THE LEE COMPANY

TECHNICAL FLUID CONTROL HANDBOOK FOR HEALTH & SCIENCE

THE LEE COMPANY

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DIGITAL EDITION 10.1

THE LEE COMPANY
theleeco.com

Manufacturing Headquarters
2 Pettipaug Road,
Westbrook, CT USA
(860) 399-6281

THE LEE COMPANY'S HISTORY

1948 | 1950s | 1958 | 1960s -1970 | 1980s

1948

THE LEE COMPANY IS FOUNDED

Leighton Lee II founded The Lee Company at his home in Rocky Hill, CT.

1950s

LANDING IN WESTBROOK

The Lee Company moved to a machine shop in Hartford, CT before purchasing an additional 88 acres of land in Westbrook, CT that would serve as the future company headquarters.

1958

THE LEE PLUG® IS PATENTED

The patent for the original Lee Plug was issued. The success of this product line became the foundation for today's extensive line of product offerings.

1960s -1970

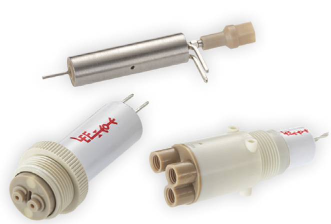
THE SPACE RACE

Several Lee products were used on the historic Apollo 11 mission that enabled Neil Armstrong and Buzz Aldrin to take their first steps on the moon.

1980s

ELECTRO-FLUIDIC SYSTEMS (EFS) DIVISION ESTABLISHED

The LFY, LFV, and VHS® Series solenoid valves served as the foundation for the company's expansion into health and science markets.



THE LEE COMPANY

ROOM TO GROW

The EFS division released the HDI® Series solenoid valves and the LPV and LPL Series pumps. To meet expansion needs, the division moved to a facility in Essex, CT.

NEW INNOVATIONS

EFS continued to introduce new product lines, most notably the IEP Series solenoid valve.

1990s - 2000 2010s 2019 - 2020 2022

INNOVATION CONTINUES

The EFS division launched the Xover® solenoid valve.

TTP VENTUS ACQUISITION

The Lee Company acquired TTP Ventus Limited, an inventor and manufacturer of silent, compact piezoelectric micropumps.

LOOKING TO THE FUTURE

The Lee Company continues to be a world leader in miniature precision fluid control, providing engineered solutions for some of the world's largest and most innovative organizations. The Lee Company remains a family-owned and operated company. On July 10th, 2023 – the 75th anniversary of The Lee Company – Marietta S. Lee, the granddaughter of the company's founder, became President and CEO.

We are proud to play an integral part in the fluid control industry as we develop pioneering products to accomplish the toughest tasks.

INNOVATION IN MINIATURE

The Lee Company is a global leader in miniature precision fluid control technology. Our products are used in multiple industries to help control fluid in everything from cars and planes to rockets and medical devices. Our mission is to design and build state-of-the-art products that exceed expectations for utility, performance, and quality. Founded in 1948, we are the original inventor of dozens of miniature fluid control products and technologies that became – and remain – industry standards. We trace our unwavering commitment to superior quality and high performance to our origins in the aerospace industry and our first-ever product: the Lee Plug®, created to solve a specific customer problem. Our unique capabilities in miniaturization and engineering expertise enable our customers to improve their designs, increase profitability, and advance their industries.

CORE MARKETS & APPLICATIONS

The Lee Company offers thousands of parts that enable our customers to create products that propel technology forward in industries such as aerospace and defense, automotive, diagnostics, industrial and off-highway, medical equipment, scientific instruments, motor-sports, oil and gas, and power generation. We support the health and science industry and offer products typically used in medical and scientific instrumentation, including:




- **In vitro diagnostics**
- **Respiratory therapy**
- **Lab automation**
- **Patient simulators**
- **Renal dialysis**
- **Drug discovery**
- **DNA sequencing and synthesis**
- **Environmental monitoring**

Typical applications of our products in these instruments include pressure driven flow in microfluidics, precision droplet dispensing, reagent dispensing, directing the flow of gases for detection or calibration, and diverting fluid to waste. These products include solenoid valves, pumps, manifolds, and other fluid control components. You'll learn more about these products, among others, in this technical handbook.

CUSTOMER SATISFACTION BACKED BY ENGINEERING AND MANUFACTURING EXPERTISE

At The Lee Company, customer satisfaction is at the center of everything we do. Every product we offer has been designed to solve a customer's fluid control problem and engineered using over 75 years of experience. Beyond the standard products described in this handbook, the majority of our offerings are custom solutions for specific applications. Lee Sales Engineers are located around the world and regularly meet with customers to help provide solutions to address the most difficult fluid control challenges.

To better support our customers, we commit to continuous innovation by investing in our people and the technology used to design, fabricate, assemble, and test our parts. This allows us to adapt to new trends and introduce increased automation into certain processes to improve efficiency. We also have an unmatched manufacturing ability to maintain tight tolerances and produce miniature parts. We utilize controlled manufacturing practices and computerized production control systems to ensure high quality and consistent long-term product performance. Our substantial inventory of standard parts helps ensure quick and on-time delivery directly to you.

Every Lee product undergoes rigorous qualification testing and must pass an extensive acceptance test procedure prior to shipment, ensuring every unit you receive will exceed its performance specification. We maintain a documented quality management system, including manufacturing lot control and traceability, that is designed and implemented to fulfill ISO 9001 standard requirements.

GLOBAL PRESENCE & LOCAL SUPPORT

The Lee Company is a close-knit organization that balances best-in-class local support with an expanding global presence to meet the evolving needs of our customers. We employ over 1,000 people and occupy over 1 million square feet of manufacturing space on several campuses in Westbrook and Essex, Connecticut, U.S.A., as well as Cambridge, U.K. Our sales offices are located in the United States, Europe, Asia, South America, and Australia. When you contact any of our offices, you'll talk with a degreed engineer who is ready to help find the right solution for your unique fluid control needs. Thanks to our global network, we can provide local technical support wherever you are in the world, engineer-to-engineer.

Health & Science products are designed and manufactured at our facility in Essex, Connecticut, U.S.A. and in Cambridge, U.K.

SALES AND SERVICE

We provide local engineering support globally through our international network of Sales Engineers. If you have a fluid control problem and would like to talk to an engineer, please contact our Manufacturing Headquarters or your local sales office.

For the most current contact information, please scan the QR code or visit theleeco.com/locations.

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THE LEE COMPANY

SALES & SERVICE
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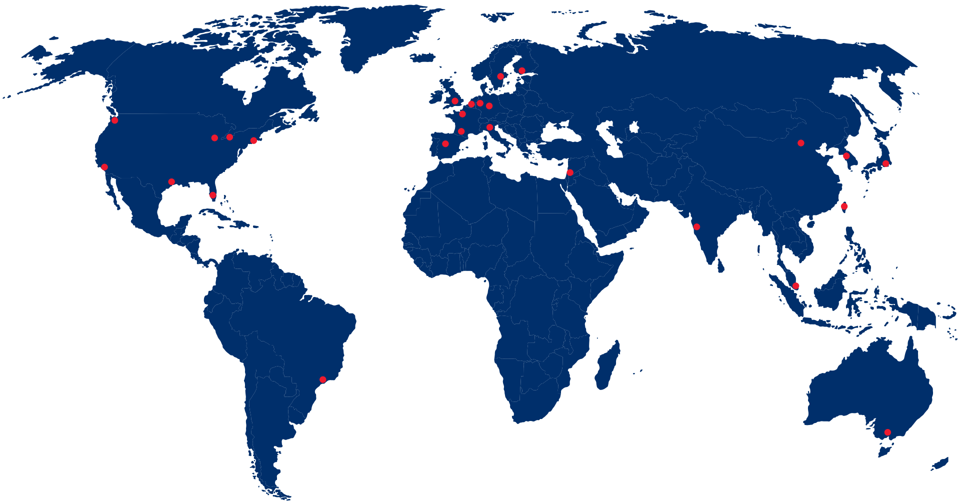

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TABLE OF CONTENTS
SOLENOID VALVES

THE LEE COMPANY

CONTROL SOLENOID VALVES

Our control valves are 2-way and 3-way valves used to flow air, gas, or mild liquids.

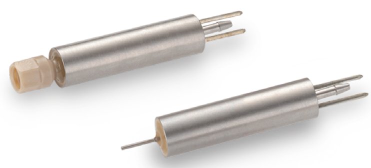
HDI® PLATFORM valves are (Ø 7 mm), compact, and lightweight. Their low power, low leakage, and long cycle life offer high value at an economical price.

- **LHD SERIES** – This conventional solenoid valve is our baseline design, offering high reliability across a variety of models.
- **LHL SERIES** – This magnetically latched valve features ultra low power consumption (as low as 5.5 mJ/switch) and low heat dissipation.
- **LHQ SERIES** – This quiet operation valve features whisper technology to drastically reduce actuation noise.

DISPENSING SOLENOID VALVES

Our dispensing valves are available in a 2-way, normally closed, axial flow configuration, and feature high speed operation that delivers drop-on-demand performance.

- **VHS® SERIES** – This small (Ø 6 mm), high speed valve is capable of dispensing repeatable spherical droplets into standard well plates or spraying with precision onto substrates.



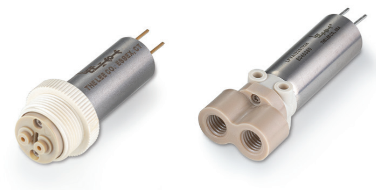
  - **DISPENSE & ATOMIZING NOZZLES (B8-9)** – Compatible with our VHS Series, dispense nozzles are capable of precision droplets as small as 10 nanoliters, while atomizing nozzles generate a fine mist in a hollow cone-shaped spray pattern.

- **IEP SERIES** – This small (Ø 6.5 mm), high speed valve is designed for higher temperature and higher pressure liquid and gas applications where fast response time is critical.

ISOLATION SOLENOID VALVES

Designed to flow aggressive fluids, our isolation solenoid valves are chemically inert and engineered so that the sensitive internal solenoid components are separated from the flow path.

DIAPHRAGM VALVES



PINCH-TUBE VALVES

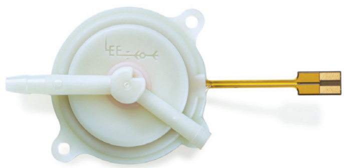
THE LEE COMPANY

PIEZOELECTRIC MICROPUMPS

Our disc pumps are highly precise pneumatic micropumps that generate pressure or vacuum in a small (29 mm), silent, vibration-free form factor. Their infinite turndown ratio and pulsation-free flow allow control over gases or liquids (indirectly) with incredibly fine resolution, enabling a multitude of innovative applications. They are available with or without electronics for added simplicity.

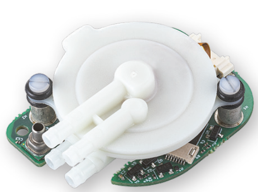
- **BL SERIES** – This disc pump strikes a balance between performance and cost.

- **LT SERIES** – Designed for conditions that maximize pump life, this disc pump can deliver in excess of 17,000+ hours of continuous operation.
- **XP SERIES** – This disc pump offers a power-efficient design and wide operating temperature.



- **HP SERIES** – This disc pump generates high pressures from 600 mbar stall pressure to -400 mbar stall vacuum.
- **US SERIES** – This disc pump offers exceptional performance and efficiency along with a narrow manifold mount profile and integrated filter.

- **SMART PUMP MODULE** – This module combines our disc pumps with drive electronics and pressure sensing in a tightly integrated package, providing a miniature pump and pressure regulator solution all-in-one.



FIXED VOLUME DISPENSE PUMPS

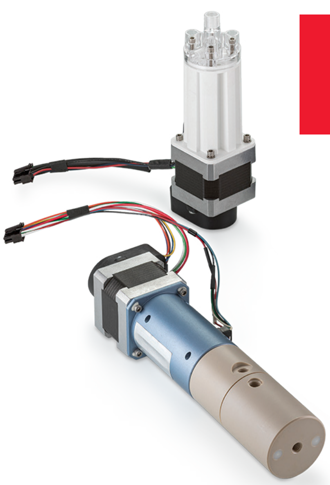
Our fixed volume pumps are solenoid-driven, positive displacement pumps with integrated check valves that provide repeatable, fixed dispense volumes in a small lightweight package.

- **LPL SERIES** – This small (Ø 16 mm) diameter fixed volume pump is available in a 25 µL or 50 µL standard dispense volume configuration.
- **LPG SERIES** – This (Ø 25 mm) fixed volume pump is available in a 100 µL or 175 µL standard dispense volume configuration.

VARIABLE VOLUME DISPENSE PUMPS

Our variable volume pumps are stepper-motor driven, positive displacement pumps that aspirate a volume of fluid and then dispense that fluid volume out in smaller, highly precise increments, with full dispense volumes ranging from 50 to 3000 µL.

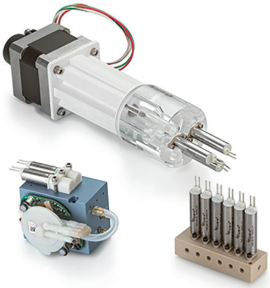
- **LPD SERIES**
  This single seal model is highly precise (CV as low as .01%) and is offered with a home sensor on all models. An encoder and integrated backlash compensation is optional.
- **DUAL SEAL**
  This stepper motor-driven precision dispense pump utilizes two seals and two fluidic chambers to reliably control more challenging fluids across an extensive cycle life.

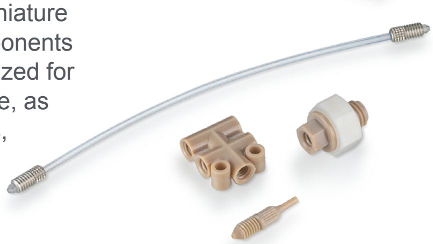


THE LEE COMPANY

MANIFOLDS, TUBING, CHECK VALVES, ORIFICES, AND COMPONENTS

We offer threaded tubing assemblies with low internal volume and low shear, as well as pre-assembled manifolds, precision orifices, check valves (for installation into tubing, plastic, or metal), safety screen filters, adapters, and other inert fluid control components.





ENGINEERING TOOLS

We have developed innovative methods to support our customers in characterizing and calculating the performance of components and their impact within a system. If you need engineering assistance beyond the resources in this section, please contact your local Lee Sales Engineer.

GENERAL INFORMATION

Information about policies, proprietary rights, patents, trademarks, copyrights, and warranties.

Our High Density Interface (HDI®) platform of miniature, 7 mm, direct-acting control solenoid valves are used to direct the flow of gases and mild liquids (with typical operating pressures ranging from vacuum to 45+ psig). Their low power, low leakage, and long cycle life offer high value at an economical price for many applications, including:

- Microfluidic piloting (lab-on-a-chip)
- Oxygen & anesthesia delivery
- Ventilators
- Gas detection & analysis
- Patient simulators
- Dialysis
- Air calibration

Engineered using long-lasting materials, each valve is 100% functionally tested to ensure reliable, consistent long-term performance. The Lee Company can customize valve performance to meet specific application requirements.

Available as a lightweight 2-way (2.5 g) or 3-way (4.5 g) design in various mounting styles, these compact valves are easily soft tube connected, or manifold mounted, making them the perfect solution for applications where many valves must be designed into the smallest space possible. In addition to conventional solenoid valves (LHD Series), we offer magnetically-latching valves (LHL Series) that consume far less power, as well as quiet operation solenoid valves (LHQ Series) where the inherent actuation sound has been significantly reduced.

A

2-WAY PLUG-IN

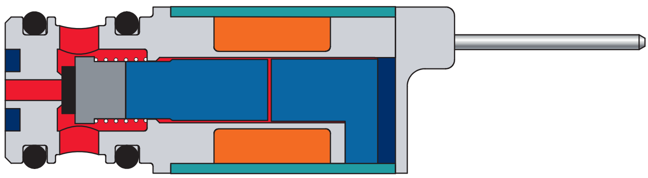
With fluidic ports buried into the mating manifold, the 7 mm, plug-in-style, 2-way (2/2) normally closed LHD Series solenoid valve reduces space and enables design flexibility for complex fluidic circuits where multiple valves are required in the smallest space possible.

- Weight: <2.5 grams
- Operating pressure: Vac to 45 psig; 10 psid max. or higher upon request.
- Leakage: less than 50 SμLPM at 10 psid air; 70°F (21°C)
- Wetted materials: housing (PBT), plunger head (PPS or PPA)[3], armature/plunger stop (FeCr alloy), seal (see below), spring (316 SS), and epoxy. The O-rings on all plug-in-style valves are FKM.
- For additional information, see pages A36-37.

PART NUMBER	LOHM RATE[1] (Cv)	MINIMUM FLOW RATE[1] (SLPM)	SPIKE[2]/HOLD VOLTAGE (Vdc)	HOLD POWER (mW)	INTERNAL SEAL[4]
LHDB0342115H	1500 (0.013)	4.4	3.3 / 2	310	Silicone
LHDB0542115H	1500 (0.013)	4.4	5 / 3	310	Silicone
LHDB1242115H	1500 (0.013)	4.4	12 / 7.2	310	Silicone
LHDB0442145D	450 (0.044)	14.6	12 / 3.5	440	Silicone
LHDB0442245D	450 (0.044)	14.6	12 / 3.5	440	FKM
LHDB0942145D	450 (0.044)	14.6	24 / 7	420	Silicone
LHDB0942245D	450 (0.044)	14.6	24 / 7	420	FKM

(1) Specifications listed are on air at 10 psid. For flow rate capabilities at other pressures, reference page A35. Refer to Section Q for a full description of the Lohm Laws.
(2) Spike voltage/hold voltage. A spike and hold electrical drive is required for most applications. To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Refer to pages Q42-45 for electrical circuit design recommendations.
(3) Plunger head material is PPS for all silicone valves and PPA for all FKM valves.
(4) Other seal materials available upon request. Refer to pages Q62-63 for material information and abbreviations.

2-WAY PLUG-IN



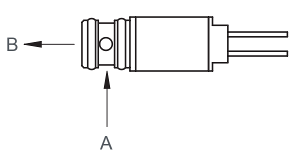
Flow Path	Housing	Seal
Coil	Shield	Epoxy
Armature & Plunger Stop	Plunger Head Assembly	Spring

- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including standard manifolds, manufacturing and installation tools, screws, and retention brackets: see pages A22-34.

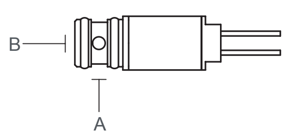
PORTING CONFIGURATION

Our standard 2-way valves are designed for unidirectional flow, where the highest absolute pressure should be maintained at Port A. Bi-directional and reverse-flow valves (Port B to A) are available upon request.

ENERGIZED



DE-ENERGIZED



	PORT A	PORT B
PRESSURE	X	
VACUUM		X

2-WAY FACE MOUNT

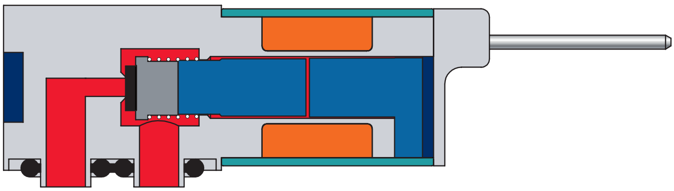
With the fluidic ports surface mounted via one-piece gasket, the 7 mm, face mount style, 2-way (2/2) normally closed LHD Series solenoid valve lends itself easily to machined or molded manifolds, enabling multiple valves to be mounted in an incredibly small package.

- Weight: <2.5 grams
- Operating pressure: Vac to 45 psig; 10 psid max. or higher upon request.
- Leakage: less than 50 SμLPM at 10 psid air; 70°F (21°C)
- Wetted materials: housing (PBT), plunger head (PPS)[3], armature/plunger stop (FeCr alloy), seal (silicone), spring (316 SS), and epoxy.
- For additional information, see pages A36-37.

PART NUMBER	LOHM RATE[1] (Cv)	MINIMUM FLOW RATE[1] (SLPM)	SPIKE[2]/HOLD VOLTAGE (Vdc)	HOLD POWER (mW)	INTERNAL SEAL[4]
LHDB0352115H	1500 (0.013)	4.4	3.3 / 2	310	Silicone
LHDB0552115H	1500 (0.013)	4.4	5 / 3	310	Silicone
LHDB1252115H	1500 (0.013)	4.4	12 / 7.2	310	Silicone

(1) Specifications listed are on air at 10 psid. For flow rate capabilities at other pressures, reference page A35. Refer to Section Q for a full description of the Lohm Laws.
(2) Spike voltage/hold voltage. A spike and hold electrical drive is required for most applications. To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Refer to pages Q42-45 for electrical circuit design recommendations.
(3) Plunger head material is PPS for all silicone valves and PPA for all FKM valves.
(4) FKM and other seal material available upon request. Refer to pages Q62-63 for material information and abbreviations.

2-WAY FACE MOUNT

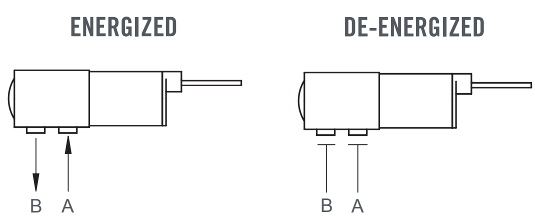


Flow Path	Housing	Seal
Coil	Shield	Epoxy
Armature & Plunger Stop	Plunger Head Assembly	Spring

- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including standard manifolds, manufacturing & installation tools, screws, and retention brackets: see pages A22-34.

PORTING CONFIGURATION

Our standard 2-way valves are designed for unidirectional flow, where the highest absolute pressure should be maintained at Port A. Bi-directional and reverse-flow valves (Port B to A) are available upon request.



	PORT A	PORT B
PRESSURE	X	
VACUUM		X

2-WAY PORTED

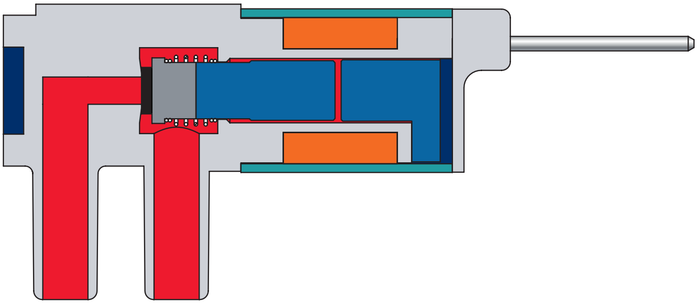
With fluidic ports designed for use with 3/32" (2.4 mm) ID tubing, the 7 mm, ported-style, 2-way (2/2) normally closed LHD Series solenoid valve enables simple setup and rapid testing. Its larger ports enable higher flow rates in a very compact package.

- Weight: <2.5 grams
- Operating pressure: Vac to 45 psig; 10 psid max. or higher upon request.
- Leakage: less than 50 SμLPM at 10 psid air; 70°F (21°C)
- Wetted materials: housing (PBT), plunger head (PPS or PPA)[3], armature/plunger stop (FeCr alloy), seal (see below), spring (316 SS), and epoxy.
- For additional information, see pages A36-37.

PART NUMBER	LOHM RATE[1] (Cv)	MINIMUM FLOW RATE[1] (SLPM)	SPIKE[2]/HOLD VOLTAGE (Vdc)	HOLD POWER (mW)	SEAL[4]
LHDB1262145D	450 (0.044)	14.6	12 / 2.8	350	Silicone
LHDB1262245D	450 (0.044)	14.6	12 / 2.8	350	FKM
LHDB2462145D	450 (0.044)	14.6	24 / 5.6	350	Silicone
LHDB2462245D	450 (0.044)	14.6	24 / 5.6	350	FKM

(1) Specifications listed are on air at 10 psid. For flow rate capabilities at other pressures, reference page A35. Refer to Section Q for a full description of the Lohm Laws.
(2) Spike voltage/hold voltage. A spike and hold electrical drive is required for most applications. To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Refer to pages Q42-45 for electrical circuit design recommendations.
(3) Plunger head material is PPS for all silicone valves and PPA for all FKM valves.
(4) FKM and other seal material available upon request. Refer to pages Q62-63 for material information and abbreviations.

2-WAY PORTED

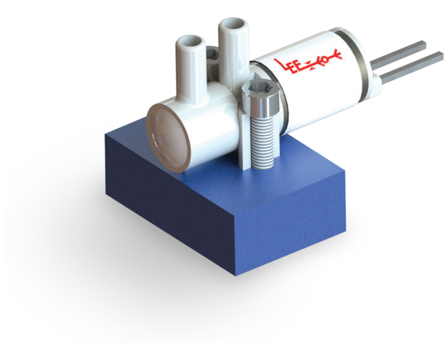


- Flow Path
- Coil
- Armature & Plunger Stop
- Housing
- Shield
- Plunger Head Assembly
- Seal
- Epoxy
- Spring

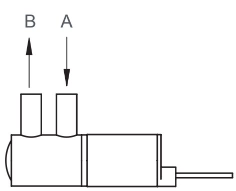
- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including screws, tubing, and lead wire connectors: see pages A22-34.

PORTING CONFIGURATION

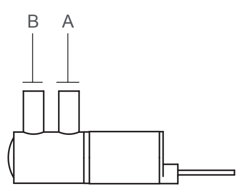
Our standard 2-way valves are designed for unidirectional flow, where the highest absolute pressure should be maintained at Port A. Bi-directional and reverse-flow valves (Port B to A) are available upon request.



ENERGIZED



DE-ENERGIZED



	PORT A	PORT B
PRESSURE	X	
VACUUM		X

A

3-WAY PLUG-IN

With fluidic ports buried into the mating manifold, the 7 mm, plug-in-style 3-way (3/2) LHD Series solenoid valve reduces space and enables design flexibility for complex fluidic circuits where multiple valves are required in the smallest space possible. Plug one port and the valve will also act as a 2-way normally open or closed valve.

- Operating pressure: Vac to 45 psig; 15 psid max. or higher upon request.
- Wetted materials: housing (PBT), seal (see below), plunger head (PPS or PPA)[4], armature & plunger stop (430 SS in 1800 Lohm models; FeCr alloy in 550 Lohm models), spring (316 SS), and epoxy. The O-rings on all plug-in-style valves are FKM.
- For additional information, see pages A36-37.

PART NUMBER	INLET PORT[1]	LOHM RATE[2] (Cv)	MIN. FLOW RATE[2] (SLPM)	ACTUATION VOLTAGE (Vdc)	HOLD POWER (mW)	SEAL[4]	MAX. SEAT LEAKAGE[2] (SμLPM)
LHDB0513418H	COM	1800 (0.011)	4.5	5	550	Silicone	25
LHDB1213418H	COM	1800 (0.011)	4.5	12	550	Silicone	25
LHDB0513518H	COM	1800 (0.011)	4.5	5	650	FKM	50
LHDB1213518H	COM	1800 (0.011)	4.5	12	650	FKM	50
LHDB0573518H	Any Port	1800 (0.011)	4.5	5	750	FKM	50
LHDB1273518H	Any Port	1800 (0.011)	4.5	12	750	FKM	50
LHDB0313155D	COM	550 (0.036)	14.6	5 / 2.5[3]	520	Silicone	50
LHDB0613155D	COM	550 (0.036)	14.6	12 / 6[3]	590	Silicone	50
LHDB0313255D	COM	550 (0.036)	14.6	5 / 2.5[3]	520	FKM	50
LHDB0613255D	COM	550 (0.036)	14.6	12 / 6[3]	590	FKM	50

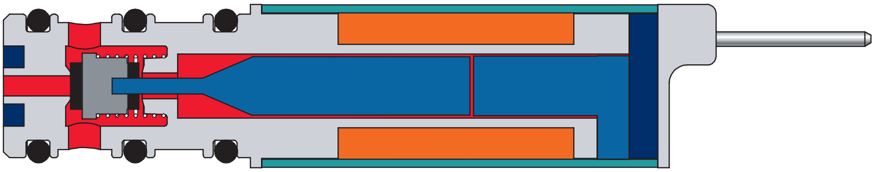
(1) Indicates the port where the highest absolute pressure must be maintained. See page A9 for more information.

(2) Specifications listed are on air at 15 psid. For flow rate capabilities at other pressures, reference page A35. Refer to Section Q for a full description of the Lohm Laws.

(3) Spike voltage/hold voltage. A spike and hold electrical drive is required for most applications. To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Refer to pages Q42-45 for electrical circuit design recommendations.

(4) Plunger head material is PPS for all silicone valves and PPA for all FKM valves. Other seal materials available upon request. Refer to pages Q62-63 for material information and abbreviations.

3-WAY PLUG-IN



- Flow Path
- Housing
- Seal
- Coil
- Shield
- Epoxy
- Armature & Plunger Stop
- Plunger Head Assembly
- Spring

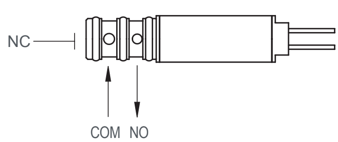
- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including standard manifolds, manufacturing & installation tools, screws, and retention brackets: see pages A22-34.

PORTING CONFIGURATION

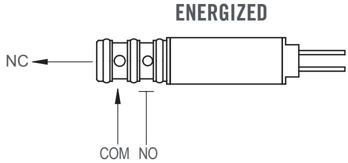
- Common port: the highest absolute pressure, often the inlet pressure, must be maintained at the common port (COM).
- Any port: the highest absolute pressure can be connected to any port.

COMMON PORT

DE-ENERGIZED



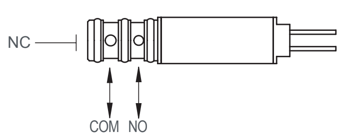
ENERGIZED



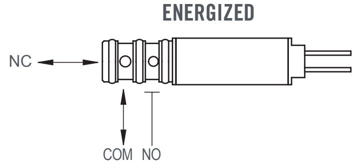
	NORMALLY CLOSED (NC)	COMMON (COM)	NORMALLY OPEN (NO)
PRESSURE		X	
VACUUM	X		

ANY PORT

DE-ENERGIZED



ENERGIZED



	NORMALLY CLOSED (NC)	COMMON (COM)	NORMALLY OPEN (NO)
PRESSURE	X	X	X
VACUUM	X	X	X

3-WAY FACE MOUNT

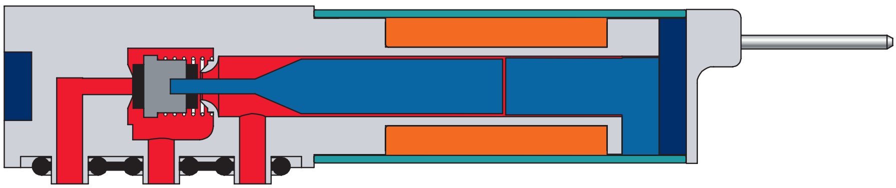
With the fluidic ports surface mounted via a one-piece gasket, the 7 mm face mount-style 3-way (3/2) LHD Series solenoid valve lends itself easily to machined or molded manifolds, enabling multiple valves to be mounted in an incredibly small package. Plug one port and the valve will also act as a 2-way normally open or closed valve.

- Operating pressure: Vac to 45 psig; 15 psid max. or higher upon request.
- Wetted materials: housing (PBT), seal (see below), plunger head (PPS or PPA)[4], armature & plunger stop (430 SS in 1800 Lohm models; FeCr alloy in 800 Lohm models), spring (316 SS), and epoxy.
- For additional information, see pages A36-37.

PART NUMBER	INLET PORT[1]	LOHM RATE[2] (Cv)	MIN. FLOW RATE[2] (SLPM)	ACTUATION VOLTAGE (Vdc)	HOLD POWER (mW)	SEAL[5]	MAX. SEAT LEAKAGE[2] (SμLPM)
LHDB0523418H	COM	1800 (0.011)	4.5	5	550	Silicone	25
LHDB1223418H	COM	1800 (0.011)	4.5	12	550	Silicone	25
LHDB0523518H	COM	1800 (0.011)	4.5	5	650	FKM	50
LHDB1223518H	COM	1800 (0.011)	4.5	12	650	FKM	50
LHDB0583518H	Any Port	1800 (0.011)	4.5	5	750	FKM	50
LHDB1283518H	Any Port	1800 (0.011)	4.5	12	750	FKM	50
LHDB0323180D	COM	800 (0.025)	10.1	5 / 2.5[3]	520	Silicone	50
LHDB0623180D	COM	800 (0.025)	10.1	12 / 6[3]	590	Silicone	50
LHDB0323280D	COM	800 (0.025)	10.1	5 / 2.5[3]	520	FKM	50
LHDB0623280D	COM	800 (0.025)	10.1	12 / 6[3]	590	FKM	50

(1) Indicates the port where the highest absolute pressure must be maintained. See page A11 for more information.
(2) Specifications listed are on air at 15 psid. For flow rate capabilities at other pressures, reference page A35. Refer to Section Q for a full description of the Lohm Laws.
(3) Spike voltage/hold voltage. A spike and hold electrical drive is required for most applications. To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Refer to pages Q42-45 for electrical circuit design recommendations.
(4) Plunger head material is PPS for all silicone valves and PPA for all FKM valves.
(5) Other seal materials available upon request. Refer to pages Q62-63 for material information and abbreviations.

3-WAY FACE MOUNT



- Flow Path
- Coil
- Armature & Plunger Stop
- Housing
- Shield
- Plunger Head Assembly
- Seal
- Epoxy
- Spring

■ Valve dimensions and mounting information: see pages A20-23.

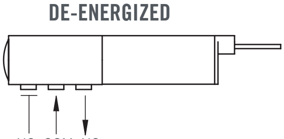
■ Accessories, including standard manifolds, manufacturing & installation tools, screws, and retention brackets: see pages A22-34.

PORTING CONFIGURATION

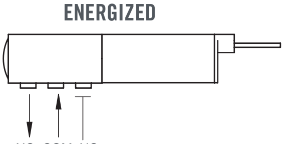
- Common port: the highest absolute pressure, often the inlet pressure, must be maintained at the common port (COM).
- Any port: the highest absolute pressure can be connected to any port.

COMMON PORT

DE-ENERGIZED



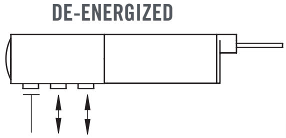
ENERGIZED



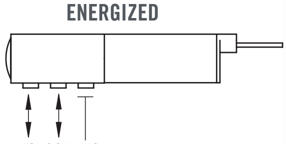
	NORMALLY CLOSED (NC)	COMMON (COM)	NORMALLY OPEN (NO)
PRESSURE		X	
VACUUM	X		

ANY PORT

DE-ENERGIZED



ENERGIZED



	NORMALLY CLOSED (NC)	COMMON (COM)	NORMALLY OPEN (NO)
PRESSURE	X	X	X
VACUUM	X	X	X

3-WAY PORTED

With fluidic ports designed for use with 1/16" (1.6 mm) ID tubing, the 7 mm ported-style 3-way (3/2) LHD Series solenoid valve enables easy setup, rapid testing, and simple system integration in tight spaces. Plug one port and the valve will also act as a 2-way normally open or closed valve.

- Operating pressure: Vac to 45 psig; 15 psid max. or higher upon request.
- Wetted materials: housing (PBT), seal (see below), plunger head (PPS or PPA)[4], armature & plunger stop (430 SS in 1800 Lohm models; FeCr alloy in 800 Lohm models), spring (316 SS), and epoxy.
- For additional information, see pages A36-37.

PART NUMBER	INLET PORT[1]	LOHM RATE[2] (Cv)	MIN. FLOW RATE[2] (SLPM)	ACTUATION VOLTAGE (Vdc)	HOLD POWER (mW)	SEAL[5]	MAX. SEAT LEAKAGE[2] (SμLPM)
LHDB0533418H	COM	1800 (0.011)	4.5	5	550	Silicone	25
LHDB1233418H	COM	1800 (0.011)	4.5	12	550	Silicone	25
LHDB0533518H	COM	1800 (0.011)	4.5	5	650	FKM	50
LHDB1233518H	COM	1800 (0.011)	4.5	12	650	FKM	50
LHDB0593518H	Any Port	1800 (0.011)	4.5	5	750	FKM	50
LHDB1293518H	Any Port	1800 (0.011)	4.5	12	750	FKM	50
LHDB0333180D	COM	800 (0.025)	10.1	5 / 2.5[3]	520	Silicone	50
LHDB0633180D	COM	800 (0.025)	10.1	12 / 6[3]	590	Silicone	50
LHDB0333280D	COM	800 (0.025)	10.1	5 / 2.5[3]	520	FKM	50
LHDB0633280D	COM	800 (0.025)	10.1	12 / 6[3]	590	FKM	50

(1) Indicates the port where the highest absolute pressure must be maintained. See page A13 for more information.

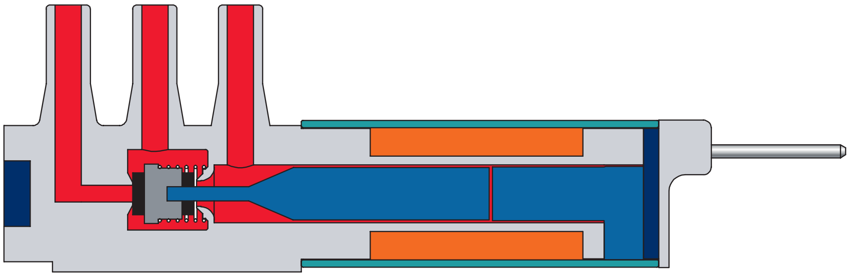
(2) Specifications listed are on air at 15 psid. For flow rate capabilities at other pressures, reference page A35. Refer to Section Q for a full description of the Lohm Laws.

(3) Spike voltage/hold voltage. A spike and hold electrical drive is required for most applications. To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Refer to pages Q42-45 for electrical circuit design recommendations.

(4) Plunger head material is PPS for all silicone valves and PPA for all FKM valves.

(5) Other seal materials available upon request. Refer to pages Q62-63 for material information and abbreviations.

3-WAY PORTED



Flow Path	Housing	Seal
Coil	Shield	Epoxy
Armature & Plunger Stop	Plunger Head Assembly	Spring

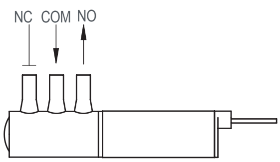
- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including screws, tubing, and lead wire connectors: see pages A22-34.

PORTING CONFIGURATION

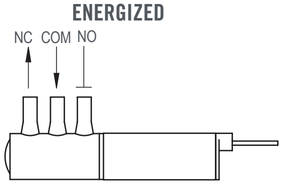
- Common port: the highest absolute pressure, often the inlet pressure, must be maintained at the common port (COM).
- Any port: the highest absolute pressure can be connected to any port.

