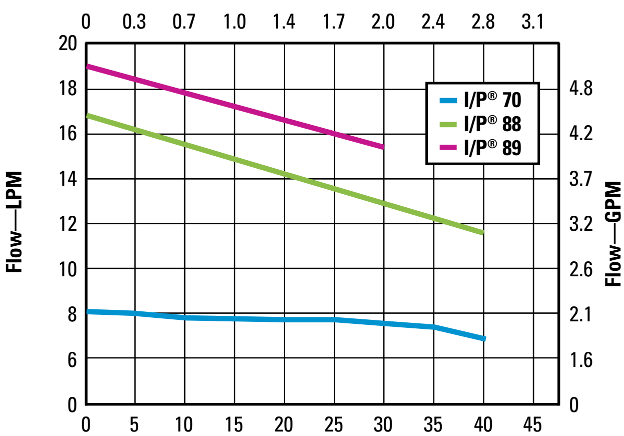


Flow vs Suction Lift

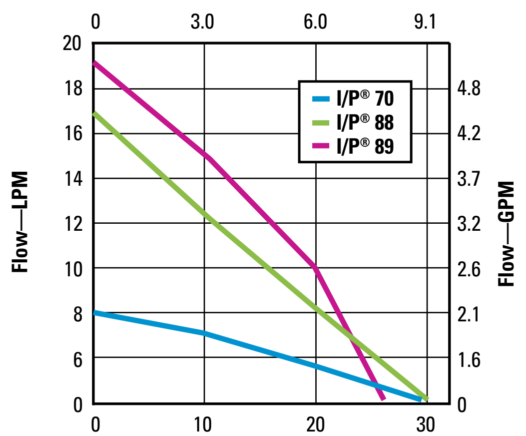


I/P® High-Performance Pump Head

Flow vs Pressure

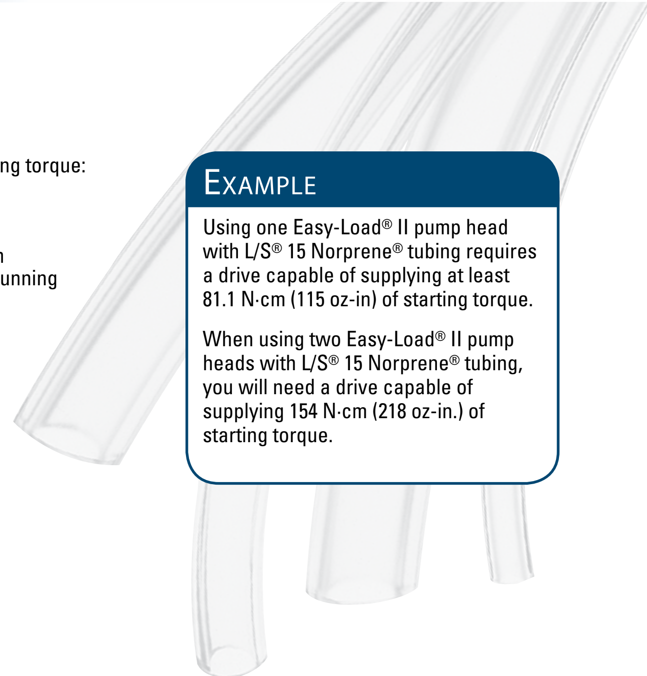


Flow vs Suction Lift



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
L/S® Precision pump tubing																						
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
L/S® High-performance Precision pump tubing																						
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
I/P® Precision pump tubing																						
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
L/S® Precision pump tubing																						
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
L/S® High-performance Precision pump tubing																						
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
I/P® Precision pump tubing																						
I/P 26	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

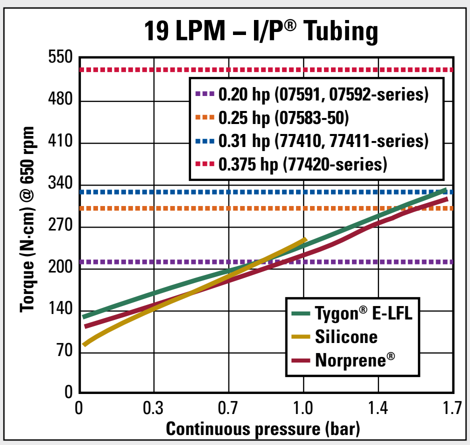
Tubing size	C-FLEX® / Silicone		BioPharm Plus silicone		Viton®		Tygon® E-Lab		Tygon® E-LFL		Tygon® E-Food / Tygon® Fuel & Lubricant		Tygon® Chemical		Chem-Durance® Bio		Norprene® / Puri-Flex™ / PharMed® BPT / C-Flex® ULTRA		PharmaPure®		GORE® Style 100SC	
	N·cm	oz-in	N·cm	oz-in	N·cm	oz-in	N·cm	oz-in	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
L/S® High-pressure pump tubing																						
L/S 15HP†	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	496.7	704	NA	NA	NA	NA
L/S® High-performance Precision pump tubing																						
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
I/P® High-performance Precision pump tubing																						
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)	0 bar (0 psi)	3.5 bar (50 psi)
Start	56.8 N·cm (80 oz-in)	—	127.4 N·cm (180 oz-in)	—
Average	21.2 N·cm (30 oz-in)	28.2 N·cm (40 oz-in)	24.5 N·cm (35 oz-in)	52.9 N·cm (75 oz-in)
Peak	31.8 N·cm (45 oz-in)	53.8 N·cm (75 oz-in)	63.5 N·cm (90 oz-in)	123.8 N·cm (175 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 ±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

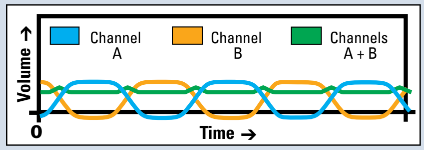
Multichannel heads are a second option for multiple channel applications. These heads combine many of the best features of both cartridge heads and stacked single-channel heads.

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.

FREE Technical Applications Assistance

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For answers, call our 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 ±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

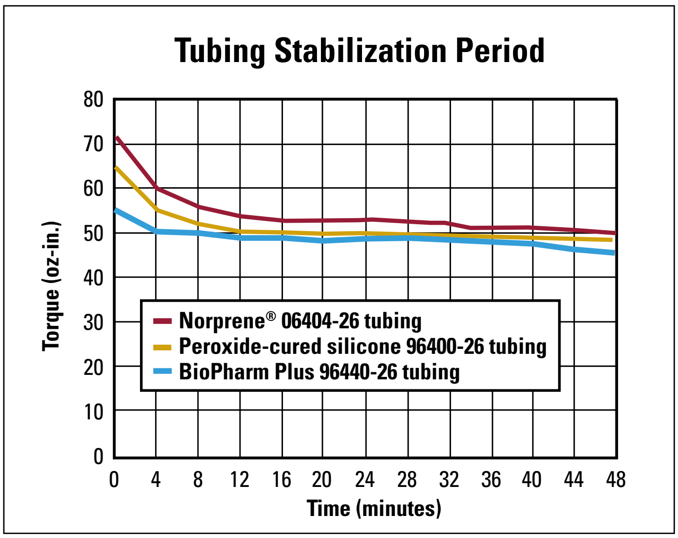
Size your tubing so that you are operating at the middle of the tubing's flow range (volume per unit time). This will give you maximum flexibility to make adjustments without approaching either the upper or lower limit of the tubing flow range.

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

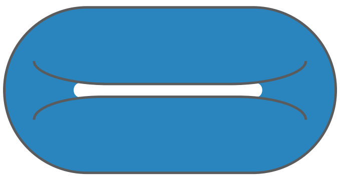
Masterflex® tubing pumps are well suited for pumping abrasive slurries for several reasons. The peristaltic pumping action is gentle on the fluid, reducing tubing wear. The only part of the pump the fluid comes in contact with is a smooth piece of tubing; there are no fittings or valves that particles 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.

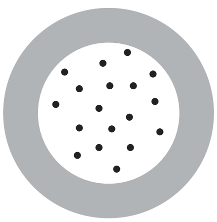
FIGURE A

Fully occluded tubing

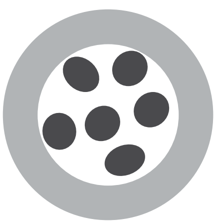


Partially occluded tubing

FIGURE B



Hard particle size should be 5% of tubing ID



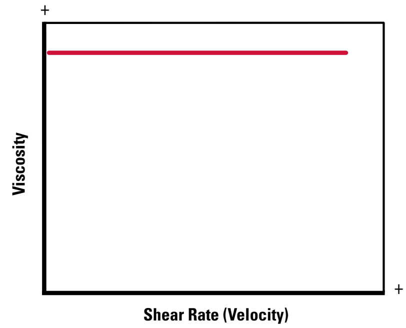
Soft particle size should be 25% of tubing ID

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.

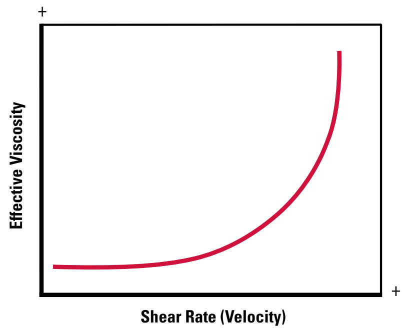
Newtonian fluids

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.



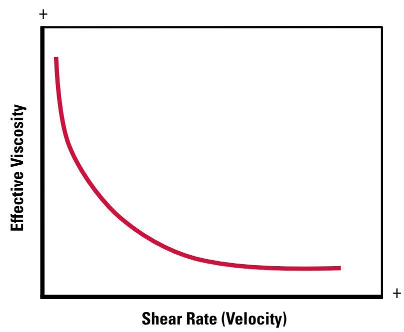
Dilatant fluids

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.



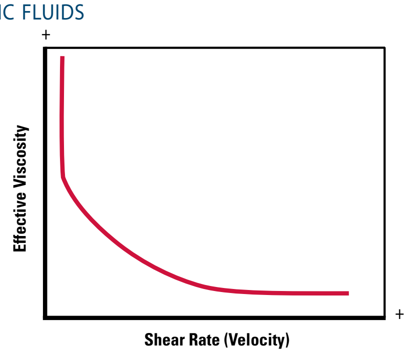
Thixotropic fluids

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:

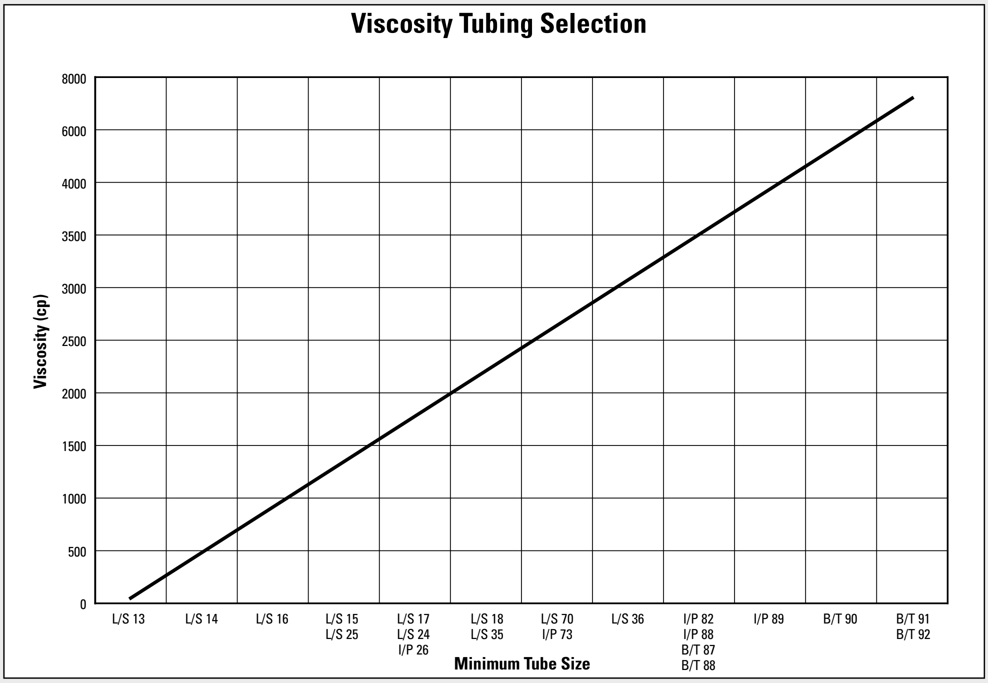
1. Slow down the speed of your pump. Increasing the speed beyond a certain point will not have any effect on flow rate. The maximum efficient speed of the pump decreases as viscosity increases and tubing size decreases.
2. Choose a larger size tubing than required to pump water. The table below will 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 or 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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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.

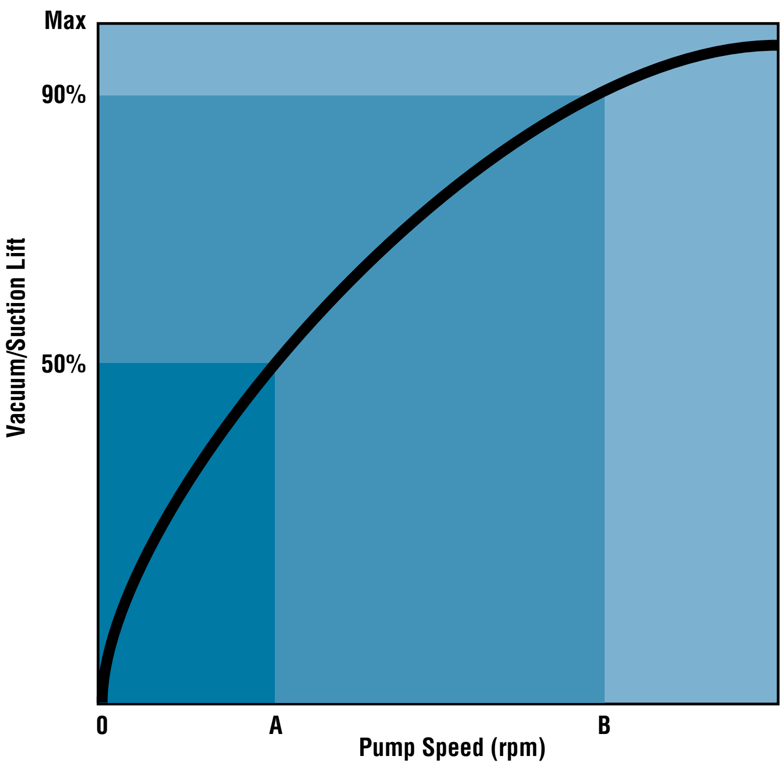
Our solution: We recommended L/S® 24 high-performance precision (thicker-walled) platinum-cured silicone tubing. Silicone is the only tubing that can be used more than once. The rapid-drying glue can actually be stored in the silicone tubing for several days if the outlet of the tubing is closed.

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.

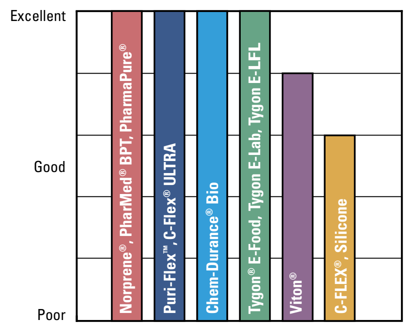
Masterflex® Vacuum/Suction Lift Data

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_2O 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.

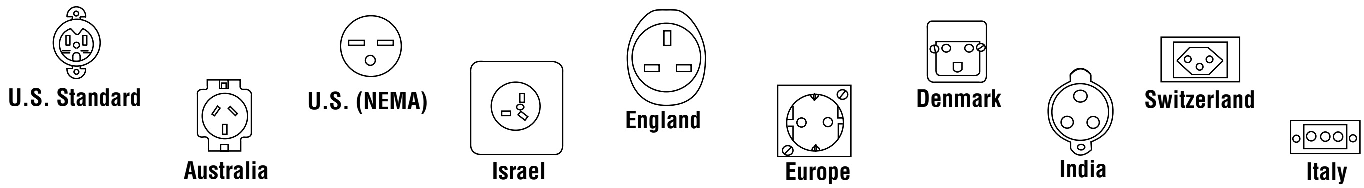
Vacuum/Suction Lift Specifications

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_2O	Pump speed (rpm)		Max vac. mm (in.) Hg	Suction m (ft) H_2O	Pump speed (rpm)		Max vac. mm (in.) Hg	Suction m (ft) H_2O	Pump speed (rpm)		Max vac. mm (in.) Hg	Suction m (ft) H_2O	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	—	—	—	—

Electrical Data / Regulatory Agencies and Approvals

Receptacle Information



Regulatory Agencies and Approvals

3-A: 3-A Sanitary Standards, Inc. (3A SSI) has developed standards and practices for sanitary and hygienic equipment and systems used in the dairy, food processing, and pharmaceutical industries. Products carrying the 3-A designation adhere to standards governing the design, fabrication, installation and operation of equipment and machinery.

ASCII: American Standard Code for Information Interchange is a method of encoding characters into 7 or 8 binary bits (typically 7 bits plus an 8th bit for parity).

ANSI: The American National Standards Institute is a private organization that coordinates the creation of voluntary standards in a number of fields including engineering, electronics, and construction.

ASTM: The American Society for Testing and Materials is a scientific and technical organization that develops material standards and testing methods.

DIN: The Deutsche Industrie Normen is a German organization that develops standards from physical quantities engineering to material engineering.

ISO 9000 series: The ISO 9000 series of process standards and guidelines address issues concerning product quality. The standards guide manufacturers on the development, production, installation, and inspection of products to ensure consistent quality. Manufacturers must pass a rigorous audit to achieve certification/registration.

FDA: Food & Drug Administration is responsible for approving food and drugs for widespread use. Definitions for proper use are found in a series of regulations published annually under Government Regulations CFR 21.

FM: FM Global (formerly Factory Mutual) is an international leader in third-party testing, certification, and approval of commercial and industrial products. Product types include electrical, fire protection, fire detection, and hazardous location equipment. FM approval indicates conformance to relevant national and international standards.

NEMA: The National Electrical Manufacturers Association is a trade association of electrical equipment manufacturers that develops and publishes many manufacturing standards.

NIST: The National Institute of Standards and Technology is a U.S. government agency that provides standard reference materials and calibration services. NIST-certified instruments have been calibrated at NIST or through an official NIST program or collaboration. NIST-traceable instruments have been factory or lab calibrated, by a non-NIST or non-official NIST program/collaboration, where an **unbroken chain of comparisons to stated references** has been established. Non-NIST or non-official NIST programs/collaborations are responsible for establishing the traceability of their own results or values to those of NIST or other stated references.

NSF: The National Sanitation Foundation is a nongovernment agency focused on health-related standards for products and services. Certification indicates products suited for applications such as food handling/processing, plumbing, and water distribution.

NTEP: National Type Evaluation Program (NTEP) is an evaluation program administered by the National Conference on Weights and Measures (NCWM). Weighing and measuring devices are examined by NTEP to verify that operating characteristics and features comply with the applicable requirements of NIST Handbook 44, *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices.*

OEM: Products used by Original Equipment Manufacturers in the design of equipment.

OSHA: The Occupational Safety and Health Administration oversees and regulates workplace health and safety.

REACH: a European Community Regulation on chemicals and their safe use (EC 1907/2006). It deals with the Registration, Evaluation, Authorization and Restriction of Chemical substances.

RoHS: The Restriction of Hazardous Substances directive aims to restrict certain dangerous substances commonly used in electrical and electronic equipment.

UL: Underwriters Laboratories, Inc. is concerned with safety of personnel and property. UL listing indicates compliance with UL safety standards for electrical, mechanical, and fire hazards.

USP Class VI: Safety evaluation standards of the U.S. Pharmacopoeia/National Formulary for biocompatibility with plastics.

The icons below represent agencies that give various product approvals. Look for them next to products in this catalog.

Products with this symbol meet ISO quality standards for design, development, and servicing capabilities. ISO9001:2008 CERTIFIED SUPPLIER

Products with this symbol are listed by Underwriters Laboratories, Inc. Samples of these products have been evaluated by UL and meet the applicable UL standards for safety.

Products with this symbol bear the UL Listing Mark for Canada.

Products with this symbol bear the UL Listing Mark for Canada and the U.S.

Products with this symbol are recognized under the Recognized Component Program of Underwriters Laboratories, Inc.

Products with this symbol are listed by ETL Testing Laboratories, Inc. and meet applicable safety standards within the U.S. and Canada.

This symbol assures you that the product meets certain safety standards and/or performance criteria as set by the Canadian Standards Association.

Products with this symbol conform to certain standards and are eligible to be placed on the market in the European Community.

Products with this symbol have been certified to Cenelec (European Electrotechnical Standardization) and/or IEC (International Electrotechnical Commission) for use in hazardous areas.

Products with this symbol conform to ATEX Directive 94/9/EC—a European directive applied to equipment intended for use in potentially explosive atmospheres. ATEX

Products with this mark meet certain requirements as reported by FM Global. FM APPROVED

Products with this symbol have been tested and certified by NSF International. NSF is a nongovernmental agency that focuses on health-related standards for products and services.

Products with this symbol have been approved for use with dairy products. It is recognized and used by industries that require sanitary products.

Products with this symbol meet specific standards related to official EPA test protocols.

Products with this symbol meet specific standards of the American Water Works Association; applicable to equipment used in the delivery, treatment, and testing of drinking water. American Water Works Association

Products with this symbol measure temperatures based on the ITS-90 temperature scale.

Products with this symbol comply with standards of the National Type Evaluation Program applicable to the performance characteristics of weighing and measuring devices.

Enclosure Ratings / Standard Pipe Thread Fittings

Ingress Protection (IP) Ratings

The IP rating system classifies the degrees of protection from solid objects and liquids afforded by electrical equipment and enclosures. The system is recognized in most countries and is set out in a number of British and European standards. These include: Classification of Degrees of Protection Provided by Enclosures, BS (British Standards) 5490:1977; IEC (International Electrotechnical Commission) 529:1976.

Specifications for Degrees of Protection of Enclosures of Switchgear and Control Gear for voltages up to and including 1000 VAC and 1200 VDC, BS 5420:1977; and IEC 144:1963.

First Digit

Protection against solid objects

0 no protection

1 protected against solid objects over 50 mm (e.g. accidental touch by hands)

2 protected against solid objects over 12 mm (e.g. fingers)

3 protected against solid objects over 2.5 mm (tools)

4 protected against solid objects over 1 mm (fine tools/wires)

5 protected against dust—limited ingress (no harmful deposits)

6 totally protected against dust

Second Digit

Protection against liquids

0 no protection

1 protected against vertically falling drops of water (e.g. condensation)

2 protected against direct sprays of water up to 15° from the vertical

3 protected against spraying water up to 60° from the vertical

4 protected against water sprayed from all directions—limited ingress permitted

5 protected against low-pressure jets of water from all directions—limited ingress permitted

6 protected against strong jets of water from all directions—limited ingress permitted (e.g. for use on ship decks)

7 protected against the effects of immersion between 15 cm and 1 m

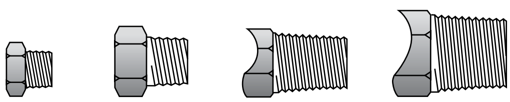
NEMA/IEC Enclosure Ratings

Conversion of NEMA type classifications to IEC classification designation (IP ratings).
Note: NEMA standards meet or exceed IEC standards; therefore, the conversion does not work in the opposite direction.

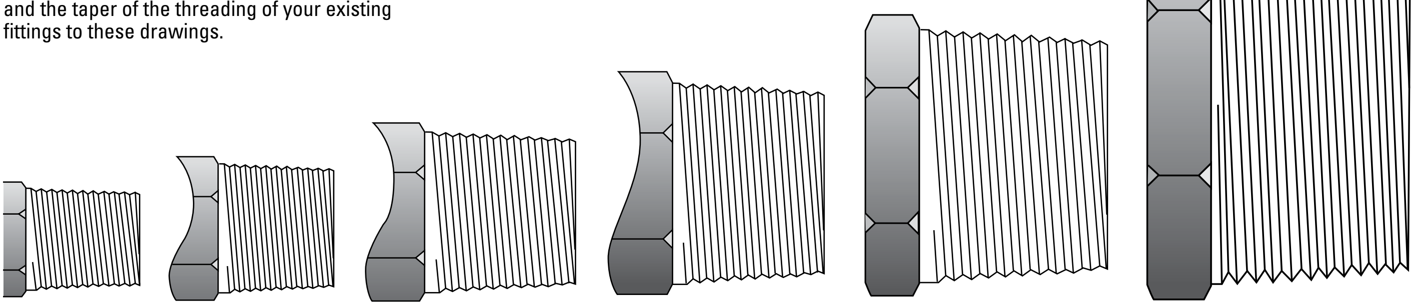
NEMA enclosure type no.	NEMA definition	IEC enclosure class
1	General-purpose. Protects against dust, light, and indirect splashing but is not dust-tight; primarily prevents contact with live parts; used indoors and under normal atmospheric conditions.	IP10
2	Drip-tight. Similar to Type 1 but with addition of drip shields; used where condensation may be severe (as in cooling rooms and laundries).	IP11
3 and 3S	Weather-resistant. Protects against weather hazards such as rain and sleet; used outdoors on ship docks, in construction work, and in tunnels and subways.	IP54
3R	Intended for outdoor use. Provides a degree of protection against falling rain and ice formation. Meets rod entry, rain, external icing, and rust-resistance design tests.	IP14
4 and 4X	Watertight (weatherproof). Must exclude at least 65 GPM of water from 1-in. nozzle delivered from a distance not less than 10 ft for 5 minutes. Used outdoors on ship docks, in dairies, and in breweries.	IP56
5	Dust-tight. Provided with gaskets or equivalent to exclude dust; used in steel mills and cement plants.	IP52
6 and 6P	Submersible. Design depends on specified conditions of pressure and time; submersible in water; used in quarries, mines, and manholes.	IP67
7	Hazardous. For indoor use in Class I, Groups A, B, C, and D environments as defined in the NEC.	—
8	Hazardous. For indoor and outdoor use in locations classified as Class I, Groups A, B, C, and D as defined in the NEC.	—
9	Hazardous. For indoor and outdoor use in locations classified as Class II, Groups E, F, or G as defined in the NEC.	—
10	MSHA. Meets the requirements of the Mine Safety and Health Administration, 30 CFR Part 18 (1978).	—
11	General-purpose. Protects against the corrosive effects of liquids and gases. Meets drip and corrosion-resistance tests.	—
12 and 12K	General-purpose. Intended for indoor use, provides some protection against dust, falling dirt, and dripping noncorrosive liquids. Meets drip, dust, and rust resistance tests.	IP52
13	General-purpose. Primarily used to provide protection against dust, spraying of water, oil, and noncorrosive coolants. Meets oil exclusion and rust resistance design tests.	IP54

Standard Pipe Thread Fittings

The illustrations are actual size. If you have any question as to the size of fitting you require, simply compare the threads per inch, the diameter and length of the threading, and the taper of the threading of your existing fittings to these drawings.



10- 32 UNF **¼"- 28 UNF** **1⁄16"- NPT(M)** **⅛" NPT(M)**



¼" NPT(M) **⅜" NPT(M)** **½" NPT(M)** **¾" NPT(M)** **1" NPT(M)** **1½" NPT(M)**

ELECTRICAL DATA / HAZARDOUS AREA CLASSIFICATIONS

ATEX DIRECTIVE 94/9/EC

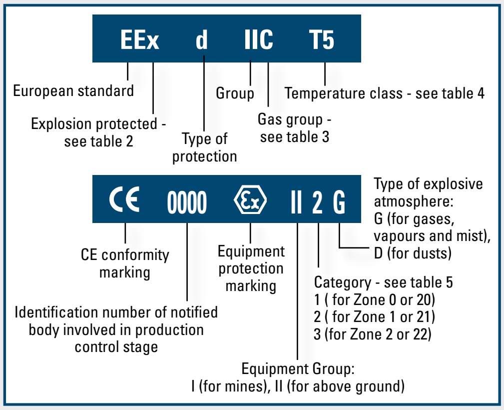
Since 1st July 2003 the ATEX Directive 94/9/EC has required equipment and protective systems that are for use in potentially explosive atmospheres, to conform to specific safety standards. The directive is applicable to all countries within the EU.

Equipment Marking

The following is a guide only to the identification markings on ATEX marked equipment and protective systems.

Determining the suitability of ATEX marked equipment and safety systems is the responsibility of the user.

EU Directive 94/9/EC from July 1, 2003 —Table 1



Methods of Protection—Table 2

Method of protection	Marking	Protection principle
Electrical equipment for gases, vapours and mists according to CENELEC		
Flameproof enclosure	**EEx d**	Contain the explosion and prevent flame propagation
Increased safety	**EEx e**	No arcs, sparks, or hot surfaces
Nonsparking	**EEx n**	No arcs, sparks, or hot surfaces
Intrinsic safety	**EEx i**	Limit the energy of the spark and surface temperature
Oil immersion	**EEx o**	Keep the ignition source constantly immersed in oil
Pressurised enclosure	**EEx p**	A protective gas contains the ignition source
Sand filling	**EEx q**	Fine ground filling surrounds the ignition source and therefore, an arc from inside of the housing cannot ignite the surrounding combustible atmosphere

Classification of Gases and Dusts per CENELEC/IEC—Table 3

Gas group	Temperature class					
	T1	**T2**	**T3**	**T4**	**T5**	**T6**
I	Methane	—	—	—	—	—
IIA	Acetone Methane Ethane Propane	Ethyl alcohol Cyclohexane *n*-butane *n*-butyl alcohol	Diesel fuel Aircraft fuel Fuel oil n-hexane Heptane	Acetaldehyde	—	—
IIB	Coal (lighting) gas Acrylonitrile	Ethylene Ethylene oxide	Ethylene glycol Hydrogen sulphide	Ethyl methyl ether	—	—
IIC	Hydrogen	Ethine (Acetylene)	—	—	—	Carbon disulphide

Temperature Classification—Table 4

CENELEC/IEC (Group II) Class	Max surface temperature	Comments
T1	450°C (842°F)	Temperature relates to all parts of equipment that can come into contact with the potentially explosive atmosphere
T2	300°C (572°F)	
T3	200°C (392°F)	
T4	135°C (275°F)	
T5	100°C (212°F)	
T6	85°C (185°F)	
Tx	Maximum surface temperature not defined	Assessment of equipment temperature class is the responsibility of the user

Example equipment marking:

CE Ex II 2 G EEx d IIC T5

ATEX Category 2 (gas) equipment designated for installation in Zone 1. Protection by flameproof enclosure, suitable for hydrogen atmosphere with maximum equipment surface temperature of 100°C.

Equipment Groups I and II: Categories M1, M2, 1, 2, and 3—Table 5

Group I Mines: methane and/or combustible dusts		**Group II** Above ground: potentially explosive atmospheres or gas/air or dust/air mixtures, mist or vapours					
Category M		**Category 1**		**Category 2**		**Category 3**	
1	**2**	**G** (Gas) (Zone 0)	**D** (Dust) (Zone 20)	**G** (Gas) (Zone 1)	**D** (Dust) (Zone 21)	**G** (Gas) (Zone 2)	**D** (Dust) (Zone 22)
Equipment which guarantees a very high degree of safety. Operation guaranteed in case of errors.	Equipment which guarantees a very high degree of safety. Switching off possible if potentially explosive atmosphere occurs.	For equipment which guarantees a very high degree of safety. Intended for cases where potentially explosive atmospheres are often or constantly to be expected.		For equipment which guarantees a high degree of safety. Intended for cases where a potentially explosive atmosphere is to be expected.		For equipment which guarantees a standard degree of safety. Intended for cases where a potentially explosive atmosphere can be expected only rarely, and then, only for a short time.	
Very high protection level	High protection level	Very high protection level		High protection level		Normal	

National Electrical Code (NEC) Hazardous Area Classifications

CLASS I: Areas where flammable gases or vapors may be present in the air in sufficient quantities to be explosive

Group A: Atmospheres containing acetylene

Group B: Atmospheres such as butadiene, ethylene oxide, propylene oxide, acrolein, or hydrogen (or gases or vapors equivalent in hazard to hydrogen, such as manufactured gas)

Group C: Atmospheres such as cyclopropane, ethyl ether, or ethylene (or gas or vapors of equivalent hazard)

Group D: Atmospheres such as acetone, alcohol, ammonia, benzene, benzol, butane, gasoline, hexane, lacquer solvent vapors, naphtha, natural gas, propane, or gas or vapors of equivalent hazard

CLASS II: Areas made hazardous by the presence of combustible dust

Group E: Atmospheres containing combustible
1) metal dusts, regardless of resistivity
2) dust of similarly hazardous characteristics having a resistivity less than 100 kΩ-cm
3) electrically conductive dusts

Group F: Atmospheres containing combustible
1) carbon black, charcoal, or coke dusts having more than 8% total volatile material
2) dusts so sensitized that they present an explosion hazard, and dusts having a resistivity greater than 100 Ω-cm but less than or equal to 1 x 10^8 Ω-cm

Group G: Atmospheres containing combustible
1) dust having resistivity equal to or greater than 100 kΩ-cm
2) electrically nonconductive dusts

CLASS III: Areas made hazardous by the presence of easily ignitable fibers or dust, but which are not likely to be suspended in the air in sufficient quantities to ignite

Division 1: Atmospheres where hazardous concentrations exist continuously, intermittently, or periodically under normal operating conditions

Division 2: Atmospheres where hazardous concentrations exist only in case of accidental rupture or breakdown of equipment

EXPLOSION-PROOF: Enclosures or housings are designed to withstand internal explosions and prevent the spread of fire to the outside.

INTRINSICALLY SAFE: Systems in which electrical energy in the circuits is not present at levels that would ignite a flammable mixture of a gas and air.

GLOSSARY

Accuracy: The degree of precision. Usually expressed, in terms of error, as a percentage of the specified value, or as a percentage of a range.

A/D: Analog-to-digital conversion. The process changes an analog signal into a digital value representative of the magnitude of the signal at the moment of conversion.

Absolute pressure (psia): The total force per unit area exerted by a fluid. It is the sum of atmospheric and gauge pressures.

Alternating current (AC): Current that reverses polarity at a uniform frequency.

Atmospheric pressure: The force exerted per unit area by the weight ofthe atmosphere.

Automatic temperature compensation (ATC): meters with ATC receive a continuous signal from a temperature sensor in a solution and then automatically standardize the displayed value to 25°C.

Baud rate: A unit of measure for data transmission speed. It represents the number of signal elements (typically bits) transmitted per second. Typical baud rates are 600, 1200, 2400, 4800, 9600, 19.2K, 35.4K, and 115.2K.

Buffer: In chemistry terms, a solution that maintains a set pH value regardless of added acids or bases; often used for calibration. In computer terms, a device used to store data temporarily, normally to compensate for differences in speed between system components (for example, a high-speed data acquisition board and main memory).

Byte: Eight related bits of information processed as a unit. Eight bits equal one byte.

Cavitation: Process in which small bubbles are formed and implode violently. This results in aggressive cleaning action in ultrasonic cleaners.

Contacts: Elements used to mechanically make or break an electric circuit.

Continuous duty: A device able to operate continuously with no off or rest periods.

Convection: Transmission of energy or mass in a medium by movement of the medium itself.

Density: The mass of a given substance per unit volume, often expressed as pounds/ft^3 or grams/cm^3.

Direct current (DC): A current with a constant polarity.

Double-pole, double-throw (DPDT): A term used to describe a switch or relay output contact form (form C). Two separate switches that operate simultaneously, each with a normally open and normally closed contact and a common connection.

Explosion-proof (XPRF) motor: A totally enclosed motor that will withstand an explosion of a specific vapor or gas within its housing, or will prevent sparks or flashes generated within its housing from igniting surrounding vapor or gas.

Factory calibration: The tuning or altering of a control device by the manufacturer to bring it into specification.

Gain: Ratio of output voltage, current, or power to input voltage, current, or power.

Gauge pressure (psig): A measure of the force per area exerted by a fluid using atmospheric pressure as a zero reference.

Impedance: The opposition in an electric circuit to the flow of an alternating current. It consists of ohmic resistance, inductive reactance, and capacitive reactance.

Inductive load: Electrical devices made of wound or coiled wire. Current passing through the coil creates a magnetic field that in turn produces mechanical work.

Intrinsically safe motor: A motor designed to prevent sparks generated within its housing from igniting surrounding vapor or gas, but is not rated "explosion-proof."

Ion-selective electrode (ISE): An electrode that is sensitive to specific ions in a solution.

LIMS (Laboratory Information Management System): A system that manages operations of a testing laboratory.

Linearity: The degree to which performance or response approaches the condition of being linear. Expressed in percent.

Normally closed (NC): A switch in which the contacts are closed (contacting) without any external force acting upon it.

Normally open (NO): A switch in which the contacts are open (separated) when no external forces act upon the switch.

On/off control: A simple control system in which the device being controlled is either full on or full off, with no intermediate operating positions.

Open drip-proof (ODP) motor: An open motor with ventilator openings that prevent liquids and solids, dropped from an angle of 0° to 15° from vertical, from interfering with its operation.

Parallel transmission: The transmission of data bits over different lines, usually simultaneously; as opposed to serial transmission.

pH: An indication of the acidity or alkalinity of a solution. Units range from 0 (most acidic), to 7 (neutral), to 14 (most alkaline).

PID control (proportional, integral, derivative): Control in which the control signal is a linear combination of the error signal, its integral, and its derivative.

Pressure: Force exerted per unit area.

Proportional control: Control in which the amount of corrective action is proportional to the amount of error.

Range: The limits within which a device or circuit operates or the distance over which a transmitter operates reliably.

RS-232: A standard computer interface used primarily to connect PCs and microprocessors with instruments, such as pH meters.

Serial transmission: Sending one bit at a time on a single transmission line.

Series (Universal) motor: A non-induction type motor utilized for small equipment. Speed will decrease as load increases.

Shaded-pole motor: A low-starting torque motor that depends on induced current to create the magnetic field necessary to start the motor.

Shunt: A conductor joining two points in an electrical circuit to form a parallel path. All or some portion of the current may pass through the shunt.

Single-phase motor: Any motor energized by a single alternation voltage.

Single-pole, double-throw (SPDT): A switch that in one position completes one of two circuits. In the second position the switch completes a second circuit and breaks the first circuit.

Single-pole, single-throw (SPST): A switch that will open or complete a circuit.

Solid-state: Any element that controls current without moving parts, heated filaments, or vacuum gaps.

Standard operating conditions, standard temperature and pressure (STP): Defined temperature and pressure to which all values are referenced for comparison. Generally 760 mm Hg (1 atm), 25°C.

Stop bit: A signal following a character or block that prepares the receiving device to receive the next character or block.

Temperature compensation: Correction for the influence of temperature on a measurement.

Tolerance: The maximum allowable deviation from a specified standard, as the range of variation permitted, expressed in actual values or more often as a percentage of the nominal value.

Totally enclosed (TE) motor: Motors that prevent the free flow of air from the inside of the motor enclosure to the outside.

Totally enclosed, nonventilated (TENV) motor: A motor in a totally enclosed housing that is not equipped with an external cooling device.

Totally enclosed, fan-cooled (TEFC) motor: A motor in a totally enclosed housing that is equipped with a separate external blower.

Transducer: Any device that generates an electrical signal from real-world physical measurements.

Transmitter: A device that translates the low-level output of a sensor or transducer to a higher level signal suitable for transmission to a site where it can be further processed.

Three-phase motor: A relatively inexpensive, self-starting motor (no starting winding or capacitor); can start heavy loads. The motor requires a three-phase AC power supply.

Universal Serial Bus (USB): A serial bus standard to connect devices to a host computer. Conveniences include plug-and-play and low-power transmission.

Viscosity: The resistance of a fluid to flow when subjected to shear stress.

CONVERSION FACTORS

To go from	Multiply by	To get
atm	33.89854	ft H_2O
atm	760	mm Hg
atm	1.033227	kg/cm^2
atm	14.705	psi
atm	1.01325	bar
atm	101.325	kPa
atm	101325	Pa
bar	14.50377	psi
bar	0.9869233	atm
bar	100,000	Pa
BTU	778.196	lb-ft
BTU/min	0.01757	kW
BTU/hr	0.216158	lb-ft/sec
BTU/min	0.023575	hp
cm	0.3937008	inch
cm	0.03280840	feet
cm^3	0.03381402	oz (fluid)
cm^3	0.001	liter
cc/min	1	mL/min
cc/min	0.016	GPH
deg C	(1.8 x °C) + 32	deg F
deg C	deg °C + 273.2	K
deg F	0.555 (°F – 32)	deg C
K	K – 273.2	deg C
dyne	0.00102	gm
dyne	0.000002248	lb (force)
dyne	0.00003597	oz
dyne-cm	0.00102	gm-cm
dyne-cm	0.00000007376	lb-ft
dyne-cm	0.000014	oz-in
dyne/cm^2	0.1	Pa
feet (ft)	30.48	cm
ft	0.3048	m
ft H_2O	0.4335	psi
ft H_2O	0.0295	atm
ft H_2O	0.8826	in Hg
ft^3	7.480519	gal
ft^3	0.028316847	m^3
ft^3/hr	0.4719474	LPM
ft^3/hr	471.9474	mL/min
ft^3/min	0.0283157	m^3/min
ft^3/min	28.3157	LPM
gallon (gal)	128	oz (fluid)
gal	3.785412	liter
gal	8.337	lb H_2O
gal	0.1337	ft^3
gal	230.9	in^3
gal	0.003785	m^3
gal (IMP)	1.20095	gal (US)
gal (US)	0.83267	gal (IMP)
GPH	63.1	mL/min
GPM	3.785412	LPM
GPM	0.2271247	m^3/hr

MORE online!
For additional technical data including more conversions, viscosity values, wire gauge sizes, conductivity values, electrical diagrams, and more.
Masterflex.com/TechInfo

To go from	Multiply by	To get
gram (gm)	0.002205	lb
gm	0.03527	oz (avd)
gm (force)	980.7	dyne
gm-cm	980.7	dyne-cm
gm-cm	0.0000723	lb-ft
gm-cm	0.01389	oz-in
gm-cm	0.000867	lb-in
gm-cm	0.000098	N-m
gm-cm^2	0.22757	oz-in^2
horsepower (hp)	0.7457	kW
hp	42.44	BTU/min
hp	1.01387	hp (metric)
hp	396,000	lb-in/min
hp (metric)	0.9862	hp
inch (in)	2.54	cm
in	25.40	mm
in^3	0.004329	gal
in^3	0.01639	liter
in^3	16.39	mL
in Hg	1.1329	ft H_2O
in Hg	0.4926	psi
in Hg	25.64	mm Hg
in Hg	3386	Pa
joule	0.0009478	BTU
joule	0.73756	lb-ft
kg	2.2046	lb
kg-cm	13.89	oz-in
kg-m	7.246	lb-ft
kg/cm^2	14.22334	psi
kg/cm^2	0.9678	atm
kW	56.92	BTU/min
kW	1.341	hp
kPa	0.009867841	atm
kPa	0.14504	psi
lb (pound)	444822	dyne
lb	453.597	gm
lb	0.453597	kg
lb	16	oz
lb (force)	4.44822	N
lbs H_2O	0.1199	gal
lb-in	1152.5	gm-cm
lb-in	0.1129	N-m
lb-in/min	0.000002525	hp
lb-ft	0.001285	BTU
lb-ft	13,560,000	dyne-cm
lb-ft	1.3558	N-m
lb-ft	192	oz-in
lb-ft	0.1383	kg-m
lb-ft	13825	gm-cm
lb-ft/sec	1.355	watt
lb-ft/sec	4.625	BTU/hr
lb-ft/min	0.022589	watt
liter (L)	1000	cm^3
liter	0.2642	gal
liter	0.001	m^3
liter	61.0237	in^3
LPM	0.2642	GPM
LPM	2.11888	ft^3/hr
LPM	0.035316	ft^3/min

To go from	Multiply by	To get
mL	0.061	in^3
mL	0.033818	oz (fluid)
mL/min	0.0158	GPH
mL/min	0.0333818	oz/min
mL/min	1	cc/min
mL/min	0.00211	ft^3/hr
mm	0.03937	in
mm Hg	0.03937	in Hg
mm Hg	0.001315	atm
mm Hg	133.3	Pa
meter (m)	3.2808	feet
m^3	1000	liter
m^3	35.316	ft^3
m^3	264.2	gal
m^3/min	35.316	ft^3/min
m^3/hr	4.405	GPM
Newton (N)	0.2248	lb (force)
N-m	141.612	oz-in
N-m	10197.16	gm-cm
N-m	0.737562	lb-ft
N-m	8.850	lb-in
Newton/m^2	1	Pa
ounce (oz)	28.3495	gm
oz	0.0625	lb
oz (force)	27801.39	dyne
oz	0.001943	slug
oz (fluid)	29.57	mL
oz (fluid)	0.007813	gal
oz (fluid)	29.57	cm^3
oz-in	0.072	kg-cm
oz-in	72.007	gm-cm
oz-in	70620	dyne-cm
oz-in	0.00521	lb-ft
oz-in	0.007061	N-m
oz-in^2	4.3941	gm-cm^2
oz/min	29.57	mL/min
Pascal (Pa)	10	dyne/cm^2
Pa	1	Newton/m^2
Pa	0.0000099	atm
Pa	0.00001	bar
Pa	0.0002953	in Hg
Pa	0.000145	psi
Pa	0.0075	mm Hg
psi	6.895	kPa
psi	0.068046	atm
psi	0.0689	bar
psi	2.30666	ft H_2O
psi	2.036	in Hg
psi	0.070307	kg/cm^2
psi	6894.76	Pa
slug	514.785	oz
watt (W)	0.737562	lb-ft/sec
W	44.2537	lb-ft/min

MASTERFLEX®

CHEMICAL RESISTANCE CHARTS

CHEMICAL COMPATIBILITY DATABASE

To find the safest materials for your application, search this database by chemical, material, or compatibility level.

Scan the QR code at right with your mobile device to get to our chemical compatibility database.