COMMON PORT

DE-ENERGIZED



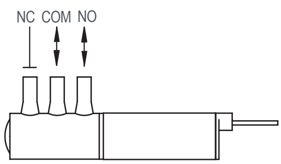
ENERGIZED



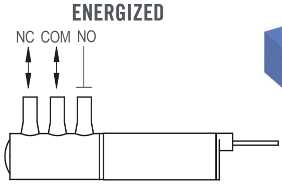
	NORMALLY CLOSED (NC)	COMMON (COM)	NORMALLY OPEN (NO)
PRESSURE		X	
VACUUM	X		

ANY PORT

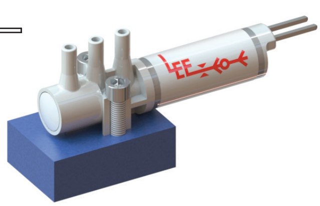
DE-ENERGIZED



ENERGIZED



	NORMALLY CLOSED (NC)	COMMON (COM)	NORMALLY OPEN (NO)
PRESSURE	X	X	X
VACUUM	X	X	X



2-WAY LATCHING

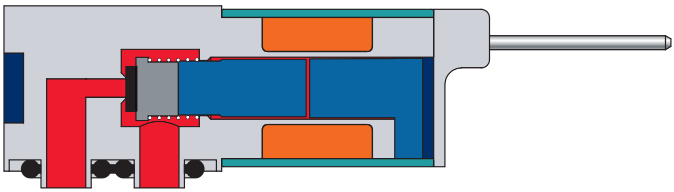
The ultra miniature, 7 mm, 2-way (2/2) LHL Series solenoid valve is a low power, latching valve ideal for directional control of gases or piloting samples in battery-operated, heat-sensitive pneumatic applications. Due to the magnetically latching design, the valve will hold its flow state without power, requiring only a momentary electrical pulse (10 to 30 ms) to switch state.

- Ultra low power and low heat: consumes only 23 mJ/switch
- Operating pressure: Vac to 45 psig; 10 psid max. or higher upon request.
- Leakage: less than 50 SμLPM at 10 psid air; 70°F (21°C)
- Wetted materials: housing (PBT), seal (see below), plunger head (PPS or PPA)[2], armature/plunger stop (FeCr), spring (316 SS), and epoxy. The O-rings on all plug-in-style valves are FKM.
- For additional information, see pages A36-37.

STYLE	PART NUMBER	ACTUATION VOLTAGE (Vdc)	LOHM RATE[1] (Cv)	MIN. FLOW RATE (SLPM)[1]	SEAL[3]
Plug-In	LHLA0342311H	3.3	1100 (.018)	6	Silicone
	LHLA0542311H	5	1100 (.018)	6	Silicone
	LHLA1242311H	12	1100 (.018)	6	Silicone
	LHLA0542411H	5	1100 (.018)	6	FKM
	LHLA1242411H	12	1100 (.018)	6	FKM
Face Mount	LHLA0352311H	3.3	1100 (.018)	6	Silicone
	LHLA0552311H	5	1100 (.018)	6	Silicone
	LHLA1252311H	12	1100 (.018)	6	Silicone
	LHLA0552411H	5	1100 (.018)	6	FKM
	LHLA1252411H	12	1100 (.018)	6	FKM

(1) Specifications listed are on air at 10 psid. For flow rate capabilities at other pressures, see page A35. Refer to Section Q for a full description of the Lohm Laws.
(2) Plunger head material is PPS for all silicone valves and PPA for all FKM valves.
(3) Other seal materials available upon request. Refer to pages Q62-63 for material information and abbreviations.

2-WAY LATCHING



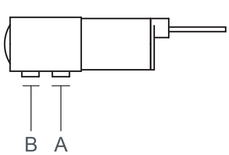
- Flow Path
- Coil
- Armature & Plunger Stop
- Housing
- Shield
- Plunger Head Assembly
- Seal
- Epoxy
- Spring

- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including standard manifolds, manufacturing & installation tools, screws, and retention brackets: see pages A22-34.
- Magnetically latching valves require drive circuitry capable of reversing the polarity to their electrical pins to provide bi-directional current flow. Refer to pages Q46-47 for additional information and example circuitry.

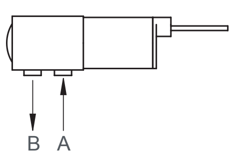
PORTING CONFIGURATION

Our standard 2-way valves are designed for unidirectional flow, where the highest absolute pressure should be maintained at Port A. The valve will switch to and remain in the state indicated when a 10 ms electrical pulse is applied at the rated voltage and polarity. Bi-directional and reverse-flow valves (Port B to A) are also available upon request.

VALVE STATE A



VALVE STATE B



	PORT A	PORT B
PRESSURE	X	
VACUUM		X

Drawings above represent the face mount-style only. Plug-in-style graphics are similar. Refer to the individual inspection drawing of a particular part number for full specifications.

3-WAY LATCHING

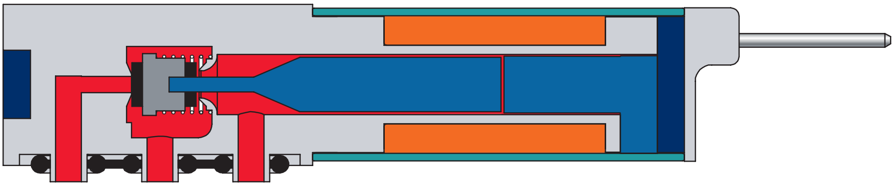
The miniature 3-way (3/2) LHL Series is an ultra low power, latching solenoid valve ideal for directional control of gases or piloting samples in battery-operated, heat sensitive pneumatic applications. Due to its magnetically latching design, the valve will hold its flow state without power, requiring only a momentary electrical pulse to switch state.

- Ultra low power and low heat: consumes as low as 5.5 mJ/switch
- Operating pressure: Vac to 45 psig; 15 psid max. or higher upon request.
- Leakage: less than 50 SμLPM at 15 psid air; 70°F (21°C)
- Wetted materials: housing (PBT), plunger head (PPS or PPA)[2], armature/plunger stop (FeCr in 550 and 800 Lohm models; 430 SS in 1100 Lohm models), seal (see below), spring (316 SS), and epoxy. The O-rings on all plug-in-style valves are FKM.
- For additional information, see pages A36-37.

STYLE	PART NUMBER	ACTUATION VOLTAGE (Vdc)	LOHM RATE[1] (Cv)	MIN. FLOW RATE (SLPM)[1]	SEAL[3]	ENERGY CONSUMPTION (mJ/switch)
Plug-In 	LHLA0511355D	5	550 (.036)	14.6	Silicone	28
	LHLA1211355D	12	550 (.036)	14.6	Silicone	35
	LHLA0511111H	5	1100 (.018)	6	Silicone	5.5
	LHLA1211111H	12	1100 (.018)	6	Silicone	5.5
	LHLA0511211H	5	1100 (.018)	6	FKM	5.5
	LHLA1211211H	12	1100 (.018)	6	FKM	5.5
Face Mount 	LHLA0521380D	5	800 (.025)	10	Silicone	28
	LHLA1221380D	12	800 (.025)	10	Silicone	35
	LHLA0521111H	5	1100 (.018)	6	Silicone	5.5
	LHLA1221111H	12	1100 (.018)	6	Silicone	5.5
	LHLA0521211H	5	1100 (.018)	6	FKM	5.5
	LHLA1221211H	12	1100 (.018)	6	FKM	5.5
Ported 	LHLA0531380D	5	800 (.025)	10	Silicone	28
	LHLA1231380D	12	800 (.025)	10	Silicone	35
	LHLA0531111H	5	1100 (.018)	6	Silicone	5.5
	LHLA1231111H	12	1100 (.018)	6	Silicone	5.5
	LHLA0531211H	5	1100 (.018)	6	FKM	5.5
	LHLA1231211H	12	1100 (.018)	6	FKM	5.5

(1) Specifications listed are on air at 10 psid for 1100 Lohm models, and at 15 psid for 550 and 800 Lohm models. For flow rate capabilities at other pressures, see page A35. Refer to Section Q for a full description of the Lohm Laws.
(2) Plunger head material is PPS for all silicone valves and PPA for all FKM valves.
(3) Other seal materials available upon request. Refer to pages Q62-63 for material information and abbreviations.

3-WAY LATCHING



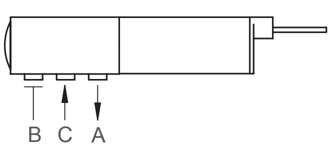
Flow Path	Housing	Seal
Coil	Shield	Epoxy
Armature & Plunger Stop	Plunger Head Assembly	Spring

- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including standard manifolds, manufacturing & installation tools, screws, and retention brackets: see pages A22-34.
- Magnetically latching valves require drive circuitry capable of reversing the polarity to their electrical pins to provide bidirectional current flow. Refer to pages Q46-47 for additional information and example circuitry.

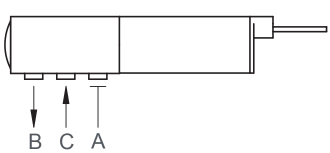
PORTING CONFIGURATION

Our standard 3-way valves are designed for unidirectional flow, where the highest absolute pressure should be maintained at the common port (C). The valve will switch to and remain in the state indicated when a 10 ms electrical pulse is applied at the rated voltage and polarity. Bi-directional and reverse-flow valves (Port B to A) are also available upon request.

VALVE STATE A



VALVE STATE B



	PORT B	COMMON PORT C	PORT A
PRESSURE		X	
VACUUM	X		

Drawings above represent the face mount-style only. Plug-in and ported-style drawings are similar. Refer to the individual inspection drawing of a particular part number for full specifications.

A

3-WAY QUIET OPERATION

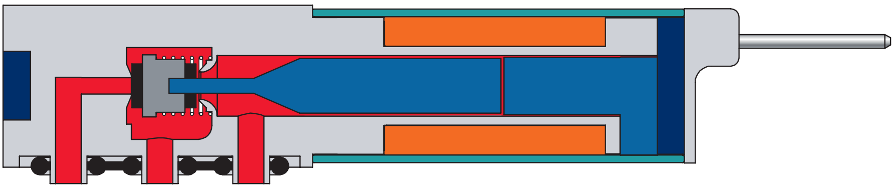
The 3-way (3/2), LHQ Series solenoid valve is a 7 mm, quiet operation valve designed to significantly reduce the actuation noise typically heard when a solenoid valve is energized. The valve's low sound profile (≤ 30 dB), low leakage, and high reliability make it ideal for patient simulators and a variety of bedside pneumatic applications where actuation sound would otherwise interfere with comfort.

- Typical sound level: ≤ 30 dBa, when measured 12 inches from valve, cycling at 1 Hz
- Flow media: fluid-damped valves are for use with non-combustible gases only. If oxygen service is required, ask about our alternative quiet design options.
- Wetted materials: housing (PBT), seal (FKM), plunger head (PPA), armature/plunger stop (430 SS), spring (316 SS), damping fluid, and epoxy. The O-rings on all plug-in-style valves are FKM. Refer to pages Q62-63 for material information and abbreviations.
- Operating pressure: 0 to 45 psig; 15 psid max.
- Power consumption: 900 mW
- Operating temperature: 60° F to 120° F (16° C to 49° C)
- Leakage: less than 50 SμLPM at 15 psid air; 70°F (21°C)
- For additional information, see pages A36-37.

STYLE	PART NUMBER	ACTUATION VOLTAGE (Vdc)	LOHM RATE[1] (Cv)	MINIMUM FLOW RATE (SLPM)[1]
Plug-In 	LHQA0511220H	5	2000 (0.01)	4
	LHQA1211220H	12	2000 (0.01)	4
	LHQA2411220H	24	2000 (0.01)	4
Face Mount 	LHQA0521220H	5	2000 (0.01)	4
	LHQA1221220H	12	2000 (0.01)	4
	LHQA2421220H	24	2000 (0.01)	4
Ported 	LHQA0531220H	5	2000 (0.01)	4
	LHQA1231220H	12	2000 (0.01)	4
	LHQA2431220H	24	2000 (0.01)	4

(1) Specifications listed are on air at 15 psid. For flow rate capabilities at other pressures, see page A35. Refer to Section Q for a full description of the Lohm Laws.

3-WAY QUIET OPERATION



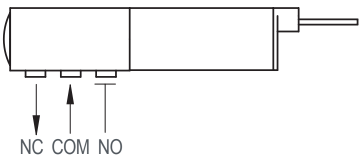
- Flow Path
- Coil
- Armature & Plunger Stop
- Housing
- Shield
- Plunger Head Assembly
- Seal
- Epoxy
- Spring

- Valve dimensions and mounting information: see pages A20-23.
- Accessories, including screws, tubing, and lead wire connectors: see pages A22-34.

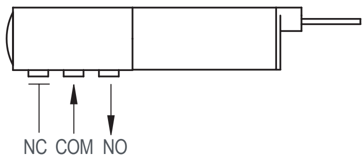
PORTING CONFIGURATION

Our standard 3-way valves are designed for unidirectional flow, where the highest absolute pressure should be maintained at the common port (COM). Bi-directional and reverse-flow valves are also available upon request.

ENERGIZED



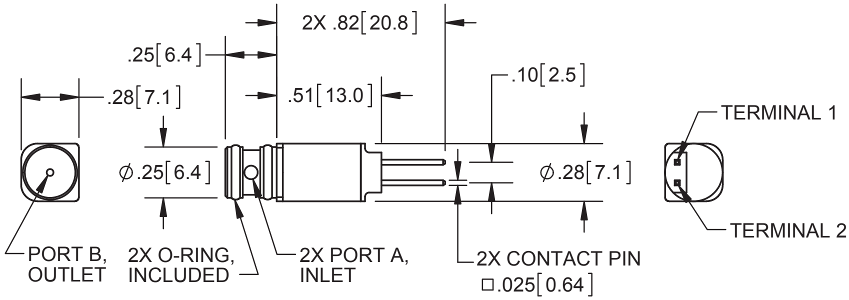
DE-ENERGIZED



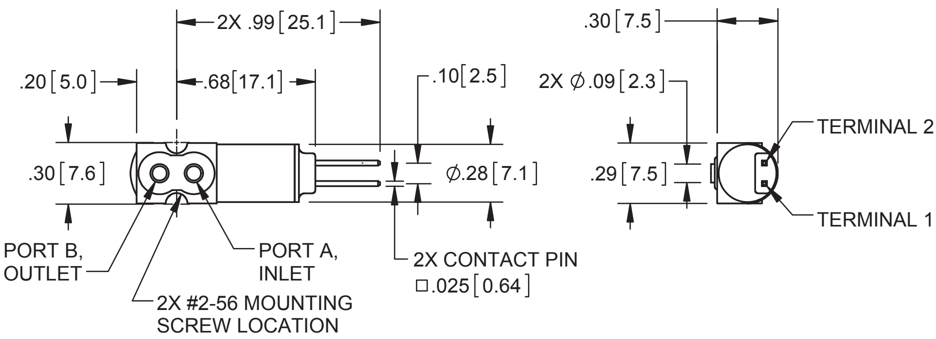
	NORMALLY CLOSED (NC)	COMMON (COM)	NORMALLY OPEN (NO)
PRESSURE		X	

Drawings above represent the face mount-style only. Plug-in and ported-style drawings are similar. Refer to the individual inspection drawing of a particular part number for full specifications.

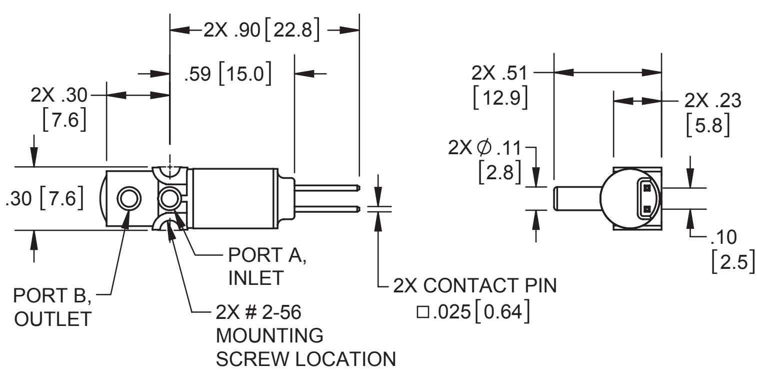
2-WAY PLUG-IN



2-WAY FACE MOUNT

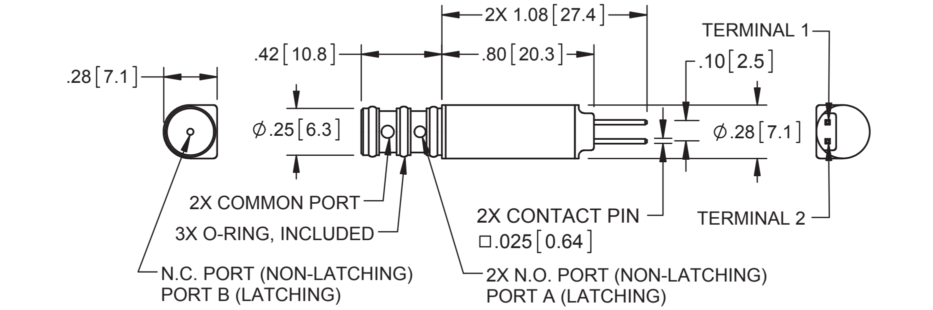


2-WAY PORTED

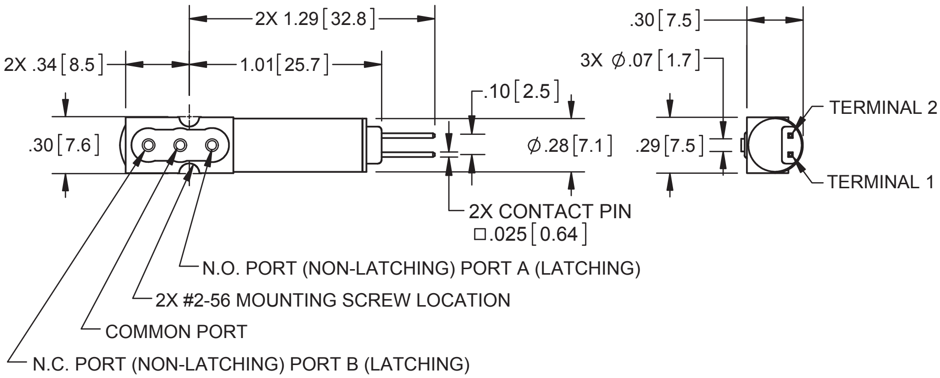


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.
Reference individual valve inspection drawings for complete specifications.

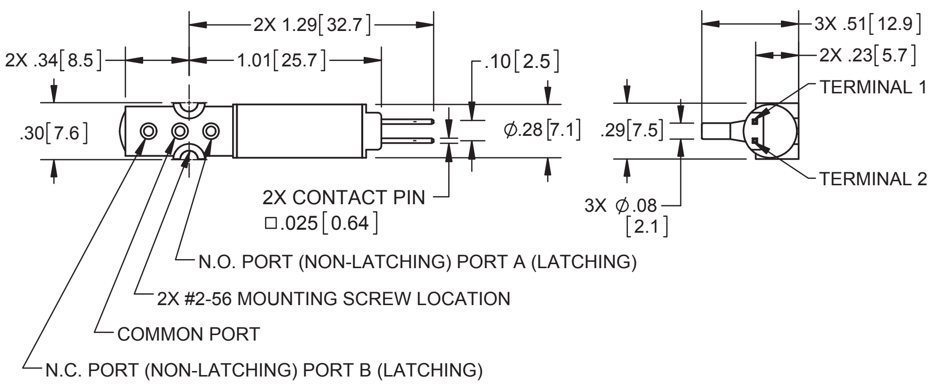
3-WAY PLUG-IN



3-WAY FACE MOUNT

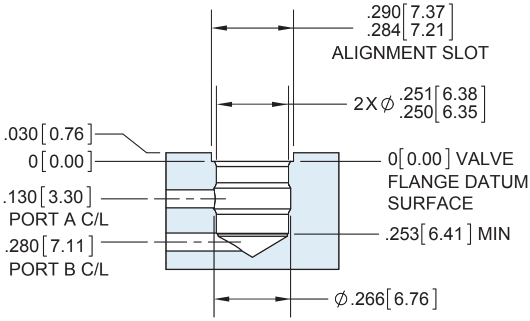


3-WAY PORTED



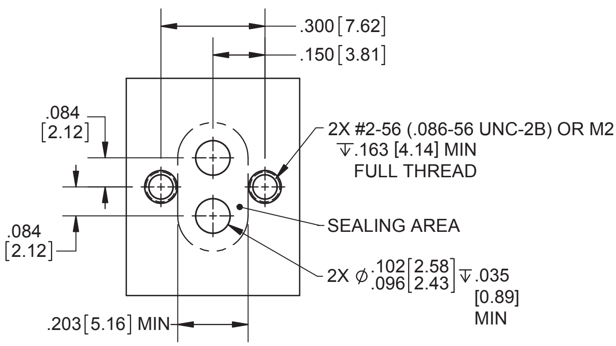
Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.
Reference individual valve inspection drawings for complete specifications.

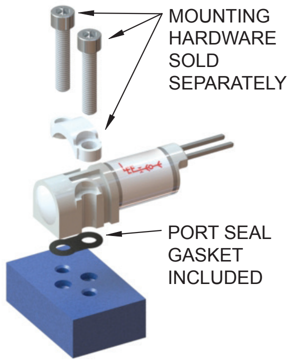
2-WAY PLUG-IN



- Valve boss may be created using the form tool, part number TTTA0000250B.
- Manifold mating boss geometries and dimensions shown above are for reference only. Refer to drawing number LCFX0300250B for complete specifications.
- Refer to document number LDOC0201050 for installation and extraction instructions.

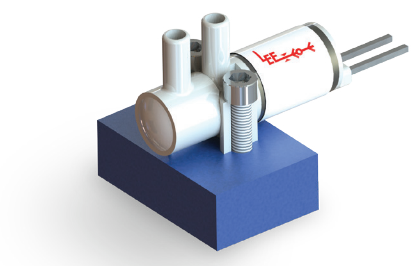
2-WAY FACE MOUNT





- Manifold mating boss geometries and dimensions shown above are for reference only. Refer to drawing number LFIX1002050A for complete specifications.
- Mounting hardware: Mounting Screw (LHWX0213420A); Screw Support (LHDX0307140A).

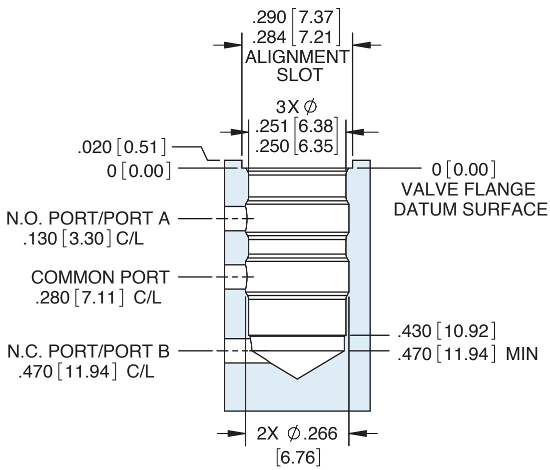
2-WAY PORTED



- Requires 2x #2-56 Mounting Screws (LHWX0503100A).
- Ports are intended for connection to soft, flexible 3/32" (2.4 mm) ID, 5/32" (4 mm) OD tubing.

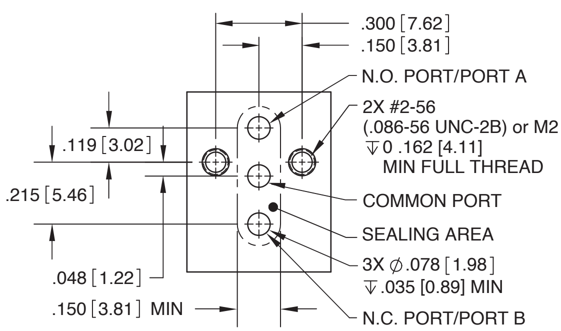
Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.
Reference individual valve inspection drawings for complete specifications.

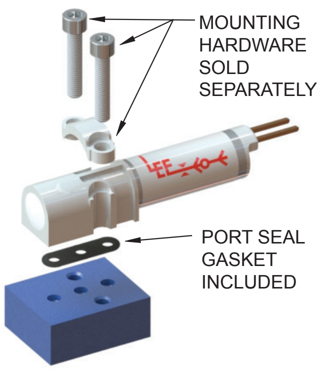
3-WAY PLUG-IN



- Valve boss may be created using the Form Tool, part number TTTA0000180B.
- Manifold mating boss geometries and dimensions shown above are for reference only. Refer to drawing number LCFX0300100B for complete specifications.
- Refer to document number LDOC0201050 for installation and extraction instructions.

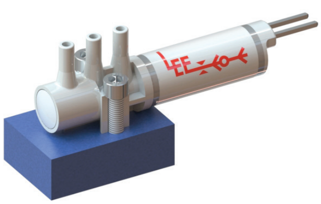
3-WAY FACE MOUNT





- Manifold mating boss geometries and dimensions shown above are for reference only. Refer to drawing number LFIX1001150A for complete specifications.
- Mounting hardware: mounting screw (LHWX0213420A); screw support (LHDX0307140A).

3-WAY PORTED



- Requires 2x #2-56 Mounting Screws (LHWX0503100A).
- Ports are intended for connection to soft, flexible 1/16" ID tubing.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale. Reference individual valve inspection drawings for complete specifications.

STANDARD, 2-WAY PLUG-IN-STYLE MANIFOLDS

Several standard manifolds are available to ease prototype setup, including one-valve, three-valve, and eight-valve options offered off-the-shelf, without valves included. Alternate materials and customized manifold designs are available upon request.

- Individual ports: this manifold configuration will allow for tubing connections to each individual valve port.
- Port A inlet header, individual Port B outlet ports: this manifold configuration provides a shared inlet header line to all valve inlet ports, as well as individual tubing connections to the outlet port of each valve.

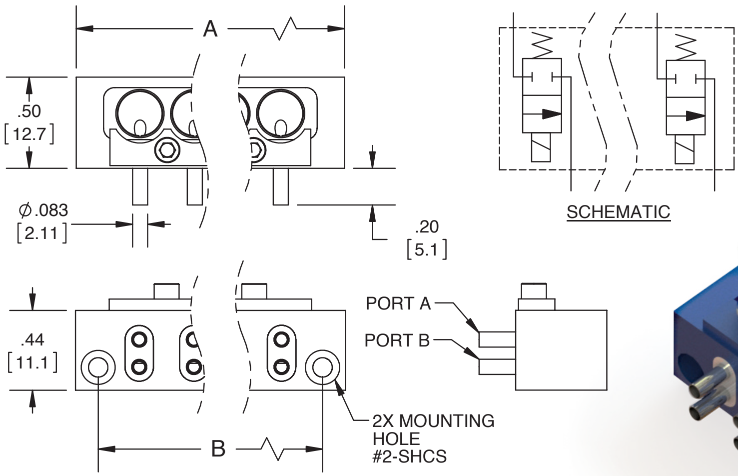
See page A25 for a visual representation of the pneumatic schematics.

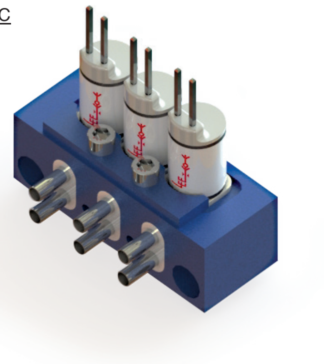
PART NUMBER	DESCRIPTION	NUMBER OF VALVE POSITIONS	DIMENSION A	DIMENSION B
LFMX0524000A	Individual ports, acrylic	1	—	—
LFMX0528200B	Individual ports, aluminum	1	—	—
LFMX0527650B	Individual ports, aluminum	3	1.30 in (33.0 mm)	1.05 in (26.7 mm)
LFMX0527700B	Individual ports, aluminum	8	2.80 in (71.1 mm)	2.55 in (64.8 mm)
LFMX0527750B	Port A inlet header, individual Port B outlet ports, aluminum	3	1.50 in (38.1 mm)	1.25 in (31.8 mm)
LFMX0527800B	Port A inlet header, individual Port B outlet ports, aluminum	8	3.00 in (76.2 mm)	2.75 in (69.9 mm)

- Manifold flow restriction may impact the flow rating of valves rated 1100 Lohms or less.
- Part numbers are for the manifold and secondary retention bracket only. Valves are sold separately.
- Refer to Section M for information on customized manifold assemblies. HDI Platform valves require only 0.300 of an inch center to center spacing.
- See page A32 for valve and manifold accessory items.

STANDARD, 2-WAY PLUG-IN-STYLE MANIFOLDS

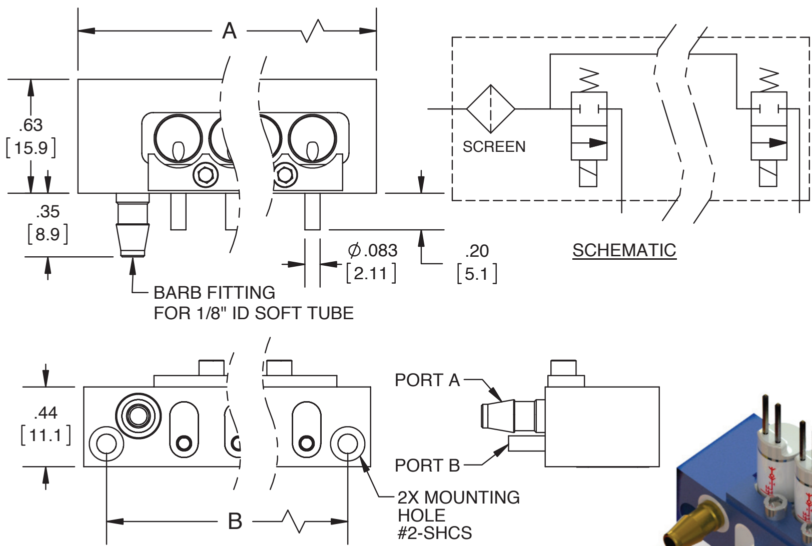
INDIVIDUAL PORTS

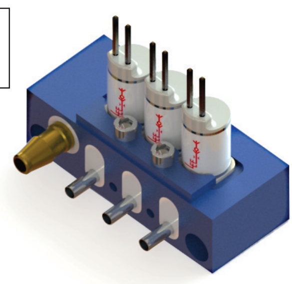




- The Ø 0.083" OD ports are intended for connection to 1/16" ID soft tubing.

PORT A INLET HEADER, INDIVIDUAL PORT B OUTLET PORTS





- The Ø 0.083" OD ports are intended for connection to 1/16" ID soft tubing.

Unless otherwise specified, dimensions are in inches [*mm*]. *Drawings are not to scale.*

STANDARD, 2-WAY FACE MOUNT-STYLE MANIFOLDS

Several standard manifolds are available to ease prototype setup, including one-valve, three-valve, and eight-valve options offered off-the-shelf, without valves included. Alternate materials and customized manifold designs are available upon request.

- Individual ports: this manifold configuration will allow for tubing connections to each individual valve port.
- Port A inlet header, individual Port B ports: this manifold configuration provides a shared inlet header line to all valve inlet ports, as well as individual tubing connections to the outlet port of each valve.

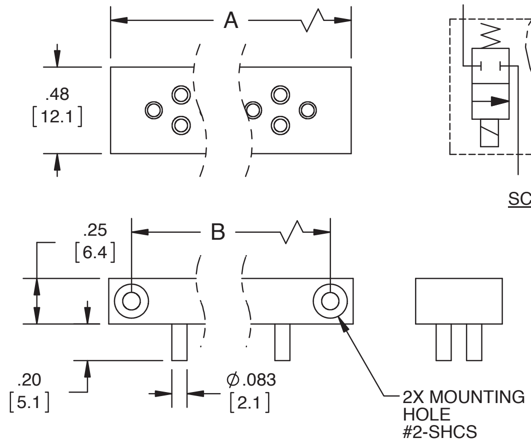
See page A27 for a visual representation of the pneumatic schematics.

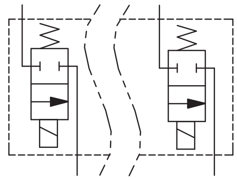
PART NUMBER	DESCRIPTION	NUMBER OF VALVE POSITIONS	DIMENSION A	DIMENSION B
LFMX0527400B	Individual ports, aluminum	1	0.75 in (19.1 mm)	0.50 in (12.7 mm)
LFMX0527450B	Individual ports, aluminum	3	1.38 in (35.1 mm)	1.13 in (28.7 mm)
LFMX0527500B	Individual ports, aluminum	8	2.88 in (73.2 mm)	2.63 in (66.8 mm)
LFMX0527550B	Port A inlet header, individual Port B ports, aluminum	3	1.50 in (38.1 mm)	1.25 in (31.8 mm)
LFMX0527600B	Port A inlet header, individual Port B ports, aluminum	8	3.00 in (76.2 mm)	2.75 in (69.9 mm)

- Manifold flow restriction may impact the flow rating of valves rated 1100 Lohms or less.
- Part numbers are for the manifold and secondary retention bracket only. Valves and mounting hardware are sold separately.
- Refer to Section M for information on customized manifold assemblies. HDI Platform valves require only 0.300 of an inch center to center spacing.
- See page A32 for valve and manifold accessory items.

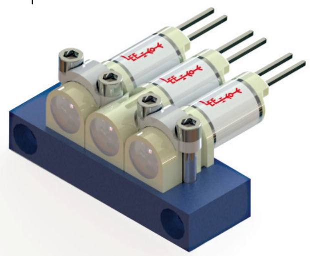
STANDARD, 2-WAY FACE MOUNT-STYLE MANIFOLDS

INDIVIDUAL PORTS



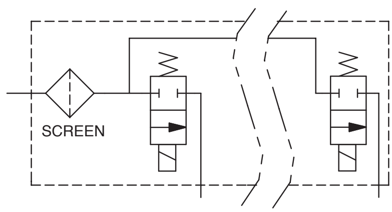


SCHEMATIC

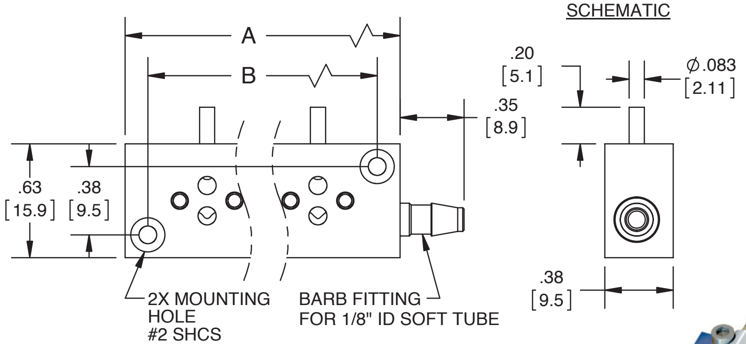


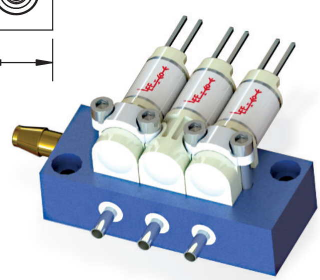
- The Ø 0.083" OD ports are intended for connection to 1/16" ID soft tubing.

PORT A INLET HEADER, INDIVIDUAL PORT B PORTS



SCHEMATIC





- The Ø 0.083" OD ports are intended for connection to 1/16" ID soft tubing.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

STANDARD 3-WAY PLUG-IN-STYLE MANIFOLDS

Several standard manifolds are available to ease prototype setup, including one-valve, three-valve, and eight-valve options offered off-the-shelf, without valves included. Alternate materials and customized manifold designs are available upon request.

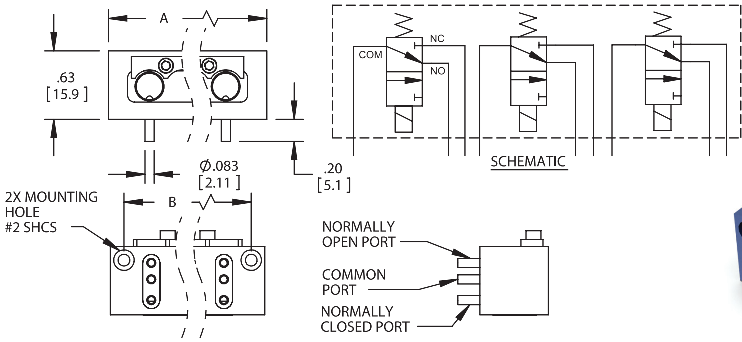
- Individual ports: this manifold configuration will allow for tubing connections to each individual valve port.
- Normally open and normally closed, header, individual common ports: this manifold configuration provides a shared header line to the normally open ports of the valves, a shared header line to the normally closed ports of the valves, and individual tubing connections to the common port of each valve.
- Common header, individual normally open, and normally closed ports: this manifold configuration provides a shared header line to the common ports of all valves, as well as individual tubing connections to the normally closed and normally open ports of each valve.

See page A29 for a visual representation of the pneumatic schematics.

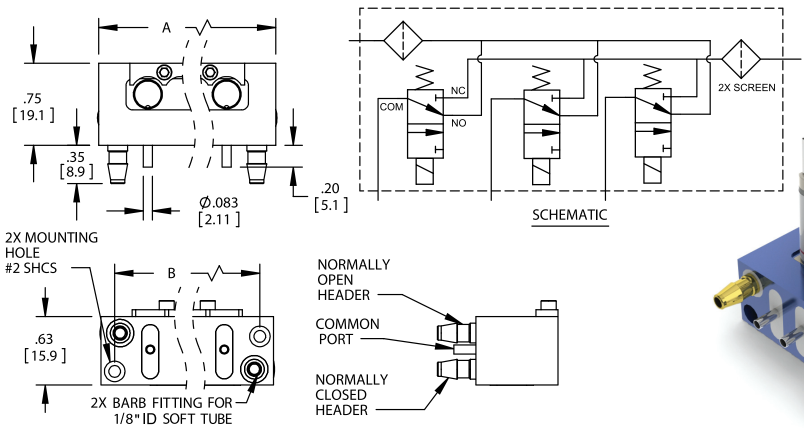
PART NUMBER	DESCRIPTION	NUMBER OF VALVE POSITIONS	DIMENSION A	DIMENSION B
LFMX0503800A	Individual ports, acrylic	1	—	—
LFMX0522450B	Individual ports, aluminum	1	0.75 in (19.1 mm)	0.50 in (12.7 mm)
LFMX0510413B	Individual ports, aluminum	3	1.35 in (34.3 mm)	1.10 in (27.9 mm)
LFMX0510418B	Individual ports, aluminum	8	2.85 in (72.4 mm)	2.60 in (66.0 mm)
LFMX0510423B	Common header, individual NC & NO Ports, aluminum	3	1.50 in (38.1 mm)	1.25 in (31.8 mm)
LFMX0510428B	Common header, individual NC & NO Ports, aluminum	8	3.00 in (76.2 mm)	2.75 in (69.9 mm)
LFMX0510433B	NC & NO headers, individual common ports, aluminum	3	1.50 in (38.1 mm)	1.25 in (31.8 mm)
LFMX0510438B	NC & NO headers, individual common ports, aluminum	8	3.00 in (76.2 mm)	2.7 in (69.9 mm)

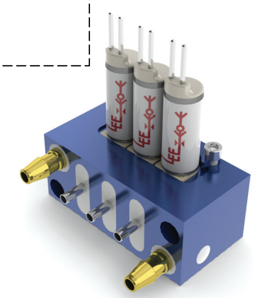
- Manifold flow restriction may impact the flow rating of valves rated 1100 Lohms or less.
- Part numbers are for the manifold and secondary retention bracket only. Valves are sold separately.
- Refer to Section M for information on customized manifold assemblies.
- See page A32 for valve and manifold accessory items.