⚠ WARNING

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠ DANGER

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

RATINGS

Chemical Behavior

A – No effect
B – Minor effect
C – Moderate effect
D – Severe effect; not recommended
— No data available

	Plastics															Elastomers										Metals										Nonmetals		
CHEMICAL	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon® (R-3603)	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Acetaldehyde	D	A	D	A	–	C	C	–	A	C[1]	A[1]	A	A	D	D	D	A	C	A	C	C	–	A	D	D	A	A	B	A	A	–	C	–	A	A	A	–	–
Acetamide	–	A	–	A	–	A	A	–	A	D	A[1]	A	A	D	C	A	A	B	A	D	B	–	B	D	B	B	A	A	–	D	–	D	–	–	–	A	–	–
Acetate Solvent	–	–	C	A	–	A	A	D	A	–	B[1]	A	A	D	A	C	A	C	A[1]	C	D	–	C	D	D	A	A	A	A	C	A	D	A	A	A	A	–	–
Acetic Acid	D	D	C	C	–	A	A[2]	A	D	B[1]	B	A	A	D	C	C	A	C	A	B	C	A	C	D	B	D	B	B	D	C	A	D	B	A	A	A	A	–
Acetic Acid 20%	C	C	A	A[1]	–	A	A	A	D	A[1]	A	A	A	D	A	B	A	A	A	B	A	A	B	D	B	B	A	B	D	C	A	D	B	A	A	A	A	A
Acetic Acid 80%	D	D	C	B[1]	–	A	D	A	D	B[1]	A	A	A	C	C	C	A	C	A	C	C	C	B	D	B	D	B	B	D	C	A	D	B	A	A	A	A	A
Acetic Acid, Glacial	D	D	B[1]	B[1]	A[1]	A	D	A	B	B[1]	A[1]	A	A	D	A[1]	C	B	C	A[2]	C	D	D	B	D	D	C	A	B	–	C	A	D	B	A	A	A	A	A
Acetic Acid Vapors	–	–	–	D	–	–	–	–	D	–	–	–	A	–	A	A	A	A	–	A	A	–	A	–	A	D	D	B	–	–	–	–	B	A	A	A	–	–
Acetic Anhydride	C[1]	D	D	C	C	C	D	D	A[1]	D	B[1]	A	A	D	B[1]	D	B	A	A	C	A	D	C	D	D	B	A	A[1]	D	C	B	D	B	A	A	A	A	–
Acetone, 50% water	D	–	–	–	–	–	–	D	–	–	A	A	A	D	A	D	–	A	–	D	D	–	A[2]	–	D	B	B	B	A	A	–	–	–	A	A	A	–	–
Acetone	D	A	D	B[1]	B	D	B[1]	D	A	D	A	A	A	D	D	D	A	C	A	C	C	A	D	D	D	A	A	A	A	A	A	A	A	A	A	A	A	–
Acetyl Bromide	–	–	–	–	–	–	D	–	D	–	–	–	A	D	–	–	–	–	–	–	–	–	–	D	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Acetyl Chloride (dry)	D	D	C	D	–	–	D	D	B	D	D	A	A	C	A[2]	D	D	D	A	D	D	A	C	D	A	A	A	D	D	–	B	B	A	A	–	–	–	–
Acetylene	–	A	C	A	A	–	D	–	A	D	A[1]	A	A	A[1]	A	B	A	B	A	B	B	–	B	A[1]	A	A	A	A	B	C	A	A	D	–	–	A	–	–
Acrylonitrile	D	–	A	A	–	A	A	–	A[1]	D	A[1]	–	A	B[1]	A[1]	D	D	C	–	B[1]	C	D	D	D	D	A[1]	A[1]	B[1]	A	–	A[1]	A[1]	A	B	–	B	–	–
Adipic Acid	–	–	A[2]	A	–	A	A	–	–	–	B[2]	–	A	A[2]	A[2]	C	A[2]	–	–	A[1]	C	–	–	D	A[2]	A[1]	A[2]	A	–	–	–	A	D	–	B	A[2]	–	–
Alcohols: Amyl	A[1]	A	A[2]	B[2]	A[1]	A	B[2]	C	A[1]	B[1]	B[1]	A	A	A[2]	A	B	A	A	A	B	A	A	D	D	A	A	A	B	A[1]	A	A	B	A	A	B	A	A	–
Benzyl	D	A	A	C	–	B	D	D	B[1]	–	A	A	A	D	A	D	B	C	A	D	C	D	–	D	A	B	B	B	–	A	A	B	B	A	A	–	A	–
Butyl	A[1]	A	A[2]	A	–	–	A	A	D	A[2]	A	A	A	A[2]	A	C	B	A	–	A	C	B	B	A[2]	A	A	A	B	A	A	A	B	A	A	A	A	A	–
Diacetone	–	A	–	A	–	A	B[1]	A	A	–	B[2]	–	A	B[1]	A[1]	D	A	D	B[1]	D	D	–	D	B[1]	D	A	A	A[1]	A	A	A	A	–	A	A	A	–	–
Ethyl	B[1]	A[1]	B	A[2]	–	A	B	A[1]	A[1]	B[2]	A	–	A	C	–	C	A	A	A	A	A	A	B	C	A	A	A	B	A	A	A	B	A	A	A	A	A	–
Hexyl	–	A	–	A	–	–	A	A	A	–	–	–	A	A[2]	–	A	C	B	–	A	A	–	B	A[2]	C	A	A	A	–	A	A	A	–	A	A	–	–	–
Isobutyl	B	A	–	A	–	A	A[2]	A	A1	–	A[1]	–	A[2]	A[1]	–	B	A	A	–	A	A	–	A	A[1]	A	A	A	B	–	A	A	C	–	A	B	A	–	–
Isopropyl	–	A	C	A	–	A	A[2]	A[1]	D	A[2]	A[2]	–	A[2]	A[1]	–	B	A	A	–	A	B	–	A	D	A	B	B	B	–	A	A	A	B	A	B	A	A	A
Methyl	D	A	A	B[1]	B	A	A[1]	A	B[1]	B[1]	A[2]	A	A	A[1]	A	A	A	A	A[1]	A	A	A	A	A[1]	C	A	A	A[1]	A	A	A	A	B[1]	A	B	A	A	A
Octyl	A[1]	A	B[1]	A	–	–	A	A	A	–	–	–	–	–	–	B	A	B	–	B	B	–	B	–	B	A	A	A	–	A	A	A	A	C	A	–	–	–
Propyl	B[1]	A	A[2]	A	–	–	A[2]	A[2]	D	–	A	A	A	A[1]	A[2]	A	A	A	–	A	A	A	A	A[1]	A	A	A	A	A	A	A	A	A	A	A	A	A	–
Allyl Chloride	D	–	D	A	–	A	–	D	–	–	A	–	A	D	A	D	D	–	–	D	D	–	–	–	A[3]	B[2]	A	D	–	–	–	–	–	–	–	A	–	–
Aluminum Acetate (saturated)	–	–	A	A	–	–	–	–	–	–	A	A	A	A	A	A	A	D	–	–	D	–	D	–	A	A	A	B	–	–	–	–	A	A[3]	–	–	–	–
Aluminum Chloride	A	–	A	A[1]	C	A	B[2]	A	B[1]	A[1]	A	A	A	A[2]	A	A	A	B	A	A	A	–	B	A[2]	A	B	B	D	D	D	B[1]	D	B	A	B	A	A	–
Aluminum Chloride 20%	–	C	A	A[1]	–	A	B[2]	A	D	A[1]	A	A	A	A[1]	A	A	A	B	A	A	A	–	B	A[1]	A	D	C[1]	D	D	D	C[1]	D	–	A	B	A	A	B
Aluminum Fluoride	A	C	A	B[1]	–	A	A[2]	A[1]	A[1]	–	A	A	A	A[2]	A	A	A	A	–	B	A	–	B	A[2]	A	D	D	B[1]	–	–	C	D	D	B	A	A	–	B
Aluminum Hydroxide	B	A	A	B[1]	–	A	A[2]	A	A[1]	B[1]	A	–	A	A[2]	A	A	A	A[2]	A[1]	D	A	–	–	A[2]	A	A[1]	C[1]	B[1]	B	C	A[1]	A	D	B	B[1]	A	–	–
Aluminum Nitrate	–	B[1]	A	A[2]	–	–	A[2]	–	A[1]	A[1]	A[2]	–	A	B[2]	A[2]	A[2]	A[2]	A[2]	A[1]	A[1]	A1	–	B[1]	B[2]	A[2]	A	A	D	–	–	–	–	–	–	A	A[2]	–	–
Aluminum Phosphate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	A	A	A	–	A	A	–	A	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–
Aluminum Potassium Sulfate 10%	–	C	B	A[1]	–	A	A[2]	A[2]	D	A[1]	A	–	A	A[2]	B	A	A	A	A	A	A	–	A	A[2]	A	A	A	C	A	–	A	D	A[2]	C	A	A	–	–
Aluminum Potassium Sulfate 100%	–	C	B	A[1]	–	A	A[2]	A[2]	D	A[2]	A	–	A	A[2]	–	A	A	A	A	A	A	–	A	A[2]	A	D	B[2]	C	–	–	B	D	B	C	A	A	–	–
Aluminum Sulfate	A[2]	B[1]	A[2]	A[2]	B[1]	A	A[2]	A	A[2]	A	A	A	A	A[2]	A	A	A	A	A	A	A	A	A	A[2]	A	B	B[2]	B[1]	B[1]	B	B	D	A[2]	B	A	A	A	–
Alums	–	–	A	A	D	–	A	–	A	–	A	–	A	–	–	A	A[1]	–	–	A	B	–	A[1]	–	A	–	A	A	–	–	A	D	C	B	A	–	–	–
Amines	–	D	D	A[2]	A[1]	B	C[1]	D	D	D	B[2]	B	A[2]	D	–	D	B	D	A	B	B	–	B	D	D	A	A	B	B[1]	D	B	D	–	B	B	A	–	–
Ammonia 10%	–	D	A	A[2]	–	A	C[1]	A[1]	A	D	A[2]	A[1]	A	B[1]	A	A	A	D	A	D	A	–	–	B[1]	D	A	A	A[2]	–	D	A[1]	A	–	A	C	A	A	–
Ammonia Nitrate	–	C	B	A	–	–	A	A[1]	D	–	A	A	A	B	A	C	A	D	–	–	C	–	–	B	D	A	A	C	–	D	A	A	–	–	–	–	–	–
Ammonia, anhydrous	D	D	A[1]	A	D	A	B[2]	B[1]	A[1]	D	A	A[1]	A	A[2]	A	B	A	D	A	D	A	–	C	B	D	A	A[2]	A[1]	D	D	A	A	D	B	C	A	–	–
Ammonia, liquid	–	D	A	A[1]	–	A	C[1]	–	B[1]	D	A[2]	A[1]	A	A[1]	A	C	A	D	A	D	A	–	–	A[2]	D	B[2]	A[2]	A	–	D	B[2]	A	–	B	C	A	A	–
Ammonium Acetate	–	–	A	–	–	A	A	–	A	–	A	–	A	A	–	B	A	–	–	–	A	–	–	A	A	B	A	A	D	D	–	–	–	–	–	–	–	–
Ammonium Bifluoride	A[2]	D	A	A[1]	–	–	A[2]	A	–	–	A	–	A	A	A	B	A[2]	–	–	–	D	–	–	A[2]	A	D	B[1]	B	–	D	B	D	–	B	–	A	–	–
Ammonium Carbonate	A[2]	D	A	A[2]	–	B	B[2]	A[2]	A[1]	–	A	A	A	A[2]	A	B	A	–	–	A	A	–	C	A[2]	A	B	B	B	D	D	B	B	D	B	A	A	A	A
Ammonium Caseinate	–	D	–	A	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	A	–	–	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–
Ammonium Chloride	A[2]	B	A[2]	A[1]	A[1]	A	A[2]	A	B	A[2]	A	A	A	A[2]	A	B	A	A	A	A	B	–	C	A[2]	A	C	B[2]	B[1]	D	D	B	D	D	D	B	A	A	A
Ammonium Fluoride 25%	D	–	A	A	–	A	–	A	A	–	A[4]	–	A	A	A	A	A	–	–	A	A	–	–	–	A	D	D	D	D	D	–	–	D	A	A	A	–	–
Ammonium Hydroxide	B	C	A	A[1]	C	A	A[1]	A	A	D	A	A	A	A	A	D	A	A	A	D	A	–	A	A	B	A[1]	A[1]	B[2]	D	D	A	D	D	B	A	A	A	A
Ammonium Nitrate	–	A[2]	A[2]	A[2]	B[1]	A	A[1]	A	A[1]	–	A	A	A	A[2]	A	A	A	A	A	C	B	–	C	A[2]	A	A[1]	A	B[1]	D	D	A	B	D	B	A	A	A	–
Ammonium Oxalate	–	B	–	A	–	A	–	–	–	A[1]	A	–	–	A	–	D	A	–	–	–	A	–	–	A	–	A	A	–	–	D	A	D	C	A	–	–	–	–
Ammonium Persulfate	A[2]	D	A	A[1]	–	A	A[2]	A[1]	D	–	A	–	A[1]	A[2]	A[1]	A	B	A	A	A	A	–	D	A[2]	A	A	B	D	D	D	B	D	D	B	A	A	A	A
Ammonium Phosphate, Dibasic	A[2]	B[2]	A	A[1]	–	–	A[2]	A	C[1]	A[2]	A	A	A[2]	A[2]	A	A	A	A	A	A	A	–	A	A[2]	A	B	C	B[1]	B[1]	D	A[1]	D	D	B	A	A	–	–
Ammonium Phosphate, Monobasic	–	B	A	A	B[1]	–	A	A	B	–	A	–	A	A	–	A	A	A	–	A	A	–	A	A	A	B	C	B	–	D	C	D	D	B	A	–	–	–
Ammonium Phosphate, Tribasic	–	B	A	A	–	–	C	A	B	–	A	–	A	A	–	A	A	A	–	A	A	–	A	A	A	B	B	B	–	C	–	D	D	B	A	–	–	–
Ammonium Sulfate	A[2]	B[1]	A	A[2]	B[1]	A	A[1]	A	A[1]	A[2]	A	A	A	A[2]	A	A	A	A	A	A	A	–	A	A[2]	A	B	B	A[1]	D	D	B	D	D	B	A	A	A	A
Ammonium Sulfite	–	D	A	–	B[1]	B	B[2]	A[2]	A[1]	–	A[2]	–	A[2]	A[2]	–	A[1]	A[1]	A[2]	A[2]	A[2]	A[1]	–	–	A[2]	D	B	B	D	–	A	A	D	D	–	–	D	–	–
Ammonium Thiosulfate	–	B	–	A	–	–	A	–	–	–	–	–	–	–	–	A	A[1]	–	–	–	A	–	–	–	–	–	A	–	D	D	–	D	D	–	A	–	–	–
Amyl Acetate	D	B[1]	D	A[2]	C[1]	–	C[1]	D	B[2]	D	B[1]	A	A	D	A2	D	A	D	A[1]	D	D	D	D	D	D	A[1]	A	A	A	A	A	C	A	A	A	A	A	–
Amyl Alcohol	A[1]	A	A[2]	B[2]	A[1]	A	B[2]	C	A[1]	B[1]	B[1]	A	A	A[2]	A	B	A	A	A	B	A	A	D	D	A	A	A	B	A[1]	A	A	B	A	A	B	A	A	–
Amyl Chloride	D	A	C	A[1]	–	B	D	D	C[1]	–	D	–	A	D	A	D	D	D	A	D	D	–	D	D	B[1]	A[2]	A[2]	A[1]	–	A	A[2]	A	A	A[1]	C	A	A	–
Aniline	D	A[1]	B[2]	D	D	B	C	D	A[2]	D	A[1]	A	A	C[1]	A[1]	D	B	D	A[2]	D	D	B	B	D	A	A	B	C	D	C	A	C	D	B	C	A	A	–
Aniline Chlorohydrate	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	B	–	–	–	–
Aniline Hydrochloride	D	–	D	D	–	–	D	–	D	D	D	–	A	B[2]	A[2]	D	B	–	–	A	D	–	D	D	A	D	D	D	D	D	B	D	B	D	A	D	–	–
Antifreeze (glycol-based)	B	B	B	A	–	–	–	A	A	–	A	–	B	B	–	A	A	–	–	A	B	–	B	B	A	B	A	A	B	B	A	B	–	A	–	–	A	A
Antimony Trichloride	A[2]	–	A[2]	D	–	B	B[2]	A[2]	D	A[2]	A	–	A	A[2]	A	B	B[1]	–	A	–	–	A	–	–	A[2]	D	D	D	D	A	B	–	–	–	B	–	B	–
Aqua Regia (80% HCl, 20% HNO_3)	D	D	C[1]	D	–	D	B[1]	D	D	D	B[1]	D	A	C[1]	A[2]	D	C	C	A	D	D	D	D	D	B	D	D	D	D	D	D	D	D	C	A[1]	D	–	C
Arochlor 1248	–	–	–	A[2]	C[1]	–	C[1]	–	A[1]	–	D	–	A	–	–	C[1]	B	D	A[1]	D	D	–	B	–	A	B	B	A	A[1]	A	–	B	–	A	A[1]	–	–	–
Aromatic Hydrocarbons	–	A	D	A	C[1]	–	C	D	–	–	D	–	–	D	–	D	D	D	–	D	D	–	D	–	A	–	C	A	–	C	–	A	–	–	–	–	–	–

Explanation of footnotes: 1. Satisfactory to 72°F (22°C) 2. Satisfactory to 120°F (48°C) 3. Satisfactory to 90°F (32°C) 4. Satisfactory to 200°F (93°C)

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CHEMICAL RESISTANCE CHARTS

⚠ WARNING

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RATINGS

Chemical Behavior

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	Plastics															Elastomers										Metals										Nonmetals		
CHEMICAL	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon®	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Arsenic Acid	A[2]	D	A[1]	A[2]	–	B	B[2]	A[1]	C[1]	A[1]	A	A	A	A[1]	A	A[2]	A[2]	A	–	B	A	B	A	B	A[2]	A[2]	A[2]	D	D	B	A[1]	D	A	B	B	A	–	–
Arsenic Salts	–	–	–	–	B[1]	–	B	–	A	–	–	–	–	A	–	–	–	–	–	–	–	–	–	A	A	–	–	–	–	–	–	–	–	–	–	–	–	–
Asphalt	–	B[2]	A[2]	A	B[1]	–	A[1]	–	A	D	B[1]	A	A[1]	A[2]	A	B	D	D	A	D	D	–	D	–	A	B	A	A	B[1]	A[1]	A	A	A	–	–	A	–	–
Barium Carbonate	A[2]	A	A[2]	A[2]	–	–	B[2]	A[2]	A[1]	A[2]	A	A[2]	A	A[2]	A	A[2]	A	–	A	–	–	–	–	–	A	B[1]	B	D	B[1]	B	B[1]	A	A	B	A	A	A	A
Barium Chloride	A[2]	A	A[1]	A[2]	B[1]	B	A[1]	A	A	A	A	A	A	A[1]	A	A	A	A	A	A	A	–	A	B	A	A[1]	A[1]	D	B[1]	B[1]	B	C	B[1]	B	A	A	A	A
Barium Cyanide	–	B	D	A	–	–	B	–	A[1]	–	D	–	A[1]	D	–	C	A	A	–	–	C	–	–	–	A	A[1]	A[2]	C[1]	C[1]	C	A[1]	C[1]	D	A	–	–	–	–
Barium Hydroxide	A[2]	D	A[2]	A[2]	B[1]	–	B[2]	A[2]	A[1]	D	B	A	A	A[2]	A	A	A	A	A	A	A	–	A	–	A	B[1]	B	D	D	D	B[1]	D	–	B	B	A	A	A
Barium Nitrate	–	B[2]	A	A[1]	–	–	B[2]	A	A[1]	D	A	–	A[1]	A	–	A[2]	A	–	A	–	A	–	B	–	A	B[1]	B	B	D	D	B	A	B	–	A	A	–	–
Barium Sulfate	A[2]	B[2]	B[1]	A[2]	D	B	B[2]	A[1]	A[1]	D	B[1]	A	A	B[1]	A	A	A	A	A	A	A	–	A	–	A	B[1]	B[1]	B	B	C	B	B	B	A	B	A	A	A
Barium Sulfide	A[2]	A	A[2]	B[2]	–	A	B[2]	A[2]	A[1]	–	B	–	A	A[2]	A	A	A	A	–	A	A	–	A	–	A	B[1]	B[2]	D	D	D	A[1]	D	D	–	A	A	A	A
Beer	A[2]	A[1]	A[2]	A[2]	A[1]	A	A[2]	A[1]	A[1]	A[2]	A[1]	A[2]	A	A[2]	A	A	A	A	A	A	A	–	A	A	A	A	A	A	B	A[1]	A	D	B	A[1]	B	A	–	A
Beet Sugar Liquids	B	B	A[2]	A[1]	–	–	A[1]	A	A	–	A[1]	–	A[1]	A[2]	A	A	A	A	A	A	A	–	A	–	A	A	A	A	–	C	A	A	A	–	A	A	–	–
Benzaldehyde	B	A	D	D	B	B	A[1]	B	A[1]	D	D	A	A[1]	D	A[2]	D	A	D	A	D	D	D	D	D	D	B	B	B	–	A	A	A	B	A	A	A	A	A
Benzene	D	A[1]	D	C[1]	C	D	D	D	A[1]	D	D	A	A	C[1]	A[2]	D	D	D	B	D	D	D	D	D	A	B	B	B	–	A	A	A	B	B	A	A	A	A
Benzene Sulfonic Acid	–	–	D	B	B	A	A[1]	A	D	D	D	A	A	A	–	D	D	–	–	A	A	–	D	D	A	B	B	D	–	–	A	–	–	B	B	A	A	–
Benzoic Acid	–	B	A[1]	A[1]	D	A	A[1]	B	D	B[1]	B[1]	A[1]	A[2]	A	A	D	D	D	A	D	B	–	B	D	A	B	B	B	–	B	B	D	–	B[1]	A	A	A	A
Benzol	D	A	–	A[1]	C	–	C[1]	B	D	D	B	A	A	–	A	D	D	D	A	D	D	D	D	C1	A	A[1]	A[1]	B[1]	–	A	A	A	B	B	A	A	A	A
Benzonitrile	–	–	–	–	–	–	–	–	–	A[1]	–	–	A[2]	–	–	–	–	–	A[2]	–	–	–	A[1]	–	–	D	D	–	–	–	–	–	–	C	–	A	–	–
Benzyl Chloride	D	A	–	–	–	–	–	D	A[2]	–	C[1]	–	–	–	–	D	D	D	–	D	D	–	D	–	A[2]	C[1]	B[1]	D	–	D	–	–	D	C	–	A[1]	–	–
Bleach	B	D	A	D	–	–	–	A	A	–	D	D	A	A	A	D	B	B	D	D	B	–	–	B	A	A	A	A	–	–	D	D	–	A	–	–	–	–
Bleaching Liquors	–	–	–	D	–	–	A[1]	–	C	–	A[1]	–	A	A[1]	–	D	A	A	–	D	D	–	B	–	A	–	–	–	–	–	–	–	–	–	A	–	–	–
Borax (Sodium Borate)	–	B	A	A[1]	A[1]	A	A[2]	A[1]	A	–	B	A	A	A[1]	A	B	A	A	A	A	A	–	B	–	A	A	A	B[1]	–	B	A	A	B	B	B	A	–	A
Boric Acid	–	A	A	A[1]	A[1]	A	A[2]	A[1]	B	–	A	A	A	A[2]	A	A	A	A	A	A	D	A	A	A	A	B[2]	A[1]	D	–	B	B[2]	D	B	A	A	A	A	A
Brewery Slop	–	B	–	A	–	–	–	–	–	–	–	–	–	–	–	A	–	–	–	–	A	–	–	–	A	–	A	–	–	A	A	A	–	–	–	–	–	–
Bromine	D	D	D	D	D	D	D	A[1]	D	C[1]	D	D	A	C[1]	A	D	D	D	A	D	D	–	D	D	A	D	D	D	–	D	D	–	–	A	D	D	A	A
Butadiene	–	A	A[1]	A[1]	–	D	D	D	C[1]	D	C	A[1]	A[2]	C[1]	A	D	C	B	A	D	B	–	D	A	B	A	A[1]	A	–	C	A	–	C	C	–	A	–	–
Butane	B	A	C[1]	A[1]	–	–	C[1]	D	A[2]	D	A[1]	A	A	C[1]	A	A	D	B	A	D	A	–	D	A	A	A[2]	A[2]	A	–	C	A	–	C	A	A	A	–	–
Butanol (Butyl Alcohol)	–	A	A	D	B[1]	–	B[2]	A	B[1]	B[1]	A[1]	A	A[2]	C[1]	A	A	A	A	A[1]	A	A	B	B	D	A	A	A[1]	B	–	A	A	–	B	B	B	A	–	–
Butter	B	A	–	A	–	–	–	B	–	–	–	–	A	–	–	A	A	B	–	D	B	D	B	B	A	C	A	A	–	D	–	D	–	–	–	–	–	–
Buttermilk	B	A	A[1]	A[1]	–	–	A[1]	A	B[1]	A[1]	A[1]	–	A	A[1]	–	A	A[1]	–	A	D	D	–	A	B	A	A	A	A	–	D	–	D	–	A	–	A	–	–
Butyl Amine	–	C[1]	–	B[2]	–	–	C[1]	D	A[2]	D	B[1]	D	A[2]	D	A[1]	–	–	–	D	D	D	–	B[1]	D	D	–	A	A[2]	–	B	–	–	–	B[2]	B[2]	A[2]	–	–
Butyl Ether	–	D	D	A[1]	–	–	–	D	A[2]	–	D	A[2]	A[1]	A[2]	A[1]	B[2]	D	–	A[1]	D	D	–	D	A[2]	D	–	A[1]	A[1]	–	–	–	–	–	–	–	A[1]	–	–
Butyl Phthalate	–	–	D	B[2]	–	A	C[1]	A[2]	A[2]	D	B[2]	A	A[2]	–	B[1]	D	B[2]	D	A[1]	D	D	–	A[1]	–	C[1]	B[1]	B[2]	B[2]	–	–	–	–	–	B[2]	B	A[2]	–	–
Butylacetate	–	A	C[1]	B[1]	B	B	C[1]	B	A	D	B[1]	A	A	D	B[2]	D	B	D	A[1]	D	D	–	D	D	D	B	A	A	A	A	B[1]	A	A	A	A	A	–	A
Butylene	–	A	A	A[1]	–	–	B[1]	–	B[1]	D	–	A	A	A[1]	A	A	D	D	B[1]	D	D	–	D	–	A	A	A	A	–	D	A	–	D	–	–	A	–	–
Butyric Acid	D	A	D	A	B[1]	D	D	D	C[1]	D	B[1]	A	A[2]	B[1]	A	D	B	D	A	D	D	A	D	D	B[1]	B[2]	B[2]	B	–	D	B	D	C	A[1]	A	A	–	A
Calcium Bisulfate	–	–	–	A	–	–	–	–	–	D	–	–	–	–	–	A	A	–	–	A	A	–	C	–	–	–	A	–	–	C	–	D	–	–	–	–	–	–
Calcium Bisulfide	–	D	A[1]	A	B[1]	–	B[1]	A	A	–	A	–	A	A[2]	A	A[1]	C	–	A	D	A	–	C	–	A	B	B	C	–	C	B	–	–	A	A	–	–	A
Calcium Bisulfite	–	D	A[1]	A[1]	B	A	A[1]	A[1]	A[2]	D	A	A	A	B	A	A	D	A	A	D	A	–	A	–	A	B	A	D	–	–	B[1]	–	–	B	A	A	–	A
Calcium Bromide 38%	–	–	–	–	–	–	–	–	–	–	–	–	A	–	A	–	–	–	–	–	–	–	–	–	–	A	–	–	B	B	–	–	–	B	B	–	–	–
Calcium Carbonate	–	A	A	A[1]	–	–	B[1]	A[2]	A	C[2]	A	–	A	A[2]	A	A	A	A	–	A	A	–	A	–	A	A[1]	B	D	–	A	B[1]	–	–	B	B	A	A	–
Calcium Chlorate	–	A	A[1]	–	–	–	–	–	–	–	–	–	A	B[2]	A	A	A	B	–	A	–	–	–	–	A	–	–	–	–	–	–	–	A	–	–	–	A	–
Calcium Chloride (30% in water)	B	D	A[2]	A[1]	A[1]	A	B[2]	A	A[1]	–	A[2]	A	A	C	A	A	A	A	A	A	A	–	A	A	A	C[2]	B[2]	D	–	A	B	C	B	A	A	A	A	A
Calcium Chloride (saturated)	A	D	A	A[4]	–	A	–	A	A	–	A	A	A	A	A	A	A	A	–	A	A	–	A	–	A	B	B	B	B	B	–	–	B	A	A[4]	A	A	–
Calcium Fluoride	–	–	–	–	–	–	–	–	–	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	B	B	B	B	B	–	–	–	B	D	–	–	–
Calcium Hydroxide 10%	–	A	A	A	–	A	–	–	A	–	A	A	A	–	A	A	A	A	–	A	A	–	A	A	A	B	B	C[1]	–	–	–	–	B	B	A	A	A	–
Calcium Hydroxide (saturated)	A	–	A	A	–	A	–	A	A	–	A	A	A	A	A	A	A	A	–	A	A	–	A	–	A	B	B	D	B	C	–	–	B	A	A	A	A	–
Calcium Hydroxide	–	D	A[2]	A[1]	B[1]	A	A[2]	A[2]	A[2]	D	A[2]	A	A	B	A[2]	A	A	A	A	A	A	–	A	B[2]	A	B[1]	B	C[1]	–	D	B	A	–	A	A	A	A	A
Calcium Hypochlorite 30%	–	–	A	A	–	A	–	–	–	–	A	–	A	A	A	D	A	A	–	–	A	–	–	–	A	D	B	D	D	D	–	–	D	–	A	–	–	–
Calcium Hypochlorite (saturated)	A	–	A	A[2]	–	A	–	A	D	–	A	–	A	A	A	D	A	A	–	A	A	–	–	–	A	D	B	D	D	D	–	–	D	A	A	A	A	–
Calcium Hypochlorite	–	D	B[1]	A[1]	C[1]	A	A[1]	A	D	D	A[1]	A	A	B[1]	A	C[1]	B[1]	A	B[1]	D	D	–	B	A	A	C[1]	B[1]	D	–	D	C	D	–	B	A[1]	A	A	A
Calcium Nitrate	A	D	A[2]	A[2]	–	B	A[1]	A[2]	A[1]	A[2]	A[2]	A	A[2]	A[2]	A[2]	A[2]	A[2]	A[1]	A[1]	A[1]	A[2]	–	B[1]	A[2]	A[2]	C[1]	B[2]	B[1]	–	B[2]	–	B	–	B[2]	B[2]	A[2]	A	–
Calcium Oxide	D	A	A	A	A	–	B[1]	A	B	–	A	A	A	B	A	A	A	A	–	B	A	–	A	C	B	A	A	C	–	D	A	–	–	A	A	–	–	–
Calcium Sulfate	C	D	A[2]	A[2]	–	–	B[1]	A	D	A[2]	A	A	A	B[2]	A	A[2]	A	A	A	B	B	–	–	–	A	B	B	C	–	A	B[1]	A	–	B	A	A	A	A
Calcium Sulfide	–	–	A	–	–	–	–	–	–	–	A	–	A	A	A	A	A	A	–	–	A	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–
Calgon	–	A	–	A	–	–	–	A	A	–	A	–	–	–	–	A	A	A	–	A	A	–	A	–	A	A	A	–	–	C	–	D	–	–	–	–	–	–
Cane Juice	–	A	A[2]	A	–	–	–	–	A	–	C[1]	–	A	A[1]	A[1]	A	A	A	–	A	A	–	A	A	A	A	A	B	–	A	A	A	–	–	–	–	–	–
Carbolic Acid (Phenol)	D	D	B[1]	C	D	–	D	D	D	D	B	A	A	D	A[1]	D	B	D	B	D	D	–	D	B	A	B	B	A	D	B	C	D	D	A	A	A	A	–
Carbon Bisulfide	–	A	D	A	C[1]	–	–	–	A	–	D	–	–	D	–	C	D	D	–	D	D	–	–	D	A	A	B	B	–	B	B	–	–	–	–	–	–	–
Carbon Dioxide (dry)	B	A	A	A[1]	A[1]	–	A[1]	A[1]	A[1]	–	A[2]	A	A	A[2]	A	A	B	B	A	B	B	–	B	A	B	A	A[1]	B[1]	B	A	A	D	–	A	A	A	–	–
Carbon Dioxide (wet)	B	A	A	A[1]	–	–	A[1]	A[1]	A[1]	–	A[2]	A	A	A[1]	A	A	B	B	A	B	B	–	B	A	B	A	A[1]	A[1]	–	A	A	D	–	A	A	A	A	–
Carbon Disulfide	–	A[1]	D	C[1]	–	D	C[1]	D	B[1]	D	D	A	A	D	B[2]	D	D	D	A	D	D	–	–	D	A[1]	A[1]	B	A	–	D	B	A	–	B	B	A	–	–
Carbon Monoxide	–	A	A[2]	A[1]	A	–	A[2]	A[2]	A[1]	–	A	–	A	A[2]	B	A	A	C	A[1]	D	B	–	A[2]	A	A	A	A	A	–	A	B	A	A	B	–	A	–	–
Carbon Tetrachloride	D	B[1]	D	A[1]	D	C	D	D	D	D	D	A	A	D	A[2]	D	D	D	A[1]	D	D	–	D	D	A	B	B	D	–	A[2]	B	D	A	A[1]	A	A	A	A
Carbon Tetrachloride (dry)	D	–	–	–	D	C	D	D	–	–	D	A[2]	A	–	A[2]	C[1]	B[1]	D	D	D	D	–	D	–	A[2]	B	B[2]	D	A[1]	B[2]	B	–	–	B	A[2]	A[2]	A	A
Carbon Tetrachloride (wet)	D	A[1]	D	–	–	C	–	D	–	–	D	A[2]	A	–	A[2]	D	D	D	A[1]	D	D	–	D	–	–	A[2]	A[2]	D	B[1]	A[2]	A	C	–	B	A[2]	A[2]	A	–
Carbonated Water	–	A	A	A	–	–	A	A	A	–	B	–	–	A	–	A	–	–	–	–	A	–	–	–	A	A	A	A	D	A	C	D	B	–	–	–	–	–
Carbonic Acid	–	B[1]	A	A[2]	D	B	B[2]	A[1]	A[1]	A[1]	A	A	A	A[2]	A	D	B	C	A	C	D	–	A	A	A	A[1]	A	B[1]	D	B	A	D	–	A[2]	B[1]	A	A	–
Catsup	B	B	A	A	–	–	–	A	A	–	A	–	–	A	–	A	A	–	–	–	A	–	–	–	A	A	A	D	–	A	C	D	D	–	–	–	–	–
Cellulose Acetate	–	–	D	A	–	–	–	–	–	–	A	–	A	D	D	D	A	D	–	–	A	–	–	–	D	B	B	A	B	B	–	–	B	B	B	–	–	–
Chloral Hydrate	A	–	A	–	–	D	–	–	–	–	D	–	A	A	A	–	–	A	–	–	–	–	–	–	D	D	–	–	–	–	–	–	–	–	–	A	–	–

Explanation of footnotes: 1. Satisfactory to 72°F (22°C) 2. Satisfactory to 120°F (48°C) 3. Satisfactory to 90°F (32°C) 4. Satisfactory to 200°F (93°C)

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⚠ Warning

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠ Danger

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

Ratings

Chemical Behavior

A – No effect
B – Minor effect
C – Moderate effect
D – Severe effect; not recommended
— No data available

	Plastics															Elastomers										Metals										Nonmetals		
CHEMICAL	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon®	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Chloric Acid	–	D	A	–	–	–	–	D	D	–	–	–	A	A[2]	–	–	–	–	A	–	–	–	–	–	–	D	C[1]	D	D	D	A[1]	D	D	A[2]	–	D	–	–
Chlorinated Glue	–	D	–	A	–	–	–	–	–	–	–	–	–	–	–	B	B	–	–	–	D	–	–	–	A	–	A	–	–	A	A	D	–	–	–	–	–	–
Chlorine Water	–	D	A[2]	A[1]	–	C	B[1]	C[1]	C[1]	–	D	D	A	A[2]	B	D	C	C	A	C	D	–	D	–	A	C	C	D	D	B	A[2]	–	D	A[2]	A	A	A	A
Chlorine, Anhydrous Liquid	–	A[1]	D	C[1]	–	C	D	B[1]	D	C	D	D	A	D	A[1]	D	B	C	B[2]	C	D	–	D	C	A	C[1]	C	D	D	D	D	D	–	D	D	A	–	C
Chlorine (dry)	–	D	D	D	D	B	D	B[1]	D	–	D	D	A	D	A	B	A	D	D	D	C	–	D	A	A	–	B	C[1]	D	B	A	D	A	A[2]	D	A	–	–
Chloroacetic Acid	–	D	D	C[1]	D	A	D	–	D	D	C[1]	A	A	B[1]	A[1]	D	B	–	A[2]	D	D	D	D	A	D	B[1]	A[1]	D	D	C	B[1]	D	D	A[1]	A[1]	A	–	–
Chlorobenzene (Mono)	D	D	D	C[1]	D	D	C[1]	D	D	D	C[1]	A	B	D	A[1]	D	D	D	A[1]	D	D	D	D	D	A	A	B	A	B[1]	C	A	B	B	A	B	A	A	A
Chlorobromomethane	–	–	–	–	–	–	A	–	C	–	A	–	A	D	–	D	B	D	–	D	D	–	D	–	A	–	–	–	–	–	–	B	B	–	–	–	A	–
Chloroform	D	A	D	C[1]	D	D	C[1]	D	A	D	C[1]	A	A[1]	D	A	D	D	D	B[1]	D	D	D	D	D	A	A	A	B[1]	B[1]	B	A	B	A	A[1]	A[2]	A	A	A
Chlorosulfonic Acid	–	D	D	C[1]	D	D	D	D	D	C[1]	D	D	A	D	D	D	D	D	A[2]	D	D	–	D	D	D	D	B[2]	C	B	D	D	D	D	A[1]	A	A	A	–
Chocolate Syrup	–	A	–	A	–	–	–	A	A	A	A[2]	–	A	–	–	A	A	–	–	D	A	–	–	–	A	A	A	A	–	–	D	D	–	–	–	–	–	–
Chromic Acid 5%	B	D	A	D	D	A	A	A[1]	–	B	D	A	A	A[2]	A	D	A	B	A	B	D	D	C	B	A	B	A	C	D	B[1]	D	D	D	B	A	A	A	A
Chromic Acid 10%	B	D	A[2]	D	D	A	A	A[1]	–	B	D	A	A	A[2]	A	D	C	C	A	D	D	D	C	C	B	B	B	D	D	D	D	D	D	A	B	A	A	–
Chromic Acid 30%	B	D	A[1]	D	D	A	A	D	–	C	D	B	A	A[1]	A[2]	D	B	C	A	D	D	D	C	B	A	B[2]	B[2]	D	D	D	D	D	D	D	A	A	A	–
Chromic Acid 50%	D	D	D	D	D	A	A	D	–	D	D	A[1]	A	D	A[2]	D	B	C	A[2]	D	D	D	C	C	A	C	B[2]	D	D	D	D	D	D	B	A[2]	A[1]	A	A
Chromium Salts	–	–	–	–	B[1]	–	B	–	B	–	–	–	–	A	–	–	–	–	–	–	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cider	–	A	–	A	B[1]	–	B	A	A	A	A	–	–	A	–	A	A	–	–	–	A	–	B[1]	–	A	A	A	B	–	A	A	D	–	–	–	–	A	A
Citric Acid	D	B[1]	B[2]	A[1]	A[1]	A	D	A[1]	A[1]	A[1]	A	A	A	B[2]	A	A	A	C	A[2]	A	A	A	A	–	A	B[1]	A[2]	C	D	D	B	D	D	A	A[2]	A	A	A
Citric Oils	–	B	–	A	–	B	–	A	–	–	A	–	–	–	–	A	B	–	–	–	D	–	–	–	A	A	A	C	–	A	D	D	–	–	–	–	–	–
Coffee	–	A	A	A	–	–	–	A	A	–	A	–	–	–	–	A	A	A	–	A	A	–	A	–	A	A	A	A	–	A	D	–	–	A	A	–	–	–
Copper Chloride	A	A	A	A	A[1]	–	–	A	D	–	A	A	A	A[1]	A	A	A	C	A	C	A	–	A[1]	A	A	D	D	–	–	D	D	–	–	–	D	–	A	A
Copper Cyanide	–	A	A	B[1]	–	–	B[2]	A[1]	D	D	A	A	A	A[2]	A	A	A	C	–	A	A	–	A	–	A	B	B	D	D	D	B	A	–	A[1]	B	A	A	A
Copper Fluoborate	–	B	A[1]	A	–	–	–	–	–	–	–	–	–	A	–	B	–	–	–	–	A	–	–	A	A	D	D	–	–	–	D	D	–	B	–	–	–	–
Copper Nitrate	–	A	A	A[1]	–	–	B[2]	A[1]	D	D	A	A	A	A[2]	A	A	–	–	A	C	A	–	–	B	A	A	A[2]	D	D	D	A	D	D	B[2]	B	A	A	A
Copper Sulfate 5%	–	D	A	A	A[1]	A	A[2]	A[1]	D	A[1]	A	A	A	A[2]	A	A	A	C	A	C	A	–	A	A	A	B	B	D	D	B	A	D	B	A	A	A	A	A
Copper Sulfate >5%	–	D	A	A	A[1]	A	A[2]	A[1]	D	A[1]	A	A	A	A[2]	A	A	A	C	A	C	A	–	A	–	A	B	B	D	D	D	B	D	–	A	A	A	–	A
Cream	–	A	A	A	–	–	–	A	A	–	A	–	A	–	–	A	–	–	–	–	D	–	–	–	A	A	A	A	–	A	D	D	–	–	–	–	–	–
Creosote	A	D	A	A	–	A	–	D	D	–	–	–	A	A	–	A	D	D	–	–	D	–	D	–	A	B	B	B	C	–	–	–	B	B	A	A	–	–
Cresols	D	D	D	A[1]	D	D	C[1]	D	D	D	D	A	–	D	A[2]	D	D	D	A[1]	D	D	D	D	B	A	A[2]	A	A	–	A	A[2]	C	A	B[2]	B	A	–	–
Cresylic Acid	–	D	D	D	–	–	B[1]	–	D	D	A[1]	–	A	D	B[1]	D	D	D	–	D	D	–	D	–	A	A[1]	A	B[2]	–	D	A	A	B	B[1]	A[1]	A	–	–
Cupric Acid	–	–	–	A[2]	–	–	B[1]	A[2]	D	A[1]	A[2]	A	A	A[2]	–	B[2]	A[2]	–	A[2]	B[2]	A[2]	–	A[1]	A[2]	A[2]	D	B[2]	D	–	–	–	–	–	A[1]	A[2]	A[2]	–	–
Cyanic Acid	–	D	–	A[1]	–	–	–	–	–	–	–	–	A	–	–	C	–	–	–	–	C	–	A[1]	–	A	A	A	–	–	–	D	D	–	–	–	A	–	–
Cyclohexane	–	A[1]	D	A[2]	A[1]	D	B[1]	D	A	B	D	A	A	D	A	B	D	D	A	D	D	D	D	D	A	A[1]	A	A	A	B	A[2]	B	B	B	A	A	–	A
Cyclohexanone	D	A	D	C	–	B	D	D	A	D	D	A	A	D	D	D	B	–	A[1]	D	D	–	D	D	D	A[1]	A[2]	A	–	B	–	B	B	A[1]	–	A	A	A
Detergents	B	A[1]	A	A[1]	–	A	D	A[1]	A[1]	A[1]	A	A	A	A	A	A	A	B	A	B	B	–	A	A	A	A[1]	A[1]	B	–	B	A[2]	–	–	B	A[2]	A	A	A
Dextrin	A	–	A	–	–	A	–	–	–	–	A	–	A	A	A	A	D	–	–	–	A	–	–	–	D	–	B	B	B	B	–	–	–	–	–	–	–	–
Dextrose	A	–	A	A	–	A	–	A	A	–	A	A	A	A	A	A	A	A	–	A	A	–	A	–	A	B	B	B	B	B	–	–	B	B	–	A	–	–
Diacetone Alcohol	–	–	D	A	–	A	A	–	A[1]	D	A[1]	–	A	D	D	D	A	A	B[1]	–	D	–	D	–	D	B[1]	B	A[1]	A[1]	B	–	–	A	–	–	A	–	–
Dibenzyl Ether	–	–	–	–	–	–	–	–	–	–	–	–	A	–	A	D	–	D	–	D	D	–	–	–	D	–	–	–	–	–	–	–	–	–	–	–	–	–
Dichlorobenzene	D	–	D	A	–	–	–	–	D	D	C[1]	–	A	D	A	D	D	D	–	D	D	D	D	–	C	–	B[1]	B[1]	–	B[1]	–	–	–	A1	–	A[2]	–	–
Dichloroethane	D	A[1]	D	D	–	C	C[1]	A[1]	A[1]	D	D	–	A[1]	D	A	D	–	C	A[2]	D	D	D	–	D	C	B	B	B[1]	B	D	–	–	A	A	B[1]	A	A	–
Diesel Fuel	–	A	A[1]	A	–	D	C[1]	D	D	A2	A[1]	A	A	A[1]	A	A	D	B	A[1]	D	B	B	D	D	A	A[1]	A[1]	A[1]	A[1]	A	A	A	A	B	B	A	–	–
Diethyl Ether	D	–	D	D	C	D	–	–	A[1]	D	A[1]	A	A	D	A[1]	D	D	D	C	D	D	A	D	–	D	B[1]	B[2]	B	B[1]	A[1]	–	–	A	B[1]	A[1]	A[2]	–	–
Diethylamine	D	B	D	A	–	D	D	–	A	D	A[1]	–	D	D	D	C	B	C	A	A	A	–	B	A	A	A	A	B	A	A	A	B	A	A	A	A	–	–
Diethylene Glycol	B	A[1]	A[1]	C	–	A	B[2]	A[1]	A[1]	B[1]	A[2]	–	A[2]	C[1]	A	A[2]	A[2]	C	–	A[1]	A[2]	A	B[1]	C[1]	A[2]	A[1]	A	B[1]	–	–	A	A	–	B[1]	A[1]	A[2]	–	–
Dimethyl Aniline	D	D	D	A[1]	–	B	–	D	A	D	D	A	A	D	A[1]	D	B[2]	–	A[2]	D	D	–	D	D	D	B2	B[2]	A[2]	–	–	–	–	–	B[2]	A[2]	A[2]	–	–
Dimethyl Ether	–	–	–	–	–	–	–	–	–	–	–	–	A	–	–	A	D	–	–	–	–	–	A	–	A	B	B	–	B	B	–	–	B	B	A	–	–	–
Dimethyl Formamide	D	D	D	D	–	A	A	D	A	D	A	A	A	D	D	D	B	D	A	C	D	A	C	D	C	A	B	A[1]	–	–	–	–	A	–	–	–	–	–
Diphenyl	–	–	–	–	–	–	–	–	–	–	D	–	A	–	–	D	D	B	B	D	B	–	D	–	A[2]	B	B	B[2]	B	B	–	–	B	B	B	–	–	–
Diphenyl Oxide	–	D	–	A	–	–	–	–	–	–	D	A	A[1]	D	B[2]	A	D	D	–	D	D	–	C	D	A	B[1]	A	B[1]	–	–	A	A	A	B[1]	A[1]	–	–	–
Disodium Phosphate	A	–	A	–	–	A	–	–	–	–	A	–	A	A	A	D	A	A	–	–	A	–	–	–	A	–	A	–	C	C	–	–	–	–	–	–	–	–
Dyes	–	C	–	A	–	–	–	A	A	–	–	–	–	B	–	–	–	–	–	–	C	–	–	C	A	A	A	B	A	–	C	–	A	–	–	–	–	–
Epsom Salts (Magnesium Sulfate)	B[2]	B	A[1]	A	–	–	A[2]	A[1]	A[1]	A[1]	A	A	A	A[1]	A	A	A	A	A	B	A	–	A	B	A	A	B	B[1]	A	A	C	A	A	B	A[1]	A	–	–
Ethane	–	A[1]	A[1]	A[1]	–	–	–	–	D	–	D	–	A	A[1]	A	A	D	B	–	D	B	–	D	A	A	A	A[1]	–	–	–	A	–	A	–	–	A	–	–
Ethanol	B[1]	A[1]	B	A[2]	–	A	B	A[1]	A[1]	B[2]	A	–	A	C	–	C	A	A	A	A	A	A	B	C	A	A	A	B	A	A	A	B	A	A	A	A	A	–
Ethanolamine	–	D	–	A[1]	–	–	–	A	A	–	D	A	A[1]	D	C[1]	B	B	C	D	B	B	–	B	–	D	A	A	B	–	A	A	–	D	B	B	A	A	–
Ether	D	A[1]	D	A[1]	–	D	D	D	A	–	D	A	A	D	B[1]	D	C	D	B[1]	D	D	–	D	D	C	A	A	B[1]	B[1]	A	A	C	A	B[1]	A[1]	A	–	–
Ethyl Acetate	D	A	D	A	B	A	A	A[1]	A[2]	D	A[1]	A	A	D	D	D	B	D	A[1]	C	D	A	B	D	D	B	B	A[2]	B	A	A	A	A	A	A[1]	A	A	–
Ethyl Benzoate	D	–	D	–	–	B	C[2]	A[2]	–	D	B[1]	–	A	D	D	D	–	–	–	D	D	–	D	D	A[1]	–	–	–	–	–	–	–	A	–	–	–	–	–
Ethyl Chloride	D	A[1]	D	D	C	C	C[1]	D	A[1]	D	D	A	A	D	A	A	A	D	B	B	C	D	D	D	A	A	A	B	A	A	A	C	B	B[1]	A	A	A	–
Ethyl Ether	D	A[1]	D	A[2]	–	D	D	D	A[1]	–	D	A	A	D	A[2]	D	D	D	A[1]	D	D	–	D	D	D	B	B	B[1]	B	A	–	C	A	B[1]	A[1]	A[2]	–	–
Ethyl Sulfate	–	–	–	A[1]	–	–	–	–	–	–	–	–	A	–	–	A	–	–	A	–	–	–	–	–	A	D	D	–	–	D	A	–	B	–	–	A	–	–
Ethylene Bromide	D	–	D	–	–	–	D	–	–	D	D	–	A	D	A	D	C	C	B	C	C	–	D	D	A	A	A	B	–	B	–	–	–	B	B	A	–	–
Ethylene Chloride	D	A[1]	D	D	–	C	D	D	A	D	C[1]	A	A	D	A	D	D	D	A[1]	D	D	–	D	–	B	B	B	B	–	A	–	–	B	–	B[1]	A	–	A
Ethylene Chlorohydrin	D	D	D	D	–	–	D	–	D	D	D	–	A	D	A	D	B	C	–	C	A	D	C	D	A	B	B	B	B	B	–	–	B	B	B	A	–	–
Ethylene Diamine	D	D	D	A[1]	–	B	A	D	D	A[2]	–	A	A	D	B	A	A	B	D	B	B	–	A	–	B	B[1]	B	B[1]	D	B	–	–	D	C	A	–	–	–
Ethylene Dichloride	D	B[1]	D	D	C	D	D	D	A[1]	D	D	A	A	D	A	D	C	D	A	D	D	D	D	D	A	B	B	A[1]	B	C	C	A	–	B	B	A	A	–
Ethylene Glycol	A	B	A	A	A	A	A[2]	A	A	B[1]	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	B	B	A	B[1]	A	A	A	A	B[1]	A[1]	A	A	A
Ethylene Oxide	D	D	C[1]	D	A	B	A	A[1]	A[1]	C[1]	D	D	A	D	A	D	C	D	A	D	D	–	D	A	D	B	B	D	D	C	A	D	D	A	–	A	–	–
Fatty Acids	A	A	A	A	–	A	D	A[1]	A[1]	B[1]	A	–	A	A	A	B	D	B	A	C	C	D	C	D	A	B	A	A	C	A	C	C	D	A	B	A	A	–
Ferric Chloride	A	D	A	A	C	D	A[1]	A[2]	A	A[2]	A	A	A	A	A	A	A	B	A[1]	A	B	–	B	–	A	D	D	D	D	D	D	D	D	B[2]	A	A	–	–