STANDARD 3-WAY PLUG-IN-STYLE MANIFOLDS, INDIVIDUAL PORTS

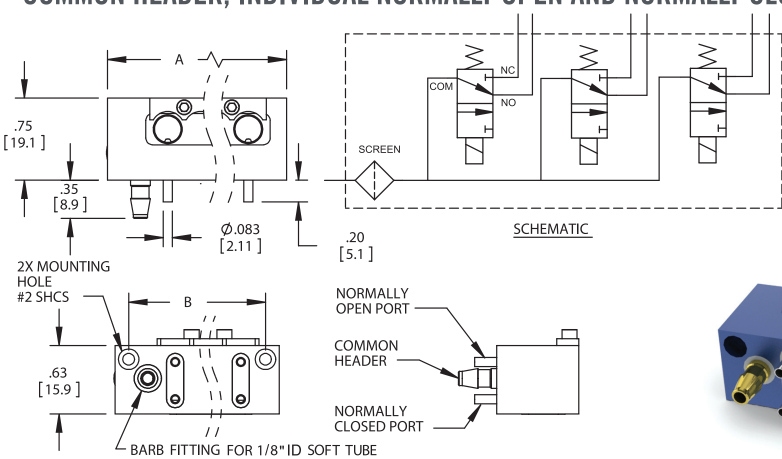


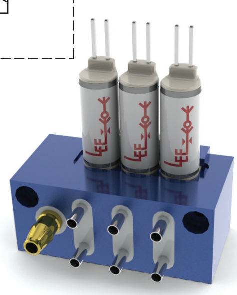
NORMALLY OPEN AND NORMALLY CLOSED HEADER, INDIVIDUAL COMMON PORTS





COMMON HEADER, INDIVIDUAL NORMALLY OPEN AND NORMALLY CLOSED PORTS





Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.
ø 0.083" OD ports are intended for connection to 1/16" ID soft tubing.

STANDARD 3-WAY FACE MOUNT-STYLE MANIFOLDS

Several standard manifolds are available to ease prototype setup, including one-valve, three-valve, and eight-valve options offered off-the-shelf, without valves included. Alternate materials and customized manifold designs are available upon request.

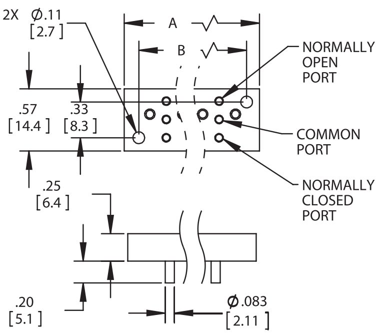
- Individual ports: this manifold configuration will allow for tubing connections to each individual valve port.
- Normally open and normally closed header, individual common ports: this manifold configuration provides a shared header line to the normally open ports of the valves, a shared header line to the normally closed ports of the valves, and individual tubing connections to the common port of each valve.
- Common header, individual normally open, and normally closed ports: this manifold configuration provides a shared header line to the common ports of all valves, as well as individual tubing connections to the normally closed and normally open valve ports.

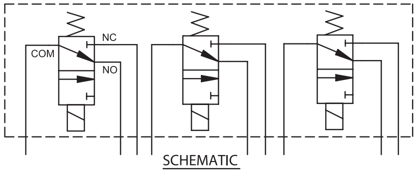
See page A31 for a visual representation of the pneumatic schematics.

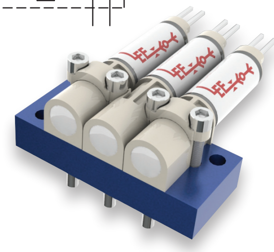
PART NUMBER	DESCRIPTION	NUMBER OF VALVE POSITIONS	DIMENSION A	DIMENSION B
LFMX0507200A	Individual ports, aluminum	1	0.44 in (11.2 mm)	0.30 in (7.6 mm)
LFMX0510513B	Individual ports, aluminum	3	1.35 in (34.3 mm)	1.10 in (27.9 mm)
LFMX0510518B	Individual ports, aluminum	8	2.86 in (72.6 mm)	2.59 in (65.8 mm)
LFMX0510523B	Common header, individual NC & NO Ports, aluminum	3	1.51 in (38.4 mm)	1.29 in (32.8 mm)
LFMX0510528B	Common header, individual NC & NO Ports, aluminum	8	3.02 in (76.7 mm)	2.79 in (70.9 mm)
LFMX0510533B	NC & NO headers, individual common ports, aluminum	3	1.5 in (39.4 mm)	1.28 in (32.5 mm)
LFMX0510538B	NC & NO headers, individual common ports, aluminum	8	3.05 in (77.5 mm)	2.78 in (70.6 mm)

- Manifold flow restriction may impact the flow rating of valves rated 1100 Lohms or less.
- Part numbers are for the manifold only. Valves and mounting hardware are sold separately.
- Refer to Section M for information on customized manifold assemblies.
- See page A33 for valve and manifold accessor items.

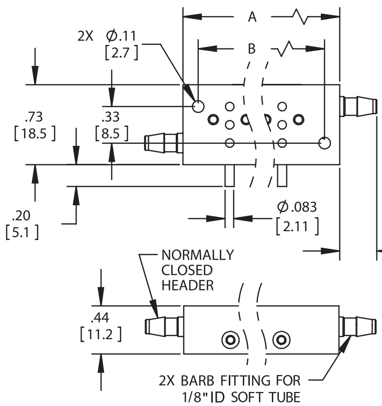
STANDARD 3-WAY FACE MOUNT-STYLE MANIFOLDS INDIVIDUAL PORTS

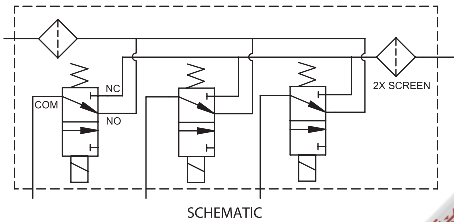


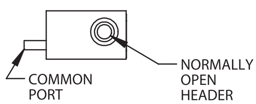


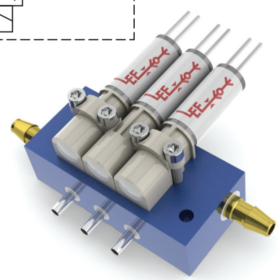


NORMALLY OPEN AND NORMALLY CLOSED HEADER, INDIVIDUAL COMMON PORTS

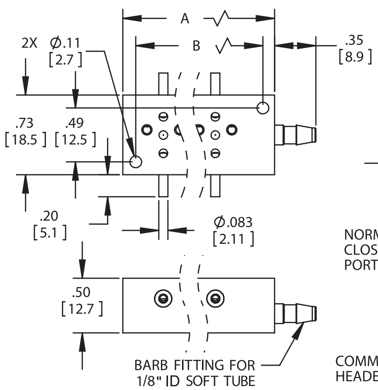


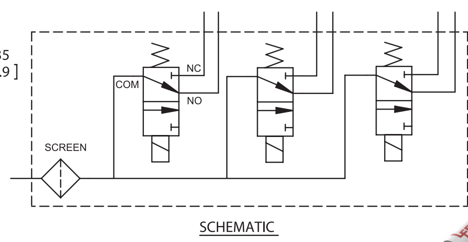


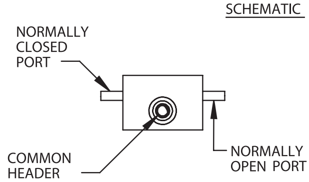


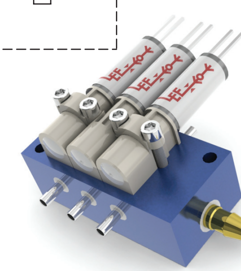


COMMON HEADER, INDIVIDUAL NORMALLY OPEN AND NORMALLY CLOSED PORTS







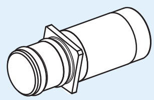
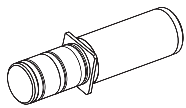
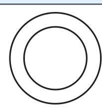
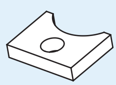
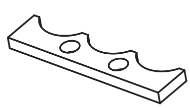
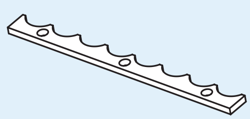
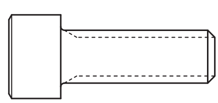
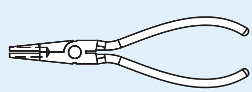


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.
ø 0.083" OD ports are intended for connection to 1/16" ID soft tubing.

A

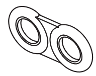
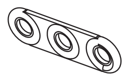
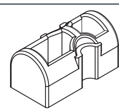
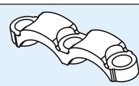
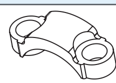
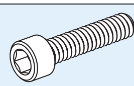
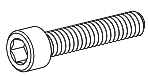
GENERAL ACCESSORIES / REPLACEMENT PARTS

PLUG-IN

CONFIGURATION	PART NUMBER	DESCRIPTION	
2-way	TTTA0000250B		Boss Cutting Tool
	LHDX0526900A		Boss Plug (POM with FKM O-rings)
3-way	LHDX0526050A		Boss Plug (POM with FKM O-rings)
	TTTA0000180B		Boss Cutting Tool
2-way and 3-way	LHWX0218030A		Replacement O-ring (FKM)
	LLWX0307140A		Retention Bracket, 1x
	LLWX0307130A		Retention Bracket, 3x
	LLWX0307120A		Retention Bracket, 8x
	LHWX0503010A		Screw, Socket Head Cap, 0.086" #2-56 x 0.250" SS
	LTTA0300000A		Installation/ Extraction Tool

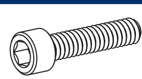
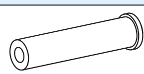
GENERAL ACCESSORIES / REPLACEMENT PARTS

FACE MOUNT

CONFIGURATION	PART NUMBER	DESCRIPTION	
2-way	LLWX0218230A		Gasket (SI)
	LLWX0218240A		Gasket (FKM)
3-way	LHWX0218000A		Gasket (SI)
	LHWX0218010A		Gasket (FKM)
	LLWX0620000A		Boss Plug (PBT with FKM gasket)
2-way and 3-way	LHDX0307130A		Mounting Screw Support-2x, PBT
	LHDX0307140A		Mounting Screw Support-1x, PBT
	LHWX0503100A		Screw, Socket Head Cap, 0.086" #2-56 x 0.375" SS
	LHWX0213420A[1]		Screw, Socket Head Cap, 0.086" #2-56 x 0.438" (7/16) SS

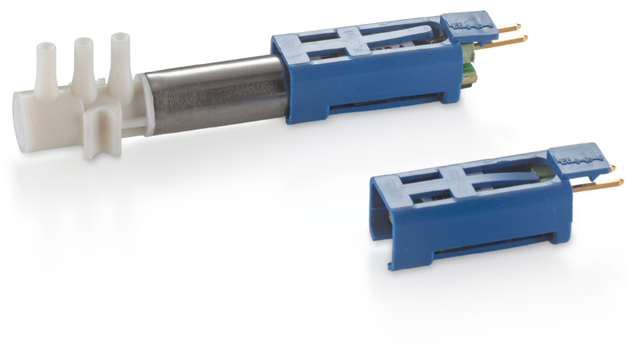
(1) Required for use with recommended mounting screw support.

PORTED

CONFIGURATION	PART NUMBER	DESCRIPTION	
2-way and 3-way	LHWX0503100A		Screw, Socket Head Cap, 0.086" #2-56 x 0.375" SS
2-way	LLWX0360100A	—	PUR tubing, 3/32" ID, 5/32" OD, 6 foot length
3-way	LHWX0320090A		Port Plug
	LLWX0360120A	—	PUR tubing, 1/16" ID, 1/8" OD, 6 foot length

Universal (all styles): LHWX0605450A Electrical Lead Wire Connector, 6 inches long

A

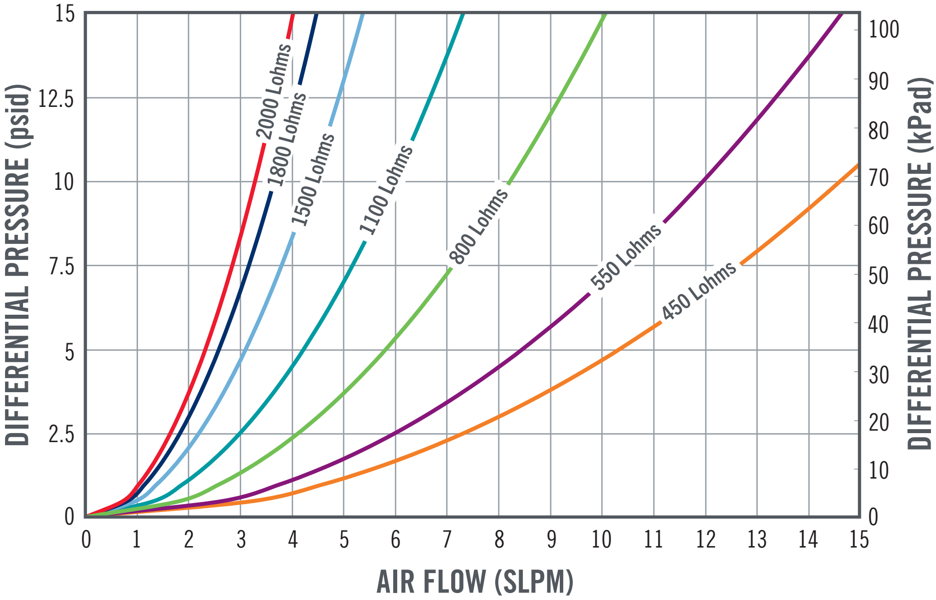


As an accessory to the LHD Series High Density Interface (HDI®) solenoid valves, the Spike and Hold Driver provides added value by allowing quick and easy prototype setup. The driver requires only a single input voltage to operate; everything else is pre-programmed and no user adjustments are required. Each driver is also equipped with an LED indicator, which provides operational feedback.

- Steady LED indicates correct installation and sufficient supply current to the driver.
- Flashing LED indicates improper installation or insufficient current supply.

The Spike and Hold Drivers are tailored for use with specific 2-way and 3-way Lo-Lohm LHD Series valve part numbers. Please contact your local Lee Sales Engineer for help with LEDX unit selection/ordering and technical assistance.

TYPICAL FLOW CHARACTERISTICS



A

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all HDI Platform solenoid valves, unless otherwise noted.

LEAKAGE

Maximum of 25 or 50 SμLPM of air at 70°F with pressure applied to the common port, depending on the specific part number and application conditions.

INTERNAL VOLUME

VALVE STYLE	PLUG-IN	FACE MOUNT	PORTED
2-way	26 μL	45 μL	94 μL
3-way	40 μL	72 μL	77 μL

WEIGHT:

2-way: less than 2.5 grams
3-way: less than 4.5 grams

CYCLE LIFE

The cycle life of the HDI Platform solenoid valves will vary depending on the seal material and application conditions. Unless otherwise specified, valves with a silicone (VMQ) seal will typically operate across a minimum of 10 million cycles under standard conditions on air; valves with an FKM seal will typically operate across a minimum of 25 to 250 million cycles.

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage. The normally closed port (Port B) seal is spring-seated, so the pressure applied to this port should not exceed the pressure on the common port or the normally open port (Port A) unless otherwise indicated.

Valve proof pressure: 2x normal rated pressure
Valve burst pressure: 3x normal rated pressure

OPERATING TEMPERATURE

- Ambient operating temperature range is 40°F to 120°F (4°C to 49°C), unless otherwise noted.
- LHQ Series ambient operating temperature range is 60°F to 120°F (16°C to 49°C).
- Maximum internal coil temperature not to exceed 225°F (107°C). To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Contact The Lee Company for recommendations specific to your application.

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% max., non-condensing

RESPONSE TIME

- Typical response times in milliseconds are as follows:

FLUID	AT RATED VOLTAGE (10 psig)	
	ENERGIZE	DE-ENERGIZE
Air	3	4
Water	4	5

- Response times can be enhanced with the use of high speed drive circuits. Refer to pages Q42-45.
- The Quiet Operation design (LHQ Series) will have a slightly slower response time due to the damping operation. Particularly after periods of inactivity, first actuation and latch-out response may be longer than the typical dynamic response. If first response is critical in your application, a warm-up cycle may be necessary after periods of inactivity. If faster response or oxygen service is required, please contact The Lee Company to discuss our alternative quiet operation design options.
- Response times are dependent upon system conditions, power, environment, etc. Extended periods of inactivity may also have an impact on the initial response time of the valve, and a warm-up cycle may be recommended.

COMPATIBILITY

The HDI Platform solenoid valves feature various material offerings for a wide range of applications. Standard seal material offerings are silicone (VMQ) and FKM, while others such as EPDM and FFKM, are also available upon request. For the armature and plunger stop, 430 SS is typically used for air and mild gas applications; models with FeCr alloy allow for additional corrosion resistance, and are therefore optimized for saline or mild liquid compatibility. While The Lee Company can offer material recommendations based on your flow media, it is important and necessary to verify compatibility of our products with the fluid media and conditions of your specific application.

FILTRATION

Filtration of 35 microns or finer is required. Refer to pages Q34-37 for additional information.

ELECTRICAL CHARACTERISTICS

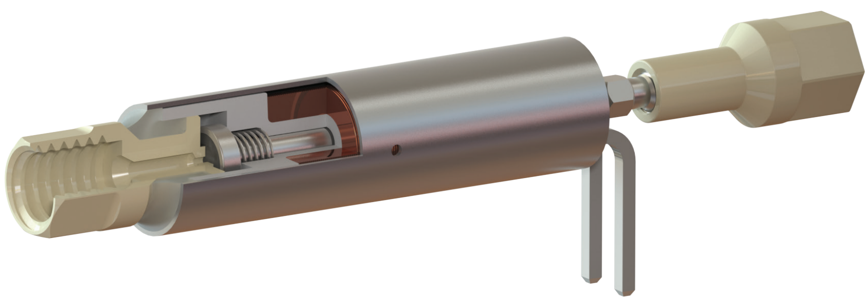
The valves are intended for operation at the rated voltage ± 5%. Refer to the inspection drawing of the individual valve for coil resistance values at room temperature. Refer to pages Q39-47 for drive circuit schematic recommendations.

The VHS Series solenoid valves are 2-way (2/2), normally closed, in-line valves designed for **high precision dispensing applications** in the **nanoliter, microliter, and milliliter ranges**. With an ultra fast response time, they are ideal for accurate fluid regulation and for dispensing repeatable and highly reproducible droplets. The valve's small size allows for mounting in tight spaces, even in arrays directly above a well plate. It is offered with integrated precision orifices, nozzles, screens, or with our MINSTAC® connectors to vary the outlet nozzle and connect tubing. The VHS Series valves have enabled advancements in high throughput screening, drug discovery, in vitro diagnostics, molecular diagnostics, cosmetic surgical equipment, semiconductor manufacturing, and bioprinting.

FEATURES:

- Fast response time: as low as 250 µs and up to 1 kHz operation
- Compact size: less than 6 mm diameter
- Versatile dispensing: as low as 10 nL up to milliliters
- Operating pressures: up to 120 psig
- Low internal volume: as low as 30 µL
- Compatibility with common reagents, biological fluids, and select solvents.

Each valve is 100% functionally tested and is designed using materials that ensure consistent long-term performance. The Lee Company can customize valve performance to meet specific application requirements.



B

VERSATILE DISPENSING TO FIT YOUR NEEDS

VHS Series solenoid valves offer incredible versatility and flexibility for dispensing applications in a small package. All VHS Series valves are available in two inlet port configurations: a barb for push-on tubing, or 062 MINSTAC for threaded tubing assemblies. Four outlet port configurations are available:

- The 062 MINSTAC outlet port allows you to thread in a variety of nozzles for rapid iterative testing of various orifice sizes or spray geometries. The MINSTAC outlet also enables system cleaning and reconfiguration to allow the same dispense valve to be used across multiple orders of magnitude of desired dispense volumes.
- The molded port outlet is designed for connection to flexible tubing, which can be connected to a precision nozzle downstream. This flexibility permits the nozzles to be placed closer than the valve center to center distance allows, enabling the valve to be located remotely.
- The remaining two outlet port options have a fixed, integrated nozzle or orifice, and offer the smallest dispense volume capabilities in the most compact package for miniaturized systems. Select from either hypodermic port or integrated orifice based on your desired dispense volume.

062 MINSTAC **BARBED PORT**

INLET PORTS

OUTLET PORTS

INTEGRATED ORIFICE OUTLET: 10 nL to microliter droplet dispense
- Configurations M/IO & P/IO (Pages B12-15)

HYPODERMIC PORT: 20 nL to microliter droplet dispense, or flow stream injection
- Configurations M/SP & P/SP (Pages B10-11)

MOLDED PORT: Connect interchangeable nozzles into flexible tubing for dispensing in the 10 nL to milliliter range.
- Configurations M/P & P/P (Pages B6-7)

062 MINSTAC: Threaded interchangeable nozzles enable dispensing in the 10 nL to milliliter range.
- Configurations M/M & P/M (Pages B4-5)

VERSATILE DISPENSING TO FIT YOUR NEEDS

Actual Size

Actual Size

Atomizing nozzle (bottom) and one inch long hypodermic tube nozzle (top) shown installed into the 062 MINSTAC outlet of the valve.

An 062 MINSTAC outlet VHS valve dispenses a cone shaped spray out an atomizing nozzle (left) and a hypodermic port outlet VHS valve (right) dispensing precision 41 µL water droplets without satellites at 15 psi.

MINSTAC OUTLET

10 nanoliter to milliliter capability

VHS Series valves with the 062 MINSTAC outlet port enable quick and easy interchangeability or cleaning of precision dispensing nozzles. The nozzles thread right into the 062 MINSTAC outlet of the valve, enabling rapid iterative testing of various orifice sizes or spray geometries. A wide range of nozzles are available, enabling the flexibility to dispense a variety of volumes. Information on compatible nozzles can be found on pages B8-9.

- **Lohm rate:** 4750 Lohms (Valve*, Ref. Cv = 0.0043) on air. Refer to page B25 for typical flow characteristics on water.
- **Internal volume:** 35 µL (barb inlet), 40 µL (062 MINSTAC inlet)
- **Wetted materials:** PEEK, stainless steel, PPS, seal material, and epoxy
- **Inlet port options:** barbed inlet for use with 1/32" ID flexible tubing; 062 MINSTAC inlet for integration with threaded tubing assemblies and safety screens.

* The combination of a valve and nozzle will result in a higher total restriction which will govern flow when dispensing. Refer to page B25 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.

PART NUMBER	INLET	SPIKE[1]/ HOLD VOLTAGE (Vdc)	MIN. SPIKE DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[2]	CON-FIGURATION[3]
INKX0511400A	062 MINSTAC	12 / 1.6	0.35	120	EPDM	M/M
INKX0514300A		24 / 3.2	0.35	120	EPDM	
INKX0511850A		12 / 1.6	0.5	120	FKM	
INKX0517500A		24 / 3.2	0.5	120	FKM	
INKX0516350A		12 / 1.6	0.5	120	FFKM	
INKX0514100A		24 / 3.2	0.5	120	FFKM	

PART NUMBER	INLET	SPIKE[1]/ HOLD VOLTAGE (Vdc)	MIN. SPIKE DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[2]	CON-FIGURATION[3]
INKX0514850A	Barb	24 / 3.2	0.35	30	EPDM	P/M
INKX0508050A		24 / 3.2	0.5	30	FKM	
INKX0515050A		24 / 3.2	0.5	30	FFKM	

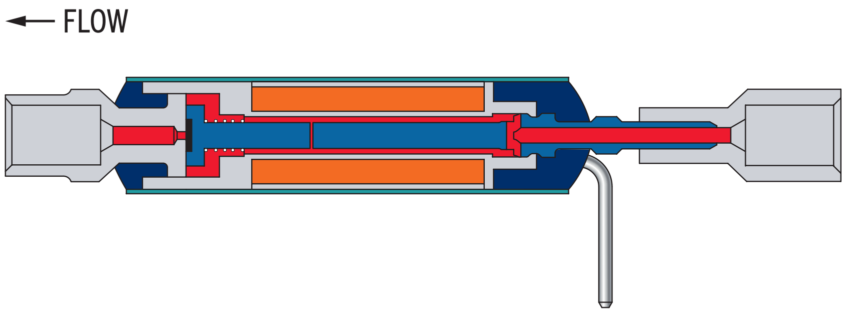
(1) Refer to page B24 for additional electrical characteristics.
(2) Refer to pages Q62-63 for material information and abbreviations.
(3) Refer to page B16-17 for reference dimensions for each configuration.

B

MINSTAC OUTLET

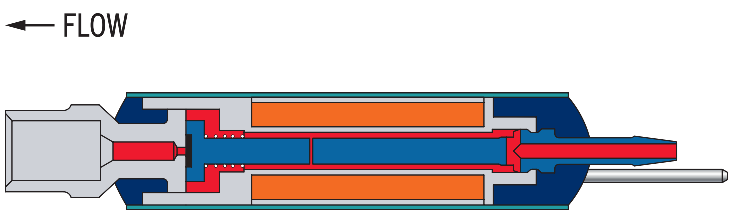
10 nanoliter to milliliter capability

CONFIGURATION M/M: MINSTAC INLET



Flow Path
Coil
Plunger & Plunger Stop
Housing, Inlet & Outlet Port
Shield
Spring
Seal
Epoxy

CONFIGURATION P/M: BARB INLET



Flow Path
Coil
Plunger, Plunger Stop & Inlet Port
Housing & Outlet Port
Shield
Spring
Seal
Epoxy

MOLDED PORT OUTLET

10 nanoliter to microliter capability

The integrated molded outlet port is designed for connection to 1/32" ID flexible tubing and a precision nozzle downstream. This permits the nozzles to be placed closer than the valve center to center distance allows, enabling the valve to be located remotely and saving space at the dispense head location. A range of compatible straight tube nozzles are available (see page B9) which can be pushed directly into tubing connected to the molded port outlet, enabling rapid iterative testing of various jeweled orifice sizes, and suitable for production systems.

- **Lohm rate:** 4750 Lohms (Ref. Cv = 0.0043) on air. Refer to page B25 for a water flow curve.
- **Internal volume:** 30 µL (barbed inlet), 35 µL (MINSTAC Inlet)
- **Wetted materials:** PEEK, stainless steel, PPS, seal material, epoxy & PK
- **Inlet port options:** barbed inlet for use with 1/32" ID flexible tubing or 062 MINSTAC inlet for integration with threaded tubing assemblies and safety screens.

PART NUMBER	INLET	SPIKE[1]/ HOLD VOLTAGE (Vdc)	MIN. SPIKE DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[2]	CON-FIGURATION[3]
INKX0511950A	062 MINSTAC	12 / 1.6	0.35	120	EPDM	M/P
INKX0514750A		24 / 3.2	0.35	120	EPDM	
INKX0519850A		12 / 1.6	0.5	120	FKM	
INKX0508200A		24 / 3.2	0.5	120	FKM	
INKX0512700A		12 / 1.6	0.5	120	FFKM	
INKX0516450A		24 / 3.2	0.5	120	FFKM	

PART NUMBER	INLET	SPIKE[1]/ HOLD VOLTAGE (Vdc)	MIN. SPIKE DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[2]	CON-FIGURATION[3]
INKA1224212H	Barb	12 / 1.6	0.35	30	EPDM	P/P
INKA2424212H		24 / 3.2	0.35	30	EPDM	
INKX0508450A		12 / 1.6	0.5	30	FKM	
INKX0514550A		24 / 3.2	0.5	30	FKM	
INKX0511900A		12 / 1.6	0.5	30	FFKM	
INKX0516550A		24 / 3.2	0.5	30	FFKM	

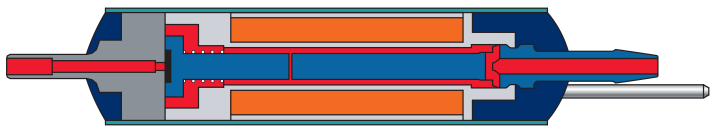
(1) Refer to page B24 for additional electrical characteristics.
(2) Refer to pages Q62-63 for material information and abbreviations.
(3) Refer to B16-17 for reference dimensional views of each configuration.

MOLDED PORT OUTLET

10 nanoliter to microliter capability

CONFIGURATION P/P: BARB INLET

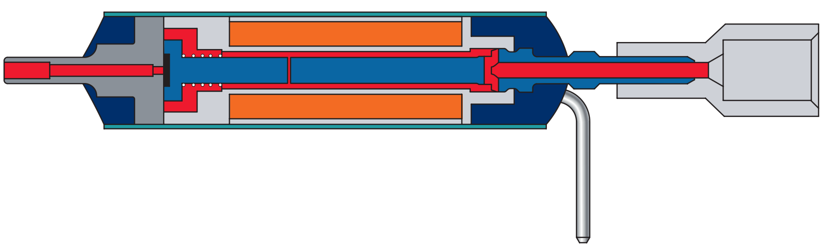
← FLOW



- Flow Path
- Coil
- Plunger, Plunger Stop & Inlet Port
- Housing
- Shield
- Spring
- Seal
- Epoxy
- Outlet Port

CONFIGURATION M/P: MINSTAC INLET

← FLOW



- Flow Path
- Coil
- Plunger & Plunger Stop
- Housing & Inlet Port
- Shield
- Spring
- Seal
- Epoxy
- Outlet Port

B

DISPENSE & ATOMIZING NOZZLES

Precision dispense nozzles are capable of dispensing droplets as small as 10 nanoliters, as well as larger volumes, depending on the time-metered dosing setup and valve cycle times. Atomizing nozzles generate a fine mist in a hollow cone-shaped spray pattern. Designed to be compatible with our 062 MINSTAC line of products, our nozzles allow simple threaded connection into the MINSTAC outlet versions of the VHS Series valve (configurations M/M or P/M). The wetted materials enable compatibility with aggressive fluids and customized nozzles can be developed to suit unique application needs. PTFE-coated nozzles further reduce surface energy and potential flooding at the dispense tip to improve droplet consistency between dispense events.

Three types of standard nozzles are available, including orifice, and hypodermic tube dispense nozzles suitable for droplet and time-metered dispensing:

- **Orifice:** integrated sapphire orifice
- **Hypodermic Tube:** consistent internal diameter tubing
- **Atomizing:** fine mist in a hollow cone at a 50° angle

WETTED MATERIALS:

- *Orifice:* stainless steel, epoxy[1], synthetic sapphire, and PTFE (as noted)
- *Hypodermic Tube:* stainless steel, epoxy[1], and PTFE (as noted)
- *Atomizing:* stainless steel

(1) PTFE-coated nozzles do not contain epoxy.

Length: 0.35 in (8.9 mm)

PART NUMBER	ID or ORIFICE SIZE	TUBE OUTER DIA.	LOHM RATE (Cv)	STYLE
INZA4620928T	0.002 in (0.05 mm)	0.05 in (1.27 mm)	280,000 (0.001)	Orifice
INZA4630912T	0.003 in (0.08 mm)	0.05 in (1.27 mm)	125,000 (0.002)	Orifice
INZA4640960K	0.004 in (0.10 mm)	0.05 in (1.27 mm)	60,000 (0.003)	Orifice
INZA3070940K	0.007 in (0.18 mm)	0.02 in (0.51 mm)	40,000 (0.005)	Hypodermic Tube
INZA4650935K	0.005 in (0.13 mm)	0.05 in (1.27mm)	35,000 (0.006)	Orifice
INZA4670915K	0.0075 in (0.19 mm)	0.05 in (1.27 mm)	15,400 (0.0013)	Orifice
INZA6670915K	0.0075 in (0.19 mm)	0.05 in (1.27 mm)	15,400 (0.0013)	Orifice (PTFE-coated)
INZA5100914K	0.010 in (0.25 mm)	0.02 in (0.51 mm)	14,000 (0.0014)	Hypodermic Tube (PTFE-coated)
INZA3100914K	0.010 in (0.25 mm)	0.02 in (0.51 mm)	14,000 (0.0014)	Hypodermic Tube
INZA4710975H	0.010 in (0.25 mm)	0.05 in (1.27 mm)	7500 (0.0027)	Orifice
INZA3330997D	0.032 in (0.81 mm)	0.05 in (1.27 mm)	750 (0.027)	Hypodermic Tube

DISPENSE & ATOMIZING NOZZLES

Length: 1 in (25.4 mm)

PART NUMBER	ID or ORIFICE SIZE	TUBE OUTER DIA.	LOHM RATE (Cv)	STYLE
INZA4542560K	0.004 in (0.10 mm)	0.02 in (0.51 mm)	60,000 (0.003)	Orifice
INZA6542460K	0.004 in (0.10 mm)	0.02 in (0.51 mm)	60,000 (0.003)	Orifice (PTFE-coated)
INZA4652535K	0.005 in (0.13 mm)	0.05 in (1.27 mm)	35,000 (0.006)	Orifice
INZA3102514K	0.010 in (0.25 mm)	0.02 in (0.51 mm)	14,000 (0.0014)	Hypodermic Tube
INZA5102514K	0.010 in (0.25 mm)	0.02 in (0.51 mm)	14,000 (0.0014)	Hypodermic Tube (PTFE-coated)
INZA3362597D	0.032 in (0.81 mm)	0.07 in (1.65 mm)	750 (0.027)	Hypodermic Tube

PART NUMBER	LOHM RATE (Cv)	STYLE
IAZA1200167K	67,000 (0.0003)	Atomizing
IAZA1200163K	63,000 (0.0003)	Atomizing
IAZA1200147K	47,000 (0.0004)	Atomizing
IAZA1200134K	34,000 (0.0006)	Atomizing
IAZA1200122K	22,000 (0.0009)	Atomizing
IAZA1200110K	10,000 (0.0020)	Atomizing

STRAIGHT TUBE WITH JEWELED ORIFICE

With jeweled orifices as small as 0.002 of an inch (0.05 mm), these straight tube dispense nozzles are capable of dispensing droplets as small as 10 nanoliters and larger volumes depending on the time-metered dosing setup and valve cycle times. Intended to be pushed into soft tubing, these interchangeable nozzles are compatible with the molded port outlet versions of the VHS Series valve (configurations P/P and M/P). Wetted materials are simply stainless steel and sapphire.

PART NUMBER	ID or ORIFICE SIZE	TUBE OUTER DIA.	TUBE LENGTH	LOHM RATE (Cv)
INZA2631412T	0.003 in (0.08 mm)	0.050 in (1.3 mm)	0.57 in (14.5 mm)	125,000 (0.0002)
INZA2543460K	0.004 in (0.10 mm)	0.020 in (0.51 mm)	1.33 in (33.8 mm)	60,000 (0.0003)
INZA2540660K	0.004 in (0.10 mm)	0.020 in (0.51 mm)	0.25 in (6.4 mm)	
INZA2651435K	0.005 in (0.13 mm)	0.050 in (1.3 mm)	0.57 in (14.5 mm)	35,000 (0.0006)
INZA2653035K	0.005 in (0.13 mm)	0.050 in (1.3 mm)	1.17 in (29.7 mm)	
INZA2671415K	0.075 in (0.19 mm)	0.050 in (1.3 mm)	0.57 in (14.5 mm)	15,400 (0.0013)
INZA2961331H	0.016 in (0.41 mm)	0.043 in (1.09 mm)	0.50 in (12.7 mm)	3,100 (0.0065)
INZA2621428T	0.002 in (0.05 mm)	0.050 in (1.3 mm)	0.57 in (14.5 mm)	280,000 (0.0001)

HYPODERMIC PORT OUTLET

20 nanoliter to microliter capability

An integrated hypodermic outlet port nozzle enables low volume dispensing of droplets as small as 20 nanoliters and practical time-metered dispensing up to 1 ml.

- **Lohm rate:** 11,000 Lohms (Ref. Cv = 0.0018) on air. Refer to page B25 for typical flow characteristics on water.
- **Internal volume:** 30 µL (barbed inlet), 35 µL (MINSTAC inlet)
- **Wetted materials:** PEEK, stainless steel, PPS, seal material & epoxy
- **Inlet port options:** barbed inlet for use with 1/32" ID flexible tubing, 062 MINSTAC inlet for integration with threaded tubing assemblies and safety screens.

PART NUMBER	INLET	SPIKE[1]/ HOLD VOLTAGE (Vdc)	MIN. SPIKE DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[2]	CON-FIGURATION[3]
INKX0514900A	062 MINSTAC	12 / 1.6	0.35	120	EPDM	M/SP
INKX0514950A		24 / 3.2	0.35	120	EPDM	
INKX0514650A		12 / 1.6	0.5	120	FKM	
INKX0508350A		24 / 3.2	0.5	120	FKM	
INKX0516200A		12 / 1.6	0.5	120	FFKM	
INKX0516250A		24 / 3.2	0.5	120	FFKM	

PART NUMBER	INLET	SPIKE[1]/ HOLD VOLTAGE (Vdc)	MIN. SPIKE DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[2]	CON-FIGURATION[3]
INKA1226212H	Barb	12 / 1.6	0.35	30	EPDM	P/SP
INKA2426212H		24 / 3.2	0.35	30	EPDM	
INKX0508600A		12 / 1.6	0.5	30	FKM	
INKX0508650A		24 / 3.2	0.5	30	FKM	
INKX0507000A		12 / 1.6	0.5	30	FFKM	
INKX0516500A		24 / 3.2	0.5	30	FFKM	

(1) Refer to page B24 for additional electrical characteristics.
(2) Refer to Q62-63 for material information and abbreviations.
(3) Refer to B16-17 for reference dimensional views of each configuration.

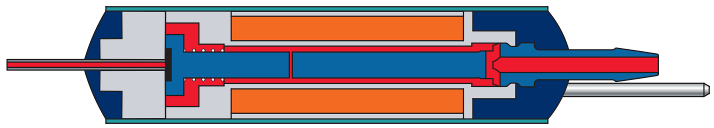
B

HYPODERMIC PORT OUTLET

20 nanoliter to microliter capability

CONFIGURATION P/SP: BARB INLET

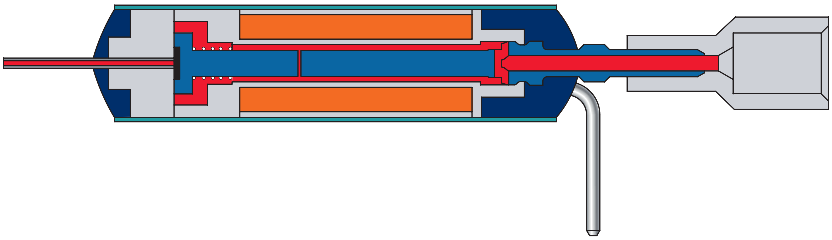
← FLOW



Flow Path
Coil
Plunger, Plunger Stop & Inlet Port
Housing
Shield
Spring
Seal
Epoxy
Outlet Port

CONFIGURATION M/SP: MINSTAC INLET

← FLOW



Flow Path
Coil
Plunger & Plunger Stop
Housing & Inlet Port
Shield
Spring
Seal
Epoxy
Outlet Port

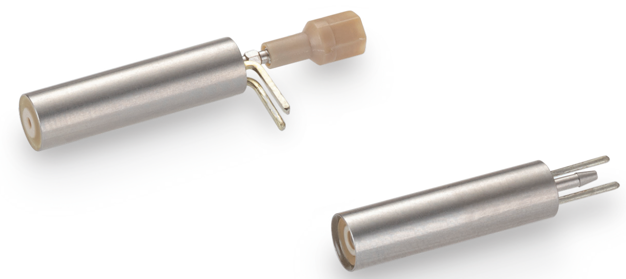
INTEGRATED ORIFICE OUTLET

10 nanoliter to microliter capability

An integrated sapphire orifice enables the lowest volume droplets the VHS Series solenoid valve is capable of (in the smallest possible package size). This outlet type is available in two different styles: the simple IO-style is easiest to flush, while the long-throw-style (LT) incorporates an internal pressure compensation bladder which allows the droplet to retain its integrity longer and travel farther.