Explanation of footnotes: 1. Satisfactory to 72°F (22°C) 2. Satisfactory to 120°F (48°C) 3. Satisfactory to 90°F (32°C) 4. Satisfactory to 200°F (93°C)

CHEMICAL RESISTANCE CHARTS

⚠ WARNING

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠ DANGER

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

RATINGS

Chemical Behavior

A – No effect
B – Minor effect
C – Moderate effect
D – Severe effect; not recommended
— No data available

CHEMICAL	Plastics															Elastomers										Metals										Nonmetals		
	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon®	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Ferric Nitrate	A[2]	D	A	A	–	–	A[2]	A[2]	A[1]	A[1]	A	A	A	A	A	A	A	A	A	A	A	–	C	–	A	B	B	D	D	C	D	–	D	B[1]	A	A	–	–
Ferric Sulfate	A[2]	D	A	A	–	–	A[2]	A[2]	A[1]	A[1]	A	A	A	A	A	A	A	A	A	A	A	–	B	–	A	B[1]	A	D	D	C	D	D	D	A[1]	A[1]	A	A	–
Ferrous Chloride	A[2]	D	A	A	–	A	A[2]	A[2]	D	D	A	A	A	A	A	A	–	A	B[1]	A	A	–	–	–	A	D	D	D	D	C[1]	C	D	B	B[1]	A	A	–	A
Ferrous Sulfate	A[1]	D	A	A	–	–	A[2]	A[2]	D	A[1]	A	A	A	A	A	A[2]	A	B	A	B	–	–	–	–	B	B	B	B[1]	B[1]	B	D	D	B	B	A[1]	A	A	A
Fluoboric Acid	A[2]	A[1]	A[2]	D	–	A	A[2]	A[1]	D	–	A	A	A	A	A[1]	A	A[2]	A	B	A	A	–	–	C	B	B	B	D	–	B[1]	D	D	–	A[1]	D	A	C	A
Fluorine	A[1]	D	D	A[1]	–	D	D	–	D	C	D	D	D	D	A[1]	D	A[1]	–	A	C	–	D	D	D	C	C	A	A	A	C	D	D	C	B[1]	D	C	–	A
Fluosilicic Acid	A[2]	A[1]	A	C	–	B	A[2]	A[2]	D	A[1]	A	A	A	D	A[1]	A	A[2]	A	C	A	A	–	–	A	B[1]	C	B	D	B[1]	B[2]	D	D	D	B	D	A	C	A
Formaldehyde 40%	A[2]	A[2]	A[2]	A[2]	B	A	D	A	A	A[1]	A	A	A	A	A	B	A	B	A	B	B[1]	A	–	D	A	A[1]	A	B	A	A	A	B	B[2]	B	B	A	–	A
Formaldehyde 100%	B	A	A	A	–	A	B	A	D	A[2]	C	B	A	A	A	C	A	C	A	C	C	A	B	D	D	C	A	A	–	B	A	C	A[2]	A	A	–	–	A
Formic Acid	D	A[2]	A[2]	C[1]	B	A	D	A	D	A[1]	A1	A	A	A[1]	A	C	A	A[1]	A[1]	C	A	–	B	C	C	B[1]	A[1]	A	D	C	C	D	C	A	C[1]	A	–	A
Fruit Juice	B	D	A	A	–	–	A	B	A	–	B	–	A	A	A	A	–	B	A	D	A	–	–	A	A	A	A	A	D	–	C	D	A	A	A	–	A	A
Fuel Oils	D	A	–	A[1]	–	C	B	B	A[1]	B[1]	A	A	B	A[2]	B	A	D	C	A	D	B	–	D	D	A	A	A	C[1]	B	A	A	A	A	A[1]	A	A	–	–
Furan Resin	–	D	–	A[1]	–	–	D	–	–	–	D	A	A	A	D	D	C	D	A[1]	D	D	A	D	A	D	A[1]	A	A	–	–	A	–	–	B	–	–	–	–
Furfural	D	A	D	A[1]	–	A	D	D	B	D	D	A	A	D	B[2]	D	D	B	D	D	D	A	D	D	D	A	B	A[1]	–	B	A	B	A	B	A	A	–	–
Gallic Acid	–	–	C	–	–	A	A	A	A	–	A	A	B	B	A[1]	B	B	D	A	A	B	–	D	D	A	A	B	D	–	B	A	D	D	B[1]	B	B	–	–
Gasoline (high-aromatic)	D	B	C[1]	A	A	B	A	B	A	A	A	A	B	A	A	A	D	B	A	D	A	D	D	–	A	A	A	D	–	A	A	A	–	A	B	A	A	A
Gasoline, leaded, ref.	D	A	–	A[2]	A	B	–	B	A[2]	A[2]	B	A	A	B	A	A[2]	D	B	A[2]	D	B	D	D	D	A[1]	A[1]	A[2]	A	–	A[2]	–	–	B	A	A	A[2]	A	A
Gasoline, unleaded	D	A	C	A[2]	–	B	–	D	A[2]	A[2]	C[1]	A	A	C[2]	A	A[1]	D	A	A[2]	D	B	D	D	D	A[1]	A[1]	A[2]	A[2]	–	A[2]	A	A	B	A	A	A[2]	–	–
Gelatin	–	B	A[2]	B	–	A	A[2]	A[2]	A[1]	–	A	–	A	B	A	A	A	B	–	A	A	–	A	A	A	A[2]	A[2]	A	D	A	A	A	A	A	A	A	–	A
Glucose	B	A	A[2]	B	–	A	A[2]	A[2]	A	A[1]	A	B	A	A[2]	A	A	A	B	–	A	A	–	A	A	A	A[1]	A	A	A	–	A	A	A	A	A	A	–	A
Glue, P.V.A.	–	A	A	A	A	A	A[1]	–	A[1]	–	–	–	A	C	–	A	A	A	–	A	A	–	A	C	B	A[1]	A[2]	A	–	A	A	A	B	A	A	A	–	A
Glycerin	C	A	A	A	A	A	A[1]	A	A[1]	A[2]	A	A	A	A	A	A	A	A	A	A	A	D	A	A	A	A[2]	A	A	B	A	A	A	A	A	A	A	A	–
Glycolic Acid	B	A	A	A	–	–	A[2]	–	–	–	A	A	A	B	B	A	A	A	B	D	A	–	A	A	A	A	A	–	–	–	–	–	–	A	A	A	–	–
Gold Monocyanide	–	A	–	A	–	–	–	–	–	–	–	–	D	–	A	A	–	–	–	–	A	–	–	A	A	A	A	–	–	–	A	D	–	–	–	–	–	–
Grape Juice	B	A	A	A	–	–	B	–	A	–	–	–	A	A	A	A	A	–	–	D	D	–	A	B	A	A	A	–	–	A	C	D	–	–	A	–	–	–
Grease	–	D	–	A	–	–	–	–	–	–	–	–	A	A	A	A	D	–	–	D	D	–	D	A	A	–	A	–	A	A	A	A	A	A	–	–	–	–
Heptane	D	A	A	A	–	B	B[1]	B	A	B	C[2]	A	A	C[1]	A	A	D	B	A	D	B	A	D	D	A	A	A	A	A	A	A	A	A	A	A	A	–	–
Hexane	D	A	B[1]	A	A	C	D	B	B	D	B[1]	A	A	B[1]	A	A	D	B	A	D	B	A	D	D	A	A	A	A	A	A	A	A	A	A	A	A	–	A
Honey	–	A	–	A	–	–	B	–	A	A[1]	A	–	A	A	A	A	A	–	–	A	–	–	A	A	A	A	A	A	–	A	A	A	–	A	–	–	–	–
Hydraulic Oil (Petro)	–	B	–	A	–	A	C	–	A[1]	–	D	D	A	A	A	A	D	A	–	D	A	B	B	A	A	A	A	A	A	A	A	A	A	A	–	B	–	–
Hydraulic Oil (Synthetic)	–	–	–	A	–	A	A	–	A1	–	D	–	A	A	A	D	A	A	–	D	A	D	B	A	A	A	A	A	A	A	A	–	A	A	–	B	–	–
Hydrazine	–	B	D	A	C	D	–	–	–	D	C	–	A	–	A	B	A	B	–	C	B	–	B	D	A	A	A	–	–	–	D	D	A	–	–	–	–	–
Hydrobromic Acid 20%	–	C	A	B[1]	–	D	B[2]	B	D	–	A[2]	–	–	B[2]	A	D	A	A	A	A	D	–	D	C	A	D	D	D	D	–	C	D	D	A	A	A	–	A
Hydrobromic Acid 100%	B	D	A[2]	D	–	D	B[1]	B	D	–	C[1]	A[1]	A	A[1]	A	D	A	A	A	A	D	–	D	C	A	D	D	D	D	–	D	D	D	C	A	A	–	A
Hydrochloric Acid 20%	A	C	A[2]	A[1]	B	A	A[2]	A	D	B[1]	B[2]	D	A	A[2]	A	–	A	A	A	A	C	A	D	C	A	D	D	D	–	D	D	D	D	A[1]	D	A	C	A
Hydrochloric Acid 37%	A	C	A[2]	A	C	A	B[2]	A	D	D	C	D	A	B	A	B	C	B	A	A	B	A	B	C	A	D	D	D	–	D	D	D	D	B	D	A	C	A
Hydrochloric Acid 100%	A	C	A	–	–	D	–	A	D	D	B[1]	D	A	D	A	D	D	D	A	D	D	A	D	C	A	D	D	D	D	D	D	D	D	A	D	A	C	A
Hydrochloric Acid, Dry Gas	–	–	A	A	–	D	A[2]	A	A[1]	–	B	D	A	A[2]	A	–	–	–	A	–	–	A	–	–	–	D	D	D	D	A	D	–	D	A	C	A	–	A
Hydrocyanic Acid	B	B	A	A	C	A	A[2]	A[1]	B	–	A	B	A	B	A	B	B	A	–	B	B	A	C	A	A	B[1]	A	A	D	A	D	D	D	A	B	A	–	–
Hydrocyanic Acid (Gas 10%)	–	C	A	–	–	A	–	C	–	B[1]	A	–	A	A	–	B	A	–	–	B	A	A	D	A	A	–	–	–	–	–	D	–	–	–	A	–	–	–
Hydrofluoric Acid 20%	C	D	C[1]	A	–	A	A[2]	C[1]	C[1]	D	A[2]	A	A	B	A	D	D	B	B	B[1]	B	D	D	C	A	D	D	D	–	B[2]	D	D	B	B	D	A	–	B
Hydrofluoric Acid 50%	C	D	C[1]	C[2]	D	A	A[1]	D	D	D	A[2]	A	A	B[1]	A	D	D	B	B	B[1]	D	D	D	C	B	D	D	D	–	B[2]	D	D	B	B	D	A	–	B
Hydrofluoric Acid 75%	C	D	C[1]	B[1]	D	B	C[1]	D	D	D	C[1]	B	A	C	A	D	C	B	B	D	D	D	D	C	B	D	D	D	–	B[1]	D	D	B	B	D	A	C	B
Hydrofluoric Acid 100%	D	D	C[1]	–	D	D	–	D	D	D	C[1]	D	A	C	A	D	D	B	A	D	D	D	D	D	B	B[1]	B[1]	D	–	B[1]	D	D	B	B	D	–	–	B
Hydrofluosilicic Acid 20%	–	B	A	C[1]	–	B	B[2]	B[2]	D	–	A	A	A	A[2]	A	A	A	B	A	A	B	–	D	A	A	C[2]	B[1]	D	–	B[2]	D	B	B	B	D	A	–	–
Hydrofluosilicic Acid 100%	–	A	–	C[1]	–	C	B[1]	B[2]	D	–	A	A[1]	A	B[1]	A[1]	B	A	B	B	A	B	–	D	D	A	D	D	D	–	B[2]	D	D	–	B	D	A	–	–
Hydrogen Gas	–	–	A[2]	–	A	A	A[2]	A[1]	A[2]	A[2]	A	A	A	A[2]	A	A	A	A	B	B	A	–	C	A	A	A	A	A	–	A	A	–	A	A	A	A	–	–
Hydrogen Peroxide 10%	A	D	A	C[1]	–	A	A	A[2]	C[1]	A[2]	A	A	A	A[1]	A	D	A	D	A	B	D	–	A	B	A	B[2]	B	A	–	B[1]	C	C	D	A	A	C	–	A
Hydrogen Peroxide 30%	–	D	A	B	–	A	C[2]	A[2]	D	A[2]	B[1]	A[1]	A	A[1]	A	D	B	D	B	C	D	–	B	B	A	B[2]	B	A	–	B[1]	B	B	D	A	B[1]	C	–	A
Hydrogen Peroxide 50%	–	D	A	–	–	A	C[2]	–	D	A[2]	B[1]	–	A	A[1]	A[1]	D	B	D	A	C	D	–	B	B	A	B[2]	A[2]	A	–	B[1]	B	–	D	A	A	C	–	A
Hydrogen Peroxide 100%	A	D	A	A	–	A	C[2]	A	D	A	B[1]	C	A	A	A[1]	D	D	D	B	C	D	–	B	B	A	B[2]	A[2]	A	D	B[1]	D	B	D	A	B	C	A	A
Hydrogen Sulfide (aqua)	B	C	A	A	–	A	A	A[1]	C[1]	A	A[1]	A	A	B[1]	A	D	B	D	A[1]	C	A	–	C	A	D	C	A	B	–	A	D	D	–	A	B	A	A	A
Hydrogen Sulfide (dry)	–	–	A	A	A	A	A	–	C[1]	–	A[1]	A	A	A[2]	A	D	B	B	B	C	A	–	C	A	D	C[1]	A	B	D	B	D	D	D	A	A	A	–	–
Hydroquinone	D	A	A	–	–	–	A	–	D	–	A	–	A	B	–	D	D	D	–	A	A	–	–	–	B	B	B	B	–	–	–	–	B	B	B	A	–	A
Hydroxyacetic Acid 70%	–	A	A	A	–	–	A	–	–	–	–	–	A	D	A	A	A	–	–	–	A	–	–	–	A	–	–	–	–	–	D	B	–	–	A	–	–	–
Ink	A	B	–	A	–	–	–	–	C	–	–	–	A	C	A	A	–	–	–	D	A	–	–	C	A	C	C	–	–	–	D	D	A	–	–	–	A	A
Iodine	D	D	D	C	B	B	A[1]	C[1]	A	–	C	D	A	A	A[2]	B	B	D	A	D	D	–	–	A	A	D	D	A	–	A	D	D	D	A	A	D	–	–
Iodine (in alcohol)	–	D	–	–	–	B	B	–	C	–	–	–	–	A	A	–	A	–	–	–	–	–	–	–	–	–	–	B	–	B	–	–	–	B	B	–	–	–
Iodoform	–	–	–	–	–	–	–	–	–	–	–	–	C	A	C	D	A	–	–	B	A	–	–	C	–	A	A	–	–	–	A	–	B	D	B	–	–	–
Isooctane	–	–	–	A[2]	A	B	B	D	A[1]	B[1]	A[2]	A	A	A[1]	A[2]	A[2]	D	–	A[1]	A[1]	B[1]	D	D	D	A[1]	A[1]	A[1]	A[1]	A	A[1]	–	–	–	–	–	A[2]	–	–
Isopropyl Acetate	–	D	–	A	C	B	B[1]	–	B[1]	D	B[1]	–	A	D	D	D	B	D	–	D	D	–	D	D	D	C	A	D	–	A[1]	B	–	–	B	–	A	–	–
Isopropyl Ether	–	D	–	D	–	D	B	–	A[1]	D	B	–	A[1]	B	D	B	D	C	A	A	D	–	D	D	D	A	A	A	A	A	A	–	B	A	–	A	–	–
Isotane	–	–	–	A	–	–	–	–	D	–	D	–	–	A	A	A	–	–	–	–	D	–	–	–	A	–	–	D	–	–	–	–	–	–	–	–	–	–
Jet Fuel (JP3, JP4, JP5, JP8)	–	A[1]	–	A	–	D	D	D	C	A[1]	A[1]	A	A	C	B	A	D	D	A	D	D	D	D	D	A	A	A	A	–	A	A	A	A	A	A	A	–	–
Kerosene	D	A[2]	–	A	C	B	C[1]	D	A	D	B	A	A	A[2]	A	A	D	D	A	D	A	D	D	D	A	A	A	A	A	A	A	A	B	B	A	A	A	B
Ketones	A	D	–	C	–	D	C[1]	D	A[2]	D	C	A	A	D	C[1]	D	A	–	B[1]	A	D	D	–	D	D	A	A	B	–	A	A	–	A	A	A	A	A	–

Explanation of footnotes: 1. Satisfactory to 72°F (22°C) 2. Satisfactory to 120°F (48°C) 3. Satisfactory to 90°F (32°C) 4. Satisfactory to 200°F (93°C)

MASTERFLEX®

CHEMICAL RESISTANCE CHARTS

CHEMICAL COMPATIBILITY DATABASE
To find the safest materials for your application, search this database by chemical, material, or compatibility level.
Scan the QR code at right with your mobile device to get to our chemical compatibility database.

⚠ WARNING

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠ DANGER

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

RATINGS

Chemical Behavior

- **A** – No effect
- **B** – Minor effect
- **C** – Moderate effect
- **D** – Severe effect; not recommended
- — No data available