Available with 062 MINSTAC or barbed inlets, three seal material options, and multiple orifice sizes, the integrated orifice VHS solenoid valve can meet your high precision dispensing needs.

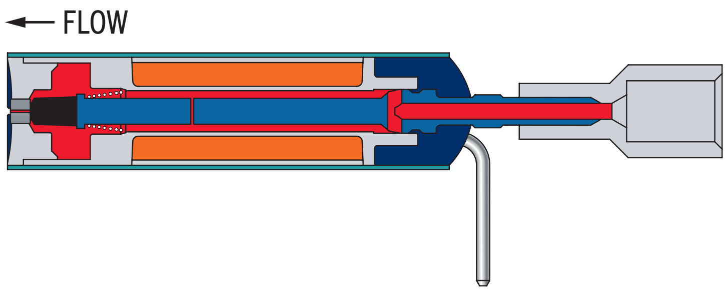
- **Spike voltage:** 24 Vdc ± 5%
- **Hold voltage:** 5 Vdc ± 5%
- **Internal volume:** varies by style and configuration
  M/LT IO: 35 µL
  M/IO: 60 µL
  P/LT IO: 30 µL
  P/IO: 55 µL
- **Wetted materials:** PEEK, PPS, stainless steel, sapphire, seal material, epoxy, and butyl (LT style only).
- **Inlet port options:** barbed inlet for use with 1/32" ID flexible tubing, 062 MINSTAC inlet for integration with threaded tubing assemblies and safety screens.



B

INTEGRATED ORIFICE OUTLET

062 MINSTAC Inlet, Configurations M/IO, M/LT IO



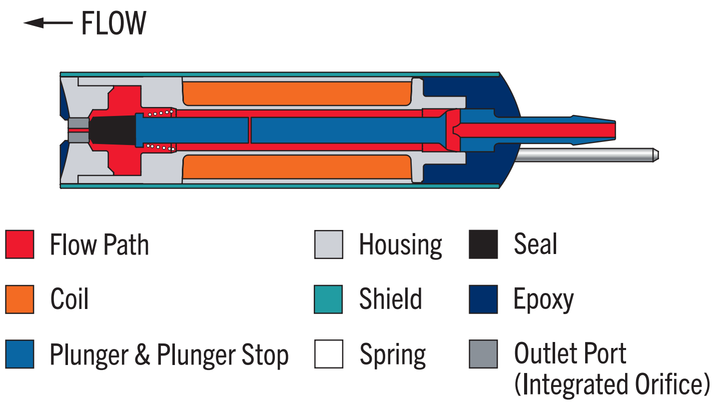
- Flow Path
- Coil
- Plunger & Plunger Stop
- Housing & Inlet Port
- Shield
- Spring
- Seal
- Epoxy
- Outlet Port (Integrated Orifice)

PART NUMBER	ORIFICE SIZE	LOHM[1] RATE	MIN. SPIKE[2] DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[3]	CON-FIGURATION[4]
INKA2435210H	0.003 in	110,000	0.35	30	EPDM	
INKA2435110H	0.003 in	110,000	0.5	30	FKM	
INKA2435510H	0.003 in	110,000	0.5	30	FFKM	
INKA2455210H	0.005 in	50,000	0.35	30	EPDM	
INKA2455110H	0.005 in	50,000	0.5	30	FKM	M/LT IO
INKA2455510H	0.005 in	50,000	0.5	30	FFKM	
INKA2475210H	0.007 in	21,000	0.35	30	EPDM	
INKA2475110H	0.007 in	21,000	0.5	30	FKM	
INKA2475510H	0.007 in	21,000	0.5	30	FFKM	
INKA2436210H	0.003 in	110,000	0.35	120	EPDM	
INKA2436110H	0.003 in	110,000	0.5	120	FKM	
INKA2436510H	0.003 in	110,000	0.5	120	FFKM	
INKA2456210H	0.005 in	50,000	0.35	120	EPDM	
INKA2456110H	0.005 in	50,000	0.5	120	FKM	M/IO
INKA2456510H	0.005 in	50,000	0.5	120	FFKM	
INKA2476210H	0.007 in	21,000	0.35	120	EPDM	
INKA2476110H	0.007 in	21,000	0.5	120	FKM	
INKA2476510H	0.007 in	21,000	0.5	120	FFKM	

(1) On air. Refer to page B25 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.
(2) Refer to page B24 for additional electrical characteristics.
(3) Refer to pages Q62-63 for material information and abbreviations.
(4) Refer to page B15 for reference dimensional views of each configuration.

INTEGRATED ORIFICE OUTLET

Barbed Inlet, Configurations P/IO, P/LT IO



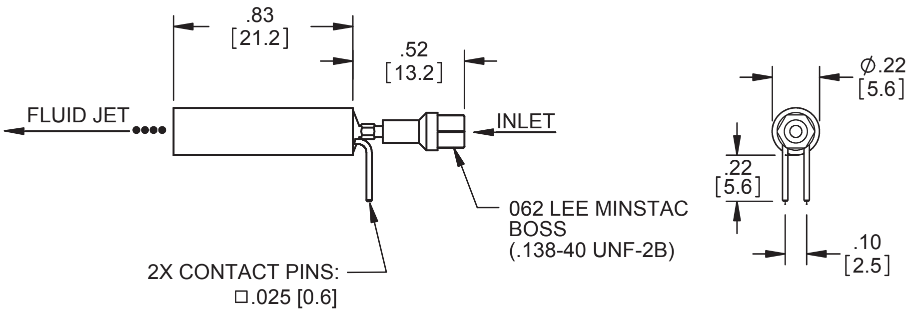
PART NUMBER	ORIFICE SIZE	LOHM[1] RATE	MIN. SPIKE[2] DURATION (ms)	OPERATING PRESSURE (psig)	SEAL MATERIAL[3]	CON-FIGURATION[4]
INKA2437210H	0.003 in	110,000	0.35	30	EPDM	P/LT IO
INKA2437110H	0.003 in	110,000	0.5	30	FKM	
INKA2437510H	0.003 in	110,000	0.5	30	FFKM	
INKA2457210H	0.005 in	50,000	0.35	30	EPDM	
INKA2457110H	0.005 in	50,000	0.5	30	FKM	
INKA2457510H	0.005 in	50,000	0.5	30	FFKM	
INKA2477210H	0.007 in	21,000	0.35	30	EPDM	
INKA2477110H	0.007 in	21,000	0.5	30	FKM	
INKA2477510H	0.007 in	21,000	0.5	30	FFKM	
INKA2438210H	0.003 in	110,000	0.35	30	EPDM	P/IO
INKA2438110H	0.003 in	110,000	0.5	30	FKM	
INKA2438510H	0.003 in	110,000	0.5	30	FFKM	
INKA2458210H	0.005 in	50,000	0.35	30	EPDM	
INKA2458110H	0.005 in	50,000	0.5	30	FKM	
INKA2458510H	0.005 in	50,000	0.5	30	FFKM	
INKA2478210H	0.007 in	21,000	0.35	30	EPDM	
INKA2478110H	0.007 in	21,000	0.5	30	FKM	
INKA2478510H	0.007 in	21,000	0.5	30	FFKM	

(1) On air. Refer to page B25 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.
(2) Refer to page B24 for additional electrical characteristics.
(3) Refer to pages Q62-63 for material information and abbreviations.
(4) Refer to page B15 for reference dimensional views of each configuration.

B

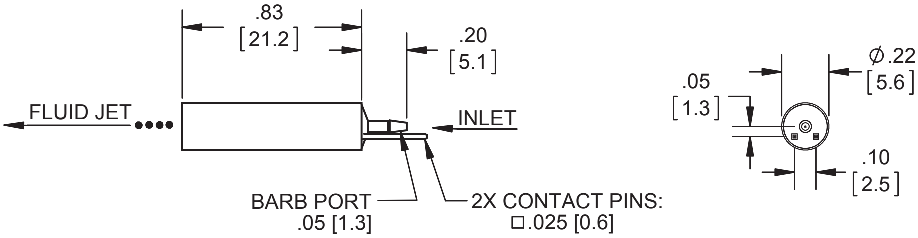
062 MINSTAC INLET, INTEGRATED ORIFICE OUTLET

Configurations M/IO & M/LT IO



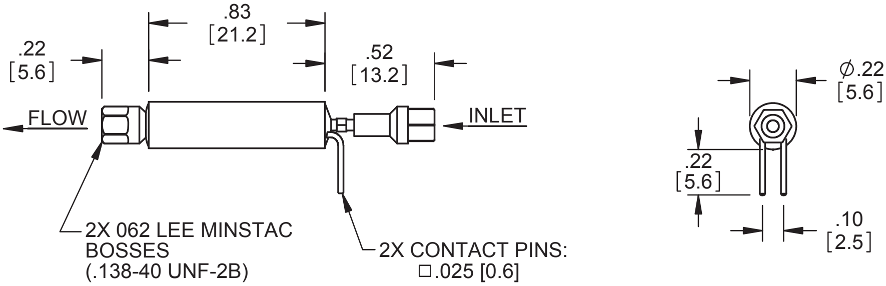
BARBED INLET, INTEGRATED ORIFICE OUTLET

Configurations P/IO & P/IO LT

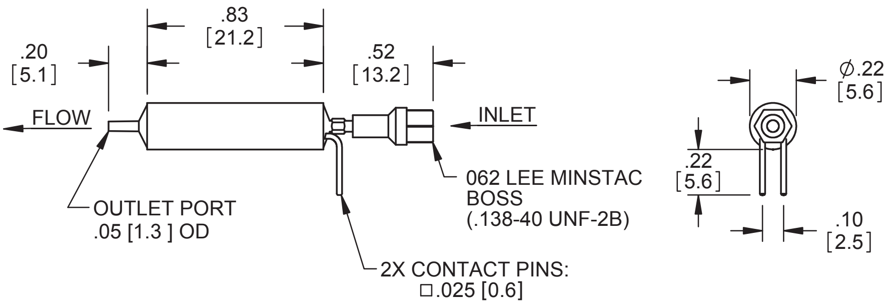


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

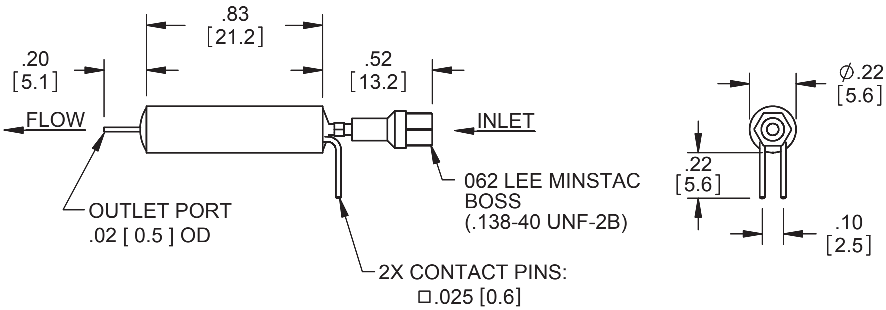
062 MINSTAC INLET, 062 MINSTAC OUTLET (M/M)



062 MINSTAC INLET, MOLDED PORT OUTLET (M/P)

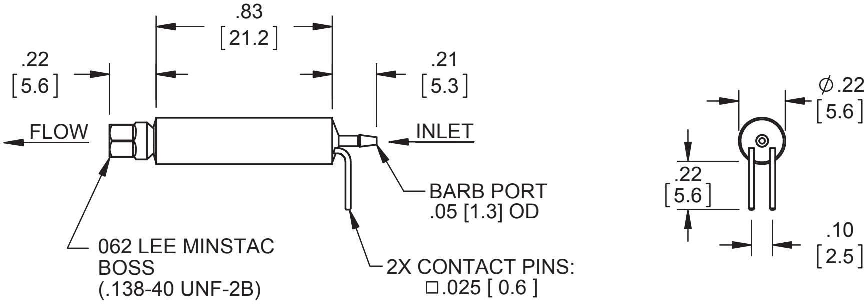


062 MINSTAC INLET, HYPO OUTLET (M/SP)

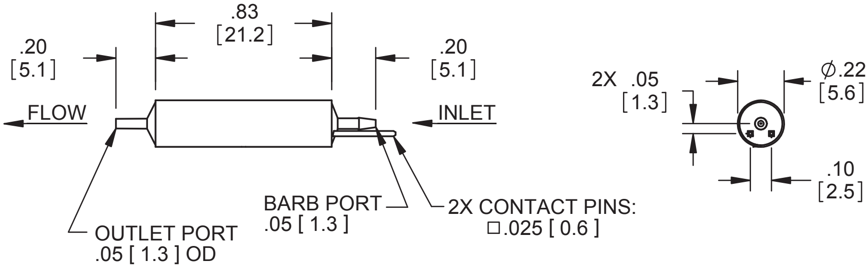


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

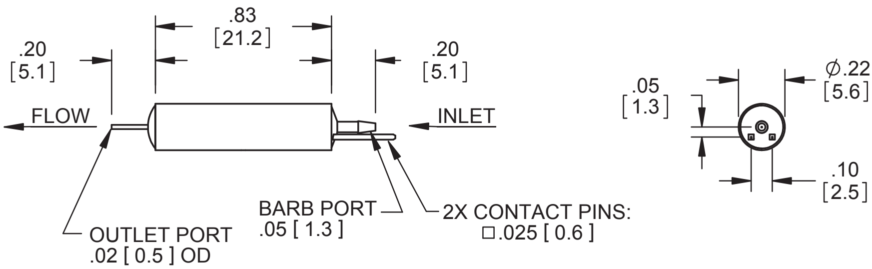
BARBED INLET, 062 MINSTAC OUTLET (P/M)



BARBED INLET, MOLDED PORT OUTLET (P/P)



BARBED INLET, HYPO OUTLET (P/SP)



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

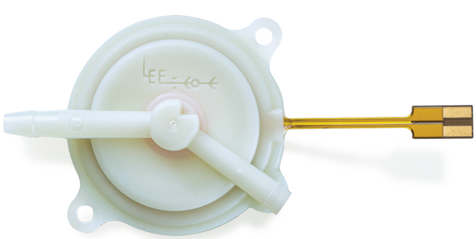
SPIKE & HOLD DRIVER

For connection to an external controller, we offer an optional, dedicated spike and hold driver. Simply supply the valve's specified spike and hold voltages and a 5 Vdc TTL signal to operate the valve. The duration of the spike can be adjusted with a screwdriver.

PART NUMBER	DESCRIPTION
IECX0501350A	Spike and Hold Driver, adjustable from 0.1 to 5 ms.
IECX0501500A	Spike and Hold Driver, adjustable from 1 to 100 ms.

RECOMMENDED PRESSURE SOURCE

Our range of Piezoelectric Micropumps (Section J) are an excellent pressure source for precision dispensing with a VHS Series valve. Though the pump is not intended to pump liquid directly, dispensed liquid can be controlled with incredible precision via a pressure driven flow or air displacement regime, where the pump is used to control the head pressure above a liquid in a fixed reservoir. When liquids cannot be exposed to air, the pump can act upon a liquid through an elastic membrane, thereby pumping the isolated dispense liquid through the valve in a bladder system. The ultra smooth, pulsation-free flow and infinite turndown ratio of the disc pump make it an ideal choice for time-metered dosing systems (where the goal is to dispense repeatable, precision droplets). The Disc Pump Development Kit, UEKA0500300A, includes electronics necessary to drive the pump and a 12V VHS Series solenoid valve. Reference pages J5-8 for more information and page J3 for a link to download the Time-Metered Dosing Application Note, which includes a dispensing system schematic.



B

GETTING STARTED

VHS VALVE EVALUATION KIT

The Lee Company offers a VHS Valve Evaluation Kit (part number IKTX0322000A) for easy setup and development testing of a dispense system. All that is required is a pressurized fluid source, control signal, and power supply. The kit includes:

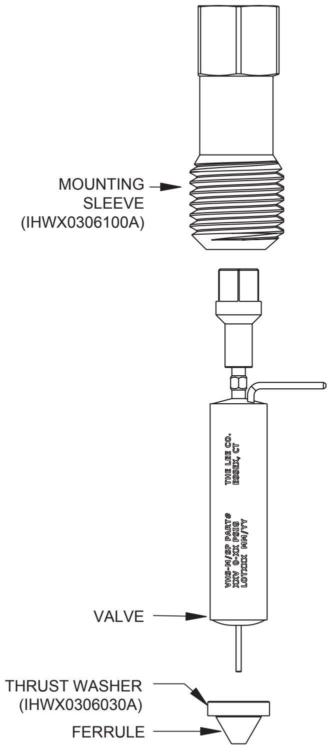
PART NUMBER	DESCRIPTION
INKX0514300A	VHS Series Valve (M/M configuration, EPDM, 24V)
IECX0501350A	Spike and Hold Driver
INZA4710975H	Dispense Nozzle: 062 MINSTAC, Ø .010" Orifice
INZA4670915K	Dispense Nozzle: 062 MINSTAC, Ø .0075" Orifice
INZA4650935K	Dispense Nozzle: 062 MINSTAC, Ø .005" Orifice
IAZA1200122K	Atomizing Nozzle: MINSTAC, 22k Lohm rate
INMX0350000A	Safety Screen Filter: 062 MINSTAC, 12 µm
TMDA3212950Z	Adapter: 062 MINSTAC Female to ¼-28 Flat Bottom Female
TMDA3201950A	Adapter: 062 MINSTAC Male to Barb for 1/16" ID Soft Tubing
TUTC3216930L	Tubing Assembly: 062 MINSTAC, 2x Fittings, 30 cm long, 0.032" ID
TTTA3201243A	MINSTAC Torque Wrench
IHWX0248120A	24" Lead Wire Assembly
IHWX0290550A	Valve Mounting Clip

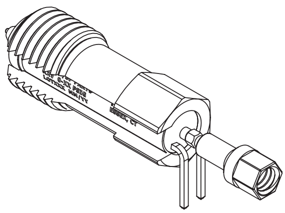
B

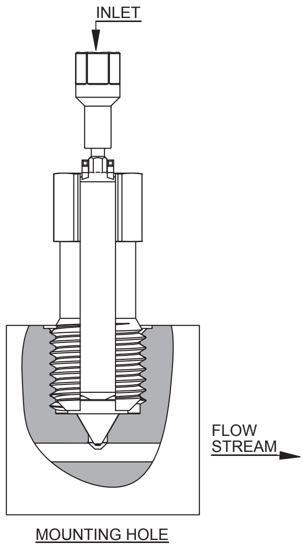
MANIFOLD MOUNT VHS VALVES

VHS Series valve configurations with a hypodermic port outlet, or a molded port outlet can be mounted on a manifold. This allows precise, controlled injection of fluids directly into flow streams. The outlet port is placed near the flow stream, decreasing carryover volume and enabling highly repeatable instrument calibration.

The Lee Company offers single and multiple valve manifolds in PEEK. Alternate materials and customized manifold designs are available upon request.





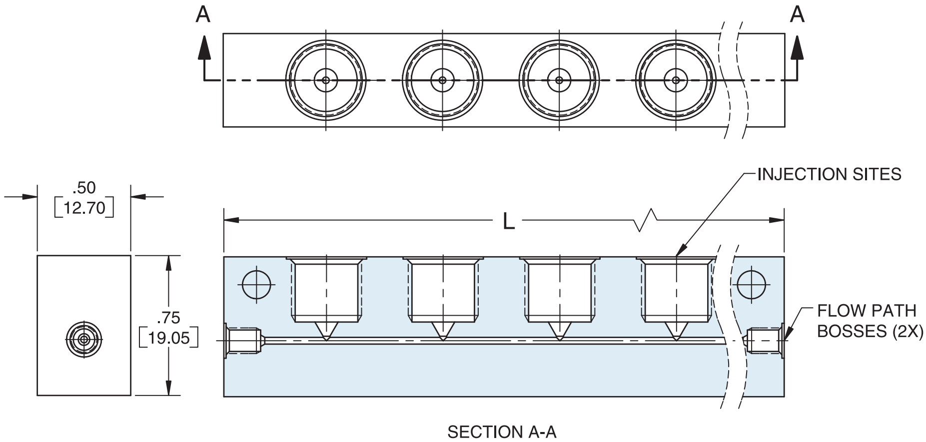


Drawings are not to scale.

Refer to drawing number INIX0500050A for mounting boss specifications.

KIT PART NUMBER	DESCRIPTION	REPLACEMENT FERRULE
IKTX0322170A	Mounting Sleeve Kit, molded port outlet (0.050 in diameter)	IHWX0306460A
IKTX0322200A	Mounting Sleeve Kit, hypodermic tube outlet (0.020 in diameter)	IHWX0306450A
IKTX0322190A	Manifold Plug Sleeve Kit	N/A

STANDARD MANIFOLDS



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

062 MINSTAC CONNECTION PORTS (MANIFOLD FLOW PATH)

PART NUMBER[1]	MANIFOLD MATERIAL[2]	NUMBER OF VALVE POSITIONS	DIMENSION "L"
INMA0602310B	PEEK	Manifold, 1x	1.10 in (27.9 mm)
INMA0602320B	PEEK	Manifold, 2x	1.73 in (43.9 mm)
INMA0602340B	PEEK	Manifold, 4x	2.98 in (75.7 mm)

¼-28 FLAT BOTTOM BOSS CONNECTION PORTS (MANIFOLD FLOW PATH)

PART NUMBER[1]	MANIFOLD MATERIAL[2]	NUMBER OF VALVE POSITIONS	DIMENSION "L"
INMA0602410B	PEEK	Manifold, 1x	1.10 in (27.9 mm)
INMA0602420B	PEEK	Manifold, 2x	1.73 in (43.9 mm)
INMA0602440B	PEEK	Manifold, 4x	2.98 in (75.7 mm)

(1) Part numbers are for the manifold only. Valves and mounting hardware are sold separately.

(2) Refer to pages Q62-63 for material information and abbreviations.

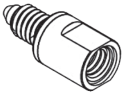
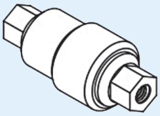
TUBING

PART NUMBER	DESCRIPTION
TUVA6231900A	1/32" ID PVC tubing, 1 meter (3 ft), for use with barbed inlet VHS valves.
TUTC3216930L	30 cm, doubled-ended 062 MINSTAC PTFE Tubing Assembly, pre-assembled and leak-tested.
TUTB3216930L	30 cm, single-ended 062 MINSTAC PTFE Tubing Assembly, pre-assembled and leak-tested. Install a 1/16 of an inch compression fitting on the blank end for connection to your system.

See page N3 for more stocked pre-assembled 062 MINSTAC tubing assemblies.

SAFETY SCREENS & FILTERS

The use of proper filtration is critical to the performance of any microfluidic system, especially with VHS Series valves. Improper filtration can result in excessive leakage through sealing surfaces. The Lee Company offers last chance safety screens and system filters. Refer to pages Q34-37 for additional information on system cleanliness.

PART NUMBER	NOMINAL PORE SIZE	LEFT CONNECTION	RIGHT CONNECTION	ISOMETRIC VIEW
INMX0350000A	12 microns	062 MINSTAC (Male)	062 MINSTAC (Female)	
TKFA3202110A	10 microns	062 MINSTAC (Female)	062 MINSTAC (Female)	

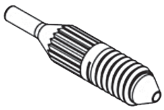
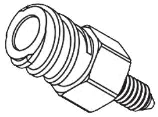
For more safety screens and system filters, see pages N14-15.

MOUNTING

IHWX0290550A – Mounting Clip to secure the VHS valve in position. The mounting clip has a 3.3 mm through hole to secure to your test system. Optimal mounting brackets exert minimal force on the outer casing of the valve.

ADAPTERS

Adapters enable connection to different types of flexible tubing, or a luer connection directly to input syringes, or for compatibility with single-use dispensing tips.

PART NUMBER	LEFT CONNECTION	RIGHT CONNECTION	ISOMETRIC VIEW
TMDA3207950Z	Adapter for 0.042" (1 mm) ID flexible tubing	062 MINSTAC	
TMDA3201950Z	Adapter for 1/16" (1.6 mm) ID flexible tubing	062 MINSTAC	
TMRA3201950Z	Female Luer Lock	062 MINSTAC	

For more adapters, see pages N16-17.

LEAD WIRE CONNECTORS

PART NUMBER	DESCRIPTION
IHWX0248460A	12 in (30.5 cm) Lead Wire Assembly with flying leads ready for termination or soldering.
IHWX0248120A	24 in (61 cm) Lead Wire Assembly with flying leads ready for termination or soldering.

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. Stated minimum dispense volumes may not be achievable in all cases as they are dependent on a variety of application parameters, including system design, fluid properties, and choice of outlet orifice. The following specifications apply to all VHS Series solenoid valves, unless otherwise noted.

CYCLE LIFE

The valves will typically operate across a minimum of 250 million cycles on water. Unique application conditions may impact cycle life such as fluid viscosity, temperature, and cycle frequency.

WEIGHT

Less than 2 grams

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage ± 5%.

Valve proof pressure: 1.5x normal rated pressure
Valve burst pressure: 2x normal rated pressure

OPERATING TEMPERATURE

- Ambient operating temperature range is 40°F to 120°F (4°C to 49°C)
- Maximum coil temperature not to exceed 150°F (66°C). A spike and hold drive is required for most applications. To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Contact us for recommendations specific to your application.

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

ELECTRICAL CHARACTERISTICS

- A spike and hold drive is required for most applications. The spike and hold driver reduces coil heating, enabling continuous operation and high frequencies.
- The valve is designed to operate at the rated voltage ± 5%, unless otherwise specified.
- To avoid overheating, it is not recommended to exceed 500 mW of average power. If active cooling is implemented (such as a fan or heat sink) a higher average power can be achieved.
- The Lee Company offers an evaluation kit (see page B19) or stand-alone spike & hold driver (see page B18) to enable easy demonstration of dispensing capabilities.
- See pages Q42-43 for a reference spike and hold drive circuit.

ELECTRICAL CONNECTION

VHS Series valves are supplied with pins spaced 0.100 of an inch (2.54 mm) on center, compatible with industry standard terminals. The Lee Company offers lead wire assemblies with flying leads to support application development (see page B23).

RESPONSE TIME

- The valves are capable of a dispensing frequency up to 1000 Hz, based on water flow within the rated pressure range. Response time and dispense volume profiles are drive dependent and vary depending on system parameters, including fluid viscosity, temperature, and ambient temperature.
- The dynamic response time of the valve is generally faster than the static response time. Following periods of sitting of more than 15 minutes, it is recommended to actuate the valve to restore dynamic conditions.

FILTRATION

The VHS Series valves are sensitive to contamination by particles as small as 12 microns in size, especially particles that are hard and fibrous. Larger, flexible particles such as cells can be qualified for applications.

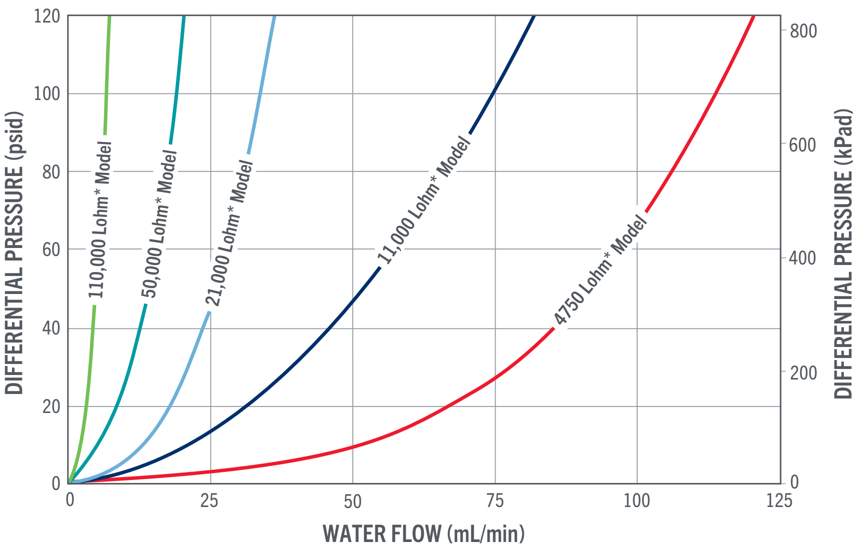
Dried fluid or precipitates can coat internal valve surfaces and lead to changes in response time or leakage. Prior to storage, it is recommended to flush the valve with water or a solvent compatible with the wetted materials of the valve.

The Lee Company offers a 12 micron safety screen that can protect the valve against particulate contaminants (see page B22).

PURGING

VHS Series valves must be purged of air for optimal dispensing performance. A combination of static purges (free flow through an open valve) and dynamic purges (rapid actuation at a variety of frequencies) dislodges bubbles from internal surfaces, clearing the valve. Please contact The Lee Company for technical assistance.

TYPICAL FLOW CHARACTERISTICS



* Lohm rating of each valve model is based on air performance. Curves shown above depict empirical data from actual product performance on water.

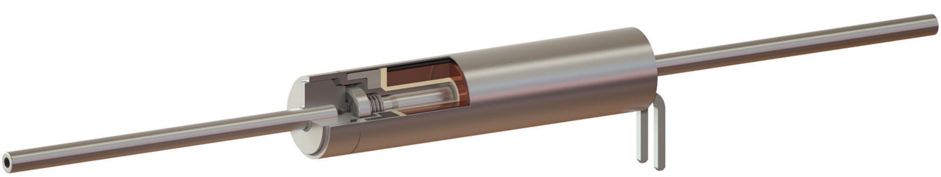
The IEP Series solenoid valve is an extended performance, 2-way (2/2) normally closed, in-line, high speed dispensing valve that performs consistently under **high pressure** and **high temperature conditions**. Featuring a welded stainless steel construction with ports conveniently sized for all standard 1/16" ID ferruled compression fittings, this robust **6.4 mm** axial flow valve offers rapid response times and can generate droplets operating up to 500 Hz. The high speed operation of this valve enables **accurate flow metering**, acting as a replacement for some pressure regulators. Its ability to operate under high temperatures enables **precision dispensing** of viscous fluids and **enables sterilization**.

Typical applications include electrolyte and wax dispensing, electron microscopes, precision propulsion systems, and cryogenic surgery devices.

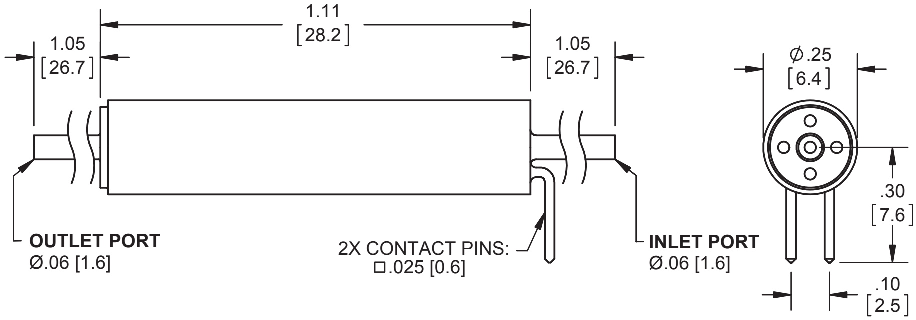
FEATURES:

- Operating pressures: up to 800 psig
- Operating temperatures: up to 275°F (135°C)
- Response time: as fast as 500 μs
- Lightweight: 4.7 grams
- Low internal volume: 62 μL
- Inert seal materials: EPDM and FFKM

Each valve is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company can customize valve performance to meet specific application requirements.



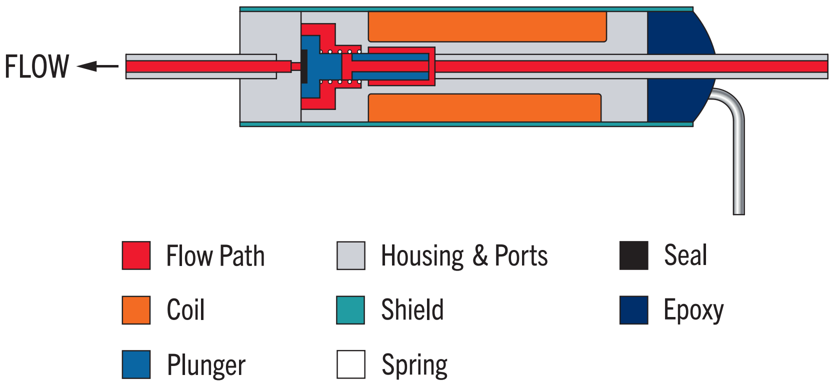
The inlet and outlet port diameters of the IEP Series solenoid valves are sized for connections to all standard 1/16" ID ferruled compression fittings. Inlet and outlet ports are also customizable. Custom examples include inlet and outlet port bends with 90 degree angles, the addition of a female MINSTAC® outlet cover to directly connect to our MINSTAC nozzles, custom edge breaks for specific weld conditions, and integrated screens. The valve can also be customized with a manifold mounting plate for direct integration onto your manifold.



Unless otherwise specified, all dimensions are in inches [mm]. Drawings are not to scale.

PART NUMBER	SPIKE [1]/ HOLD VOLTAGE (Vdc)*	OPERATING PRESSURE (psig)	LOHM [2] RATE (Cv)
IEPA1211541H	12 / 1.6	0-300	4100 Lohms (0.005)
IEPA2411541H	24 / 2.5	0-300	4100 Lohms (0.005)
IEPA1221541H	12 / 1.6	0-300	4100 Lohms (0.005)
IEPA2421541H	24 / 2.5	0-300	4100 Lohms (0.005)
IEPA1211241H	12 / 1.6	0-800	4100 Lohms (0.005)
IEPA2411241H	24 / 2.5	0-800	4100 Lohms (0.005)

(1) Actuate with rated spike voltage for 1 ms at 10 psig, 70°F (21°C). For higher pressure operation, a longer pulse duration may be required.
(2) Nominal Lohm rate flowing air at 70°F (21°C). Reference the flow curve on page C5 for flow rate at varying pressures. Refer to Section Q for a full description of the Lohm Laws.



WETTED MATERIALS:

- Ports, housing, and spring: 316 SS
- Plunger and plunger stop: FeCr alloy
- Seal material: EPDM or FFKM. Other materials available upon request.

POWER CONSUMPTION AT HOLD VOLTAGE (mW)	SEAL MATERIAL[3]	OPERATING TEMPERATURE RANGE	COIL RESISTANCE (Ohms)	MAX INTERNAL COIL TEMPERATURE[4] AT 0.5 W
250	FFKM	40 to 120°F (4 to 49°C)	10	250°F (121°C)
250	FFKM	40 to 120°F (4 to 49°C)	38	250°F (121°C)
250	FFKM	40 to 275°F (4 to 135°C)	10	350°F (177°C)
250	FFKM	40 to 275°F (4 to 135°C)	38	350°F (177°C)
250	EPDM	-20 to 120°F (-29 to 49°C)	10	250°F (121°C)
250	EPDM	-20 to 120°F (-29 to 49°C)	38	250°F (121°C)

(3) FKM, PTFE, and other options available upon request.

(4) To avoid overheating and ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. It is not recommended to exceed 500 mW of average power. If active cooling is implemented such as a fan or heat sink, a higher average power can be achieved. Contact The Lee Company for recommendations specific to your application.

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all IEP Series solenoid valves, unless otherwise noted.

WEIGHT

4.7 grams

INTERNAL VOLUME

62 μL

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage ± 5%.

Valve proof pressure: 1.5x normal rated pressure
Valve burst pressure: 3200 psi minimum

OPERATING TEMPERATURE

- Refer to the part number table on pages C2-3.
- During application development, the temperature of the solenoid coil's shield can be monitored to ensure that steady state operation does not exceed the limitations of the internal materials. Refer to the inspection drawing of an individual valve part number for its rated maximum coil temperature at steady state.

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

ELECTRICAL CHARACTERISTICS

- The IEP Series valves require the use of a spike and hold drive to operate safely and efficiently.
- For connection to an external controller, we optionally offer a dedicated spike and hold driver (part number IECX0501500A). Simply supply the valve's specified spike and hold voltages and a 5VDC TTL signal to operate the valve. The duration of the spike can be adjusted with a screwdriver. See page B18 for more information.
- The spike and hold drive reduces coil heating, enabling continuous operation and high frequencies. The minimum required spike (actuation voltage and duration) is dependent upon pressure conditions.
- IEP Series valves are designed to operate at the rated voltage ± 0.5 Vdc, unless otherwise specified.
- To avoid overheating and ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. It is not recommended to exceed 500 mW of average power. If active cooling is implemented such as a fan or heat sink, a higher average power can be achieved. Contact The Lee Company for recommendations specific to your application.

CYCLE LIFE

Cycle life is dependent on system conditions and varies by application. The valves will typically operate across a minimum of 2.5 million cycles on air and 4 million cycles on water.

ELECTRICAL CONNECTION

IEP Series valves are supplied with pins spaced 0.100 of an inch (2.54 mm) on center, compatible with industry standard terminals. The Lee Company offers lead wire assemblies with flying leads to support application development.

- Part number IHWX0248120A – lead wire assembly, 24 inches long
- Part number IHWX0248010A – lead wire assembly, 8 inches long

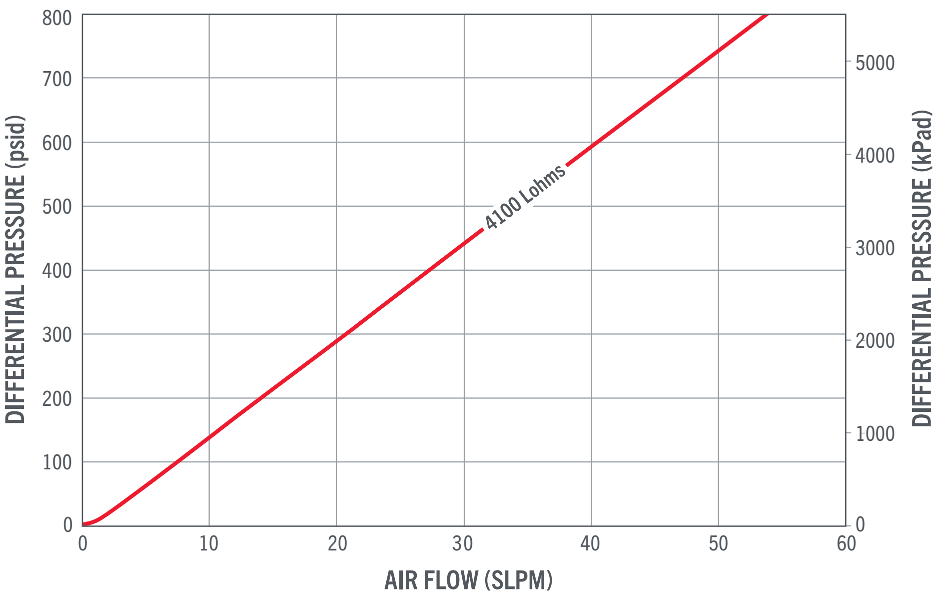
RESPONSE TIME

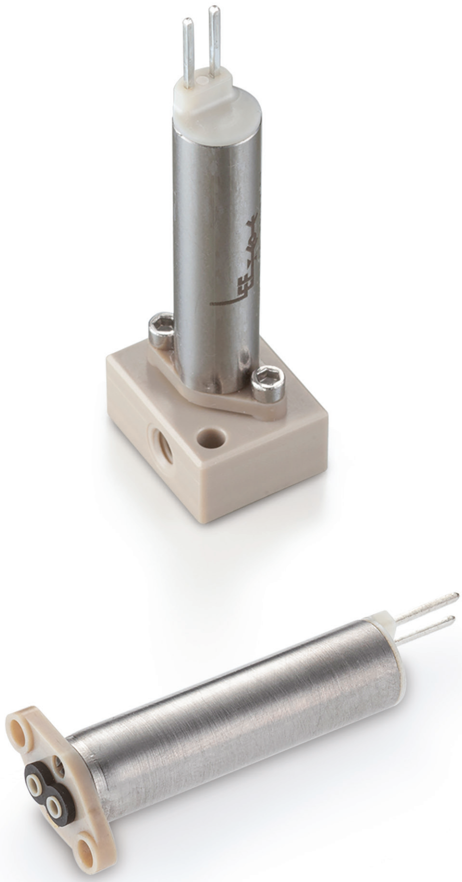
- The typical response time is 0.5 ms on air at 10 psig based on the spike and hold drive parameter.
- Dispensing frequency up to 500 Hz is based on gas flow within the rated pressure range. Response times are impacted by various system parameters and are application dependent.
- Application parameters such as fluid viscosity, temperature, and ambient temperature may impact response time.
- Extended periods of inactivity may impact response time. The dynamic response time of the valve is generally faster than the static response time.

FILTRATION

- Filtration of 17 microns or finer is recommended. Contact your local Lee Sales Engineer for safety screen filter options.

TYPICAL FLOW CHARACTERISTICS



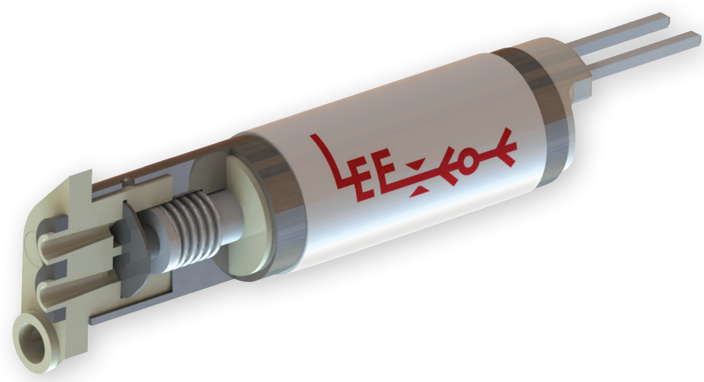


The LFN Series 2-way (2/2) valve is a compact, normally closed, bidirectional, low power solenoid valve featuring a media-separating diaphragm and chemically inert materials. The valve offers minimal internal volume, **zero dead volume, fast response times, and excellent flushing to reduce reagent consumption**. The LFN Series valves are ideal for diagnostics, sequencing, and a variety of other medical and scientific applications, particularly when multiple valves are needed in extremely tight spaces.

FEATURES:

- Small size (7 mm) and lightweight (6 grams)
- Zero dead volume
- Low internal volume: 9 µL
- Operating pressure: Vac to 30 psig or higher upon request
- Inert seal material options: EPDM, FKM, and FFKM
- Low power consumption: 900 mW
- Fast response time: <5 ms (application dependent)

Each valve is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company can customize valve performance to meet specific application requirements.



FLANGE MOUNT

The LFN Series 2-way (2/2) normally closed solenoid valve is available in a flange mount configuration that enables extremely tight valve-to-valve mounting and simple manifold design and integration.

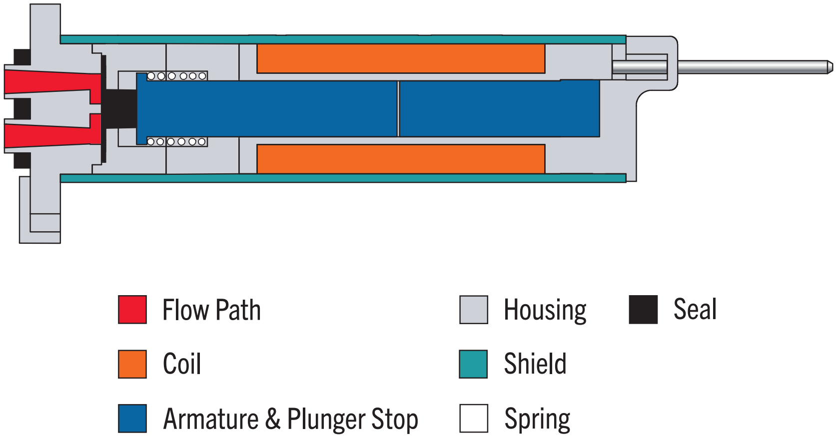
- Operating pressure: Vac to 30 psig or higher upon request
- Power consumption: 900 mW
- Internal volume: 9 µL
- Zero dead volume
- For additional information, see pages D8-9.

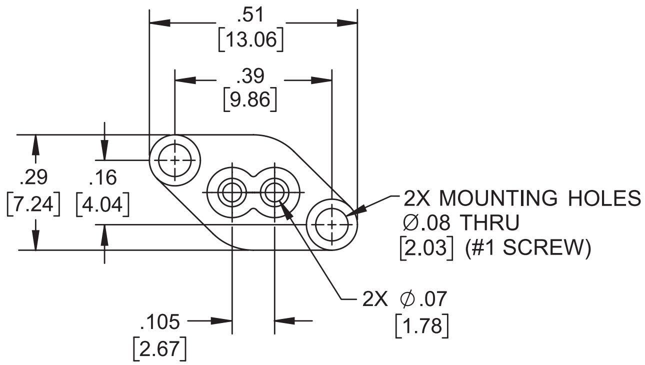
PART NUMBER	VOLTAGE (Vdc)	LOHM[1] RATE (Cv)	WETTED MATERIALS[2]	
			SEALS	PORT HEAD
LFNA1250125H	12	3450 Lohms (0.006)	FKM	PEEK
LFNA2450125H	24		FKM	PEEK
LFNA1250225H	12		EPDM	PEEK
LFNA2450225H	24		EPDM	PEEK
LFNA1250427H	12	4050 Lohms (0.005)	FFKM	PEEK
LFNA2450427H	24		FFKM	PEEK

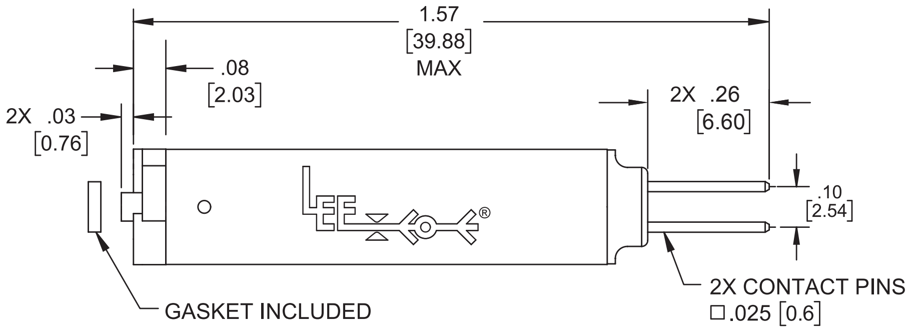
(1) Maximum Lohm rate on air. Reference page D5 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm laws.
(2) Refer to pages Q62-63 for material information and abbreviations.

D

FLANGE MOUNT







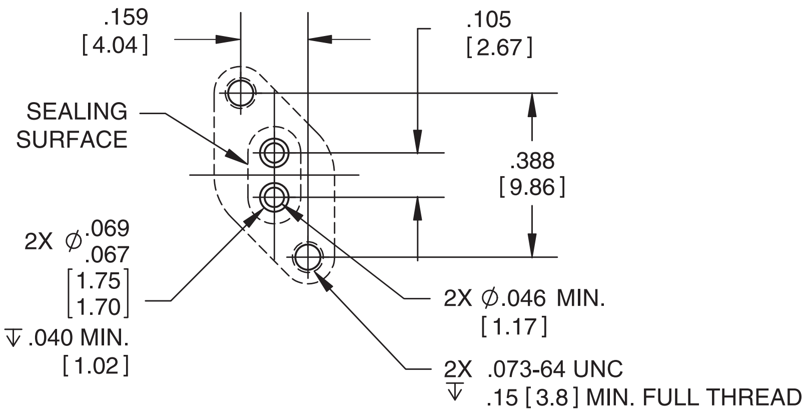
Refer to page D4 for mounting details.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MOUNTING & FLUIDIC CONNECTIONS

FLANGE MOUNT VALVES:

Manifold mating boss geometries and dimensions shown below are for reference only. Refer to drawing number LSIX1001800A for complete specifications.

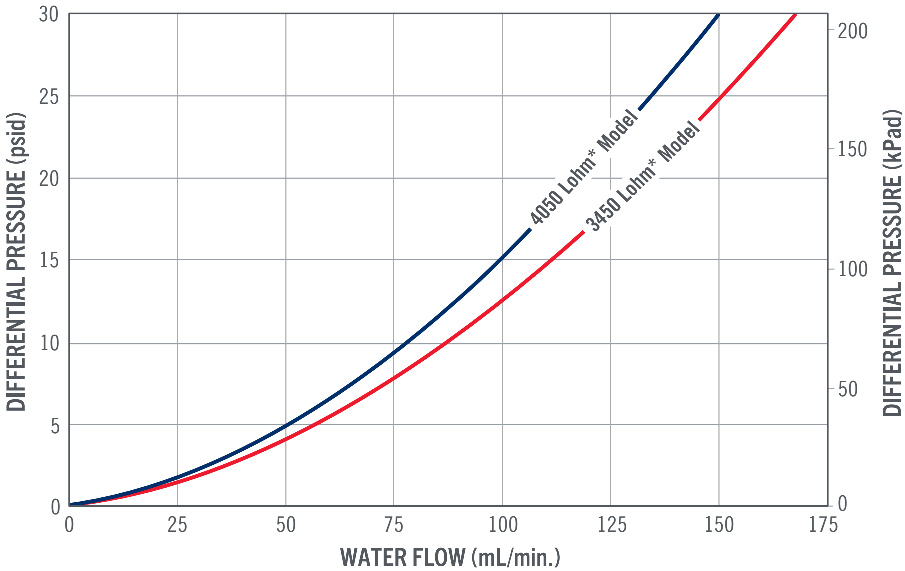


The valves should be mounted to a surface using #1-64 x 0.1875 (M1.6) mounting screws. The torque specification is 5 to 7 in-oz (0.035 to 0.049 N-m).

Unless otherwise specified, all dimensions are in inches [mm]. Drawings are not to scale.

D

TYPICAL FLOW CHARACTERISTICS



* Lohm rating of each valve model is based on air performance. Curves shown above depict empirical data from actual product performance on water.

GENERAL ACCESSORIES/ REPLACEMENT PARTS

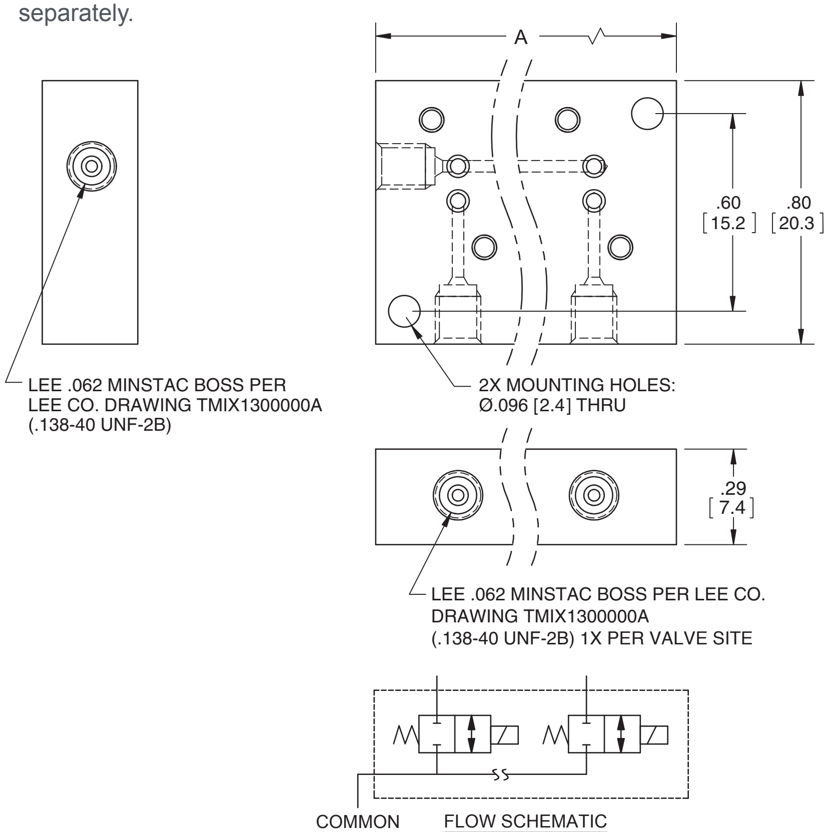
PART NUMBER	DESCRIPTION
LSWX0503110A	Mounting Screw (#1-64 x 0.1875")
LSWX0508170A	EPDM Gasket
LSWX0508200A	FKM Gasket
LSWX0508290A	FFKM Gasket
LSWX0609060A	Electrical Lead Wire Connector, 6"
LSWX0670580A	Electrical Lead Wire Connector, 12"

STANDARD MANIFOLDS

To ease the setup of prototype systems, several standard manifold configurations are offered in both PMMA and PEEK materials, off-the-shelf, and without valves. Refer to Manifold Assemblies (Section M) for custom design capabilities.

PART NUMBER [1]		NUMBER OF VALVE POSITIONS	DIMENSION "A"
PEEK	PMMA		
LSMX0509700B	N/A	1x	0.63" (16.0 mm)
LSMX0509520B	LSMX0509560B	2x	0.80" (20.3 mm)
LSMX0509530B	LSMX0509570B	3x	1.10" (27.9 mm)
LSMX0509540B	LSMX0509580B	4x	1.40" (35.6 mm)
LSMX0509550B	LSMX0509590B	5x	1.70" (43.2 mm)

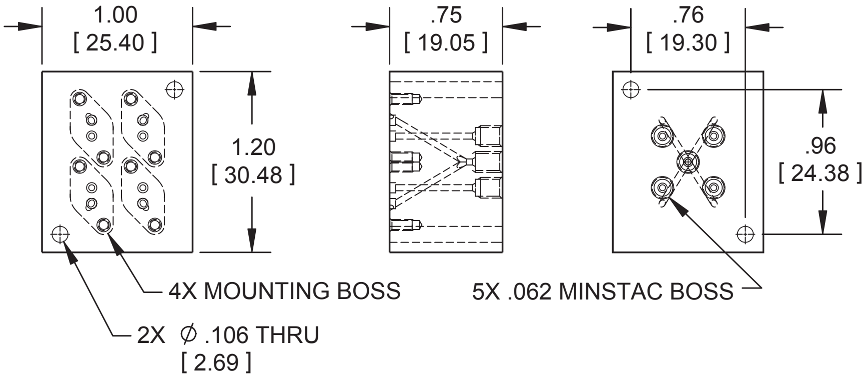
(1) Part numbers are for the manifold and mounting screws only. Valves are sold separately.



Unless otherwise specified, all dimensions are in inches [mm]. Drawings are not to scale.

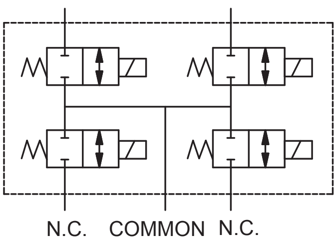
STANDARD MANIFOLDS

The Lee Company also offers a standard manifold design allowing for 4x valve positions arranged in a different layout, as shown below. This design minimizes internal volume and maintains a consistent volume between the common port and each valve.



Part number LSMX0512650B (Manifold, 4x valve positions, PMMA).

Part number is for the manifold and mounting screws only. Valves are sold separately.



FLOW SCHEMATIC

D

Unless otherwise specified, all dimensions are in inches [mm]. Drawings are not to scale.

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all LFN Series solenoid valves, unless otherwise noted.

CYCLE LIFE

The valves will typically operate across a minimum of 10 million cycles on water, depending on application conditions.

WEIGHT

6 grams

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage ± 5%.

OPERATING TEMPERATURE

- Ambient operating temperature range is dependent on the elastomer; refer to the table below for details.
- Increasing the operating temperature tends to limit coil performance. Maximum internal coil temperature not to exceed 170°F (77°C). To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required or spike and hold operation can be used. Contact The Lee Company for recommendations specific to your application.

ELASTOMER	AMBIENT OPERATING TEMPERATURE RANGE
EPDM	30°F to 120°F (-1°C to 49°C)
FKM & FFKM	40°F to 120°F (4°C to 49°C)

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

FILTRATION

Filtration of 35 microns or finer is recommended.

RESPONSE TIME

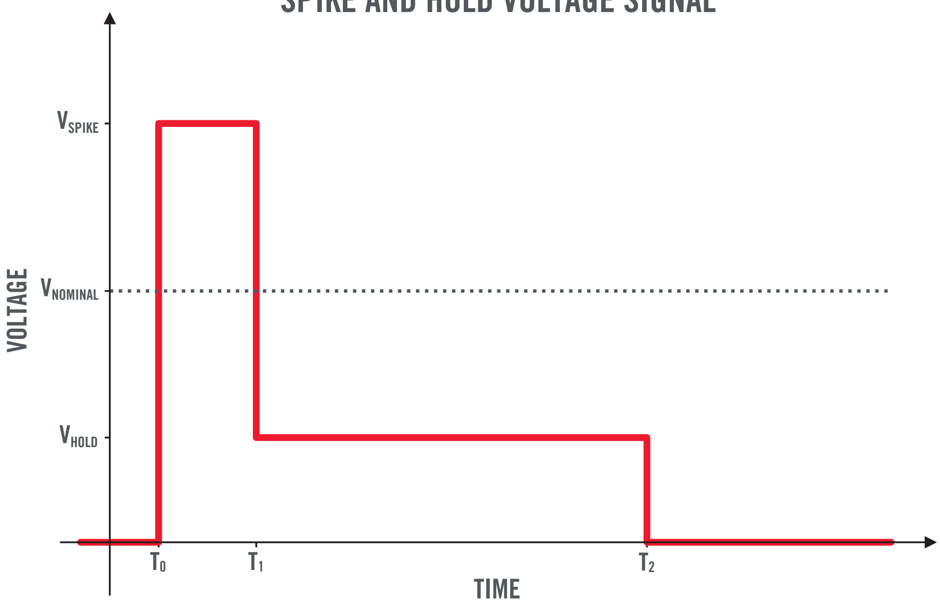
- The rated response time is 20 ms maximum at 68°F (20°C), 2 Hz on air at 10 psig.
- Response times are dependent upon system conditions, power, environment, etc. The response will typically increase as the ambient temperature decreases and decrease as pressure increases. Extended periods of valve inactivity may also have an impact on the initial response time of the valve.
- Response times can be enhanced (to less than 5 ms in some cases) with the use of spike and hold drive circuits. Refer to the electrical characteristics on page D9.

ELECTRICAL CHARACTERISTICS

- Valves are designed to operate under continuous duty at the rated voltage ± 5%.
- The valves are also designed to operate using a spike and hold drive to enhance response time and reduce the average power consumption. Average power consumption not to exceed 900 mW. Over heating the valve can lead to reduction in flow. Refer to pages Q39-45 for information on electrical drive schematics.

NOMINAL VOLTAGE (Vdc)	SPIKE ACTUATION VOLTAGE (Vdc)	MAXIMUM SPIKE DURATION (ms)	HOLD VOLTAGE (Vdc)	POWER CONSUMPTION AT HOLD VOLTAGE (mW)
12	20	25	5	160
24	40	25	10	160

SPIKE AND HOLD VOLTAGE SIGNAL



This figure shows a typical spike and hold drive signal. At T_0, a spike voltage above the valve's nominal value is applied, making response times faster and more consistent. At T_1, the valve has fully opened and a hold voltage is applied. The hold voltage is lower than the valve's nominal voltage which reduces heating and power consumption. Finally at T_2, the valve is turned off.

The LFV Series solenoid valve is a 13 mm, 2-way, normally closed, bidirectional, chemically inert, isolation-style valve. It is **widely used to reliably control aggressive fluids in diagnostics and analytical instruments.** It features a media-separating diaphragm seal, high flow rates, low internal volume, and consistent performance across an extensive cycle life.

FEATURES:

- Zero dead volume
- Internal volume as low as 21 µL
- Operating pressure: Vac to 30 psig or higher upon request
- Inert seal material options: EPDM, FKM, and FFKM
- Low power consumption
- Long cycle life: 10 million cycles

Each valve is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company can customize valves to meet specific application requirements, such as higher pressure operation.

MANIFOLD MOUNT - FLANGE

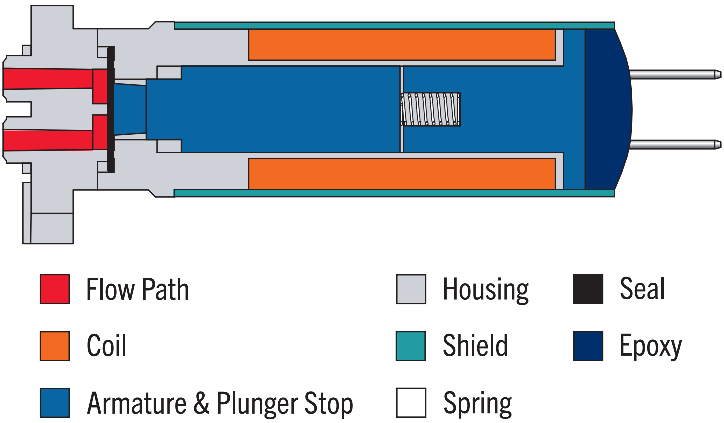
The flange mount configuration enables tight valve-to-valve mounting as well as simple manifold design and integration.

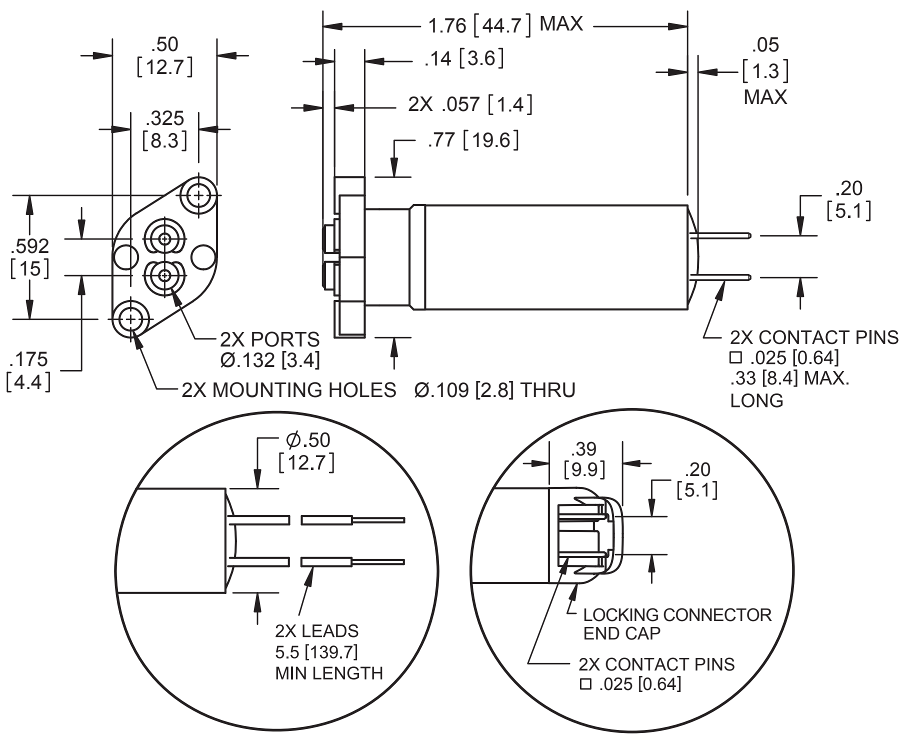
- **Operating pressure:** Vac to 30 psig or higher upon request
- **Internal volume:** 21 µL
- Zero dead volume
- **Electrical connection:** contact pins. Lead wires or the locking end cap connector also available upon request (shown on page E3).
- For additional specifications see pages E14-15.

PART NUMBER	ACTUATION VOLTAGE	MAX LOHM RATE [1] (Ref. Cv)	POWER CONSUMP-TION (W)	WETTED MATERIALS [2]	CONFIGURA-TION [3]
LFVA1258110H	12	1350 (0.015)	1.5	FKM & PEEK	A
LFVA2458110H	24	1350 (0.015)	1.5	FKM & PEEK	A
LFVA1258210H	12	1350 (0.015)	1.5	EPDM & PEEK	A
LFVA2458210H	24	1350 (0.015)	1.5	EPDM & PEEK	A
LFVA1251410H	12	1350 (0.015)	1.5	FFKM & PEEK	B
LFVA2451410H	24	1350 (0.015)	1.5	FFKM & PEEK	B

(1) Maximum Lohm rate on air. Reference page E15 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.
(2) Refer to pages Q62-63 for material information and abbreviations.
(3) Configuration A valves are sold with O-ring seals; Configuration B valves are sold with gasket seals. See page E10 for standard manifold offerings and page E11 for mounting information, including installation boss reference material.

MANIFOLD MOUNT - FLANGE





Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MANIFOLD MOUNT - COUPLING SCREW

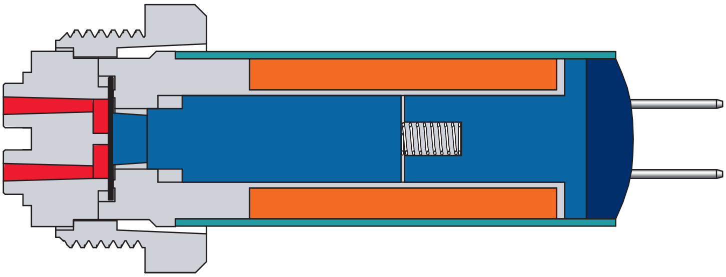
The fluidic ports of the coupling screw configuration are buried into the manifold, resulting in a space-saving, leak-free design. Its threaded connection also enables easy installation without the need for mounting screws.

- **Operating pressure:** Vac to 30 psig or higher upon request
- **Internal volume:** 21 μL
- Zero dead volume
- **Electrical connection:** contact pins. Lead wires or the locking end cap connector also available upon request (shown on page E5).
- For additional specifications see pages E14-15.

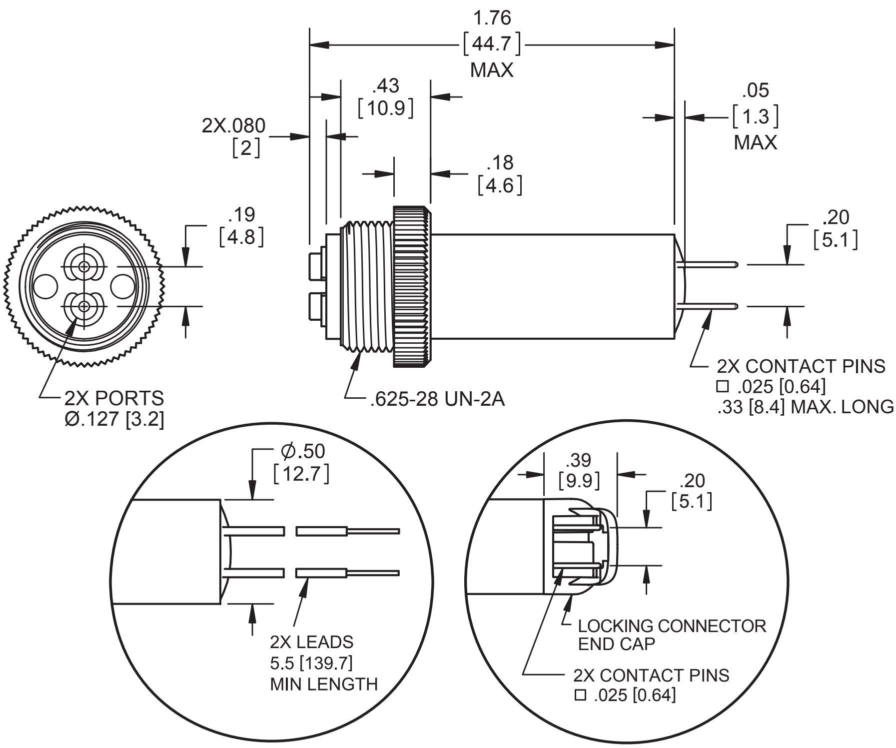
PART NUMBER	ACTUATION VOLTAGE	MAX LOHM RATE [1] (Ref. Cv)	POWER CONSUMPTION (W)	WETTED MATERIALS [2]	CONFIGURATION [3]
LFVA1248110H	12	2600 (0.008)	1.5	FKM & PEEK	C
LFVA2448110H	24	2600 (0.008)	1.5	FKM & PEEK	C
LFVA1248210H	12	2600 (0.008)	1.5	EPDM & PEEK	C
LFVA2448210H	24	2600 (0.008)	1.5	EPDM & PEEK	C
LFVA1241420H	12	2600 (0.008)	1.5	FFKM & PEEK	D
LFVA2441420H	24	2600 (0.008)	1.5	FFKM & PEEK	D

(1) Maximum Lohm rate on air. Reference page E15 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.
2) Refer to pages Q62-63 for material information and abbreviations.
(3) Configuration C valves are sold with O-ring seals; Configuration D valves are sold with gasket seals. See page E10 for standard manifold offerings and page E11 for mounting information, including installation boss reference material.

MANIFOLD MOUNT - COUPLING SCREW



- Flow Path
- Coil
- Armature & Plunger Stop
- Housing
- Shield
- Spring
- Seal
- Epoxy



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

¼-28 PORTS

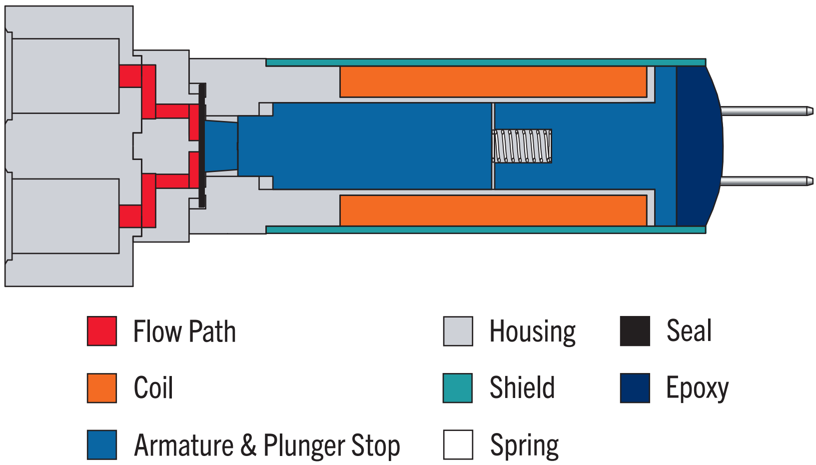
The threaded ¼-28 flat bottom (FB) ports of this configuration enable quick and simple connection to industry standard ¼-28 FB tubing and fitting systems. This allows rapid prototype setup and connection to other fluidic components, such as dispense pumps (see Variable Volume Pumps, Section L).

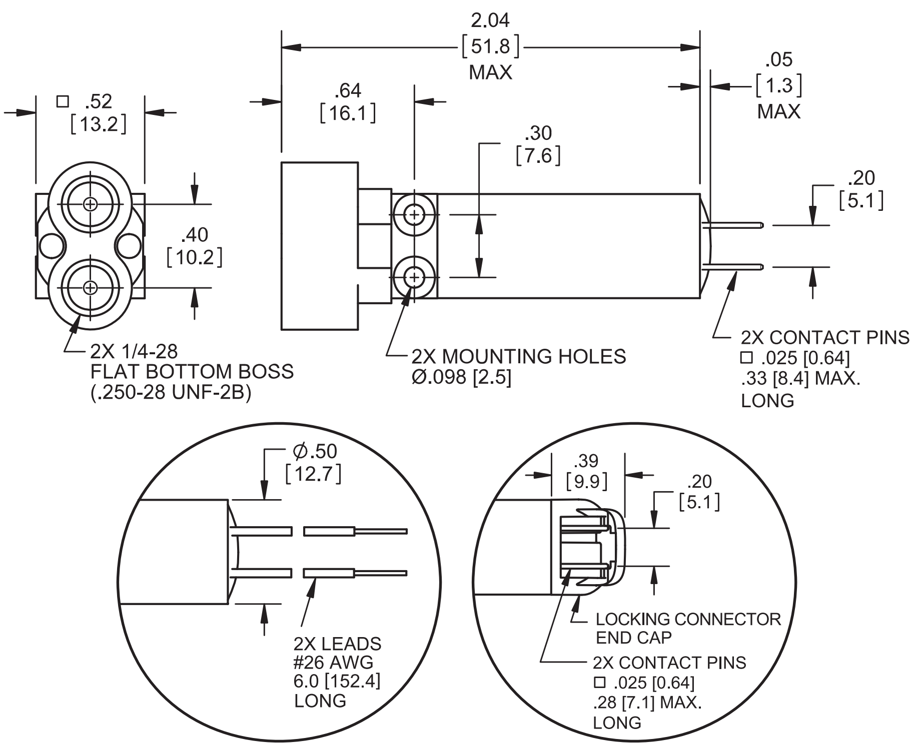
- **Operating pressure:** Vac to 30 psig or higher upon request
- **Internal volume:** 21 µL
- Zero dead volume
- **Electrical connection:** contact pins. Lead wires or the locking end cap connector also available upon request (shown on page E5).
- For additional specifications see pages E14-15.
- For compatible ¼-28 tubing assemblies, adapters, filters, and components, refer to the MINSTAC® Section (pages N10-18).

PART NUMBER	ACTUATION VOLTAGE	MAX LOHM RATE [1] (Ref. Cv)	POWER CONSUMPTION (W)	WETTED MATERIALS [2]
LFVA1238110H	12	1800 (0.011)	1.5	FKM & PEEK
LFVA2438110H	24	1800 (0.011)	1.5	FKM & PEEK
LFVA1238210H	12	1800 (0.011)	1.5	EPDM & PEEK
LFVA2438210H	24	1800 (0.011)	1.5	EPDM & PEEK
LFVA1231413H	12	1800 (0.011)	1.5	FFKM & PEEK
LFVA2431413H	24	1800 (0.011)	1.5	FFKM & PEEK

(1) Maximum Lohm rate on air. Reference page E15 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.
2) Refer to pages Q62-63 for material information and abbreviations.

¼-28 PORTS





Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

SOFT TUBE BARBED PORTS

The barbed ports of this configuration enable quick and simple connection to 1/16" (1.6 mm) ID soft, flexible tubing, resulting in rapid prototype setup.

- **Operating pressure:** Vac to 30 psig or higher upon request
- **Internal volume:** 43 µL
- Zero dead volume
- **Electrical connection:** contact pins. Lead wires or the locking end cap connector also available upon request (shown on page E5).
- For additional specifications see pages E14-15.

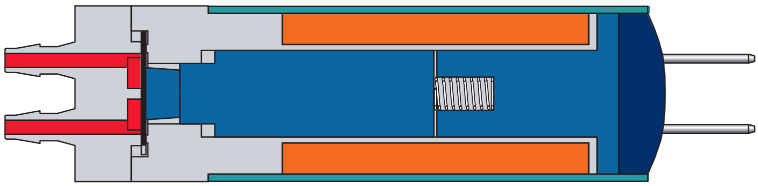
PART NUMBER	ACTUATION VOLTAGE	MAX LOHM RATE [1] (Ref. Cv)	POWER CONSUMPTION (W)	WETTED MATERIALS [2]
LFVA1228110H	12	1350 (0.015)	1.5	FKM & PEEK
LFVA2428110H	24	1350 (0.015)	1.5	FKM & PEEK
LFVA1228210H	12	1350 (0.015)	1.5	EPDM & PEEK
LFVA2428210H	24	1350 (0.015)	1.5	EPDM & PEEK
LFVA1221410H	12	1350 (0.015)	1.5	FFKM & PEEK
LFVA2421410H	24	1350 (0.015)	1.5	FFKM & PEEK

(1) Maximum Lohm rate on air. Reference page E15 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.

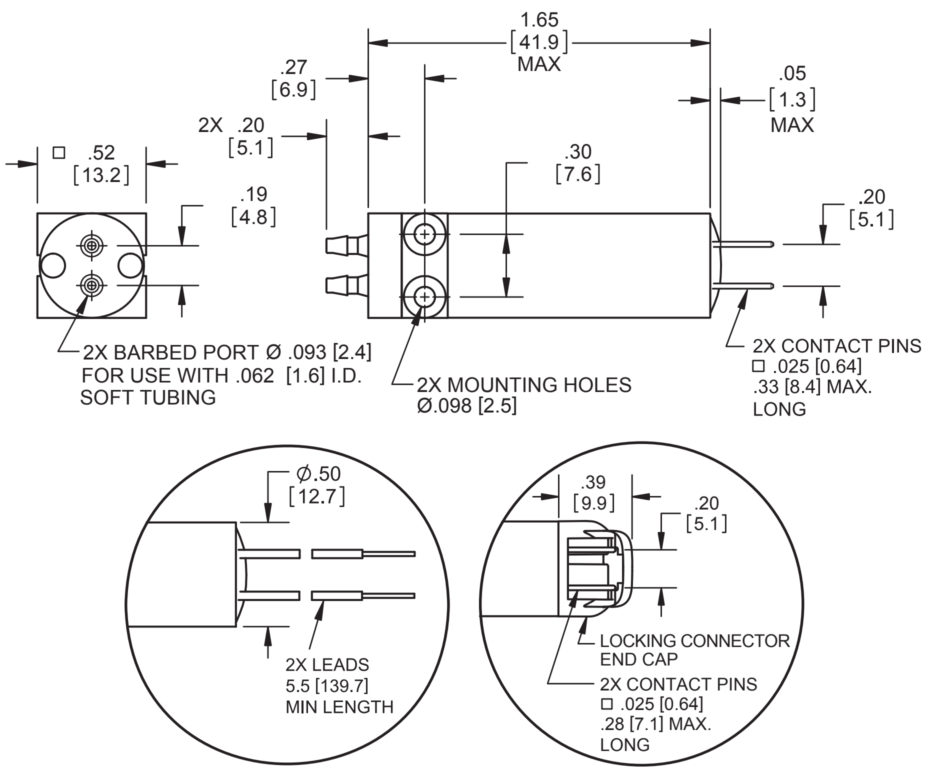
2) Refer to pages Q62-63 for material information and abbreviations.