CHEMICAL	Plastics															Elastomers										Metals										Nonmetals		
	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon® (R-3603)	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Lacquer Thinners	A	D	–	A	D	D	A	D	A[1]	B	D	–	A	D	–	D	D	D	–	D	D	–	D	D	D	A[1]	A	A	A	A	A	C	A	A	C	A	–	–
Lacquers	A	D	–	A	–	D	A	D	A[1]	D	D	–	A	D	D	D	D	D	–	D	D	–	D	A	D	A[1]	A	A	–	A	A	C	A	A	–	A	–	–
Lactic Acid	D	B	A[1]	B[1]	D	A	A[1]	A	B	B	B	A	A	B[1]	B[1]	A	A	A	A[1]	A	A	–	A	A	A	B[1]	B[1]	B	D	B[2]	C	D	B	B[1]	A	A	A	–
Lard	–	A	–	B	–	A	A	A	A[1]	A[1]	B[1]	–	A	A[1]	A	A	D	B	–	D[1]	D	A	B	D	A	A	A	A	–	A	A	A	–	A	A	A	–	–
Latex	B	B	–	A	–	–	–	–	A[1]	–	A[2]	–	A	–	A	A	A	–	–	–	–	–	A	A	A	A[2]	A[2]	A	–	–	A	–	–	A	–	–	–	–
Lead Acetate	B	B	A[2]	A	–	A	A[2]	A[1]	A	–	A[1]	A	A	B	A	B	A	D	A	A	A	–	A	B	D	B	B[1]	D	–	B[1]	A	A	–	B[1]	A[1]	A	A	–
Lead Nitrate	B	–	A[2]	–	–	A	A[2]	A[1]	–	–	A[1]	A	A[1]	A[2]	A[2]	A[2]	A[2]	–	–	A[1]	A[1]	–	B[1]	A[2]	A[2]	B[1]	B[1]	D	–	B[2]	–	–	–	B[2]	–	A[1]	–	–
Lead Sulfamate	–	A	–	A	–	–	A[1]	–	B[1]	A[1]	A[2]	–	B	B	A	B	A	A	–	B	A	–	B	–	A	C	C	C	–	–	–	–	–	–	–	–	–	–
Ligroin	–	B	–	A	–	–	A	–	D	–	A[2]	–	A	–	A	A	D	C	–	D	B	–	D	A	A	–	A	D	–	–	A	–	–	–	–	–	–	–
Lime	–	B	–	A	–	–	A	–	A[1]	–	–	–	A[1]	B	A	A	D	–	–	–	A	–	–	A	A	A	A	A	–	–	A	A	–	–	A	A	–	–
Linoleic Acid	A	B	A[2]	–	–	–	A	–	–	–	B[1]	–	A	A[2]	A[2]	B[1]	D	D	–	D	–	–	B[1]	A[2]	B[1]	B	A	A[2]	–	–	–	–	D	–	–	A[2]	–	–
Lithium Chloride	–	A	A[2]	–	–	D	A[2]	–	–	B[1]	A[2]	–	A	D	A[2]	A[2]	A[1]	–	–	B[1]	A[1]	–	A[1]	A[2]	A[1]	A[1]	A[2]	D	–	A[2]	A	A	–	–	–	A[2]	–	–
Lithium Hydroxide	–	–	–	–	–	D	–	–	–	D	–	–	A	–	–	C	–	–	–	–	–	–	–	–	–	B	B	D	–	B	D	–	–	B	–	B	–	–
Lubricants	–	A	–	A	A	B	D	C[1]	A[1]	A[1]	A[1]	A	A	B2	A	A	D	A	–	D	D	–	D	B	A	A[2]	A[2]	A[2]	–	A[2]	A	A	A	A	A	A	–	–
Lye: KOH Potassium Hydroxide	A	A	A	A	D	B	A	A[1]	C	D	A	A	A	B	A	B[1]	A[2]	A	B	B	B	A	C	B	B	B	A[1]	D	D	D	B	B[2]	B	B[1]	D	C	D	A
Lye: NaOH Sodium Hydroxide	C	C	A	A	C	B	D	A	A	D	A	A	A	A	D	A[1]	B[1]	A	B	A[1]	B[2]	A	A[1]	B	B[1]	B	B[1]	D	D	D	D	D	B	C	B	–	A	–
Lye: Ca(OH)$_2$ Calcium Hydroxide	–	D	A[2]	A[1]	B[1]	B	A[2]	A[2]	A[2]	D	A[2]	A	A	B[2]	A[2]	A	A	A	A[2]	B[2]	A	A	A	B[2]	B[1]	B[1]	B	C[1]	–	D	B	A	–	A[1]	A	A	A	A
Magnesium Bisulfate	–	–	–	–	–	–	–	–	A[1]	A[1]	A[2]	–	A	A[2]	–	B	–	–	–	B[2]	B	–	–	A[2]	–	A[1]	A[1]	D	–	A[1]	–	–	–	–	–	A[1]	–	–
Magnesium Carbonate	B	A	A[2]	A	–	–	B	A[2]	–	A[1]	A	–	A[1]	B	A	A[2]	A	A	–	–	A	–	–	–	A	B	B	A	–	A	A	–	A	B	A	–	A	A
Magnesium Chloride	B	B[1]	A	A	C	A	A[1]	A[1]	A[1]	A[2]	A[2]	A[1]	A	B	A	A[2]	A	A[2]	A	A	A	–	A	–	A[2]	D	D	D	D	B	C	D	A[2]	A[2]	A[2]	A[2]	A[2]	A
Magnesium Hydroxide	B	A	A	A	C	B	A[2]	A[2]	B[1]	A[1]	A	A	A	A[2]	A	A	A	A	A	A	A	–	A	A	A	B	A[1]	C[1]	D	B	A	A	B	A	A	A	A	–
Magnesium Nitrate	B	A	A	A	–	B	A[2]	A[1]	A[1]	A[1]	A	A	A	A[2]	A	A	A	A	–	A	A	–	–	A	A	B	B	B	–	A	D	D	B	A	A	–	A	A
Magnesium Oxide	–	A	–	A	–	–	–	–	–	–	–	–	A	–	–	A	–	–	–	–	A	–	–	–	C	A	A	B	–	–	A	A	–	–	–	–	–	–
Magnesium Sulfate (Epsom Salts)	B[2]	B	A[1]	A	–	A	A[2]	A[1]	A[1]	A[1]	A	A	A	A[1]	A	A	A	A	A	B	A	–	A	A	A	A	B	B[1]	A	A	C	A	A	B	A[1]	A	–	–
Maleic Acid	–	A	A	A	–	A	B[2]	A[1]	A	–	A	B	A	A[2]	A	D	D	D	–	B	D	–	–	D	A	A	B	B[1]	–	B	A	A	–	B	A	A	–	–
Maleic Anhydride	–	D	–	A	–	A	D	–	–	–	D	–	A	–	A	D	D	D	–	D	D	–	–	–	A	A	A	A	–	–	–	–	–	–	–	–	–	–
Malic Acid	–	A	–	–	–	–	B[2]	–	A	–	A[1]	–	A	A[2]	A	A	D	D	–	B	D	–	B	A	A	A	A[2]	B[1]	B	B[2]	A	–	D	B	A	B	–	–
Manganese Sulfate	B[2]	A[1]	A	–	–	–	A[1]	A[2]	A[2]	A[1]	–	A[2]	A	C	A[2]	A[2]	A[2]	–	A[1]	A[2]	A[2]	–	A[1]	A[1]	A[2]	B	B[2]	B[1]	D	A[2]	C	A	B	A[2]	A[2]	A[2]	A	–
Mash	–	A	–	A	–	–	A	–	A	–	–	–	–	–	–	A	A	–	–	–	A	–	–	A	A	A	A	A	–	–	A	–	–	–	–	–	–	–
Mayonnaise	–	A	–	A	–	–	D	–	A	–	–	–	A	D	A	C	–	–	–	D	A	–	–	D	A	C	A	A	–	–	D	D	B	A	–	–	–	–
Melamine	–	A	A[2]	A	–	–	–	–	A	–	A	–	A	D	–	C	A	–	–	–	D	–	C	D	A	–	D	–	–	–	D	D	–	–	–	D	–	–
Mercuric Chloride (dilute)	B	B	A	A	B	A	A	A[2]	D	A	B	A	A	A	A	A	A[1]	A	A	A	A	–	–	D	A	D	D	D	D	D	D	D	D	C	A[1]	C	A	–
Mercuric Cyanide	B	–	A	A	–	–	A	–	A[2]	–	B	A	B	A	A	A	A[1]	–	D	–	A	–	A	–	A[1]	C	C	D	–	D	–	C	D	A	A	–	A	–
Mercurous Nitrate	C[2]	–	A[2]	–	–	–	A	A[2]	–	A[2]	A	–	A	A	A	B[1]	A[1]	–	–	B[1]	B[1]	–	–	A[2]	A[1]	A[1]	A[1]	D	–	–	–	–	–	A[1]	A[1]	C	A	A
Mercury	B	A	A	A	B	A	A	A[1]	A	D	B	–	A	A	A	A	A	A	A	A	A	–	–	A	A	A	A	D	D	A	D	A	D	A[2]	A	C	A	A
Methane	–	A	–	–	–	–	–	–	A	–	A	–	A	B	A	A	D	B	–	D	B	D	D	A	A	A	A	A	–	A	A	–	–	A	–	B	–	–
Methanol (Methyl Alcohol)	D	A	A	B[1]	B	A	A[1]	A	B[1]	B[1]	A[2]	A	A	A[1]	A	A	A	A	A[1]	A	A	A	A	D	C	A	A	A[1]	A	A	A	A	B[1]	A	B	A	A	A
Methyl Acetate	D	B	–	D	–	C	B[1]	–	A[2]	D	D	–	A	D	B[1]	D	B	D	A	D	B	–	D	D	D	A	B	A	–	A	A	A	B	A	–	A	–	–
Methyl Acetone	–	D	–	C	–	–	–	–	A	–	–	–	A	D	D	D	A[1]	–	–	A	D	–	–	A	D	A	A	A	A	A	B	A	–	–	–	A	–	–
Methyl Acrylate	–	B	–	A	–	–	–	–	–	–	D	–	–	–	B[1]	D	B	D	–	D	B	D	D	–	D	A	–	–	–	–	–	A	–	–	–	–	–	–
Methyl Alcohol 10%	D	A	A	B[1]	B	A	A[1]	A[2]	B[1]	B[1]	A[2]	A	A	A[1]	A	A	A	A	A	A	A	A	A	A[1]	C	A	A	A[1]	A	A	A	A	A	A	B	A	A	A
Methyl Bromide	D	D	D	B	–	–	C[1]	–	B[1]	–	C	–	A	D	A	B[1]	D	D	–	D	D	D	–	D	A	A	A	D	–	–	–	A	B	–	–	A	–	–
Methyl Butyl Ketone	–	D	–	C	–	–	–	–	D	D	D	–	–	A	D	D	A[1]	D	–	D	D	–	D	–	D	A	A	–	–	–	A	–	–	–	–	–	–	–
Methyl Cellosolve	–	D	D	C	–	–	–	–	C	D	B	–	A	D	A	A[1]	B[2]	D	–	D	B	–	D	C	D	B	B	B	A	A	–	C	B	–	–	A	–	–
Methyl Chloride	D	B	D	A	–	–	C[1]	D	B[1]	D	D	B	A	D	A	D	D	D	A	D	D	D	D	D	A[1]	A	A	D	A	B[2]	C	D	–	B	A	A	–	–
Methyl Dichloride	–	D	–	A	–	–	–	–	C	–	D	–	–	A	D	D	D	–	–	–	–	–	–	–	A[1]	–	–	–	–	–	–	–	–	–	–	–	–	–
Methyl Ethyl Ketone	D	C	D	C[1]	B	D	D	D	A[1]	D	B[2]	A	A	D	D	D	A[2]	D	A	D	D	D	D	D	D	A	A	B	A	A	A	A	A	A	A	A	A	A
Methyl Ethyl Ketone Peroxide	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	D	D	D	–	D	D	–	B	–	D	–	–	–	–	–	–	–	–	–	–	–	–	–
Methyl Isobutyl Ketone	D	–	D	C	B	D	C	D	B[2]	D	A	A	A	D	D	D	B[1]	D	A	D	D	D	D	D	D	B	B	B	–	A	C	C	B	A	A	A	–	–
Methyl Isopropyl Ketone	–	–	–	A	–	–	D	D	A	D	–	–	A	D	–	D	C[1]	D	–	D	D	–	C	–	D	A	A	A	–	A	–	C	A	–	–	A	–	–
Methyl Methacrylate	–	D	–	A	–	–	–	–	–	–	D	–	–	A	B[1]	D	D	D	–	D	D	C	C	–	D	B	B	–	–	–	–	C	–	–	–	–	–	–
Methylamine	D	D	–	A	–	–	A[1]	–	–	–	A[2]	–	A	D	C	B	A[1]	–	A	B	–	–	–	D	D	A	A	A	D	A[2]	D	A	–	–	–	A[2]	–	–
Methylene Chloride	D	B	D	A	D	D	D	D	C[1]	D	B[1]	A	A	D	B[1]	D	C[1]	–	A	B	–	D	–	D	B	B	B	C	A	B	A	B	B	B	B	A	–	–
Milk	B	A	A	A	–	–	A	A[2]	A	A	B	–	A	A[2]	A[2]	A[1]	A	A	A	A	A	–	A	A	A	A	A	A	D	A	C	D	D	A	A	A	A	A
Mineral Spirits	D	A	A	A	–	D	B	A	A	C	B	A	A	A	–	A	D	C	A	D	C	–	D	D	A	A	A	A	–	A	C	B	–	B	B	A	–	–
Molasses	B	A	A	A	–	A	A	A[2]	A[1]	–	B	–	A	A	B[1]	A	A[1]	–	A	A	A	–	–	A	A	A	A	A	B	A	D	B	A	A	A	A	A	A
Monochloroacetic Acid	–	D	–	–	D	D	–	–	D	D	–	–	A[2]	–	B[1]	D	C	A[2]	B	–	A[1]	D	–	–	C	A[1]	A[1]	D	B	B[1]	–	D	D	A[2]	A[2]	B[2]	–	–
Monoethanolamine	–	D	–	A	–	–	C	A	A	–	B	A	A	D	C	B[1]	B	D	–	B	D	–	B	D	D	A	A	B	–	A	–	A	D	–	B	A	–	–
Morpholine	C	–	–	–	–	–	–	D	A[2]	D	B[2]	C	A[2]	–	B[1]	D	D	–	–	A[1]	D	–	–	–	–	–	A[1]	A[1]	–	–	–	–	–	A[1]	–	A[1]	–	–
Motor Oil	C	B	A	–	B	–	C[1]	A	A[2]	A	A[1]	A	A	B	B	A	D	–	A	–	B[1]	–	–	D	–	A[1]	A[2]	A[1]	–	A[1]	–	–	–	–	A[1]	A[2]	A	A
Mustard	B	C	A	A	–	–	A	A	A	A	A	–	A	B	A	B	A	–	–	B	A	–	–	B	D	A	A	B	–	A	D	D	–	A	A	A	–	–
Naphtha	D	A[1]	A	A	B	–	A[1]	D	A	B	B	A	B	A[1]	A	A	D	D	A	D	D	D	D	D	A	A	A	A	A	A	B	B	A	B	B	A	–	–
Naphthalene	D	A[1]	D	A	B	B	C	D	A[1]	–	B	A	A	D	A[2]	D	D	D	A	D	D	D	D	D	A	A	A	B[1]	–	A	C	A	–	A	A	A	A	–
Natural Gas	B	B	–	–	–	–	A	–	–	–	A	–	A	A	–	A	D	–	–	–	A	D	A	A	A	A	A	A	–	A	–	A	–	–	–	–	–	–
Nickel Chloride	A	A	A	A	–	B	A	A[1]	C1	A[2]	A	A	A	A	A	A[1]	A[1]	A	A	A	B	–	A	B	A	D	C	D	D	B[1]	D	D	–	B	A	A	A	–
Nickel Nitrate	A	–	A[2]	A[1]	–	B	A	A[2]	A[1]	D	A[2]	–	A[2]	A	A[2]	A[1]	A[2]	D	A	A[1]	A[2]	–	–	A[2]	A[2]	B	B[2]	D	–	A[2]	–	C	–	B[2]	–	–	A	A
Nickel Sulfate	B	A	A	A	–	B	A	A[1]	A[1]	A	A	A	A	A	A	A[1]	A[1]	A	A	B	A	–	A	A	A	B	B[1]	D	D	B	C	D	–	B	B	A	A	–
Nitrating Acid (<1% Acid)	–	–	–	–	–	–	–	–	–	–	C	C	A	D	–	–	–	–	–	C	A	–	–	D	–	C	A	D	–	–	D	–	–	A	–	–	–	–
Nitrating Acid (<15% H_2SO_4)	–	–	–	–	–	–	–	–	–	–	C	C	A	D	–	–	–	–	–	C	A	–	–	D	–	C	C	D	–	–	D	A	–	A	A	–	–	–

Explanation of footnotes: 1. Satisfactory to 72°F (22°C) 2. Satisfactory to 120°F (48°C) 3. Satisfactory to 90°F (32°C) 4. Satisfactory to 200°F (93°C)

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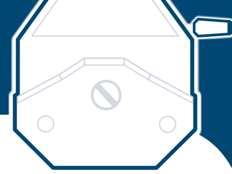

CHEMICAL RESISTANCE CHARTS

⚠ WARNING

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠ DANGER

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

RATINGS

Chemical Behavior

A – No effect
B – Minor effect
C – Moderate effect
D – Severe effect; not recommended
— No data available

CHEMICAL	Plastics															Elastomers										Metals										Nonmetals		
	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS (Ryton®)	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon®	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Nitrating Acid (>15% H_2SO_4)	–	D	–	D	–	–	–	–	–	–	C	D	A	D	–	D	A[1]	–	–	C	A	–	–	D	–	C	C	D	–	–	D	C	–	A	C	–	–	–
Nitrating Acid (<15% HNO_3)	–	–	–	–	–	–	–	–	–	–	C	C	A	D	–	–	–	–	–	C	A	–	–	D	–	C	D	D	–	–	D	C	–	A	C	–	–	–
Nitric Acid (5 to10%)	B	D	A	A[1]	C	A	B	A	D	A	A	B[1]	A	A[1]	A[1]	D	A[1]	B	A	D	B	D	C	B	A	A	A	A	D	A[1]	D	D	D	A[1]	A[1]	A	A	–
Nitric Acid (20%)	B	D	A[2]	B[1]	D	B	C	B[2]	D	B[1]	A[2]	C	A	A[1]	A	D	A[1]	D	A[1]	D	D	D	D	B	A	A	A	D	D	A[1]	D	D	D	A[1]	A[1]	A	A	–
Nitric Acid (50%)	C	D	B[1]	D	D	D	B[1]	B[2]	D	B	B	C	A	B[1]	A[1]	D	D	D	A	D	D	D	D	B	A	A[2]	A[1]	D	D	A[1]	D	D	D	A[1]	A[1]	D	A	C
Nitric Acid (Concentrated)	D	D	D	D	D	D	C1	B[1]	D	C[1]	D	C	A	B[1]	A[1]	D	D	D	A[1]	D	D	D	D	D	A	A[1]	A[1]	D	D	A[2]	D	D	D	B[1]	A[1]	D	A	C
Nitrobenzene	D	C	D	C[1]	D	D	C[1]	D	B[1]	D	B[1]	A[2]	A	D	A[1]	D	B[1]	D	A[1]	D	D	–	D	D	B	B	B	B	–	A	C	C	B	D	A	B	–	–
Nitrogen Fertilizer	–	–	–	–	–	–	–	–	–	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitromethane	D	A	–	–	C	D	A	D	B[1]	D	B[2]	A[2]	A	B[2]	A[2]	D	B[2]	–	A	B[1]	D	–	D	D	D	A	A[1]	A	–	–	–	–	D	A	–	A[2]	–	–
Nitrous Acid	D	–	A	D	–	–	–	–	–	–	A	–	A	A	B	–	A	–	B	C	D	–	–	A	B	B	B	D	D	B	A	–	C	D	–	–	–	–
Nitrous Oxide	–	–	–	–	–	–	C	–	C	–	D	–	A	A	D	–	A	–	–	A	A	–	–	A	B	B	B	B	B	D	B	–	B	B	–	C	–	–
Oils: Aniline	D	D	–	A	D	–	–	D	A	–	A	–	A	D	A	D	B	D	–	D	D	–	D	D	C	A	A	D	D	A	A	A	D	B	D	–	–	–
Anise	–	D	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	D	–	–	–	–	–	A	–	–	A	A	A	–	–	–	–	–	–
Bay	–	D	–	A	–	–	–	–	–	–	–	–	–	–	A	–	–	–	–	–	D	–	–	–	A	–	A	–	–	A	A	A	–	–	–	–	–	–
Bone	–	D	–	A	–	–	–	–	–	–	A	–	A	–	A	A	–	–	–	–	D	–	–	A	A	–	A	–	–	A	A	A	–	–	–	–	–	–
Castor	A	A	C	A	B[1]	–	–	–	A	–	A	–	A	A	A	B	B	A	–	A	A	–	A	A	A	A	A	A	A	–	A	A	A	–	A	–	A	A
Cinnamon	–	D	–	A	–	D	D	–	–	D	D	–	A	D	–	–	–	–	–	–	C	–	–	–	A	A	A	–	–	–	A	–	–	–	–	–	–	–
Citric	D	A	–	A	–	–	A	A	A	A	A	–	A	B	A	D	B	–	–	–	D	–	–	D	A	A	A	A	B	–	D	D	–	A	–	–	–	–
Clove	–	–	–	A	–	–	–	–	–	–	–	–	A	–	–	A	–	–	–	–	C	–	–	–	A	A	A	B	–	–	A	–	–	A	–	–	–	–
Coconut	A	A	A[1]	A	–	–	A	–	–	–	A[1]	–	A	A[1]	A	A	D	C	–	D	C	–	A	A	A	A	A	A	–	–	A	A	–	A	–	–	–	–
Cod Liver	A	B	A[1]	A	–	–	–	–	–	–	A[1]	–	A	A[1]	A	A	A	B	–	D	B	–	B	–	A	A	A	A	–	–	A	–	–	A	–	–	–	–
Corn	B	A	–	A	A	–	A	A	A	–	A[2]	–	A	B	A	D	C	B	–	D	A	–	A	B	B	A	A	A	–	–	C	A	B	A	–	–	–	–
Cottonseed	A	A	A	A[1]	A[1]	–	A	A	B	–	A	A	A	B[2]	A	A	D	B	A	D	C	–	A	B	A	A	A	A	A	–	A	A	A	A	A	A	A	–
Creosote	–	D	–	A	D	–	C	D	D	–	C	–	A	C	–	D	D	D	A	D	C	–	D	–	A	B	B	B	–	A	C	–	–	B	A	A	–	–
Crude Oil	A	A	A	A	–	D	–	D	A	–	A	A	A	A	A	A	D	D	–	D	D	–	–	–	A	A	A	A	B	C	–	–	B	A	A	A	–	–
Diesel Fuel (20, 30, 40, 50)	–	D	–	A[1]	A[1]	–	A	D	A	–	A[1]	A	A	B	A	A	D	B	A[1]	D	B	–	D	A	A	A	A	A	–	A	A	A	–	B	B	A	–	–
Fuel (1, 2, 3, 5A, 5B, 6)	D	D	–	A[1]	A	–	B	A[1]	A	B	B	A	A	A[2]	B	A	D	D	A	D	D	–	C	A	B	A	A	C[1]	B	A	A	A	A	A[1]	B	A	–	–
Ginger	–	A	–	A	–	–	–	–	–	–	–	–	A	–	A	A	A	–	–	–	A	–	–	–	A	D	D	–	–	D	D	–	–	–	–	–	–	–
Hydraulic Oil (Petro)	–	B	–	A	–	–	C	–	A[1]	–	D	D	A	A	A	A	D	A	–	D	A	–	B	A	A	A	A	A	A	A	A	A	A	A	–	B	–	–
Hydraulic Oil (Synthetic)	–	–	–	A	–	–	A	–	A[1]	–	D	–	A	A	A	D	A	A	–	D	A	–	B	A	A	A	A	A	A	A	A	–	A	A	–	B	–	–
Lemon	C	D	–	A	–	–	–	–	–	–	–	–	A	–	A	–	D	–	–	–	D	–	–	–	A	A	A	A	–	A	A	–	–	–	–	–	–	–
Linseed	–	A	C	A	B[1]	–	A	A[1]	A[1]	–	A	B	A	A[2]	A	A	D	C	–	D	D	–	A	A	A	A	A	B	B	A	A	–	B	B	A	A	A	A
Mineral	A	A	A	A	A	A	B[1]	A[1]	A	B	A	A	A	B	A	A	D	B	A	D	B	–	C	B	A	A	A	A	A	A	A	–	B	A	A	A	A	A
Olive	A	A	C	A	–	A	A[1]	A[2]	A[1]	A[2]	A	–	A[1]	C	–	D	D	B	–	D	B	–	D	B	A	A	A	A	–	A	A	–	–	A	A	A	A	–
Orange	–	D	–	A	–	C	C[1]	–	–	C[1]	A	–	–	C[1]	A	A	–	–	–	–	C	–	D	–	A	A	A	A	–	A	A	–	–	A	A	–	–	–
Palm	A	A	A	A	–	–	A	–	–	–	–	–	A	A	A	A	A	–	–	–	D	–	–	–	A	A	A	–	–	A	A	A	A	–	A	–	–	–
Peanut	–	A	C	A	–	–	A	–	–	–	D	–	A	A[1]	A	A	D	B	–	D	B	–	A	A	A	A	A	A	–	A	A	A	A	–	A	–	–	–
Peppermint	D	D	–	A	–	–	–	–	–	–	–	–	A	–	A	D	–	–	–	–	D	–	–	–	A	A	A	D	–	A	A	–	–	–	–	–	–	–
Pine	D	A	A	A	–	B	D	–	A	A	B	–	A	D	A	D	D	D	–	D	D	–	D	D	A	A	A	A	–	A	D	C	–	–	A	–	–	–
Rapeseed	–	A	A	A	–	–	D	–	–	–	D	–	A	–	A	D	A	D	–	D	B	–	D	–	A	A	A	–	–	A	A	A	–	–	A	–	–	–
Rosin	–	–	–	A	–	–	B[2]	–	A[1]	–	A[2]	–	A	C[1]	A	A	–	–	–	–	–	–	–	–	A	A[1]	A[1]	B[1]	–	B[1]	A	–	B	A	–	A	–	–
Sesame Seed	A	D	A	A	–	–	–	–	–	–	A	–	A	A	A	A	–	–	–	–	D	–	–	A	A	A	A	–	–	A	A	A	–	–	A	–	–	–
Silicone	A	A	A	A	A	A	A	A[1]	A[1]	–	A	A[1]	A	A	A	A	A	A	–	D	D	–	C	A	A	A	A	A	–	A	A	A	A	A	–	A	–	A
Soybean	A	A	A[2]	A	B	–	A[1]	–	A	–	A[1]	–	A	A[1]	A	A	C	C	–	D	C	–	A	B	A	A	A	A	–	A	A	A	–	A	A	A	–	–
Sperm (whale)	A	D	A	A	–	–	–	–	–	–	–	–	A	–	A	A	–	–	–	–	D	–	–	A	A	A	A	–	–	A	A	A	–	–	A	–	–	–
Tanning	–	D	–	A	–	–	–	–	–	–	–	–	–	–	A	A	–	–	–	–	D	–	–	–	A	A	A	–	–	A	A	–	–	–	–	–	–	–
Transformer	–	A	A	B	–	–	C[1]	–	A[1]	–	B	–	A	B	A	A	D	–	–	D	B	–	B	–	A	A	A	A	–	–	A	–	A	–	–	A	–	–
Turbine	–	A	A	A	–	–	C	–	A	–	B[1]	–	A	A[1]	A	B	A	D	–	D	D	–	D	A	A	A	A	A	–	A	A	A	A	–	A	–	–	–
Oleic Acid	D	A	A	A	A	C	C[2]	A[1]	A	–	B[1]	A	A	C[2]	A	B	B	C	B	D	C	–	D	D	B	A	A	A	D	B[1]	C	–	A	A[2]	B	A	A	–
Oleum 25%	–	D	D	D	C	–	D	–	D	–	D	A[1]	A	D	C[1]	D	D	D	A	D	D	–	D	A	A	B[2]	B	B	–	B	D	–	–	A	D	D	–	–
Oleum 100%	D	D	D	D	–	–	D	A[1]	D	–	D	A[1]	A	D	D	D	D	D	A	D	D	–	D	C	A	A	A	B	–	D	D	–	–	D	D	D	–	–
Oxalic Acid (cold)	A	B	A	A	D	A	A[2]	A[1]	B[2]	–	A[2]	A	A[1]	B	B	D	A	B	D	B	D	A	B	C	A	B	A	A	D	B[2]	A	C	B	B	A	A	A	–
Ozone	B[1]	C	A	A[1]	C	C[2]	C[1]	A[1]	B	B[1]	C	–	A	B	A	D	A	A	A	D	C	D	A	A	A	B	A	B	–	B	–	–	A	–	–	–	–	–
Palmitic Acid	A	A	A[1]	A	A	–	–	–	A	–	B[1]	–	A[2]	B[1]	A[2]	A[2]	B[1]	D	–	B[1]	D	A	D	D	A[1]	B[1]	A[1]	B	D	A	–	–	B	B	–	A[2]	–	–
Paraffin	A	A	A	A	–	B	B	A	A[1]	A[1]	A[1]	–	A	B	A	B	D	–	–	B	B	–	–	D	B	A	A	A	A	A	A	–	B	B	A	A	A	–
Pentane	–	B	–	A	–	–	D	–	A[1]	A	D	–	A	A	A	A	D	B	–	D	B	B	D	A	A	A	A	A	–	A	C	–	–	A	–	A	–	–
Perchloric Acid	–	C	A[1]	–	–	D	B	–	D	–	C	–	A	C	A	D	B	–	B	–	A	D	D	–	A	C	C	D	–	B	–	–	D	B	D	A	–	–
Perchloroethylene	D	B	C[1]	D	C	D	D	D	C[1]	D	D	A	A	C[1]	A	C	D	D	A	D	D	D	D	D	A	B	A[1]	C	–	B	D	A	B	B	A	A	A	–
Petrolatum	–	B	–	A	–	–	B	–	D	–	D	–	C	B	A	A	A	–	–	C	A	–	D	B	A	A	A	–	–	A	A	–	–	A	–	A	–	–
Petroleum	B	B	A[2]	A[2]	B	D	C[1]	D	A[1]	–	B[1]	–	A[2]	–	A	A[2]	D	D	–	D	B[1]	C	D	–	A[2]	A[1]	A[1]	D	–	A[1]	–	–	B	–	A[1]	A[2]	–	–
Phenol (10%)	D	B	A[1]	C	–	D	B	D	D	B[1]	B[1]	A	A	C[1]	A	D	B	D	B	A	D	D	D	B	A	B	B	A	–	B	C	D	B	B	B	A	A	–
Phenol (Carbolic Acid)	D	D	B[1]	C	D	D	D	D	D	D	B	A	A	D	A[1]	D	B	D	B	D	D	–	D	B	A	B	B	A	D	B	C	D	D	A	A	A	A	–
Phosphoric Acid (<40%)	B	D	A	A	–	A	A	A	B[1]	A	A[2]	A	A	B	B	D	B	B	A	B	B	A	C	A	A	D	C	C	D	B	D	D	D	A[2]	C	A	A	–
Phosphoric Acid (>40%)	C	D	A	B	–	A	B[1]	A	B[1]	A	A[2]	A	A	B	B	D	B	B	A	B	B	C	D	D	A	D	D	C	D	B	D	D	D	A[2]	C	B	A	C
Phosphoric Acid (crude)	C	D	–	B	–	B	B[1]	A	B[1]	A	B[2]	A	A	B[2]	A	D	B	B	A	D	D	–	D	D	A	D	B	C	–	B	D	D	D	A[2]	C	A	–	–
Phosphoric Acid (molten)	D	D	–	–	–	D	–	–	–	–	D	–	–	D	D	–	–	–	–	–	A	–	–	D	–	–	C	C	–	–	A	–	D	C	D	–	–	–
Phosphoric Acid Anhydride	–	D	–	–	–	A	–	–	–	D	A	D	–	–	D	D	–	–	–	–	A	–	–	–	–	–	–	C	–	–	A	–	–	–	D	–	–	–
Phosphorus	–	B	B[1]	–	–	–	B	–	–	–	A	–	A[2]	A[1]	A[1]	–	–	–	–	–	–	–	–	B[1]	–	A[2]	A[2]	B	–	A[2]	–	–	B	A[2]	–	D	–	–