E

SOFT TUBE BARBED PORTS



- Flow Path
- Coil
- Armature & Plunger Stop
- Housing
- Shield
- Spring
- Seal
- Epoxy

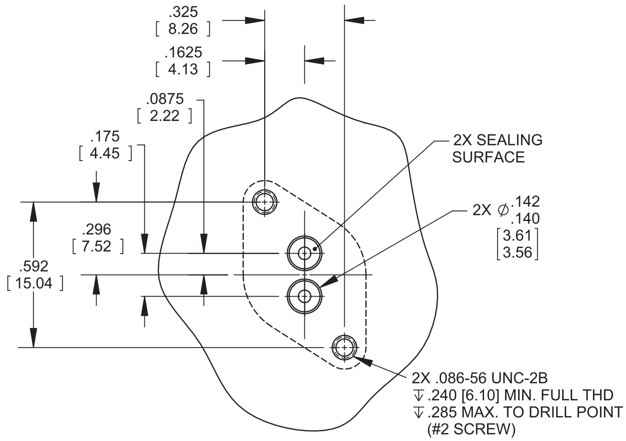


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MOUNTING & FLUIDIC CONNECTIONS

Manifold mating boss geometries and dimensions shown are for reference only. Refer to drawing part numbers listed below for complete specifications.

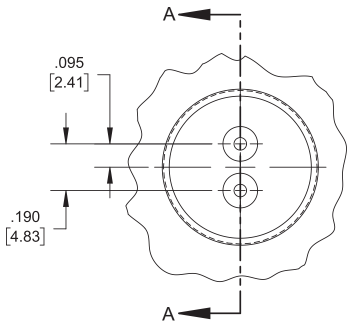
FLANGE MOUNT VALVES



Mount using #2 (M2) screws tightened within 10 to 14 in-oz maximum.
For full boss manufacturing details:

- Configuration A valves: reference drawing number LSIX1001540A.
- Configuration B valves: reference drawing number LSIX1001100A.

COUPLING SCREW VALVES



Coupling screw valves should be tightened within 60 to 120 in-oz of torque.
For full boss manufacturing details:

- Configuration C valves: reference drawing number LSIX1001530A.
- Configuration D valves: reference drawing number LFIX1000850A.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MOUNTING & FLUIDIC CONNECTIONS

¼-28 PORT VALVES

- Fluidic connections: for use with standard ¼-28 flat bottom fittings.
- Mount valves using #2 (M2) mounting screws.

BARBED PORT VALVES

- Fluidic connections: for use with soft, flexible 1/16" (1.6 mm) ID tubing.
- Mount valves using #2 (M2) mounting screws.

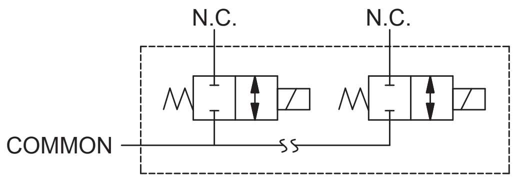
GENERAL ACCESSORIES/REPLACEMENT PARTS

STYLE	PART NUMBER	DESCRIPTION
Flange Mount Configuration A	LSWX0508810A	O-ring (FKM)
	LSWX0508820A	O-ring (EPDM)
Flange Mount Configuration B	LSWX0208050A	Gasket (FFKM)
Coupling Screw Configuration C	LSWX0508810A	O-ring (FKM)
	LSWX0508820A	O-ring (EPDM)
Coupling Screw Configuration D	LHWX0208750A	Gasket (FFKM)
Coupling Screw (Universal)	LSWX0610030B	Splined Installation Wrench[1]
Valves with Pins or Locking End Cap	LSWX0504300A	Lead Wire Connector, 6" length
	LSWX0606700A	Lead Wire Connector, 24" length

(1) Splined installation wrench is only needed for torque measurements. Coupling screw LFV Series valves can be installed by hand.

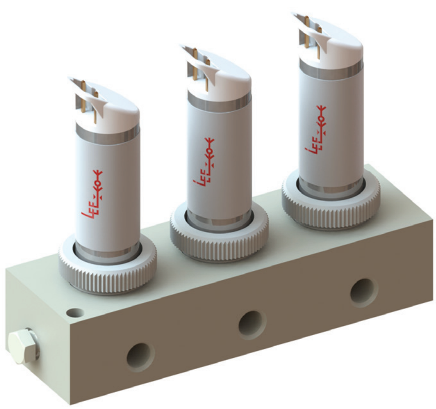
STANDARD MANIFOLDS

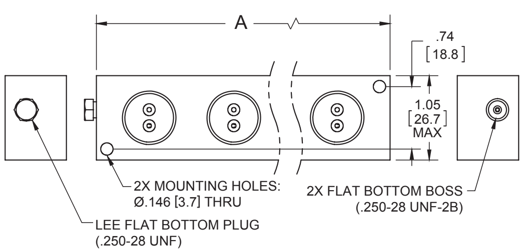
To ease the setup of prototype systems, standard manifolds are available for either style of manifold mount LFV Series valve: Flange and Coupling Screw. Standard manifolds are stocked in both PMMA and PEEK materials and do not include valves. Each manifold has a shared header line which interconnects one port of each valve, and an individual ¼-28 threaded connection to the second port of each valve (see flow schematic below).



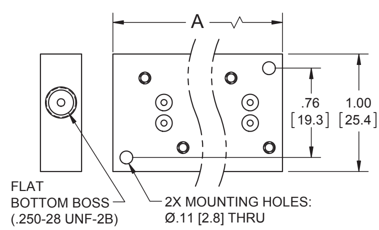
FLOW SCHEMATIC

COUPLING SCREW





FLANGE MOUNT



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

STANDARD MANIFOLDS

VALVE STYLE & CONFIGURATION	PART NUMBER [1]		NUMBER OF VALVE POSITIONS	DIMENSION "A" [2]
	PEEK	PMMA		
Flange Mount Configuration A	LSMX0521600B	—	1	1.00" (25.4 mm)
Flange Mount Configuration B	LSMX0522550B	LSMX0502400B	1	1.00" (25.4 mm)
	LSMX0503600B	LSMX0502360B	2	1.22" (31.0 mm)
	LSMX0503610B	LSMX0502370B	3	1.73" (43.9 mm)
	LSMX0503620B	LSMX0502380B	4	2.24" (56.9 mm)
	LSMX0503630B	LSMX0502390B	5	2.75" (69.9 mm)
Coupling Screw Configuration C	LSMX0521550B	—	1	1.25" (31.75 mm)
Coupling Screw Configuration D	LSMX0517010B	LSMX0517020B	1	1.00" (25.4 mm)
	LFMX0514100B	LFMX0514300B	3	3.25" (82.6 mm)
	LFMX0514200B	LFMX0514400B	8	8.25" (209.6 mm)

(1) Part numbers are for the manifold and mounting screws only. Valves are sold separately.
(2) Length measured across flats of manifolds. Refer to Manifold Assemblies (Section M) for custom design capabilities.

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all LFV Series solenoid valves, unless otherwise noted.

CYCLE LIFE

The valves will typically operate across a minimum of 10 million cycles on water, depending on application conditions.

WEIGHT

24 to 26 grams

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage ± 5%.

OPERATING TEMPERATURE

- Ambient operating temperature range is dependent on the elastomer; refer to table below for details.
- Maximum coil temperature not to exceed 220°F (104°C).
- Increasing the operating temperature tends to limit coil performance. The valve duty cycle and energized time must be evaluated for conformance with the maximum rated operating and coil temperatures.

ELASTOMER	AMBIENT OPERATING TEMPERATURE RANGE
EPDM	30°F to 120°F (-1°C to 49°C)
FKM	40°F to 120°F (4°C to 49°C)
FFKM	70°F to 120°F (21°C to 49°C)

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% max. non-condensing

RESPONSE TIME

- The typical response time is 30 ms maximum at 65°F (18°C), 2 Hz on air under vacuum at 10 psig.
- Response times are dependent upon system conditions, power, environment, etc. The response will typically increase as the ambient operating temperature decreases and decrease as pressure increases. Extended periods of valve inactivity may also have an impact on the initial response time of the valve.
- Response times can be enhanced with the use of spike and hold drive circuits. Refer to pages Q42-45.

ELECTRICAL CONNECTIONS

- *Lead wires:* Valves are supplied with 6", #26 AWG lead wires with the ends of the wires stripped and tinned. An electrical connector can be added as part of a custom design.
- *Pins:* Valves are supplied with two 0.025" square electrical pins spaced 0.20 of an inch center to center. For use with standard electrical connectors designed for 0.10 of an inch spacing.
- *Pins with locking end caps:* Adds secondary retention to pin connection. The locking end cap mates with TE Connectivity part number 104257-2 style connectors.

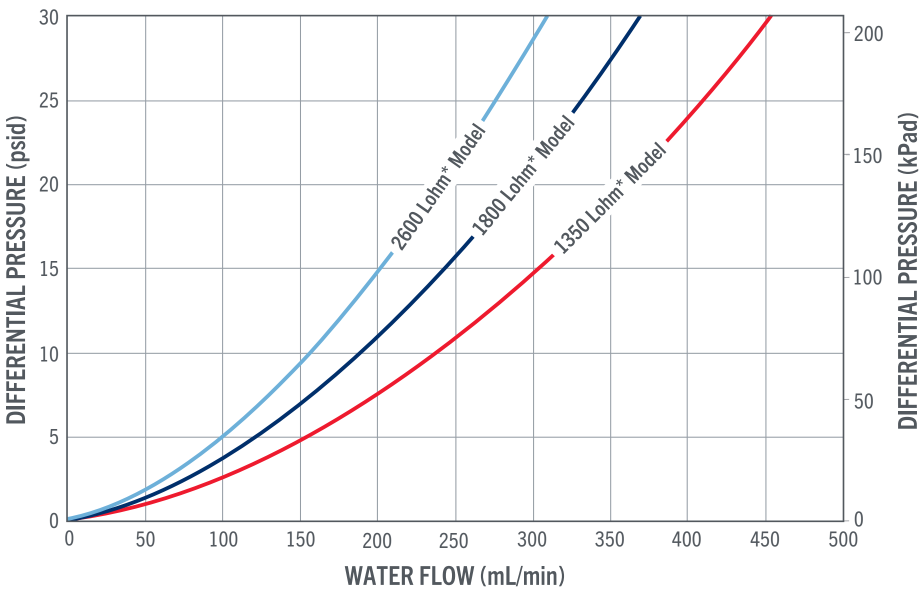
ELECTRICAL CHARACTERISTICS

- Standard actuation voltages available: 12 and 24 Vdc (±5%)
- Refer to individual valve tables on pages E2-9 for power consumption.
- The valves are designed for continuous duty operation. Following actuation at nominal voltage, the voltage can be lowered to a hold voltage that is 50% of the rated nominal voltage. This will reduce power consumption and heat. Refer to pages Q39-45, for information on electrical drive schematics.

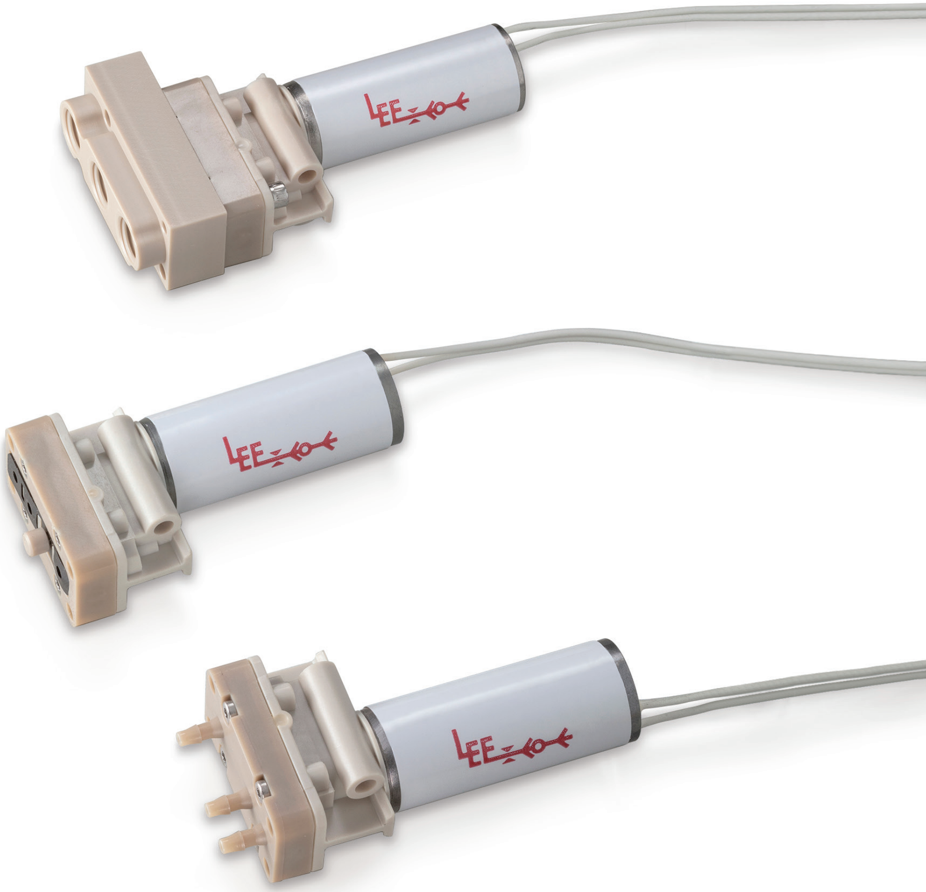
FILTRATION

Filtration of 35 microns or finer is recommended.

TYPICAL FLOW CHARACTERISTICS



* Lohm rating of each valve model is based on air performance. Curves shown above depict empirical data from actual product performance on water.


LEE
LEE
LEE

The LFR Series solenoid valves are 3-way, 13 mm, chemically inert, isolation-style valves optimized for high flow performance without sacrificing size or reliability. These **rocker-style media-separated valves** are well-suited for use in diagnostics, sequencing, or other analytical applications to **divert fluid to waste**.

FEATURES:

- High flow: as low as 700 Lohms (Cv = 0.029)
- Operating pressure: Vac to 30 psig or higher upon request
- Inert seal material options: EPDM, FKM, and FFKM
- Low power consumption
- Multiple styles: barbed port, ¼-28 port, and manifold mount

Each valve is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company can customize valves to meet specific application requirements.

BARBED PORT

The barbed ports of this configuration enable quick and simple connection to 1/16" (1.6 mm) ID soft, flexible tubing, resulting in rapid prototype setup.

- **Operating pressure:** Vac to 30 psig or higher upon request.
- **Internal volume:** 150 µL
- **Power consumption:** 1.6 W
- For additional information, see pages F12-13.

PART NUMBER[1]	LOHM RATE[2] (Cv)	WETTED MATERIALS[3]		ELECTRICAL CONNECTION
		SEALS	PORT HEAD	
LFRA__20270D	700 Lohms (0.029)	EPDM	PEEK	Lead Wire
LFRA__22270D		EPDM	PEEK	Pin with Locking End Cap
LFRA__20170D		FKM	PEEK	Lead Wire
LFRA__22170D		FKM	PEEK	Pin with Locking End Cap
LFRA__20370D		FFKM	PEEK	Lead Wire
LFRA__22370D		FFKM	PEEK	Pin with Locking End Cap

(1) Solenoid valves are available in 12 and 24 Vdc configurations.

LFRA__20270D

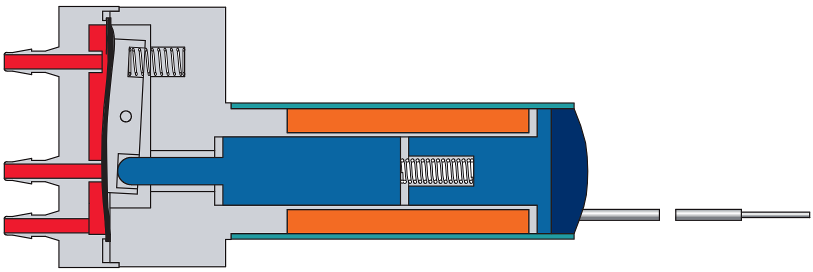
Coil voltage: 12 = 12 volts
24 = 24 volts

(2) Maximum Lohm rate on air. Reference page F9 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.

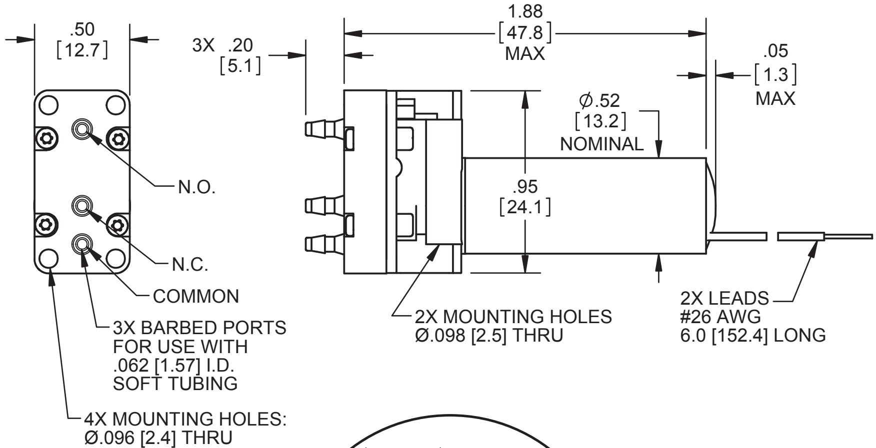
(3) Refer to pages Q62-63 for material information and abbreviations.

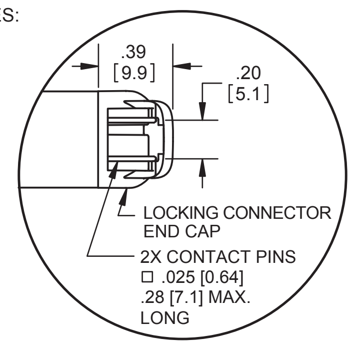
F

BARBED PORT



- Flow Path
- Coil
- Armature & Plunger Stop
- Housing & Ports
- Shield
- Spring
- Seal
- Epoxy





F

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

¼-28 PORT

The threaded ¼-28 flat bottom (FB) ports of this configuration enable quick and simple connection to industry standard ¼-28 FB tubing and fitting systems. This allows rapid prototype setup and connection to other fluidic components, such as dispense pumps (see Variable Volume Pumps, Section L).

- **Operating pressure:** Vac to 30 psig or higher upon request.
- **Internal volume:** 180 μL
- **Power consumption:** 1.6 W
- For additional information, see pages F12-13.

PART NUMBER [1]	LOHM RATE [2] (Cv)	WETTED MATERIALS [3]		ELECTRICAL CONNECTION
		SEALS	PORT HEAD	
LFRA_ _30210H	1000 Lohms (0.020)	EPDM	PEEK	Lead Wire
LFRA_ _32210H		EPDM	PEEK	Pin with Locking End Cap
LFRA_ _30110H		FKM	PEEK	Lead Wire
LFRA_ _32110H		FKM	PEEK	Pin with Locking End Cap
LFRA_ _30310H		FFKM	PEEK	Lead Wire
LFRA_ _32310H		FFKM	PEEK	Pin with Locking End Cap

(1) Solenoid valves are available in 12 and 24 Vdc configurations.

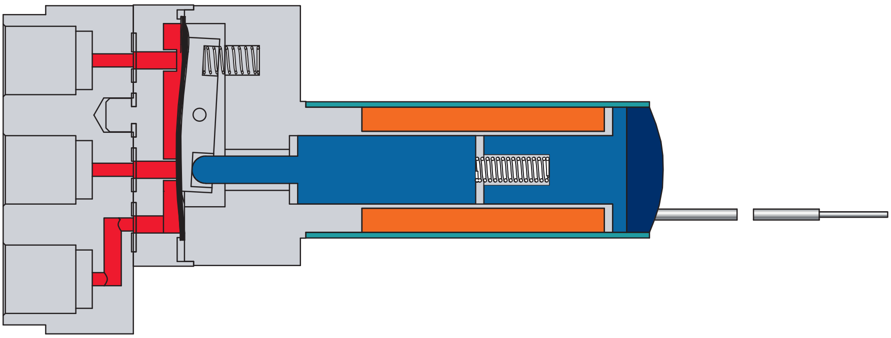
LFRA _ _ 30210H

Coil voltage: 12 = 12 volts
24 = 24 volts

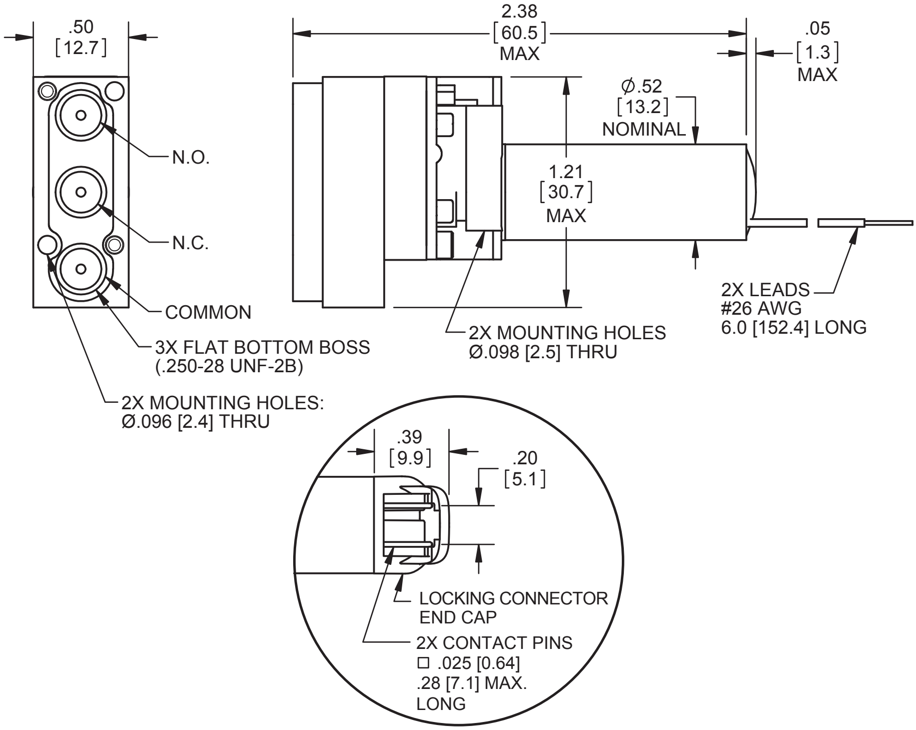
(2) Maximum Lohm rate on air. Reference page F9 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.

(3) Refer to pages Q62-63 for material information and abbreviations.

¼-28 PORT



Flow Path	Housing & Ports	Seal
Coil	Shield	Epoxy
Armature & Plunger Stop	Spring	



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MANIFOLD MOUNT

The manifold mount configuration has a simple one piece gasket and is easily surface mounted on to a manifold with several integrated valves or other fluidic components.

- **Operating pressure:** Vac to 30 psig or higher upon request.
- **Internal volume:** 150 µL
- **Power consumption:** 1.6 W
- For additional information, see pages F12-13.

PART NUMBER[1]	LOHM RATE[2] (Cv)	WETTED MATERIALS[3]		ELECTRICAL CONNECTION
		SEALS	PORT HEAD	
LFRA _ _ 50270D	700 Lohms (0.029)	EPDM	PEEK	Lead Wire
LFRA _ _ 52270D		EPDM	PEEK	Pin with Locking End Cap
LFRA _ _ 50170D		FKM	PEEK	Lead Wire
LFRA _ _ 52170D		FKM	PEEK	Pin with Locking End Cap
LFRA _ _ 50370D		FFKM	PEEK	Lead Wire
LFRA _ _ 52370D		FFKM	PEEK	Pin with Locking End Cap

(1) Solenoid valves are available in 12 and 24 Vdc configurations.

LFRA _ _ 50270D

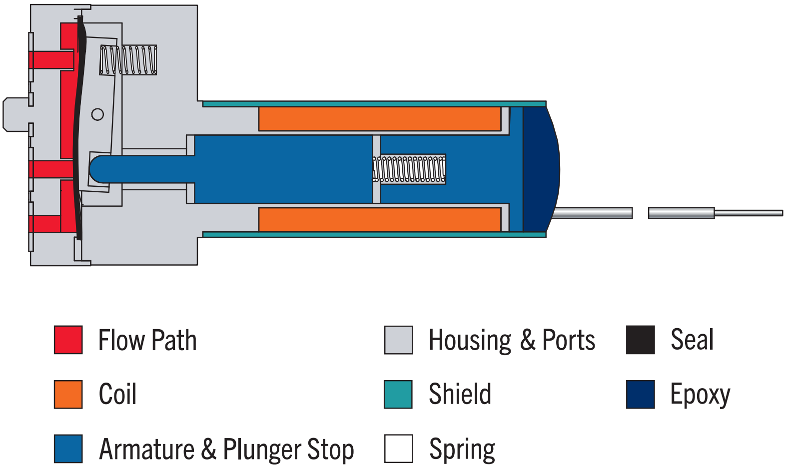
Coil voltage: 12 = 12 volts
24 = 24 volts

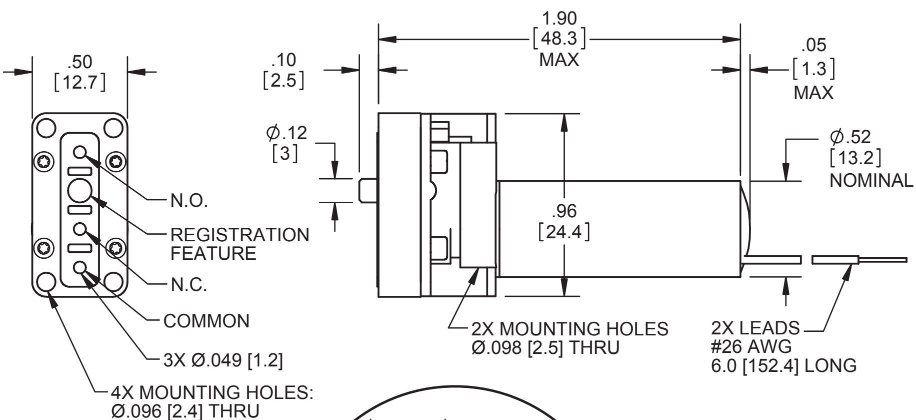
(2) Maximum Lohm rate on air. Reference page F9 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm Laws.

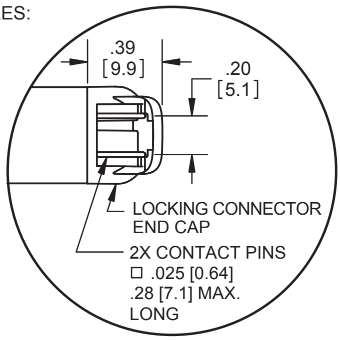
(3) Refer to pages Q62-63 for material information and abbreviations.

F

MANIFOLD MOUNT







Refer to page F8 for mounting details.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MOUNTING & FLUIDIC CONNECTIONS

BARBED PORT VALVES

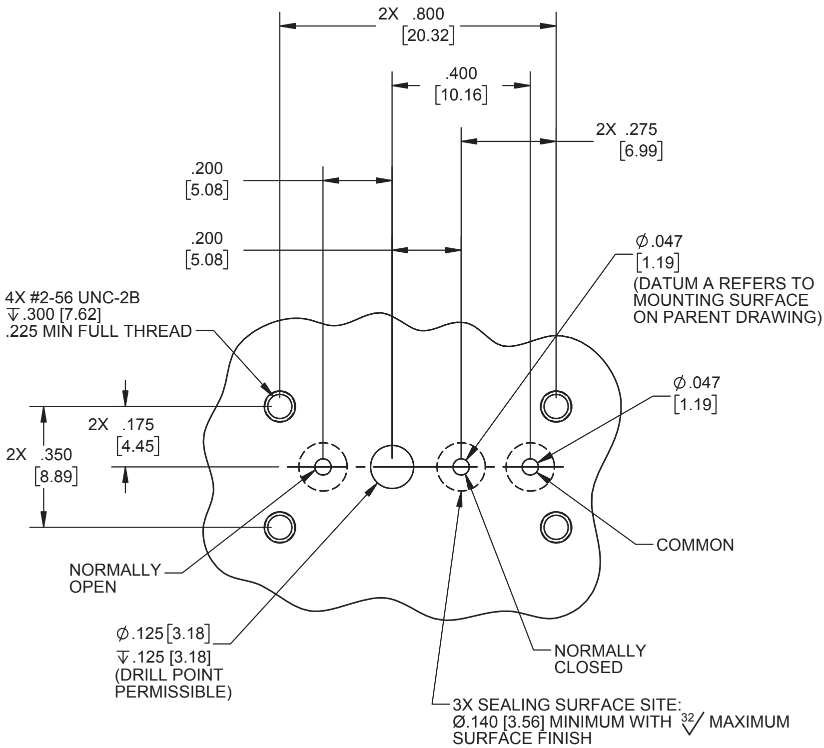
- Fluidic connections: For use with soft, flexible 1/16" (1.6 mm) ID tubing
- Mount valves using #2 (M2) mounting screws

¼-28 PORT VALVES

- Fluidic connections: for use with standard ¼-28 flat bottom fittings
- Mount valves using #2 (M2) mounting screws

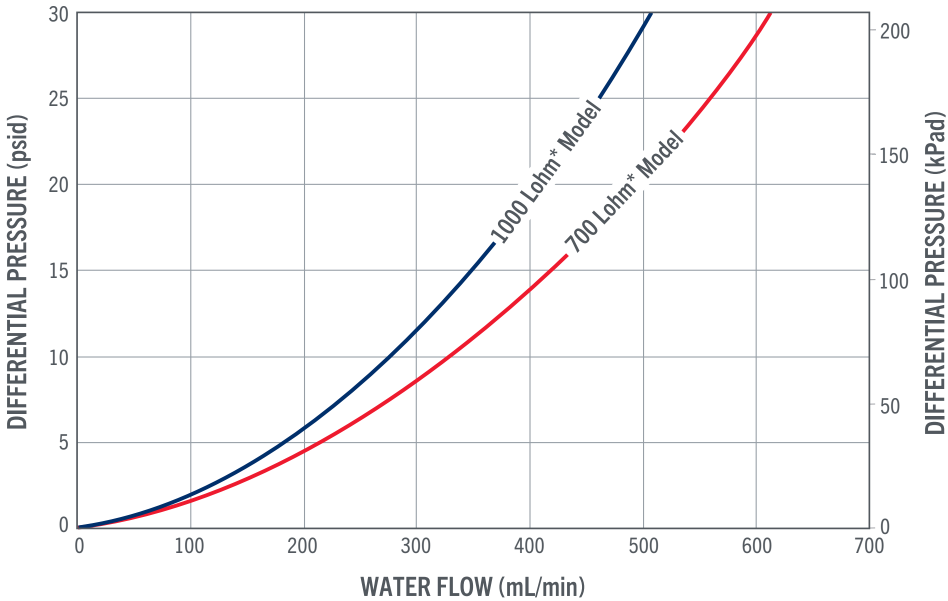
MANIFOLD MOUNT VALVES

- Fluidic connections: manifold mating boss geometries and dimensions shown below are for reference only. Refer to drawing number LSIX1001600A for complete manufacturing specifications.
- Minimum center-to-center spacing of 0.5 of an inch between valves is required. The valves use four #2 (M2) screws for mounting and the torque specification is 13.5 to 16.5 in-oz (0.095 to 0.117 N-m).



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

TYPICAL FLOW CHARACTERISTICS



* Lohm rating of each valve model is based on air performance. Curves shown above depict empirical data from actual product performance on water.

GENERAL ACCESSORIES/ REPLACEMENT PARTS

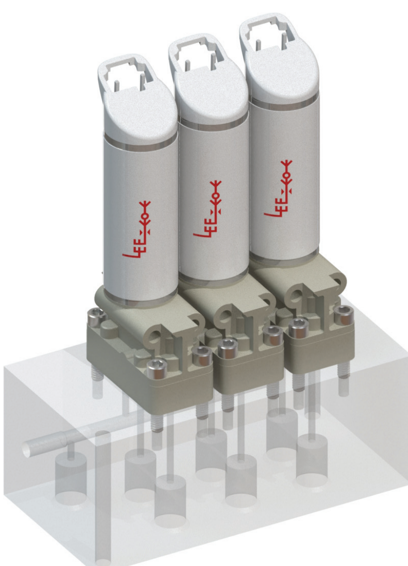
PART NUMBER	DESCRIPTION
LHWX0213420A	Mounting Screws, #2 (or 2 mm), 0.438" length
LSWX0504300A	Lead Wire Connector, 6" length
LSWX0606700A	Lead Wire Connector, 24" length
LHWX0218130A	FKM Gasket (Manifold Mount Valve)
LHWX0218130A	EPDM Gasket (Manifold Mount Valve)
LSWX0508210A	FFKM Gasket (Manifold Mount Valve)

STANDARD MANIFOLDS

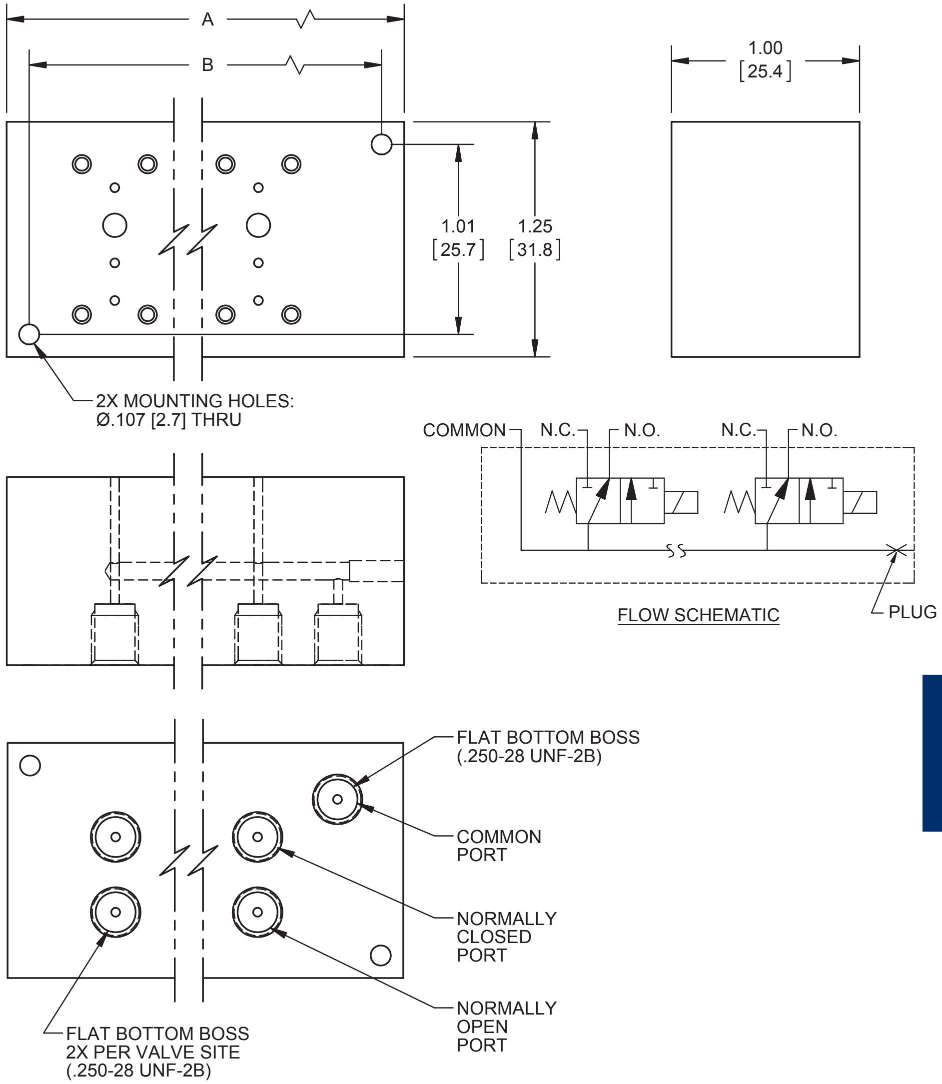
To ease prototype setup, we offer several standard manifolds compatible with our manifold mount valves. These manifolds are available in two-valve through five-valve PEEK and PMMA options. Alternate materials and customized manifold designs are available upon request.

PART NUMBER[1]		NUMBER OF VALVE POSITIONS	DIMENSION "A"	DIMENSION "B"
PMMA	PEEK			
LSMX0501402C	LSMX0501412C	Manifold, 2x	1.90" (48.26 mm)	1.66" (42.16 mm)
LSMX0501403C	LSMX0501413C	Manifold, 3x	2.45" (62.23 mm)	2.21" (56.13 mm)
LSMX0501404C	LSMX0501414C	Manifold, 4x	3.00" (76.20 mm)	2.76" (70.10 mm)
LSMX0501405C	LSMX0501415C	Manifold, 5x	3.55" (84.07 mm)	3.31" (84.07 mm)
LSMX0501406C	LSMX0501416C	Manifold, 6x	4.10" (104.10 mm)	3.86" (98.04 mm)

(1) Manifold part numbers include the manifold and mounting screws only. All solenoid valves are sold separately. Each manifold has a shared header line that interconnects the common port of each valve. There is an individual ¼-28 flat bottom connection to each normally closed port and normally open port, as shown in the artwork on the opposite page. Refer to Manifold Assemblies (Section M) for custom design capabilities.



STANDARD MANIFOLDS



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all LFR Series solenoid valves, unless otherwise noted.

CYCLE LIFE

The valves will typically operate across a minimum of 10 million cycles on water, depending on application conditions.

WEIGHT

27 to 31 grams

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage ± 5%.

OPERATING TEMPERATURE

- Ambient operating temperature range is dependent on the elastomer. Refer to table below for details.
- Increasing the operating temperature tends to limit coil performance. Maximum internal coil temperature not to exceed 200°F (90°C). To ensure solenoid coil temperatures remain within specification, duty cycle limitations may be required. Contact The Lee Company for recommendations specific to your application.

ELASTOMER	AMBIENT OPERATING TEMPERATURE RANGE
EPDM	30°F to 120°F (-1°C to 49°C)
FKM	45°F to 120°F (7°C to 49°C)
FFKM	80°F to 120°F (27°C to 49°C)

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

RESPONSE TIME

- The typical response time is:
  - EPDM/FKM: 30 ms at 68°F (20°C), on air under vacuum.
  - FFKM: 75 ms at 80°F (27°C), on air under vacuum.
- Response times are dependent upon system conditions, power, environment, etc. The response will typically increase as the ambient operating temperature decreases. Extended periods of valve inactivity may also have an impact on the initial response time of the valve.

ELECTRICAL CONNECTIONS

There are two different connection designs available:

- *Lead wires:* valves are supplied with 6", #26 AWG lead-wires with the ends of the wires stripped and tinned. An electrical connector can be added as part of a custom design.
- *Pins with locking end caps:* valves are supplied with two 0.025" square electrical pins spaced 0.20" center-to-center. This design should be compatible for use with standard electrical connectors designed for 0.10" spacing. There is an added secondary retention clip that is compatible with AMP part number 104257 style connectors. The Lee Company also offers compatible lead wire assemblies in two different lengths.

ELECTRICAL CHARACTERISTICS

- Standard operating voltages available: 12 and 24 Vdc (± 5%)
- Refer to individual valve tables on pages F2-6 for power consumption.
- The valves are designed for continuous duty operation. Following actuation at nominal voltage, the voltage can be lowered to a hold voltage that is 50% of the rated nominal voltage. This will reduce power consumption and heat. Refer to pages Q39-45, for information on electrical drive schematics.

FILTRATION

Filtration of 35 microns or finer is recommended.

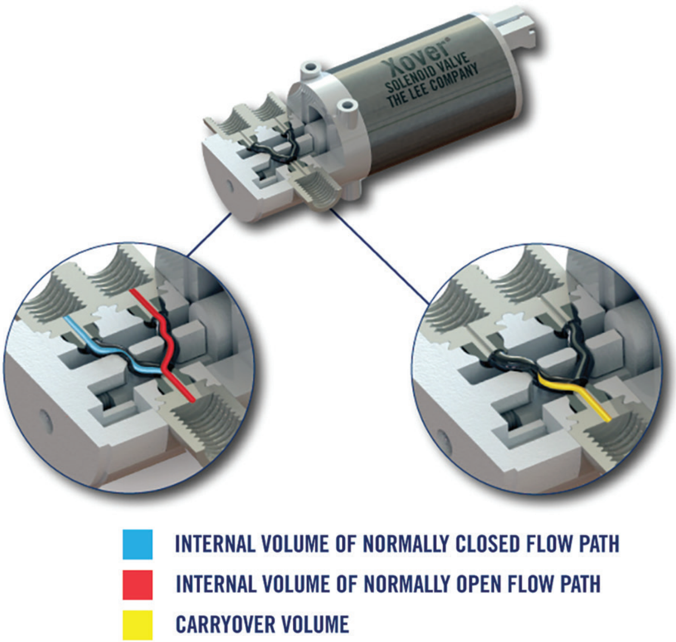
Xover®
SOLENOID VALVE
THE LEE COMPANY
NC
ON
COM

The Xover® solenoid valve is a revolutionary inert, internal pinch-tube valve designed to minimize reagent consumption, improve throughput, and **maintain the vitality of cells**. Available with either ¼-28 flat bottom or 062 MINSTAC® fluidic port connections, Xover configurations boast low internal volumes and a **smooth, low shear, easily flushable fluid path** on all models. The 3-way configuration features an **innovative Y-shaped elastomer tube**, which offers **ultra low carryover volume** when switching between fluids. This tube also allows for single-plane flow through the valve, keeping fluid flow laminar and minimizing mixing. The valve is also offered in a 2-way normally closed or a 2-way normally open configuration. Unlike conventional, replaceable external pinch-tube designs, the Xover boasts a robust, integrated pinch-tube that will **never need replacement during the valve's extensive life**, and consistently switches in 40 ms or less. It is ideal for applications in **flow cytometry, gene sequencing**, and **analytical chemistry**.

FEATURES:

- Ultra low carryover volume: as low as 3.7 µL
- Zero dead volume: excellent flushability
- Low internal volume: as low as 11 µL
- Laminar flow path: low shear, minimizes mixing
- Operating pressure: Vac to 30 psig
- Long, maintenance-free cycle life

Each valve is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company can customize valves to meet specific application requirements.



3-WAY, 062 MINSTAC PORTS

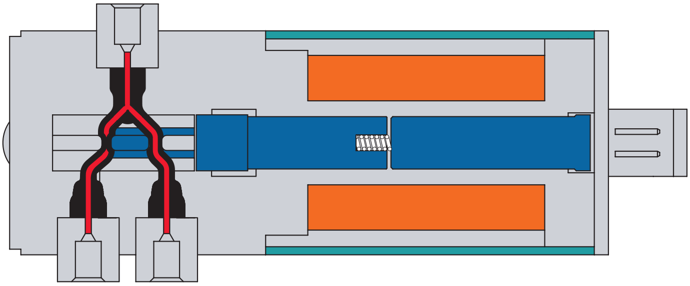
The 3-way (3/2) Xover is available with 062 MINSTAC ports, which allow simple connection to our MINSTAC tubing assemblies and components. With chamfered PTFE fitting ends that facilitate smooth liquid flow, and narrow tubing diameters (0.012" ID, 0.032" ID, or 0.04" ID standards) that reduce fluid volume, this style of valve further minimizes swept volume in your setup. All standard models feature:

- **Wetted materials:** PEEK (ports), treated FKM (tube)
- **Operating pressure:** Vac to 30 psig
- **Cycle life:** 5 million cycles minimum on water
- **Power consumption:** 2.1 W; rated for continuous duty
- For additional specifications, see pages G12-13.

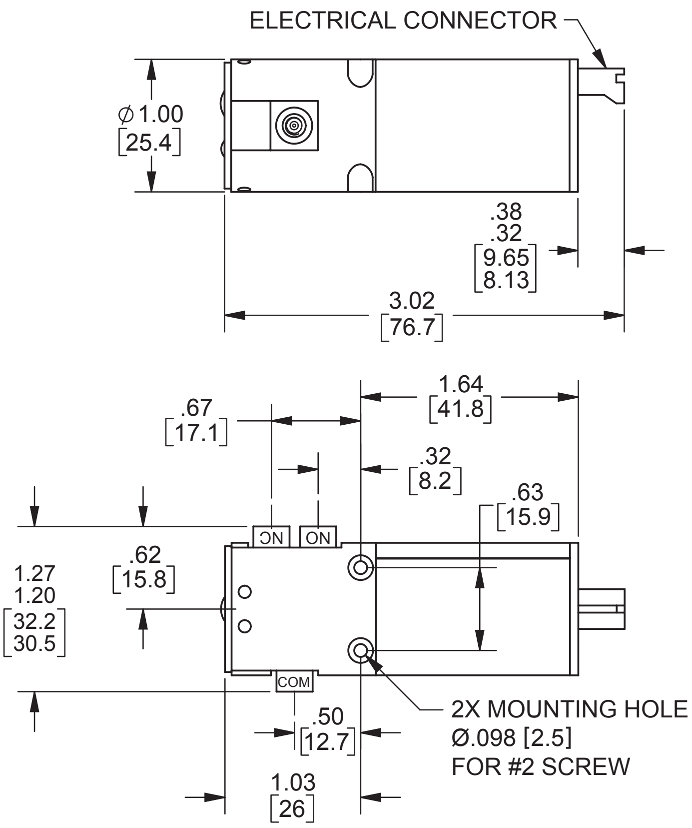
PART NUMBER	VOLTAGE (Vdc)	LOHM[1] RATE (Cv)	INTERNAL VOLUME (µL)	CARRYOVER VOLUME[2] (µL)	MINIMUM PASSAGE SIZE[3]
LXRA1202000B	12	3800 Lohms (0.005)	11	3.7	0.008" (200 microns)
LXRA2402000B	24	3800 Lohms (0.005)	11	3.7	0.008" (200 microns)

(1) Maximum Lohm rate on air. Refer to Section Q for a full description of the Lohm Laws. Reference page G13 for typical flow characteristics on water.
(2) Carryover volume is defined as the internal volume between the open flow path and the pinch point internal to the valve.
(3) Valves can pass soft, spherical media (such as cells) within the listed passage size limitations. To protect against hard particulate contamination, filtration of 35 microns or finer is recommended.

3-WAY, 062 MINSTAC PORTS



Flow Path
Housing & Ports
Tube
Coil
Shield
Armature & Plunger Stop
Spring



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

3-WAY, ¼-28 FLAT BOTTOM PORTS

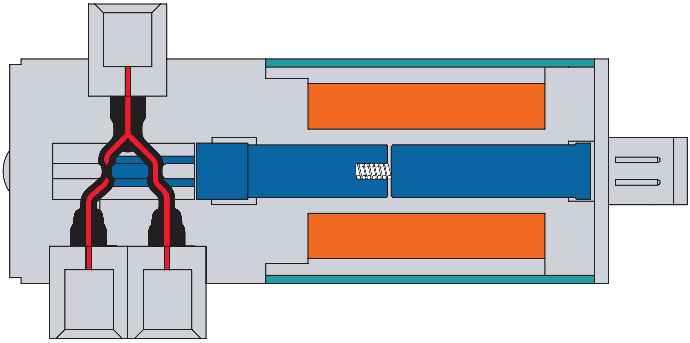
The 3-way (3/2) Xover is available with ¼-28 flat bottom ports in two different internal tube sizes, offering lower internal volume or higher flow rates and larger passage sizes. All standard models feature:

- **Wetted materials:** PEEK (ports), treated FKM (tube)
- **Operating pressure:** Vac to 30 psig
- **Cycle life:** 5 million cycles minimum on water
- **Power consumption:** 2.1 W; rated for continuous duty
- For additional specifications, see pages G12-13.

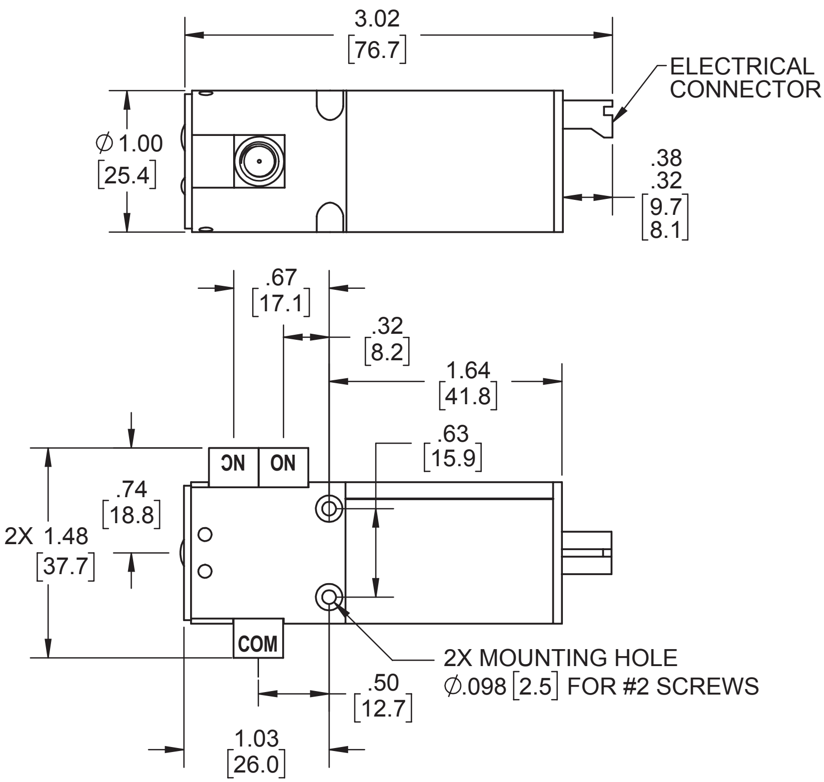
PART NUMBER	VOLTAGE (Vdc)	LOHM[1] RATE (Cv)	INTERNAL VOLUME (µL)	CARRYOVER VOLUME[2] (µL)	MINIMUM PASSAGE SIZE[3]
LXRA1201000B	12	3800 Lohms (0.005)	11	3.7	0.008" (200 microns)
LXRA2401000B	24	3800 Lohms (0.005)	11	3.7	0.008" (200 microns)
LXRA1205000B	12	1050 Lohms (0.02)	32	9.9	0.012" (300 microns)
LXRA2405000B	24	1050 Lohms (0.02)	32	9.9	0.012" (300 microns)

(1) Maximum Lohm rate on air. Refer to Section Q for a full description of the Lohm Laws. Reference page G13 for typical flow characteristics on water.
(2) Carryover volume is defined as the internal volume between the open flow path and the pinch point internal to the valve.
(3) Valves can pass soft, spherical media (such as cells) within the listed passage size limitations. To protect against hard particulate contamination, filtration of 50 microns or finer is recommended for 1050 Lohm models, or 35 microns or finer for 3800 Lohm models.

3-WAY, ¼-28 FLAT BOTTOM PORTS



Flow Path	Housing & Ports	Tube
Coil	Shield	
Armature & Plunger Stop	Spring	



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

2-WAY NORMALLY CLOSED, ¼-28 FLAT BOTTOM PORTS

The 2-way (2/2) normally closed Xover is available with ¼-28 flat bottom ports. All standard models feature:

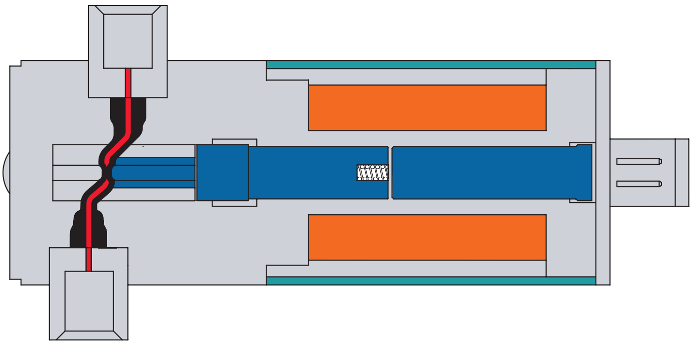
- **Wetted materials:** PEEK (ports), treated FKM (tube)
- **Operating pressure:** Vac to 30 psig
- **Cycle life:** 5 million cycles minimum on water
- **Power consumption:** 2.1 W; rated for continuous duty
- For additional specifications, see pages G12-13.

PART NUMBER	VOLTAGE (Vdc)	LOHM[1] RATE (Cv)	INTERNAL VOLUME (µL)	MINIMUM PASSAGE SIZE[2]
LXRA1205100B	12	1050 Lohms (0.02)	19	0.012" (300 microns)
LXRA2405100B	24	1050 Lohms (0.02)	19	0.012" (300 microns)

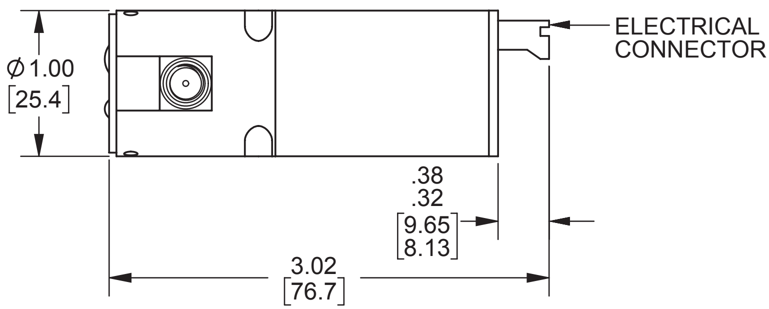
(1) Maximum Lohm rate on air. Refer to Section Q for a full description of the Lohm Laws. Reference page G13 for typical flow characteristics on water.

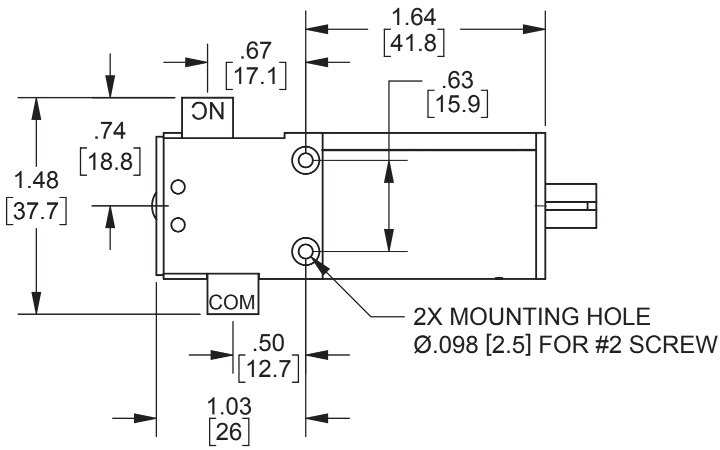
(2) Valves can pass soft, spherical media, (such as cells) within the listed passage size limitations. To protect against hard particulate contamination, filtration of 50 microns or finer is recommended for 1050 Lohm models, or 35 microns or finer for 3800 Lohm models.

2-WAY NORMALLY CLOSED, ¼-28 FLAT BOTTOM PORTS



- Flow Path
- Coil
- Armature & Plunger Stop
- Housing & Ports
- Shield
- Spring
- Tube





Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

2-WAY NORMALLY OPEN, ¼-28 FLAT BOTTOM PORTS

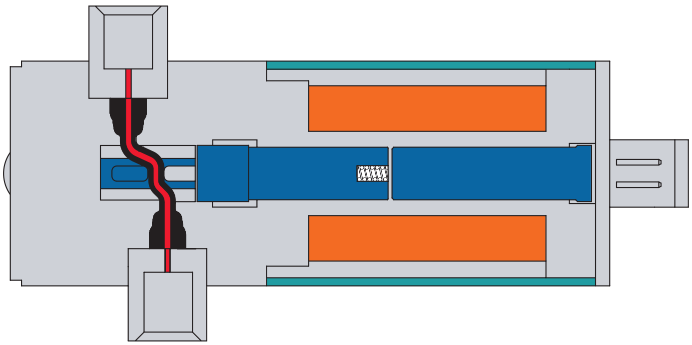
The 2-way (2/2) normally open Xover is available with ¼-28 flat bottom ports. All standard models feature:

- **Wetted materials:** PEEK (ports), treated FKM (tube)
- **Operating pressure:** Vac to 30 psig
- **Cycle life:** 5 million cycles minimum on water
- **Power consumption:** 2.1 W; rated for continuous duty
- For additional specifications, see pages G12-13.

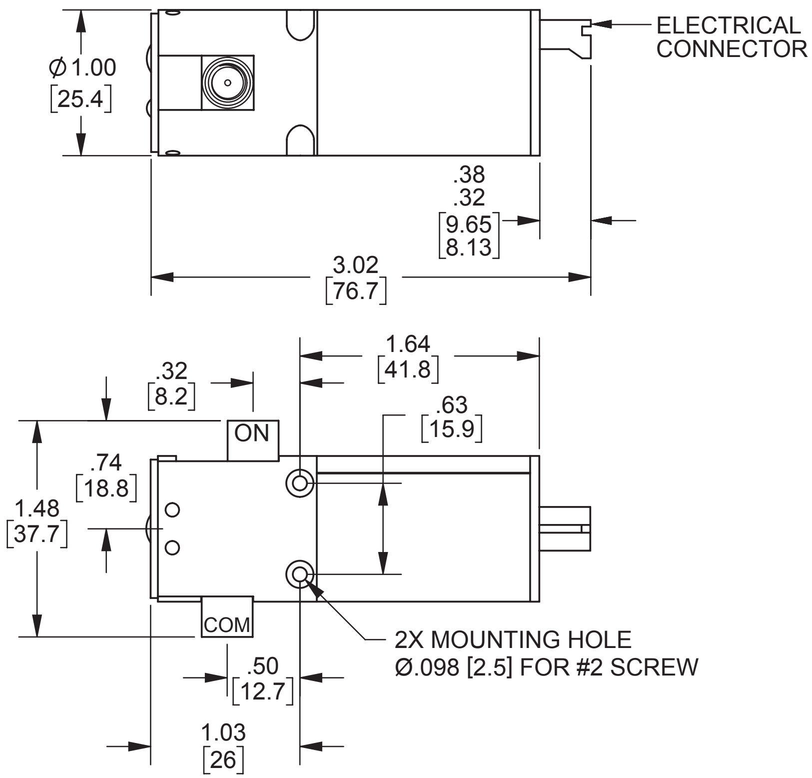
PART NUMBER	VOLTAGE (Vdc)	LOHM[1] RATE (Cv)	INTERNAL VOLUME (μL)	MINIMUM PASSAGE SIZE[2]
LXRA1205200B	12	1050 Lohms (0.02)	19	0.012" (300 microns)
LXRA2405200B	24	1050 Lohms (0.02)	19	0.012" (300 microns)

(1) Maximum Lohm rate on air. Refer to Section Q for a full description of the Lohm Laws. Reference page G13 for typical flow characteristics on water.
(2) Valves can pass soft, spherical media (such as cells) within the listed passage size limitations. To protect against hard particulate contamination, filtration of 50 microns or finer is recommended for 1050 Lohm models, or 35 microns or finer for 3800 Lohm models.

2-WAY NORMALLY OPEN, ¼-28 FLAT BOTTOM PORTS



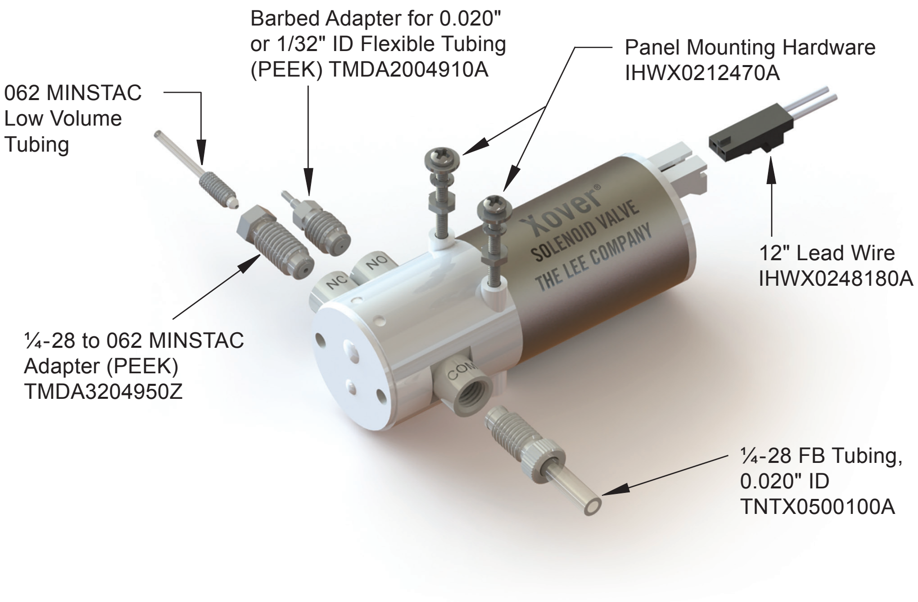
Flow Path | Housing & Ports | Tube
Coil | Shield
Armature & Plunger Stop | Spring



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

STARTER KITS & ACCESSORIES

The Lee Company offers accessories and starter kits (with and without valves) to help you adapt to your system or prototype setup quickly.



See exploded view above for various Xover accessories (shown with a 3-way, ¼-28 flat bottom model of the valve). Starter kits do not include all accessories shown in this image. Reference starter kit table on opposite page for included components. All accessories are available for individual purchase using the listed part numbers. Additional accessories can be found in Section N (MINSTAC).

STARTER KITS & ACCESSORIES

PART NUMBER	DESCRIPTION
IKTX0322860A[1]	Starter Kit (062 MINSTAC models): three TUTC1226930L Tubing Assemblies, one IHWX0212470A Panel Mounting Hardware Kit, three TMDA3207950Z 062 MINSTAC to 0.042" ID Soft Tubing Adapters, and a IHWX0248180A Lead Wire.
IKTX0322850A[1]	Starter Kit (¼-28 models): three TNTX0500100A Tubing Assemblies, one IHWX0212470A Panel Mounting Hardware Kit, three TMDA2004910A ¼-28 Flat Bottom to 1/32" ID Flexible Tubing Adapters, and a IHWX0248180A Lead Wire
IKTX0322760A	Starter Kit: one LXRA2401000B ¼-28 3-way Xover valve (24 Vdc, 3800 Lohms), three TNTX0500100A Tubing Assemblies, one IHWX0212470A Panel Mounting Hardware, and a IHWX0248180A 12" Lead Wire
IKTX0322770A	Starter Kit: one LXRA1201000B ¼-28 3-way Xover valve (12 Vdc, 3800 Lohms), three TNTX0500100A Tubing Assemblies, one IHWX0212470A Panel Mounting Hardware, and a IHWX0248180A 12" Lead Wire
TMDA2004910A	Barbed Adapter for 0.020" or 1/32" ID Soft Tubing; PEEK and PTFE
TMDA3204950Z	062 MINSTAC to ¼-28 FB Adapter; PEEK and PTFE
TMPA9502909Z	¼-28 Boss Plug; PEEK and PTFE
IHWX0248180A	12" Lead Wire Assembly
IHWX0212470A	Panel Mounting Hardware Kit for panels up to 0.25 of an inch thick

(1) Valve not included.

COMPATIBLE TUBING

PART NUMBER	INNER DIAMETER	LENGTH	NUMBER OF CONNECTORS	INTERNAL VOLUME (µL)	WETTED MATERIALS
TNTX0500100A[1]	0.5 mm (0.020")	30 cm (11.8")	2	61	PTFE, ETFE
TUTC1226915L[2]	0.3 mm (0.012")	15 cm (5.9")	2	11	PTFE, PCTFE
TUTC1226930L[2]	0.3 mm (0.012")	30 cm (11.8")	2	22	
TUTC1226960L[2]	0.3 mm (0.012")	60 cm (23.6")	2	44	
TUTB1226910D[1, 2]	0.3 mm (0.012")	100 cm (39.4")	1	73	

(1) Additional lengths available upon request.
(2) Requires TMDA3204950Z adapter for ¼-28 port models.

See Section N (MINSTAC) for additional tubing, adapters, and accessories.

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all Xover solenoid valves, unless otherwise noted.

CYCLE LIFE

The valve will operate across a minimum of 5 million cycles on water, depending on application conditions.

WEIGHT

93 grams nominal.

OPERATING PRESSURE

The valves operate within the specified pressure range when supplied with the rated voltage ± 5%.

Valve proof pressure: 2x maximum system pressure
Valve burst pressure: 3x maximum system pressure

OPERATING TEMPERATURE

Ambient operating temperature range is 45°F to 118° F (7°C to 48°C).

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

RESPONSE TIME

- Typical response time is 40 ms maximum based on water flow at 10 psid. Actual response times are dependent upon system conditions and may vary.
- The response is measured by the presence of flow. The movement of the armature occurs faster than flow.
- Extended periods of inactivity may impact the impact the initial response time of the valve.

FILTRATION

If properly controlled and flushed, valves can pass soft, spherical media (such as cells), within the listed passage size limitations. To protect against fibrous or hard particulate contamination, filtration of 50 microns or finer is recommended for 1050 Lohm models, or 35 microns or finer for 3800 Lohm models.

ELECTRICAL CHARACTERISTICS

- Xover is designed to operate under continuous duty at the rated voltage ± 5%.
- Electrical connector: mates with TE connectivity part number 104257-1
- See page G11 for pre-assembled lead wires for testing purposes.

MOUNTING

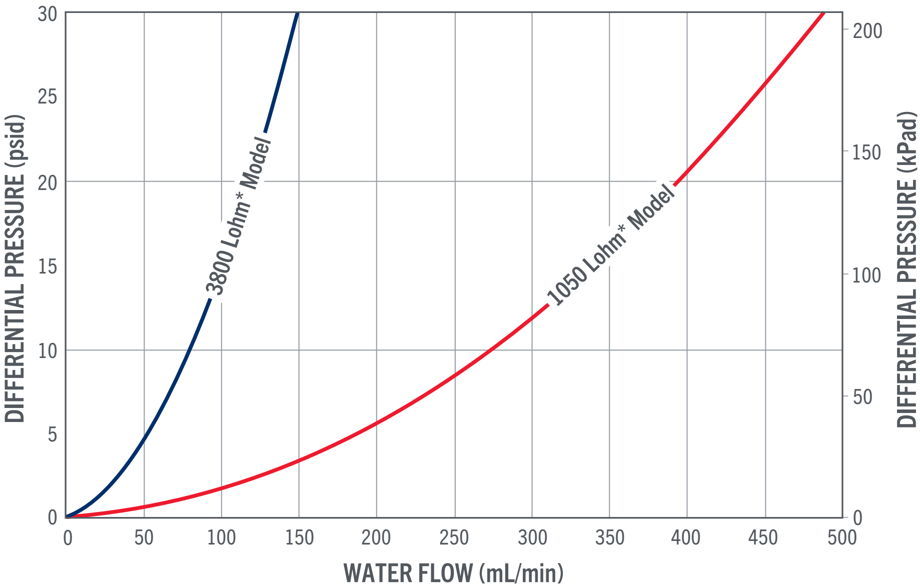
Two through holes 0.098 of an inch in diameter, 0.63 of an inch nominal spacing molded within the valve body, compatible with #2 fasteners. See page G11 for a compatible mounting hardware kit.

PORT CONNECTIONS

062 MINSTAC style compatible with 062 MINSTAC system of fittings and components. Select part numbers listed under accessories on page G11. For a full list of compatible tubing assemblies and components, see Section N (MINSTAC).

¼-28 FB ports are compatible with commonly available fitting systems. For 3-way configurations, ensure that nut diameter is 0.31 of an inch (7.9 mm) or less to avoid interference. See pages N10-12 for stock tubing assemblies.

TYPICAL FLOW CHARACTERISTICS



* Lohm rating of each valve model is based on air performance. Curves shown above depict empirical data from actual product performance on water.

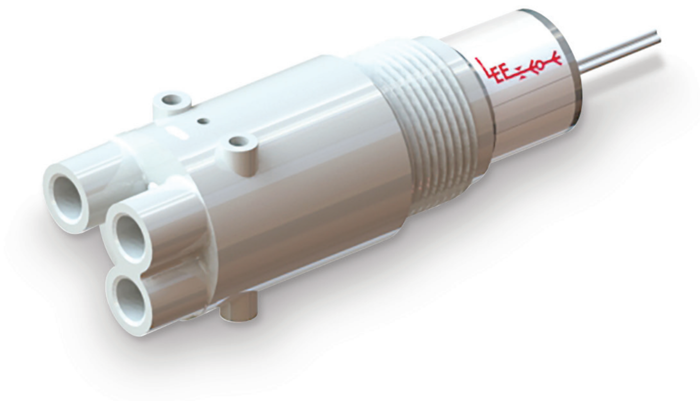
LFY SERIES
SOLENOID VALVES

The LFY Series solenoid valves are chemically inert, **internal pinch-tube valves** available in **2-way and 3-way configurations** with zero dead volume. Intended for applications flowing aggressive fluids, this valve features a unique internal pinch-block design which isolates the fluid path and minimizes internal volume. Typical applications include hematology, urinalysis, and flow cytometry.

FEATURES:

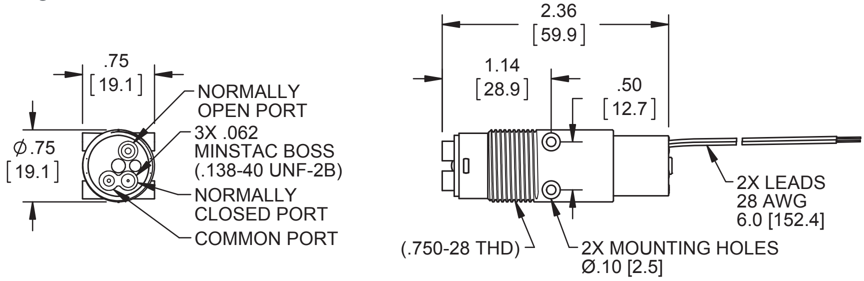
- Zero dead volume
- Low internal volume
- Operating pressure: Vac to 30 psig
- Different Lohm rates: 1000 and 3200
- Available elastomers: FKM and FFKM
- Multiple styles: 062 MINSTAC®, 156 MINSTAC (compatible with most ¼-28 fittings systems), and manifold mount

Each valve is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company can customize valves to meet specific application requirements.



3-WAY 062 MINSTAC PORT STYLE

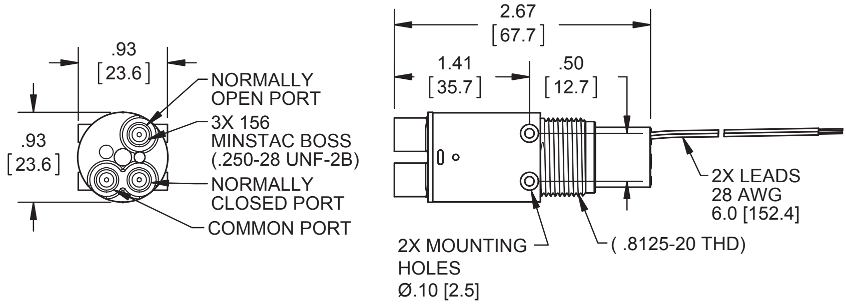
Fluidic ports compatible with 062 MINSTAC tubing system. Reference Section N for mating assemblies and accessories.



PART NUMBER	VOLTAGE (Vdc)	LOHM RATE [1]	OPERATING PRESSURE (psig)	POWER (W)	INTERNAL VOLUME [2] (μL)	WETTED MATERIALS [3]
LFYA1218032H	12	3200 (Ref. Cv = 0.006)	0-15	1.0	18	PPS/FFKM
LFYA2418032H	24		0-15	1.0	18	PPS/FFKM

3-WAY 156 MINSTAC PORT STYLE

Fluidic ports compatible with most ¼-28 flat bottom fitting systems. Reference Section N for mating assemblies and accessories.

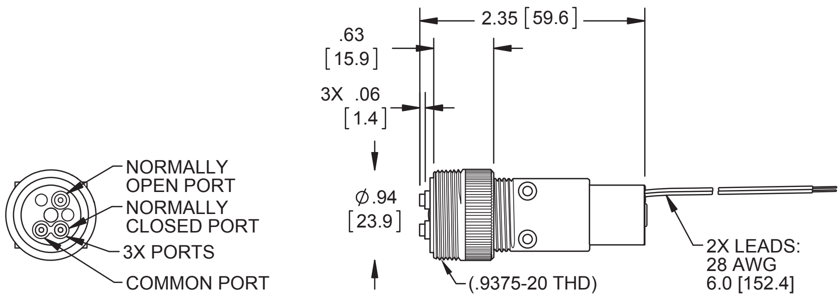


PART NUMBER	VOLTAGE (Vdc)	LOHM RATE [1]	OPERATING PRESSURE (psig)	POWER (W)	INTERNAL VOLUME [2] (μL)	WETTED MATERIALS [3]
LFYA1215010H	12	1000 (Ref. Cv = 0.02)	0-15	2.0	72	PEEK/FFKM
LFYA2415010H	24		0-15	2.0	72	PEEK/FFKM

(1) Nominal Lohm rate on air. Reference page H7 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm laws.
(2) Internal volume per channel.
(3) Other seal materials available upon request. Refer to pages Q62-63 for material information and abbreviations.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

3-WAY MANIFOLD MOUNT STYLE

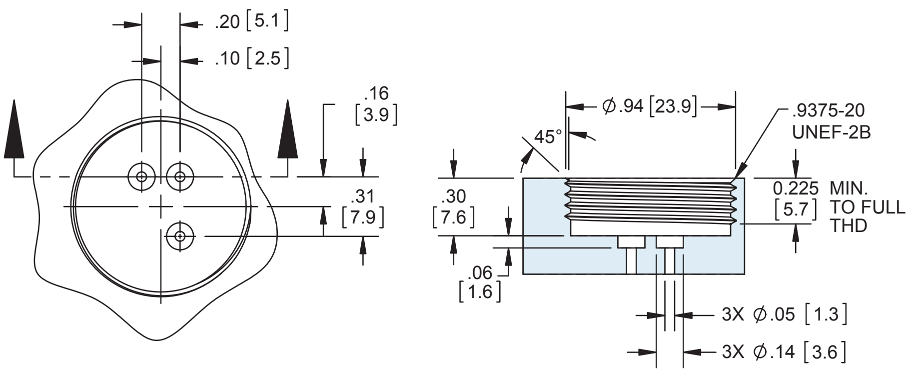


PART NUMBER	VOLTAGE (Vdc)	LOHM RATE [1]	OPERATING PRESSURE (psig)	POWER (W)	INTERNAL VOLUME [2] (μL)	WETTED MATERIALS [3]
LFYA1236032H	12	3200 (Ref. Cv = 0.006)	0-30	1.5	22	PPS/FKM

(1) Nominal Lohm rate on air. Reference page H7 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm laws.
(2) Internal volume per channel.
(3) Includes housing and internal elastomeric tubing. The 3x gaskets on external ports are FFKM. For replacement gaskets, use part number LHWX0218040A. Refer to pages Q62-63 for material information and abbreviations.

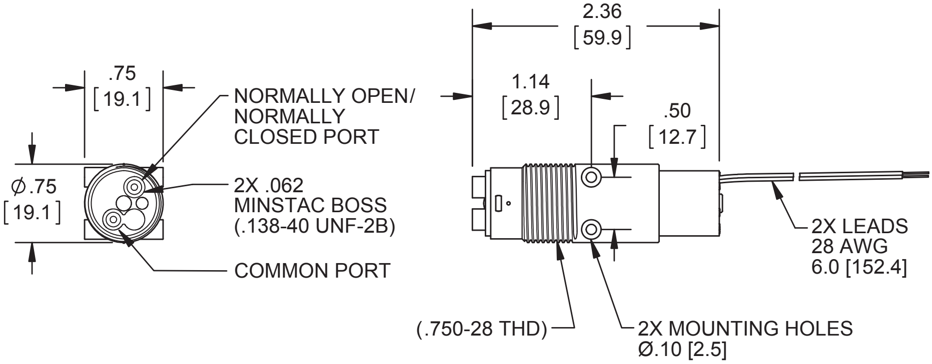
MANIFOLD MOUNT BOSS

Manifold mating boss geometries and dimension shown below are for reference only. Refer to drawing number LFIX1001350A for complete specifications.

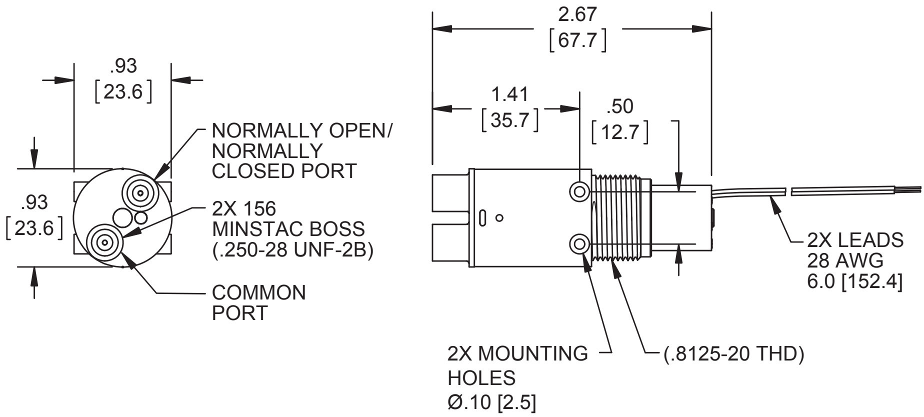


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

2-WAY 062 MINSTAC PORT STYLE



2-WAY 156 MINSTAC PORT STYLE



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

2-WAY 062 MINSTAC PORT STYLE

PART NUMBER	TYPE	VOLTAGE (Vdc)	LOHM RATE[1]	OPERATING PRESSURE (psig)	POWER (W)	INTERNAL VOLUME (µL)	WETTED MATERIALS[2]
LFYA1218232H	NO	12	3200 (Ref. Cv = 0.006)	0-15	1.0	14	PPS/FFKM
LFYA2418232H	NO	24		0-15	1.0	14	PPS/FFKM
LFYA1218132H	NC	12		0-15	1.0	11	PPS/FFKM
LFYA2418132H	NC	24		0-15	1.0	11	PPS/FFKM

(1) Nominal Lohm rate on air. Reference page H7 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm laws.
(2) Refer to pages Q62-63 for material information and abbreviations.