Explanation of footnotes: 1. Satisfactory to 72°F (22°C) 2. Satisfactory to 120°F (48°C) 3. Satisfactory to 90°F (32°C) 4. Satisfactory to 200°F (93°C)

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⚠ WARNING

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠ DANGER

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

RATINGS

Chemical Behavior

- **A** – No effect
- **B** – Minor effect
- **C** – Moderate effect
- **D** – Severe effect; not recommended
- — No data available

	Plastics															Elastomers										Metals										Nonmetals		
CHEMICAL	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon®	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Phosphorus Trichloride	D	D	D	A[1]	–	A	B	–	–	C	–	A	A[2]	D	A[2]	D	A[1]	D	A[2]	D	D	–	–	C	A[1]	A[1]	A[2]	D	–	–	–	–	D	A[2]	A	A	–	–
Photographic Developer	B	D	A	A	–	–	A	A	–	A[2]	A	–	A	A	–	A	B	A	–	A	A	–	B	A	A	A	A	–	–	A	D	D	D	B	A	A	A	A
Photographic Solutions	–	D	A	B[2]	B	A	A	A[1]	A[1]	A[1]	A[2]	A[2]	A[2]	A	B[2]	B	A[1]	A[1]	A[2]	B	B[1]	–	A	A[2]	B[1]	D	–	–	–	A[2]	–	–	D	B[2]	A[1]	A[2]	–	–
Phthalic Acid	B	C	B	–	–	B	B[2]	–	B[1]	–	A	–	A[2]	–	A[2]	D	A[1]	A[2]	–	–	A	–	B[1]	D	A[1]	B[2]	A	B[2]	–	B[2]	–	–	C	B[2]	A	A[1]	–	–
Phthalic Anhydride	B	C	D	–	–	–	–	–	–	A[1]	D	–	A	D	A	D	A	–	–	A	A	–	–	D	A	A	A	A	–	A	B	–	C	A	–	A	–	–
Picric Acid	A	A	D	A	–	D	A	–	C1	D	B[1]	A	A	D	A[1]	C	B	B	A	D	A	D	D	A	A	B	B	C	–	B	D	A	D	B	A	A	–	–
Plating Solutions																																						
Antimony Plating 130°F	–	A	A	B	–	–	–	A	D	–	A	–	A	A	A	A	–	–	–	–	A	–	–	–	A	A	A	A	–	A	A	A	–	A	A	–	–	–
Arsenic Plating 110°F	–	A	A	B	–	–	–	–	A	–	A	–	A	A	A	A	–	–	–	–	A	–	–	–	A	A	A	A	–	A	A	A	–	A	A	–	–	–
Brass Plating:																																						
Regular Brass Bath 100°F	–	A	A	B	–	–	B	A	A	–	A	–	A	A	B	A	–	–	–	–	A	–	–	–	A	A	A	A	–	A	A	A	–	A	A	A	–	–
High-Speed Brass Bath 110°F	–	A	A	B	–	–	B	A	A	–	A	–	A	A	B	A	–	–	–	–	A	–	–	–	A	–	A	A	–	–	A	A	–	A	A	A	–	–
Bronze Plating:																																						
Cu-Cd Bronze Bath R.T.	–	A	A	B	–	–	–	A	A	–	A	–	A	A	A	A	A	–	–	–	A	–	–	–	A	A	A	A	–	–	A	A	–	A	A	–	–	–
Cu-Sn Bronze Bath 160°F	–	B	D	C	–	–	–	A	A	–	A	–	A	D	A	A	A	–	–	–	A	–	–	–	A	A	A	A	–	–	A	A	–	A	D	–	–	–
Cu-Zn Bronze Bath 100°F	–	A	A	B	–	–	–	A	A	–	A	–	A	A	A	A	–	–	–	–	A	–	–	–	A	A	A	A	–	–	A	A	–	A	A	–	–	–
Cadmium Plating:																																						
Cyanide Bath 90°F	–	A	A	B	–	–	–	A	A	–	A	–	A	A	A	A	–	–	–	–	A	–	–	–	A	–	A	A	–	–	A	A	–	A	A	–	–	–
Fluoborate Bath 100°F	–	C	A	B	–	–	–	A	D	–	A	–	A	A	A	B	–	–	–	–	C	–	–	–	A	A	A	A	–	–	A	D	–	D	D	–	–	–
Chromium Plating:																																						
Barrel Chrome Bath 95°F	–	D	A	C	–	–	–	D	D	–	A	–	A	A	C	D	–	–	–	–	D	–	–	–	C	–	D	A	–	–	D	C	–	D	C	–	–	–
Black Chrome Bath 115°F	–	D	A	C	–	–	–	D	D	–	A	–	A	A	C	C	–	–	–	–	D	–	–	–	C	–	C	A	–	–	C	A	–	D	A	–	–	–
Chromic-Sulfuric Bath 130°F	–	D	A	C	–	–	–	D	D	–	A	–	A	A	C	D	–	–	–	–	D	–	–	–	C	–	C	A	–	–	C	A	–	D	A	–	–	–
Fluoride Bath 130°F	–	D	A	C	–	–	–	D	D	–	A	–	A	A	C	D	–	–	–	–	D	–	–	–	C	–	D	A	–	–	D	C	–	D	C	–	–	–
Fluosilicate Bath 95°F	–	D	A	C	–	–	–	D	D	–	D	–	A	A	C	D	–	–	–	–	D	–	–	–	C	–	C	A	–	–	C	C	–	D	C	–	–	–
Copper Plating (Cyanide):																																						
Copper Strike Bath 120°F	–	A	A	B	–	–	–	A	A	–	A	–	A	A	B	A	–	–	–	–	A	–	–	–	A	–	A	–	–	–	–	A	–	A	–	–	–	–
High-Speed Bath 180°F	–	B	D	C	–	–	–	A	A	–	A	–	A	D	A	A	–	–	–	–	B	–	–	–	A	–	A	A	–	–	–	A	–	A	D	–	–	–
Rochelle Salt Bath 150°F	–	B	D	C	–	–	–	A	A	–	A	–	A	D	A	A	–	–	–	–	B	–	–	–	A	–	A	A	–	–	–	A	–	A	D	–	–	–
Copper Plating (Acid):																																						
Copper Fluoborate Bath 120°F	–	C	A	D	–	–	–	A	D	–	A	–	A	A	A	B	–	–	–	–	C	–	–	–	A	A	D	A	–	–	D	D	–	D	D	–	–	–
Copper Sulfate Bath R.T.	–	A	A	D	–	–	–	A	D	–	A	–	A	A	A	A	–	–	–	–	A	–	–	–	A	–	D	A	–	–	D	A	–	D	A	–	–	–
Copper Plating (Misc):																																						
Copper Pyrophosphate	–	A	A	B	–	–	–	A	A	–	A	–	A	A	A	A	–	–	–	–	A	–	–	–	A	–	A	A	–	–	A	A	–	A	A	–	–	–
Copper (Electroless)	–	D	A	B	–	–	–	A	A	–	A	–	A	A	A	D	–	–	–	–	D	–	–	D	A	–	–	A	–	–	–	–	–	–	A	–	–	–
Gold Plating:																																						
Acid 75°F	–	–	A	A	–	–	–	A	A	–	A	–	A	A	–	A	–	–	–	–	A	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Cyanide 150°F	–	–	D	D	–	–	–	A	A	–	A	–	A	D	–	A	–	–	–	–	A	–	–	–	A	–	A	–	–	–	–	–	–	A	A	–	–	–
Neutral 75°F	–	–	A	A	–	–	–	A	A	–	A	–	A	A	–	A	–	–	–	–	A	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Indium Sulfamate Plating R.T.	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	A	–	–	–	–	A	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	A	–
Iron Plating:																																						
Ferrous Am Sulfate Bath 150°F	–	–	D	D	–	–	–	A	D	–	A	–	A	D	–	A	–	–	–	–	B	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Ferrous Chloride Bath 190°F	–	–	D	D	–	–	–	A	D	–	C	–	A	D	–	B	–	–	–	–	D	–	–	–	A	–	D	–	–	–	–	–	–	D	A	–	–	–
Ferrous Sulfate Bath 150°F	–	–	D	D	–	–	–	A	D	–	A	–	A	D	–	A	–	–	–	–	B	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Fluoborate Bath 145°F	–	–	D	D	–	–	–	A	D	–	A	–	A	D	–	B	–	–	–	–	C	–	–	–	A	–	D	–	–	–	–	–	–	B	D	–	–	–
Sulfamate 140°F	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	A	–	–	–	–	A	–	–	–	A	–	D	–	–	–	–	–	–	B	A	–	–	–
Sulfate-Chloride Bath 160°F	–	–	D	D	–	–	–	A	D	–	A	–	A	D	–	B	–	–	–	–	C	–	–	–	A	–	D	–	–	–	–	–	–	D	A	–	–	–
Lead Fluoborate Plating	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	B	–	–	–	–	A	–	–	–	A	–	C	–	–	–	–	–	–	A	D	–	A	–
Nickel Plating:																																						
Electroless 200°F	–	–	D	B	–	–	–	D	D	–	D	–	A	D	–	D	–	–	–	–	D	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–
Fluoborate 100–170°F	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	B	–	–	–	–	A	–	–	–	A	–	C	–	–	–	–	–	–	A	D	–	–	–
High–Chloride 130–160°F	–	–	D	D	–	–	–	A	D	–	A	–	A	D	–	A	–	–	–	–	B	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Sulfamate 100–140°F	–	–	A	A	–	–	–	A	A	–	A	–	A	A	–	A	–	–	–	–	A	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Watts Type 115–160°F	–	–	D	D	–	–	–	A	A	–	A	–	A	D	–	A	–	–	–	–	A	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Rhodium Plating 120°F	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	A	A	–	–	–	B	–	–	–	A	–	D	–	–	–	–	–	–	D	D	–	A	–
Silver Plating 80–120°F	–	–	A	A	–	–	–	A	A	–	A	–	A	A	–	A	A	–	–	–	A	–	–	–	A	–	A	–	–	–	–	–	–	A	A	–	–	–
Tin-Fluoborate Plating 100°F	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	B	–	–	–	–	C	–	–	–	A	–	C	–	–	–	–	–	–	A	D	–	–	–
Tin-Lead Plating 100°F	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	B	–	–	–	–	C	–	–	–	A	–	C	–	–	–	–	–	–	A	D	–	–	–
Zinc Plating:																																						
Acid Chloride 140°F	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	A	–	–	–	–	A	–	–	–	A	–	D	–	–	–	–	–	–	D	A	–	–	–
Acid Fluoborate Bath R.T.	–	–	A	A	–	–	–	A	D	–	A	–	A	A	–	B	–	–	–	–	C	–	–	–	A	–	C	–	–	–	–	–	–	A	D	–	–	–
Acid Sulfate Bath 150°F	–	–	D	D	–	–	–	A	D	–	A	–	A	D	–	A	–	–	–	–	B	–	–	–	A	–	C	–	–	–	–	–	–	A	A	–	–	–
Alkaline Cyanide Bath R.T.	–	–	A	A	–	–	–	A	A	–	A	–	A	A	–	A	–	–	–	–	A	–	–	–	A	–	A	–	–	–	–	–	–	A	A	–	–	–
Potash (Potassium Carbonate)	A	B	A	A	D	B	A[1]	A	A	–	A	–	–	A	A	A	A[1]	–	–	A	A	–	–	A	A	B	B	D	–	B	B	C	B	B	A	A	D	–
Potassium Bicarbonate	A	–	A	A	–	B	A	A[1]1	A[1]	–	A	A	A	A	B	A	A	–	A	A	A	–	A[1]	A	A	B	B	D	–	B	B	A	B	B	A	A	A	A
Potassium Bromide	A[1]	A	A	A	–	B	A	A[1]	A[1]	A[1]	A	A	A	A	A	A	A[1]	–	A	A	A	–	A[1]	B	A	B	B	C[1]	–	B	B	D	B	B	A	A	C	A
Potassium Chlorate	A	B	A	A	–	B	A[1]	A[1]	C[1]	A[1]	A	A	A	A	A	A[1]	A[1]	–	A[2]	–	A	–	B	B	A	B[1]	B	B	–	B[1]	B	C	B[1]	B	A	A[2]	B	–
Potassium Chloride	A	A	A	A	B	A	A[1]	A[1]	A[1]	A	A	A	A	A	A	A[1]	A[1]	A	A	A	A	–	A	A	A	B[1]	A[1]	D	D	B	A	A	B	A	A	A	–	–

Explanation of footnotes: 1. Satisfactory to 72°F (22°C) 2. Satisfactory to 120°F (48°C) 3. Satisfactory to 90°F (32°C) 4. Satisfactory to 200°F (93°C)

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CHEMICAL RESISTANCE CHARTS

⚠WARNING

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠DANGER

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

RATINGS

Chemical Behavior

A – No effect
B – Minor effect
C – Moderate effect
D – Severe effect; not recommended
— No data available

CHEMICAL	Plastics															Elastomers										Metals										Nonmetals		
	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon®	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Potassium Chromate	–	C	A	C	–	–	A	A[2]	B	–	A	–	A[1]	A	B	A[1]	A[2]	–	–	B	A	–	–	B	A	B[1]	B[1]	B[1]	–	B[1]	B	A	–	A	–	A	B	–
Potassium Cyanide Solutions	A	C	A	A	B	–	A	A[1]	A[1]	–	A	A	A	A	A	A[1]	A[1]	A	A	A	B	–	A	A	A	B[1]	B[1]	D	D	D	B	B	D	B	A	A	D	–
Potassium Dichromate	B[1]	A	A	C	C	B	A	A[1]	B[1]	A[1]	A	A	A	A	A	A[1]	A[1]	A	A	B	A	–	A	–	A	B	B[1]	B	–	B[1]	B	A	B	B	A	A	B	A
Potassium Ferricyanide	B	B[1]	A	A[1]	–	–	A[2]	A[2]	B[1]	–	A[2]	–	A[2]	A	A[2]	D	A	A[1]	A[1]	B	A[1]	–	–	B	A	B[1]	B[1]	B[2]	–	B[2]	B	C	B	B[2]	A[2]	A[2]	B	A
Potassium Ferrocyanide	–	–	B	A	–	–	A[1]	A	B[1]	–	A	–	A	A	A	D	A	–	A	A	A	–	–	B	A	B	B	B[1]	–	B[1]	B	C	B	B	A	A	–	A
Potassium Hydroxide (Caustic Potash)	A	A	A	A	D	A	A	A[1]	C[1]	D	A	A	A	A[1]	A	B[1]	A[2]	A	B	B	B	B	C	B	B	B	A[1]	D	D	D	B	B[2]	B	B[1]	D	C	D	A
Potassium Hypochlorite	–	–	–	–	–	–	C[1]	–	B[1]	–	–	A	A[2]	B[1]	A[1]	A[1]	A[1]	A[1]	–	C[1]	B[2]	–	–	B[1]	–	C[1]	B	D	–	D	B	A	D	B[2]	A[1]	–	D	–
Potassium Iodide	B	–	A	–	–	B	B[1]	–	A[1]	–	A[2]	A[2]	A[2]	A[2]	A[2]	A[1]	A	A[2]	–	B	A	–	–	B	A	A[1]	A[1]	B[1]	–	A[1]	A	A	A[1]	A[2]	A[1]	A[1]	B	–
Potassium Nitrate	B	A	A	A	B	B	A	A[1]	B[1]	A[1]	A	A	A	A	A	A[2]	A	A	–	A	A	–	A	A	A	B	B	B	B	B[1]	B	A	A	B[1]	A	A	B	–
Potassium Oxalate	–	–	–	–	–	–	–	–	–	–	–	–	A[2]	–	–	–	–	–	–	–	–	–	–	–	–	B	B[1]	B[1]	–	A[1]	B	A	B	A[1]	A[1]	A[1]	A	–
Potassium Permanganate	B[1]	A	A[1]	A	D	A	A	A	D	A[2]	A[1]	A	A	A[1]	A	C	A	–	–	A[1]	A	–	–	B	A	B[1]	B	B[1]	–	A[1]	B	A	A	A[1]	A	B[1]	A	–
Potassium Sulfate	B	B	A	A	B	B	A[2]	A	A[1]	A[1]	A	A	A	A[2]	A	A[2]	A[1]	A	A[1]	A	A	–	A	A	A[2]	B[1]	A	C	D	A[1]	A	A	B	B[1]	A	A	A	A
Potassium Sulfide	B	–	A[2]	–	–	–	A[2]	A	A	–	A	A	A	A[2]	A	A	A	B	A	B	A	–	A	–	A	B	B	D	–	D	A	B	D	–	A	A	A	–
Propane (liquefied)	–	A	A[1]	A	A	D	C[1]	A[1]	A[1]	C[1]	A	–	A	A[1]	A	A	D	–	A	D	C	–	D	–	A	A	A	A	A	A[2]	A	A	A	A	–	A	–	–
Propylene	B	–	–	–	–	–	–	–	–	–	–	–	A[2]	B[1]	–	D	D	D	–	D	D	–	D	A	A[1]	B[1]	A[1]	A	–	–	A	A	A	–	–	A[2]	–	–
Propylene Glycol	B	B	C[1]	B	–	A	B[2]	–	A	B[1]	A[2]	–	A	C[1]	–	A	A	A	–	A	C	–	A	A	A	B	B	B	–	A	A	A	A	B	A	–	A	A
Pyridine	–	B	D	A	C	D	B[1]	B	C[1]	D	A[2]	A	A	D	D	D	B	D	A[1]	D	D	A	D	D	D	A	A	B	B	B	A	A	B	B	B	A	A	–
Pyrogallic Acid	–	D	A	A	–	–	–	–	–	–	A	–	A	A	A	–	B	–	A	–	A	D	–	–	A	B[2]	B	B	–	A	B	D	B	B	A	A	–	–
Resorcinal	A	–	–	–	D	–	B[2]	–	D	B[1]	A[2]	–	A[2]	C	–	–	B[1]	–	–	–	D	–	–	C	A[1]	–	–	–	–	–	–	–	–	–	–	A[2]	–	–
Rosins	–	B	C[1]	A	–	B	B[1]	–	A[1]	–	A[2]	–	A	C[1]	–	A[2]	–	B	A	–	A	–	A	–	A	A[1]	A[1]	B[1]	–	B	B	D	B	–	–	A	–	–
Rum	–	A	A	A	–	–	–	A	A	–	A	–	–	A	–	A	A	A	–	A	A	–	A	–	A	A	A	–	–	A	–	–	–	–	–	–	–	–
Rust Inhibitors	–	A	–	A	–	–	–	–	–	–	A	–	–	–	–	A	–	–	–	–	C	–	–	–	A	A	A	–	–	A	B	C	–	–	–	–	–	–
Salad Dressings	–	A	–	A	–	–	–	A	A	–	A	–	–	–	–	A	–	–	–	–	–	–	–	–	A	A	A	B	–	–	B	D	–	–	–	–	–	–
Salicylic Acid	A	D	–	–	–	–	B[2]	–	A[1]	A[1]	A[1]	–	A[2]	B[1]	A	B	A	A	A[1]	A	–	–	–	B[1]	A[1]	B[2]	B[2]	B[2]	–	A	B	A	A	A[2]	A[1]	A[2]	–	–
Salt Brine (NaCl saturated)	–	–	A[2]	A	A[1]	A	A	A	A	A	A	A	A2	A	A	A	A	A[2]	–	A	A[2]	A	A[1]	–	A[2]	B[1]	A[2]	B[1]	–	B[2]	B	D	B	A[2]	A[2]	A[2]	–	–
Sea Water	–	A	A	A	A	A	A[2]	A[1]	A[2]	A[2]	A	A	A	A[2]	A	A[2]	A[2]	A	A	A[1]	B[2]	A	A[1]	–	A	C	C	B	D	A	A	D	B	A	A	A	–	–
Shellac (Bleached)	–	A	–	A	–	–	A[1]	–	A[1]	–	A	–	A	–	–	A[2]	A[2]	A	–	A[1]	B[2]	–	–	–	A	A	A	A	B	A	A	A	A	–	–	A	–	–
Shellac (Orange)	–	A	–	A	–	–	A[1]	–	A[1]	–	A	–	A	–	–	A	A	–	–	D	D	–	–	–	A	A	A	A	B	A	A	A	A	–	–	A	–	–
Silicone	D	A	A	A	A	–	–	A[1]	A[1]	A[2]	A	A[1]	A	A	A	A	A	A	–	C	A	–	C	–	A	A	A	A	–	–	A	A	A	–	–	A	–	–
Silver Bromide	–	C	–	A	–	–	A	A	–	–	–	–	A	–	–	–	–	–	A	–	–	–	–	–	–	D	D	D	–	D	A	D	–	A	–	–	–	–
Silver Nitrate	B	A	A[1]	A	–	A	A	A	A[1]	A[2]	A[1]	A	A	A[1]	A	B	A	A	A	A	A	–	A	B	A	B	B	D	–	B	C	C	–	A	A	A	–	–
Soap Solutions	A	A	A	A	A	B	D	A[1]	A[1]	A[1]	A	A	A	A	A[1]	A	A	A	–	B	B	A	A	A	A	A	A[1]	C	B	B	A	A	A	A	A	A	A	A
Soda Ash (see Sodium Carbonate)	B	A	A	C	B	A	B	A	B	A	A	A	A	A	A	A[1]	A[2]	A	–	A	A[1]	–	A	–	A	A	A	D	–	B	A	B	–	–	–	–	–	–
Sodium Acetate	B	B	A	A	–	A	A	A[1]	B[1]	A[1]	A	A	A	B[1]	A	B	A	–	A	A	B	–	D	A	D	B	B[1]	B	B	B	A	B	A	A	A	A	A	–
Sodium Aluminate	–	B	–	A	–	–	–	A	A[1]	–	–	A	A	–	–	A	A	A	–	B	A	–	–	–	A	A	A	–	–	A	B	A	–	B	A	A	–	–
Sodium Benzoate	A	–	A[2]	A[2]	–	B	A[2]	–	B[1]	A[2]	A[2]	–	A[2]	B[1]	A[2]	B	A	B	–	A	A[1]	–	–	B[1]	A[1]	–	–	A[1]	–	A	–	–	–	A[1]	A[1]	A[2]	–	–
Sodium Bicarbonate	A	A	A[2]	A	–	A	A[2]	A	A	A[2]	A	A	A	A[2]	A	A[1]	A[2]	A	A	A	A	–	A	B	A	A	A[1]	D	D	A	A	C	B	B[1]	A[2]	A	A	A
Sodium Bisulfate	A	B	A[2]	A	C	B	A[2]	A[1]	A[1]	A[1]	A	A	A	A[2]	A	B[2]	A[2]	A	A[2]	A	A	–	A	B	A	D	C	D	D	A[2]	C	D	B	B[2]	A	A	A	–
Sodium Bisulfite	A	C	A[2]	A	B	B	A[2]	A[1]	C[1]	A[1]	A	A	A	A[2]	A	A[2]	A[2]	A	–	A	A	–	A	B	A	B[1]	B[1]	D	–	B[1]	B	D	B	B	A	A	A	–
Sodium Borate (Borax)	A	–	A[2]	A	B	B	A[2]	A[1]	A[1]	A[1]	A[2]	A	A	A[2]	A	A[1]	A	A	–	A	A	–	A	–	A	B[2]	B	C	–	A	A	–	B	A	B	A	A	A
Sodium Bromide	B	A	A[2]	A	–	–	A[2]	A[2]	B[1]	–	–	–	A[2]	B[2]	A[2]	–	A	B	A[1]	A[1]	A[1]	–	–	B[2]	A[1]	C	C	D	–	A	B	C	D	–	A[1]	A[2]	–	–
Sodium Carbonate	B	A[1]	A[2]	C[1]	–	A	B[2]	A	B[1]	A[2]	A	A	A	A[2]	A	A	A[2]	A	A	A	A	–	A	B	A	A	A	D	B	A[2]	B	B	A	A	A[1]	A	A	A
Sodium Chlorate	A	A	A[1]	A	–	–	B[2]	A[1]	D	A[1]	A	A	A	A[1]	A	B	A	A	–	A	A	–	C	B	A	A	B[1]	C[1]	–	B[1]	B	–	B	B[1]	A	C	A	–
Sodium Chloride	A	A[1]	A[2]	A	A	A	A[2]	A	A[1]	A[2]	A	A	A	A[2]	A	A	A	A	A	A	A	A	A	B	A	B	B	C	D	B	B	D	B	A	A	A	A	A
Sodium Chromate	–	D	–	C	–	–	–	A	C	A[2]	–	A	A	–	A	A	–	C	A	B	A	–	–	–	A	B[1]	B	B	–	B	B	A	B	A	–	A	–	–
Sodium Cyanide	A	A	A[2]	A	B	B	A[2]	A[1]	A[1]	–	A	A	A	A[2]	A	A	A[2]	A	A	A	A[1]	–	A	A	A[2]	A[1]	B[1]	D	D	D	A	A	D	A	A	A	A	A
Sodium Ferrocyanide	–	A	A	A	–	–	A	A	–	–	A	–	A	A	A	A	A	B	–	B	A	–	–	A	A	B	B	A	–	–	–	–	D	A	–	A	A	–
Sodium Fluoride	A	–	A[2]	A	–	–	A[2]	A[2]	B	–	A	–	A[1]	A[2]	A	A[1]	A	B	–	–	A	–	–	D	A	D	D	B	–	A	C	C	D	A	A	A	A	–
Sodium Hydrosulfite	–	–	C	–	–	–	–	–	A	–	–	–	A	C	–	C	B	B	–	C	B	–	C	A	A	–	–	A	–	–	C	–	–	A	–	–	–	–
Sodium Hydroxide (20%)	A	A	A	A[2]	B	C	B	A	A	A[2]	A	A	A	A	A	A	B	A	A	A[1]	B[2]	A	A[2]	A[1]	B[1]	B	B[2]	D	B	B	A[2]	A[2]	A[2]	B	A[1]	A[2]	A	–
Sodium Hydroxide (50%)	A	A	A	A	C	C	B	A	A	D	A	A	A	A	D	A[1]	B[1]	A	B	A[1]	B[2]	A	A[1]	C	B[1]	B	B[1]	D	D	C	B[2]	D	B	C	B	–	A	–
Sodium Hydroxide (80%)	A	D	A	A[1]	–	C	–	A	C	D	A	A	A[1]	A	D	D	B[1]	A[2]	B	A[1]	B[1]	C	A[1]	C	B[1]	C	B[1]	D	D	C	D	D	D	C	D	A[2]	A	C
Sodium Hypochlorite (100%)	–	D	C[2]	D	D	C	B[2]	A	D	–	B	A	A	B	A	D	B[1]	B	A	C	C	D	B	–	A[1]	D	D	D	D	C	D	D	–	B	C	C	A	A
Sodium Hypochlorite (<20%)	B	D	A	C	A	A	A	A	D	C	A	A	A	A	A	B	B	A	A	C	C	A	B	C	A[1]	C	C	D	D	C	D	D	–	A	C	B	A	A
Sodium Hyposulfate	–	–	–	C	–	–	–	–	–	–	–	–	A	–	–	–	–	–	–	C	C	–	–	–	–	A	A	D	–	–	D	D	–	–	–	–	–	–
Sodium Metaphosphate	–	B	A[1]	A	–	B	A[1]	–	A[1]	–	A[1]	–	A	A	A	A	A	B	–	A	B	–	A	–	A	A	A	C	D	A	A	C	B	–	–	A	–	–
Sodium Metasilicate	–	D	A	A	–	–	–	–	–	–	A	–	A	A	–	A	A[1]	B	–	A	A	–	–	–	A	A	A	D	–	A	B	A[1]	B	A	–	–	–	–
Sodium Nitrate	–	A	A	A	–	B	A[2]	A[1]	A[1]	–	A	A	A	A[2]	A	A[1]	A	A	A	B	B	–	D	B	A	B[1]	B[1]	B	–	B	C	B	D	B	A	C	A	A
Sodium Perborate	–	B	A[1]	B	–	–	A[1]	A	B[1]	–	A	–	A	A[2]	–	B	A	B	A	B	B	–	B	–	A	B	B	C	D	B	D	C	B	B	–	C	–	–
Sodium Peroxide	–	D	A[2]	C	–	B	A	–	A[1]	A[2]	B	–	A	B[2]	A	B	A	B	A	B	B[1]	–	D	–	A	A	A	C	D	A	D	C	B	B	–	A	–	–
Sodium Polyphosphate	–	B	A[1]	A	–	B	A	A[1]	A[1]	–	A	–	A	A[1]	A	A	A	B	A	C	B	–	D	–	A	B	B	D	D	B	C	D	A	A	A	A	–	–
Sodium Silicate	–	C	A[2]	A	–	A	A[2]	A[1]	A[1]	–	A	A	A	A[2]	A	A	A	A	A	A	A	–	A	B	A	A	B	A	D	B	A	B	B	B	A	A	A	–
Sodium Sulfate	–	B	A[2]	A	–	–	A[2]	A	A	A[2]	A	A	A	A[2]	A	A	A	A	A	B	A	–	A	A	A	B	B[1]	A	B	B	C	B	B	B	A	A	A	–
Sodium Sulfide	–	B	A[2]	A	–	B	A[2]	A	A[1]	D	A	A	A	A[2]	A	A	A[2]	A	A[1]	B	A	–	A	B	A[2]	B	D	D	D	B[1]	D	C	D	B[1]	A	A	A	–
Sodium Sulfite	–	–	A[2]	A	–	B	B[1]	A	D	–	A[2]	–	A	A[2]	A	A	A	A	A	B	A	–	A	A	A[2]	B	A	C[1]	D	B	C	A[1]	D	B	A	A	–	–
Sodium Tetraborate	–	B	A	A	–	B	A[2]	A	A	–	–	–	A	A[2]	–	A	A	A	–	A	B	–	A	–	A	A[2]	A	C	–	A	–	–	B	–	–	A	–	–
Sodium Thiosulfate (hypo)	–	C[1]	A[2]	A	–	–	A[1]	A	B	D	A[2]	A	A	A[2]	A	B	A[2]	A	A	B	A[2]	–	A	–	A	A[2]	B	A	D	A[2]	D	C	D	A[2]	A	A	–	–
Sorghum	–	A	–	A	–	–	–	–	A	–	–	–	–	–	–	A	–	–	–	A	A	–	–	–	A	A	A	–	–	A	D	A	–	–	–	–	–	–
Soy Sauce	–	A	–	A	–	–	–	A	A	–	–	–	–	–	–	A	–	–	–	–	A	–	–	–	A	A	A	A	–	A	A	D	–	–	–	–	–	–

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⚠ WARNING

The information in this chart has been supplied to Cole-Parmer by other reputable sources and is to be used **ONLY** as a guide in selecting equipment for appropriate chemical compatibility. Before permanent installation, test the equipment with the chemicals under the specific conditions of your application. Ratings of chemical behavior listed in this chart apply to a 48-hour exposure period; Cole-Parmer has no knowledge of possible effects beyond this period. Cole-Parmer does not warrant (neither expressed nor implied) that the information in this chart is accurate or complete or that any material is suitable for any purpose.

⚠ DANGER

Variations in chemical behavior due to factors such as temperature, pressure, and concentration can cause equipment to fail, even though it passed an initial test.

SERIOUS INJURY MAY RESULT.

Use suitable guards and/or personal protection when handling chemicals.

RATINGS

Chemical Behavior

A – No effect
B – Minor effect
C – Moderate effect
D – Severe effect; not recommended
— No data available

	Plastics															Elastomers										Metals										Nonmetals		
CHEMICAL	ABS plastic	Acetal	CPVC	Epoxy	Hytrel®	HDPE	LDPE	Noryl®	Nylon	Polycarbonate	Polypropylene	PPS	PTFE	PVC	PVDF	Nitrile (Buna N)	EPDM	Hypalon®	Kel-F®	Natural rubber	Neoprene	Santoprene®	Silicone	Tygon®	Viton®	304 stainless steel	316 stainless steel	Aluminum	Brass	Bronze	Carpenter 20	Cast iron	Copper	Hastelloy C®	Titanium	Carbon graphite	Ceramic Al_2O_3	Ceramic magnet
Stannic Chloride	–	C	A[2]	A	–	–	A[2]	A[1]	B[1]	A[1]	A	A	A	A[2]	A	A	A	C[1]	A	A	C[1]	–	B	–	A	D	D	D	–	A	D	D	–	B	A	A	A	–
Stannic Fluoborate	–	C	–	A	–	–	–	A	–	–	–	–	–	–	–	A	–	–	–	–	A	–	–	–	A	–	A	–	–	–	D	D	–	–	–	–	–	–
Stannous Chloride	–	–	A[2]	A	C	–	B[2]	A[2]	C[1]	–	A	A[1]	A	A[1]	A	A	C	A[1]	A	A	A[1]	–	B	A	A	C[2]	A[2]	D	–	A[1]	D	–	–	B	A	–	A	–
Starch	–	A	A	A	–	–	B	A[2]	A[1]	–	A[2]	–	A	A	–	A	A	A	A	A	A	–	–	–	A	A	A	A	–	–	A	C	–	–	–	A	A	A
Stearic Acid	–	A	B[2]	B	C	A	B[1]	A	A[2]	A[1]	A[2]	–	A	B[2]	A	B	B	C	–	–	B[1]	A	B	D	A[1]	B	A	B	D	B	C	C	D	B	A	A	–	–
Stoddard Solvent	B	A	C[1]	A	–	–	C[2]	D	A	A[2]	C	A	A	C[1]	A	A	D	–	A	D	C[1]	D	D	C	A	A	A	A	–	A	A	A	A	A	A	A	–	–
Styrene	–	A	D	A	D	–	–	A	A[1]	D	–	–	A	D	–	D	D	D	–	D	D	–	D	–	B	A	A	A	A	A	A	A	B	D	–	A	–	–
Sugar (Liquids)	B	A	–	A	–	–	–	A[2]	A[1]	–	A	–	A	–	–	A	A	A	–	A	A	–	A	B	A	A	A	A	–	A	A	–	A	A	–	A	–	–
Sulfate (Liquors)	–	D	B	A	–	A	A[2]	–	B[1]	–	A	–	A	B	A	A[2]	A	B	–	B	B	–	B	–	A[1]	B	B	D	–	B	D	C	D	B	–	A	–	–
Sulfur Chloride	–	D	C[1]	C	–	–	C[1]	A	A[1]	–	C[1]	–	A	C[1]	A[1]	D	D	–	A	D	D	–	C	D	A	D	D	D	D	B	D	D	B	A	D	D	–	–
Sulfur Dioxide	D	B	A[2]	A[1]	C	D	B[1]	A	C[1]	–	A[1]	A	A	A[1]	A	D	A[2]	C	A	–	B	–	B	A	A	D	A[1]	B	D	B	B	–	B	C	A	A	–	–
Sulfur Dioxide (dry)	–	B	A[2]	A[1]	C	A	A[1]	A	B[1]	A[1]	A[1]	A	A	A[2]	A	D	A[2]	–	A	C	D	–	B	A	A	D	A	B	D	B	A	A	A	B	A	A	–	–
Sulfur Hexafluoride	–	–	–	–	–	–	B	–	B	–	–	–	–	B	–	B	B	B	–	D	A	–	B	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Sulfur Trioxide	–	–	A	A	–	–	–	D	D	–	C	–	A	A	–	D	C[2]	D	–	C	D	–	B	A	A	A	C	A	D	C	A	B	–	–	–	B	–	–
Sulfur Trioxide (dry)	–	D	A	A	–	–	C[1]	D	A[1]	–	D	–	A	A[1]	C[1]	D	C[1]	–	–	–	D	–	B	B	A	D	A	A	A	B	B	A	B	B	D	D	–	–
Sulfuric Acid (<10%)	B	D	A	A[1]	A	A	A[1]	A	C[1]	A[1]	A[2]	A	A	A[1]	A	A[1]	A	A	A	A[1]	B[2]	A	C	A	A	D	B	D	–	B	D	C	–	B[1]	D	A[1]	A	–
Sulfuric Acid (10-75%)	B	D	A	A[1]	–	A	A[1]	A	D	B[1]	A[1]	A	A	A[1]	A	B[1]	B[2]	A	A	C	B[1]	B	D	C	A[2]	D	D	D	–	B	A[2]	D	–	B[1]	D	A[1]	A	–
Sulfuric Acid (75-100%)	–	–	C	C[1]	C	B	C	A	D	D	C[1]	A[1]	A	D	A	C	B[1]	A	A	D	D	D	D	D	A[1]	D	D	D	–	B	A[2]	D	D	B[1]	D	C[1]	A	A
Sulfuric Acid (cold concentrated)	–	–	D	D	B	B	D	A	D	–	A[2]	A[1]	A	D	A	D	C	A	A	D	D	D	D	D	B	C	B	B	–	B	A[2]	D	–	A[1]	D	D	–	–
Sulfuric Acid (hot concentrated)	–	–	D	D	–	B	D	D	D	D	D	D	A	D	C	D	D	A	A	D	D	D	D	D	A[2]	D	C	D	–	B	D	D	–	D	D	D	A	–
Sulfurous Acid	–	C	A[2]	A	–	B	B[1]	A	D	–	A	A	A	A[2]	A	B[1]	B	A	A	B	C	–	D	B	A	B[1]	B	B[1]	–	B	D	D	D	B	A	A	–	–
Sulfuryl Chloride	–	A	–	A	–	–	–	–	–	–	–	–	A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tallow	–	A	–	A	–	A	C	A	A[1]	–	A[2]	–	A	–	–	A	A	C	–	–	B	–	–	–	A	A	A	A	–	–	–	–	–	–	–	A	–	–
Tannic Acid	–	B	A[1]	A	A	A	B[2]	A[2]	C[1]	C	A	A	A	A[1]	B	A	A	A	A	A	A	A	C	C	A	B[1]	A	C	B	B	A	C	A	B[1]	A	A	A	A
Tanning Liquors	–	B	A[1]	A	–	–	A[1]	A[2]	A[1]	–	A[1]	–	A	A[1]	–	B[1]	B	B	–	C	A	–	B	B	A	A[2]	A[2]	A	–	A[2]	A	–	–	B	A	A	–	–
Tartaric Acid	–	B	A[1]	A	C	A	A[1]	A[1]	B[2]	–	A	A	A	A[1]	B	A	B	A	A[2]	A	A[2]	A	A	B	A	C[2]	C[2]	B[1]	D	B[1]	A	C	A	B	A[1]	A	A	A
Tetrachloroethane	–	A	C	A	–	–	–	D	C[1]	–	C	–	A	C	A	D	D	D	A	D	D	D	D	–	A	B	A	C	–	–	–	A	A	A	A	A	–	–
Tetrachloroethylene	–	A	D	–	–	C	B	D	A[1]	D	D	–	A	D	–	D	D	D	A	D	D	–	D	–	A	–	A	–	–	–	–	A	A	–	–	A	–	–
Tetrahydrofuran	–	A	D	A	B	C	C[1]	D	A	D	C[2]	A	A	D	B[1]	D	D	D	A[1]	D	D	D	D	–	D	A	A	–	–	A	D	–	–	A	B	A	A	–
Tin Salts	–	–	–	–	–	–	–	–	–	–	A	–	A	A	A	A	B	A	–	A	–	–	B	A	A	–	D	D	–	–	–	–	–	C	A	–	–	–
Toluene (Toluol)	D	C[1]	D	B[1]	B	D	C[1]	D	A[1]	D	C[1]	A	A	D	A[1]	D	D	D	B[2]	D	D	D	D	D	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Tomato Juice	B	B	–	A	–	A	A[1]	A	A[1]	A[1]	A	A	A	A	A	A	A	–	A	–	A	–	–	–	A	A	A	A	–	A	C	–	–	–	–	A	–	–
Trichloroacetic Acid	–	–	–	D	–	C	A	–	C	D	A	A	A	B	B	–	B	–	A	C	D	–	D	A	C	D	C	D	–	–	–	D	D	B	D	A	A	–
Trichloroethane	–	A	–	A	–	D	–	D	C[1]	D	C	–	A	C	A	D	D	D	A	D	D	D	D	D	A	B	B	D	–	A	A	B	–	A	A	A	–	–
Trichloroethylene	D	D	D	C[1]	C	D	D	D	C[1]	–	C[1]	A[1]	A	D	B	D	D	D	A	D	D	D	D	D	A	B	B	D	–	B	A	C	A[1]	A	A	A	A	A
Trichloropropane	D	A	–	A	–	–	–	D	–	–	–	–	A[1]	–	–	D	–	–	A	D	A	–	–	D	A	A	A	D	–	A	A	A	A	A	–	–	–	–
Tricresylphosphate	B	C	D	A	–	–	B[1]	A	A[2]	–	A[1]	–	A	D	D	D	A	D	–	B	C	–	C	D	A[2]	B	B	D	–	A[2]	A	B	B	A	B	A	D	–
Triethylamine	–	D	A	A	–	–	–	B	A[1]	–	D	–	A	B	A[2]	C	A	–	A	B	A	–	–	A	D	A	A	–	–	–	A	A	A[1]	–	–	A	B	–
Trisodium Phosphate	B[1]	A	A	A	A	A	A	A	A	–	A	A	A	A	A	A	A	–	–	A	A	–	A	A	A	B	B	D	–	A	C	–	B[1]	A	–	A	–	–
Turpentine	D	A[2]	A	B	–	B	D	D	B	D	D	A	A	D	A	–	D	D	A	D	D	D	D	D	A	A	A	A	D	A	C	–	B	B	B	A	A	–
Urea	B	A	A	–	–	A	A	A	A	D	A	A	A	D	A	B	A	–	–	–	B	–	B	B	A	B	B	B	–	B	–	–	–	B	A	A	B	–
Uric Acid	–	–	–	–	–	–	B	–	A	–	–	–	A	A	–	–	–	–	–	–	A	A	–	A	–	B	B	D	–	B	–	D	A	B	A	A	D	–
Urine	–	A	A	A	–	A	A[2]	A[2]	B	–	A	–	A[1]	A	A	A[1]	A[1]	–	–	D	D	–	–	–	A[1]	A	A	B	–	A	C	A	–	–	–	A	–	–
Varnish	–	A	–	A	–	B	A	D	A	–	A	–	A	D	–	B	D	D	A	D	D	–	D	D	A	A	A	A	A	–	A	C	B	A	–	A	–	–
Vegetable Juice	B	A	–	A	–	–	–	A	A	–	–	–	A	–	–	A[2]	A	–	–	–	–	–	B	A	A	A	A	D	A	A	C	D	A	–	–	–	A	–
Vinegar	A	B	A	A	–	A	A	A[1]	A	A[2]	A	A	A	B	B	B	A	A	A	B	B	–	A	A[1]	A	A	A	D	D	A	C	D	B	A	A	A	A	A
Vinyl Acetate	–	–	D	A[1]	–	D	A	–	–	–	B[1]	–	A[2]	D	A[2]	D	B[2]	A[2]	–	D	D	–	D	D	A[1]	B	B	A[1]	–	–	–	B	B	–	–	A[2]	B	–
Vinyl Chloride	D	–	D	–	–	–	–	–	A[1]	–	–	–	A[2]	D	B[1]	D	C	–	–	C	D	–	–	D	A[1]	B[2]	A[1]	B[1]	–	A[2]	–	B	B	A[2]	A	A[2]	A	–
Water, Deionized	–	–	A	A[2]	–	A	–	A[2]	A[1]	–	A[2]	A	A[2]	A[2]	A[2]	A[1]	A[1]	A[2]	A[1]	A	A	A	–	A[2]	A[1]	A[1]	A[2]	A[2]	A	–	–	D	B	A[2]	A[2]	A[2]	B	–
Water, Acid, Mine	B	A[1]	A	A	–	A	A[2]	–	A	B[2]	A	A	A	B	A	A	A	–	A	B	C	A	B	–	A	B	B	D	D	A	C	D	D	A	A	A	A	–
Water, Distilled	B	B	A	A	–	A	A[2]	A	A[1]	A[2]	A	A	A	A[2]	A	A	A	–	A	A	A	A	C	B	A	A	A	A	A	A	D	D	B	A	A	A	–	–
Water, Fresh	A	A[2]	A	A	A	A	A[2]	A	A[1]	A[2]	A	A	A	B	A	A	A	–	A	A	A	A	B	B	A	A	A	B	D	A[1]	A	D	B	A	A	A	A	–
Water, Salt	–	A	A	A	A	A	A[2]	A	A[2]	A[2]	A	A	A	B	A	A	A	–	A	A	A	A	B	B	A	B	B	B	D	A	D	D	B	A	A	A	B	–
Weed Killers	–	A	–	A	–	–	–	–	A	–	–	–	–	–	–	A	–	–	–	–	C	–	A	–	A	A	A	D	–	–	C	–	–	–	–	–	B	–
Whey	–	A	–	A	–	–	–	–	–	–	–	–	A	–	–	A	–	–	–	–	–	–	–	–	A	A	A	B	–	–	–	–	–	–	–	–	–	–
Whiskey and Wines	C	A	A[2]	B	–	B	C	A[2]	A[1]	A[1]	A	–	A	A[2]	A	A	A	A	A	A	C	–	A	C	A	A	A	C[1]	B	A	C	D	B	–	A	A	A	A
White Liquor (Pulp Mill)	–	D	A	A	–	–	A[2]	A[1]	A[1]	–	A[1]	–	A	A[2]	A[1]	A	–	–	–	–	A	–	A	–	A	A	A	B	B	A	D	C	–	A	–	A	–	–
White Water (Paper Mill)	–	B	–	A	–	–	–	D	A	–	A	–	–	A	–	–	–	–	–	–	A	–	–	–	A	A	A	–	–	–	A	A	–	–	–	–	–	–
Xylene	D	A	D	A	B	D	B	B	A[2]	D	B	A	A	D	A	D	D	D	A	D	D	D	D	D	B	B	B	A[1]	A	A	A	B	A	A	A	A	A	–
Zinc Chloride	A	C	A	A	A	A	A[1]	A[1]	A	A[2]	A	A	A	B	A	A	A	A	A	A	A	B	B	A	A	B	B	D	D	B[1]	D	D	C	B	A[1]	A	D	–
Zinc Hydrosulfite	A	C	–	A	–	–	–	A	A	–	–	A	A	–	–	A	A	–	–	–	A	–	–	–	–	A	A	D	–	–	D	D	B	–	–	–	–	–
Zinc Sulfate	A	C	A	A	–	A	A[2]	A[1]	A	A[2]	A	A	A	A[2]	A	A	A	A	A	B	A	–	A	A	A	B[1]	A	D	B[2]	B	C	D	B[1]	A[2]	A[2]	A	D	A

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