2-WAY 156 MINSTAC PORT STYLE
COMPATIBLE WITH MANY ¼-28 SYSTEMS

PART NUMBER	TYPE	VOLTAGE (Vdc)	LOHM RATE[1]	OPERATING PRESSURE (psig)	POWER (W)	INTERNAL VOLUME (µL)	WETTED MATERIALS[2]
LFYA1215210H	NO	12	1000 (Ref. Cv = 0.006)	0-15	2.0	54	PEEK/FFKM
LFYA2415210H	NO	24		0-15	2.0	54	PEEK/FFKM
LFYA1215110H	NC	12		0-15	2.0	54	PEEK/FFKM
LFYA2415110H	NC	24		0-15	2.0	54	PEEK/FFKM

(1) Nominal Lohm rate on air. Reference page H7 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm laws.
(2) Refer to pages Q62-63 for material information and abbreviations.

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all LFY Series solenoid valves, unless otherwise noted.

CYCLE LIFE

The valves will typically operate across a minimum of 5 million cycles on water, depending on application conditions.

WEIGHT

40 to 43 grams

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage ± 5%.

Valve proof pressure: 2x maximum system pressure

Valve burst pressure: 3x maximum system pressure

OPERATING TEMPERATURE

- Ambient operating temperature range is 60°F to 118°F (16°C to 48°C).
- Maximum coil temperature not to exceed 250°F (121°C).
- Increasing the operating temperature tends to limit coil performance. The valve duty cycle and energized time must be evaluated for conformance with the maximum rated operating and coil temperatures.

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

RESPONSE TIME

- The typical response time is 50 ms at 65°F (18°C).
- Response times are dependent upon system conditions, power, environment, etc. Extended periods of valve inactivity may also have an impact on the initial response time of the valve.

ELECTRICAL CHARACTERISTICS

Valves are designed to operate under continuous duty at the rated voltage ± 5%.

MOUNTING INFORMATION

Surface Mount: the valves may be mounted to a flat surface using #2 (M2) screws and there must be sufficient length to allow for valve thickness and proper thread engagement into the mounting surface. The recommended mounting torque is 10 to 15 in-oz. (0.071 to 0.106 N-m).

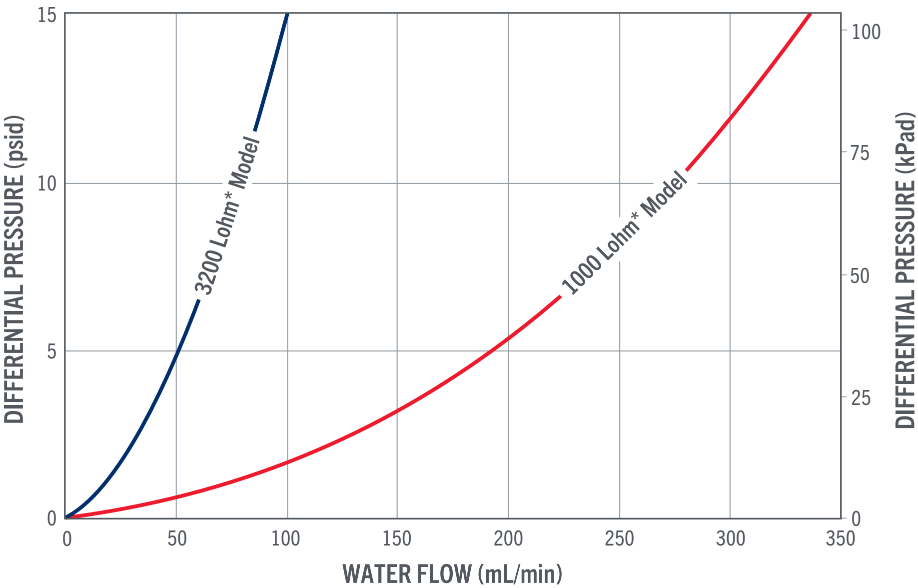
Panel Mount: the valves may also be mounted using a panel nut.

- The 3200 Lohm valve design will require a 0.79 of an inch (20 mm) clearance hole with a maximum 0.44 of an inch (11 mm) panel thickness. Use part number LHWX0203250A (Panel Nut) to mount the valve.
- The 1000 Lohm valve design will require a 0.83 of an inch (21 mm) clearance hole with a maximum 0.44 of an inch (11 mm) panel thickness. Use part number LHWX0203760A (Panel Nut) to mount the valve.

FILTRATION

Filtration of 35 microns or finer is recommended.

TYPICAL FLOW CHARACTERISTICS



* Lohm rating of each valve model is based on air performance. Curves shown above depict empirical data from actual product performance on water.

The LSP Series internal pinch-tube solenoid valves are chemically inert, 2-way, normally closed, isolation valves with **just one wetted material (the tube)**, zero dead volume, and **high flow capability for rapid flushing**. It features a unique internal pinch-block design with a full bore-tubed path which minimizes damage to sensitive fluids flowing through the valve and ensures maximum flushing.

These valves are generally used in waste and drain lines in medical and scientific applications, in markets such as in vitro diagnostics, genomics, and biotechnology.

FEATURES:

- High flow capability: 330 Lohms (Cv = 0.06)
- One wetted material: FKM
- Designed for applications requiring rapid flushing
- Manifold mount
- Extensive cycle life: 10 million cycles minimum (water)

Each valve is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company can customize valve performance to meet specific application requirements.

MANIFOLD MOUNT

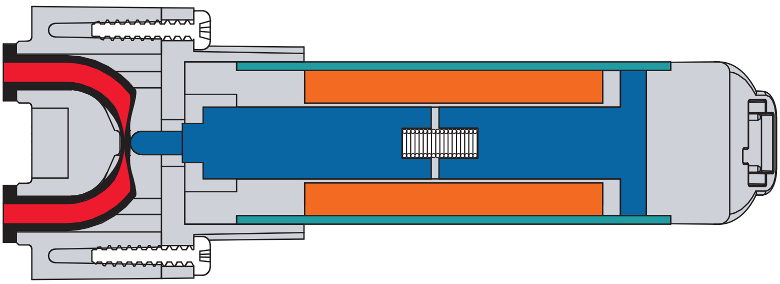
The internal tubing of this manifold mount, 2-way, normally closed, bi-directional pinch-tube valve is also integrated onto the external port connections. This enables simple manifold integration by eliminating the need for a secondary sealing gasket between the valve and mounting surface.

- **Zero dead volume:** 100% flushable
- **Internal volume:** 100 µL
- **Wetted material:** FKM
- **Standard drive voltage:** 12 or 24 Vdc. Customization available upon request.

PART NUMBER	VOLTAGE (Vdc)	LOHM RATE (Cv)	OPERATING PRESSURE (psig)	POWER CONSUMPTION (W)
LSPA1242130D	12	330 Lohms (0.06)	0-15	3
LSPA2442130D	24		0-15	3

(1) Nominal Lohm rate on air. Reference page I7 for typical flow characteristics on water. Refer to Section Q for a full description of the Lohm laws.
(2) Refer to pages Q62-63 for material information and abbreviations.

MANIFOLD MOUNT



Flow Path

Coil

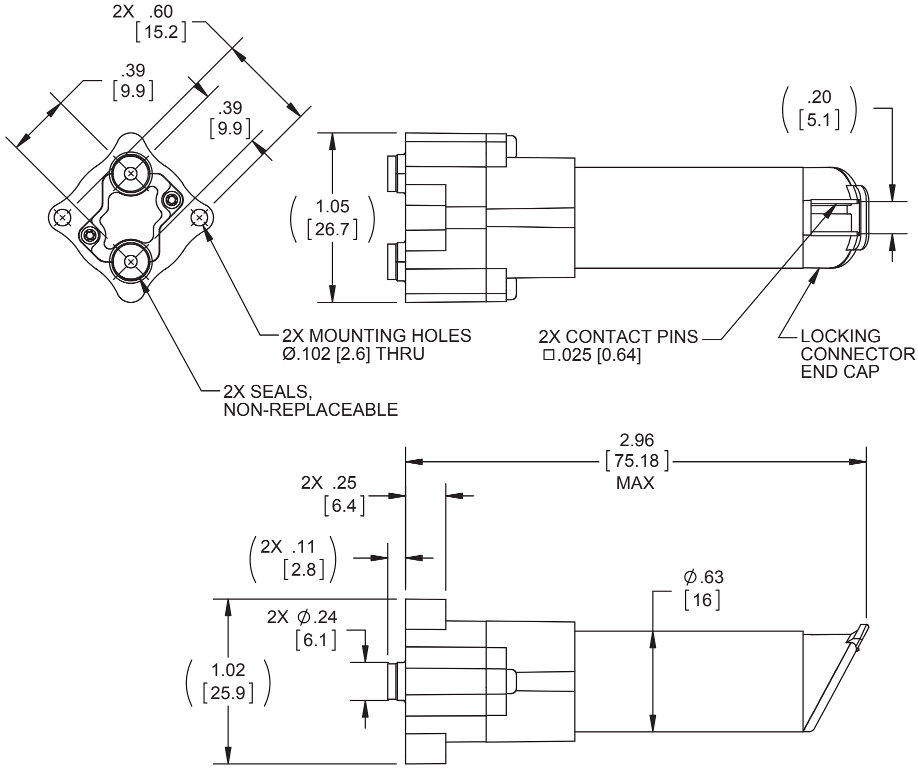
Armature & Plunger Stop

Housing

Shield

Spring & Screws

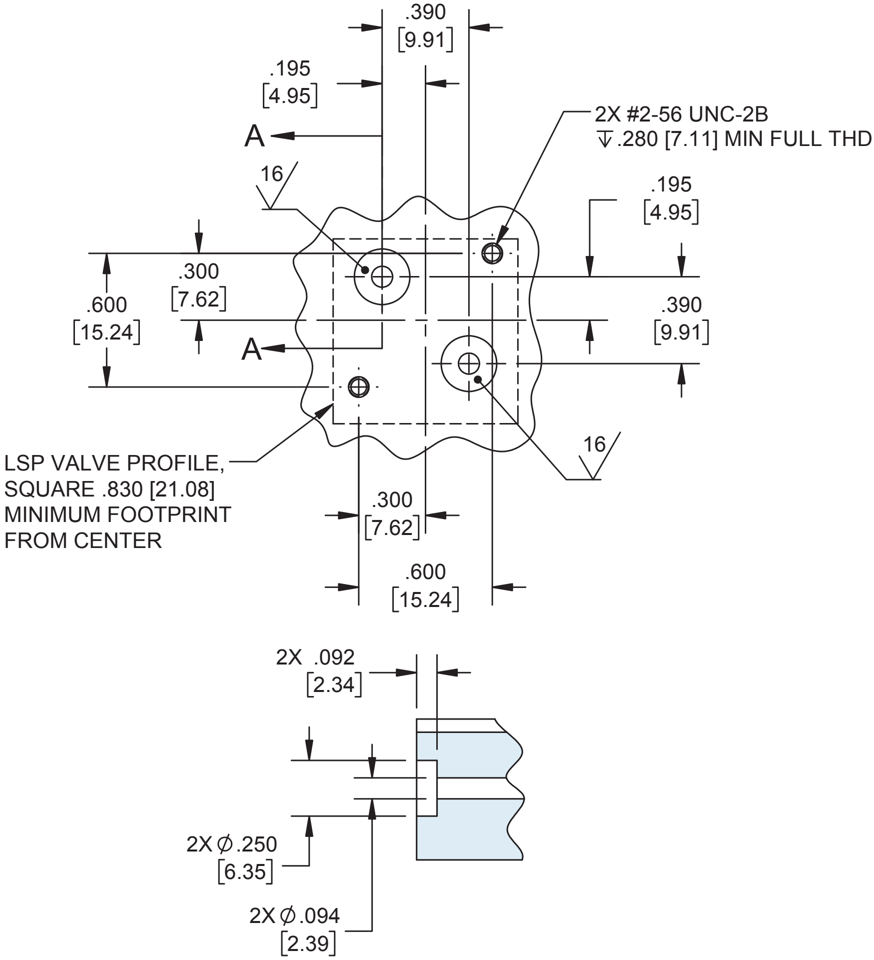
Seal (elastomer tube)



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MOUNTING & FLUIDIC CONNECTIONS

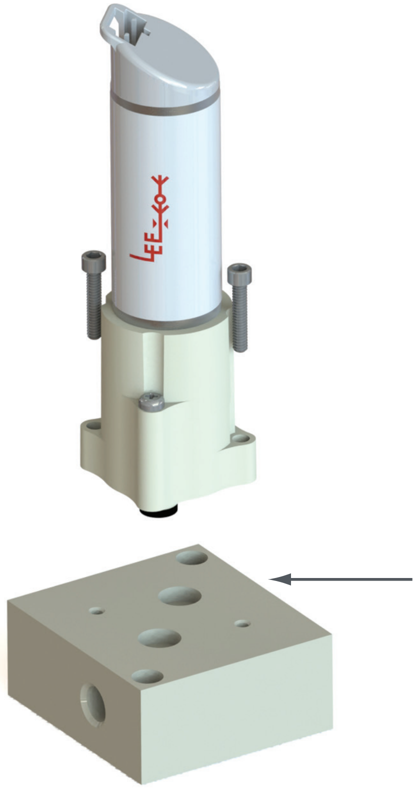
Manifold mating boss geometries and dimensions shown below are for reference only. Refer to drawing number LSIX1001450A complete specifications.



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MOUNTING & FLUIDIC CONNECTIONS

Flange manifold mount-style LSP valves should be mounted using #2 (M2) screws. The torque specification is 10 to 15 in-oz (0.071 to 0.106 N-m).



¼-28 manifold adapter available in two materials. See table below.

GENERAL ACCESSORIES

PART NUMBER	DESCRIPTION
LSWX0504300A	Lead Wire Connector, 6" length
LSWX0606700A	Lead Wire Connector, 24" length
LSMX0517560B	PEEK Manifold Adapter for connection to ¼-28 ports
LSMX0517570B	PMMA Manifold Adapter for connection to ¼-28 ports
LHWX0213420A	Screw, SHC, #2-56 x 0.438" SS

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all LSP Series solenoid valves, unless otherwise noted.

CYCLE LIFE

The valves will typically operate across a minimum of 10 million cycles on water, depending on application conditions.

WEIGHT

57 grams

OPERATING PRESSURE

The valves will operate within the specified pressure range when supplied with the rated voltage ± 5%.

OPERATING TEMPERATURE

- Ambient operating temperature range is 40°F to 150°F (4°C to 65°C)
- Maximum coil temperature not to exceed 180°F (82°C)
- Increasing the operating temperature tends to limit coil performance. The valve duty cycle and energized time must be evaluated for conformance with the maximum rated operating and coil temperatures.

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

RESPONSE TIME

- The typical response time is 30 ms maximum at 70°F (21°C), on air at 5 psig.
- Response times are dependent upon system conditions, power, environment, etc. The response will typically increase as the ambient operating temperature decreases and decrease as operating pressure increases. Extended periods of valve inactivity may also have an impact on the initial response time of the valve.

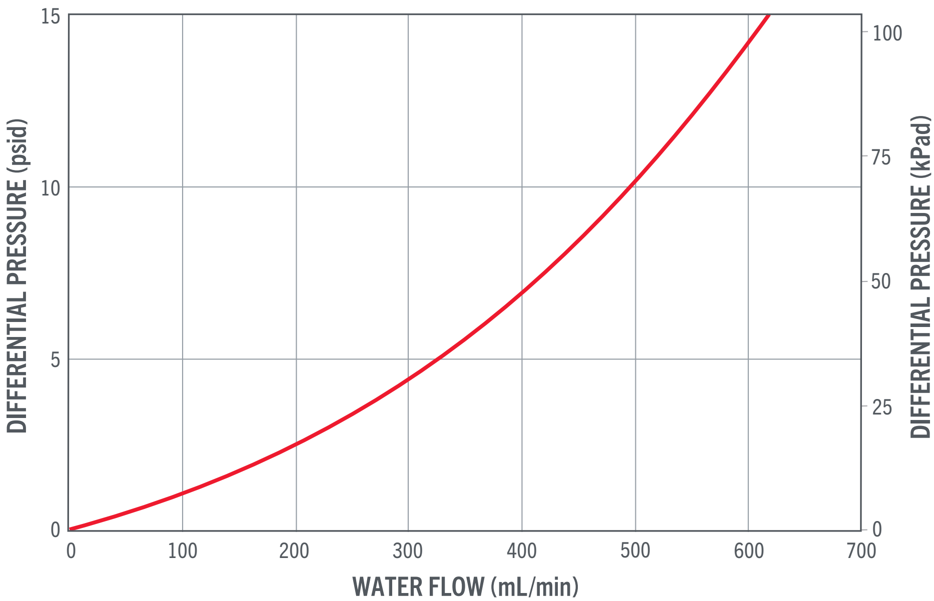
ELECTRICAL CHARACTERISTICS

Valves are designed to operate under continuous duty at the rated voltage ± 5%.

FILTRATION

Filtration of 100 microns or finer is recommended.

TYPICAL FLOW CHARACTERISTICS



Lohm rating of each valve is based on air performance. Curve shown above is based on empirical data of actual product performance on water.

Shown at actual size.

The disc pump is a revolutionary **miniature** (29 mm), ultrasonic, pneumatic piezoelectric micropump that **generates pressure or vacuum** in a small, **silent, vibration-free** form factor. It is available with or without integrated electronics for added simplicity. Designed for **highly accurate, ultra smooth flow control**, the disc pump delivers unrivaled pneumatic performance and enables innovation wherever precision control of small volumes is critical. While not intended to pump liquids directly, its infinite turndown ratio and pulsation-free flow allow the user to control liquids indirectly via an air-over-liquid method. The disc pump allows you to generate and control a head pressure (air) with unprecedented resolution, resulting in **impeccable precision liquid dispensing or displacement** (lab-on-a-chip). When liquids cannot be exposed to air, the pump can act upon a liquid through an elastic membrane, thereby pumping the isolated liquid through a dispensing valve in a bladder system. Each pump is 100% functionally tested and designed using materials that ensure consistent, long-term performance.

FEATURES:

- Silent (< 10 dB), vibration-free operation
- Ultra fast, millisecond response time
- High precision controllability: < 0.1%
- Lightweight (5 g), compact size (29 mm diameter)
- True pulsation-free flow

Available in five different product series, these innovative pumps are ideal for a wide range of medical, life sciences, and environmental monitoring applications, including microfluidics, pipetting, wearable devices, and portable sensing technologies.

PERFORMANCE RANGE

PRODUCT LINE	SUMMARY	STALL PRESSURE (mbar)	FREE FLOW (LPM)	STALL VACUUM (mbar)
BL Series	Entry-level pumps striking a balance between performance and cost	300	1.65	200
XP Series	Highest performance and widest temperature range of -25°C to 55°C	400	2.00	300
LT Series	Long life models offering 17,000+ hours[1] of continuous operation	270	1.20	220
HP Series	High differential pressure models	600	0.10	400
US Series	Ultra slim manifold mount pumps with an integrated filter	420	0.92	N/A

(1) Represents onset time of performance degradation. Pump will continue to operate beyond this point at a reduced performance level. Reference pages J12-13 or request Technical Guide TG005 "Wear Characteristics" for more information on pump performance over life.

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GETTING STARTED – HOW DO THEY WORK?

In contrast to conventional air pumping mechanisms (such as diaphragm and piston pumps), the disc pump does not rely on the bulk compression of air within a cavity. Instead, this micropump generates a high amplitude, high frequency acoustic standing wave within a specially designed acoustic cavity.

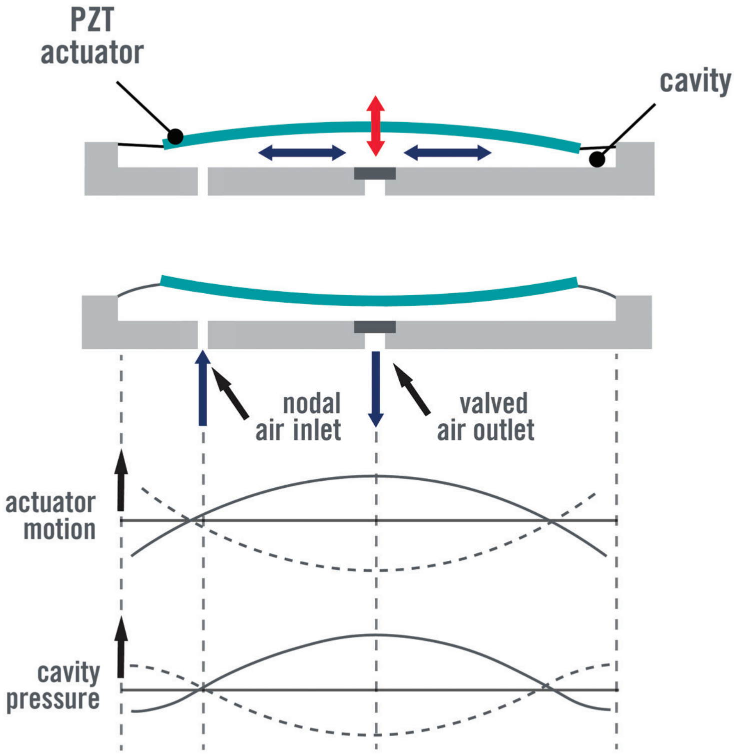

FIGURE 1: A SCHEMATIC OF THE DISC PUMP

A simplified schematic is shown in Figure 1 above. The out-of-plane motion of the actuator drives in-plane (radial) motion of the gas in the cavity and creates a standing pressure wave, resulting in the oscillating cavity pressure shown. The motion of the actuator is highly exaggerated; there is virtually no net volume change of the cavity during operation. At any given point in time, there exists both a region of compression and a region of rarefaction within the cavity. Rectification of the alternating cavity pressure is the key to delivering useful pump performance and device lifetime.

GETTING STARTED – HOW DO THEY COMPARE?

Traditional pump technologies typically operate at speeds up to 50 Hz (3000 RPM). The disc pump cycles more than 400 times faster, at 21,000 Hz (1.26 million RPM). The resulting airflow is ultra smooth and creates negligible pressure pulsations within the system. Reference Technical Guide TG013 "Pulsation Free Output" for more information.

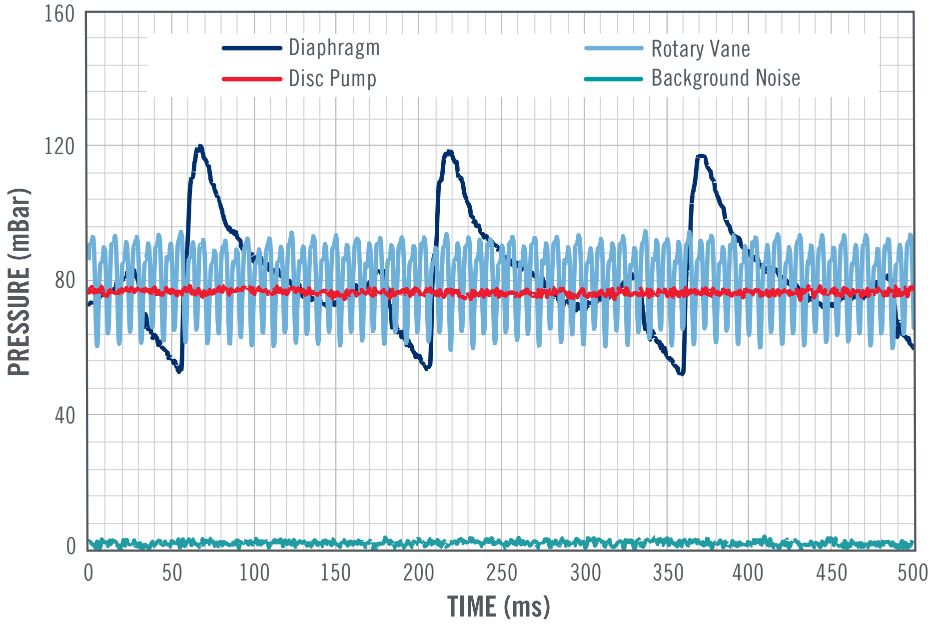

FIGURE 2: OUTPUT PULSATION FOR THREE PUMP TYPES

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GETTING STARTED – HOW DO THEY COMPARE?

Even though the disc pump cannot pump liquids directly, its set point response and pulsation free output enable it to move liquids very accurately and precisely using pressure driven flow (Figure 3). Figure 4 below shows how the disc pump compares with a syringe pump (with the disc pump offering a much better set point response and flow rate stability).

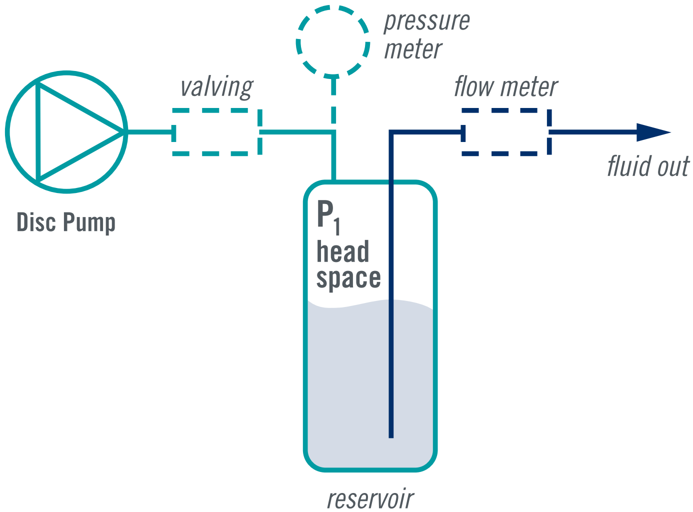


FIGURE 3: USING A DISC PUMP FOR PRESSURE DRIVEN FLOW

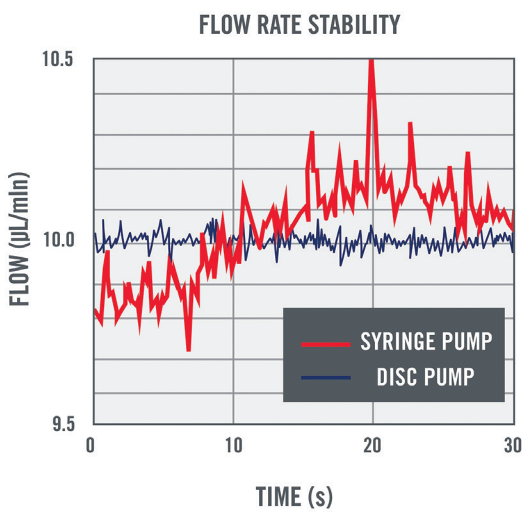


FIGURE 4: FLOW RATE STABILITY OUTPUT OF SYRINGE PUMP & DISC PUMP

GETTING STARTED – APPLICATIONS & RESOURCES

The disc pump is new technology that is enabling many markets to evolve with smaller, quieter, higher performing devices. Combined with a sensor and electronics, it is an all-in-one pressure regulator solution (see Smart Pump Module on pages J24-29), which eliminates the need for other system components — often saving not just weight, but cost.

TYPICAL APPLICATIONS:




- **Microfluidics and lab-on-a-chip:** precisely push and pull liquids through microchannels; droplet generation
- **Time-metered dosing:** precision droplet dispensing and drug delivery
- **Pipetting:** aspirate and dispense
- **Blood pressure monitoring:** measure on inflation
- **Compression therapy:** cuff inflation and deflation
- **Patient simulators:** silent, smooth flow ideal for simulating bodily functions
- **Environmental monitoring:** gas sampling
- **Pick and place robotics:** on-demand vacuum generation, no need for a main line
- **Patient monitoring:** compatible in an MRI environment

To simplify the process and help you get a running start when evaluating and integrating this technology, we offer numerous easily accessible resources. This includes application notes, technical guides, manuals, software, and a user-friendly development kit (see pages J6-9) which enables you to test the disc pump with solenoid valves. An abbreviated list of available resources is shown below. To learn more about the technology and download resources, please scan the QR code below, or contact your local Lee Sales Engineer for detailed application support.

- **Piezoelectric Disc Pump User Manual**
- **Microfluidics Application Note:** AN002
- **Pressure Driven Flow Application Note:** AN007
- **Blood Pressure Monitoring Application Note:** AN006
- **Pipetting Application Note:** AN049
- **Time-Metered Dosing Application Note:** AN059
- **Volume Controlled Method for Time-Metered Dosing:** AN074
- **Wear Characteristics Technical Guide:** TG005
- **Pulsation Free Operation:** TG013

theleeco.com/disc-pumps

GETTING STARTED – DEVELOPMENT KIT

The Disc Pump Development Kit (part number UEKA0500300A) is a versatile plug and play starter kit for product development, enables control of solenoid valves and up to five disc pumps. With a user-friendly GUI, easily accessible software, onboard pressure sensors, and integrated valve drivers, the kit offers advanced fluidic control and allows you to quickly create functional prototypes for a wide range of applications, from microfluidic and liquid handling systems to medical devices and industrial instruments.

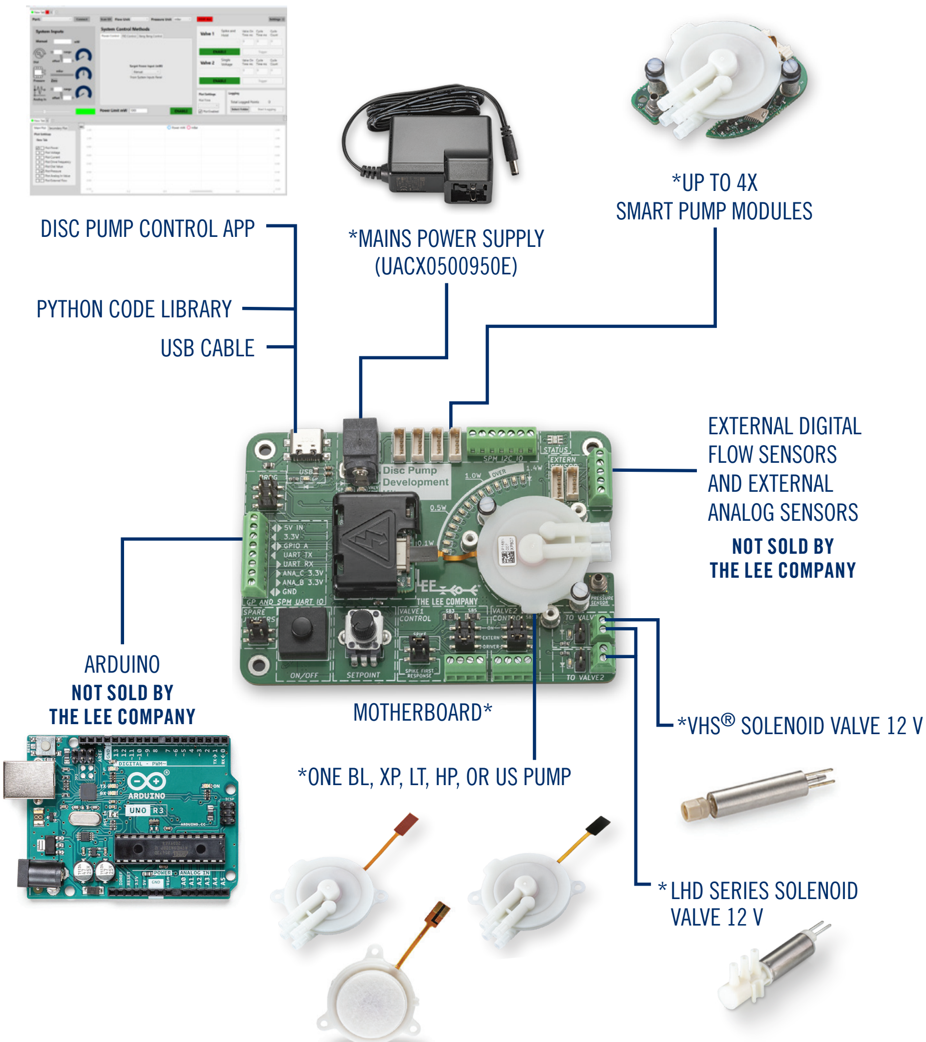
UEKA0500300A DISC PUMP DEVELOPMENT KIT INCLUDES*:

- Development Kit Motherboard (UEKA0300100A)
- General Purpose Drive PCB (UEKA0300000A) mounted on the motherboard, with protective cap
- Pneumatic accessories kit (tubing, filters and connectors)
- Precision 30k Lohm RIGX0029515S orifice (to bleed pressure from systems)
- Cable kit for connecting Smart Pump Modules and valves to the kit
- USB cable for connecting the kit to a PC
- Pump mounting kit (one set of bolts and O-rings)
- Quick Start Guide

* Note that disc pumps, solenoid valves, and power supply must be purchased separately. This enables you to select the exact model(s) that you wish to test. For assistance in selecting the right model for your application, please speak to a Lee Sales Engineer.

GETTING STARTED – DEVELOPMENT KIT

Below is an overview of the kit's capability. Note that not every product shown below is included with the kit. The mains power supply (sold separately as UACX0500950E) is required when using the kit to drive more than one pump, the Smart Pump Module, or valves. A list of recommended valve part numbers can be found on page J9, while pump part numbers for each product series can be found throughout this section.



One disc pump can be mounted directly on the motherboard. In addition, up to four Smart Pump Modules can be connected to the motherboard via the cables provided.

**Components available separately from The Lee Company.*

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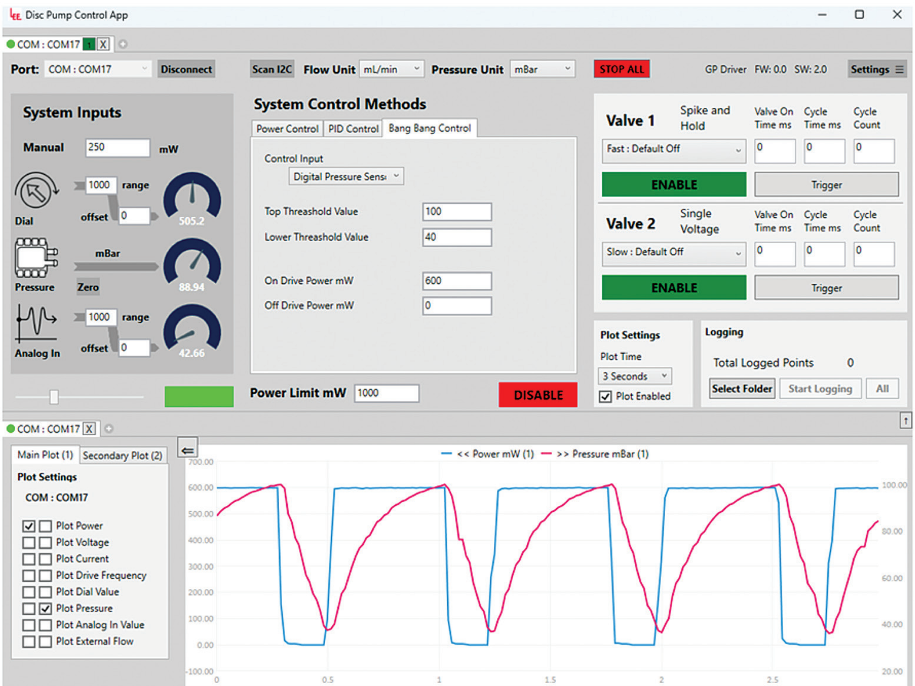
GETTING STARTED – DEVELOPMENT KIT (CONT.)

The kit can be controlled by the Disc Pump Control App (for PCs) or by the physical controls on the motherboard. More advanced control is possible via the serial communication over the USB-to-serial interface (reference Technical Guide TG003 "PCB Series Communications Guide"). Our GitHub Python code snippet library provides examples of how to get started, and our driver designs are freely available. The Development Kit also includes a screw terminal block, enabling control by other development platforms (e.g., Arduino) via an analog and digital I/O interface.

DISC PUMP CONTROL APP



LINK TO DOWNLOADS & VIDEOS

Scan the QR code for more information on the UEKA0500300A Development Kit, including instructional videos, application notes, and a link to the User Manual where you can find detailed instructions.

theleeco.com/devkit

GETTING STARTED – DEVELOPMENT KIT (CONT.)

The Development Kit allows you to get up and running quickly - not just with pumps, but with solenoid valves as well. This facilitates easy and rapid testing of a variety of system setups, whether pneumatic (pressurizing and venting a bladder or cuff), lab-on-a-chip (pushing and pulling or recirculating liquid through microchannels), pipetting, or time-metered dosing (precision dispensing). The Lee Company offers a variety of valves, nozzles, and components ideal for these fluidic systems. Below is an abbreviated list of components compatible with the Disc Pump Development Kit. For additional options with alternate seal materials, fluidic connections, etc., please reference the handbook section listed, or contact your local Lee Sales Engineer for more information.

Left: A VHS Series dispense valve shown with an interchangeable threaded nozzle on the outlet and MINSTAC® fitting assembly threaded into the inlet. Right: The compact LFMX0534570B Reversible Flow Manifold (29 x 25 x 19 mm) comes with two LHD Series valves and is plumbed to enable switching between vacuum and pressure.

PART NUMBER	DESCRIPTION	PRODUCT SERIES & CONFIGURATION	REF. SECTION[2]
LHDB1293518H	Pneumatic 3/2 control solenoid valve for direct connection to tubing. Ideal for a variety of applications.	LHD Series[1], soft tube ported-style, any port inlet, FKM, 12V	A
LFMX0534570B	Manifold and valves ideal for pushing and pulling fluids back and forth in microfluidic, lab-on-a-chip applications.	Reversible Flow Manifold, 2x LHDB1283518H[1] face mount pneumatic control valves.	A
INKX0511400A	Precision dispensing solenoid valve with outlet that enables interchangeable nozzles. Dispense range from nanoliter to microliter.	VHS Series[1], MINSTAC inlet, MINSTAC outlet (M/M), 12V, EPDM	B
INKX0514900A	Precision dispensing solenoid valve capable of 20 nanoliter to microliter precision droplet dispense.	VHS Series[1], MINSTAC inlet, hypodermic port outlet (M/SP), 12V, EPDM	B
LFNA1250225H	Inert 2/2 isolation solenoid valve. Zero dead volume, low internal volume, and low power valve for larger volume dispensing or microfluidic applications.	LFN Series[1] solenoid valve, 2-way, 12V, EPDM	D
TUTB1226930L	For connection to VHS valve MINSTAC ports.	MINSTAC Tubing Assembly, single-ended, 30 cm, 0.012" ID	N
INZA4650935K	Interchangeable nozzle for use with VHS valve.	Dispense Nozzle, .005" ID	B
INZA4630912T	Interchangeable nozzle for use with VHS valve.	Dispense Nozzle, .003" ID, .035"	B
INMX0350000A	Threads directly into VHS valve inlet port for protection against rogue contaminants.	MINSTAC 12 micron inert	N

(1) The kit is compatible with many 12V LHD Series and LFN Series valves not requiring a spike and hold drive. It is also compatible with many spike and hold 12V VHS Series valves. Contact your local Lee Sales Engineer for assistance in selecting compatible options outside of those shown in this table.
(2) Reference the listed handbook section for more information.

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The BL Series entry-level piezoelectric disc pump strikes a balance between performance and cost. The BL Series Disc Pump can be mounted as a Smart Pump Module that includes integrated drive electronics and pressure sensing.

FEATURES[1]:

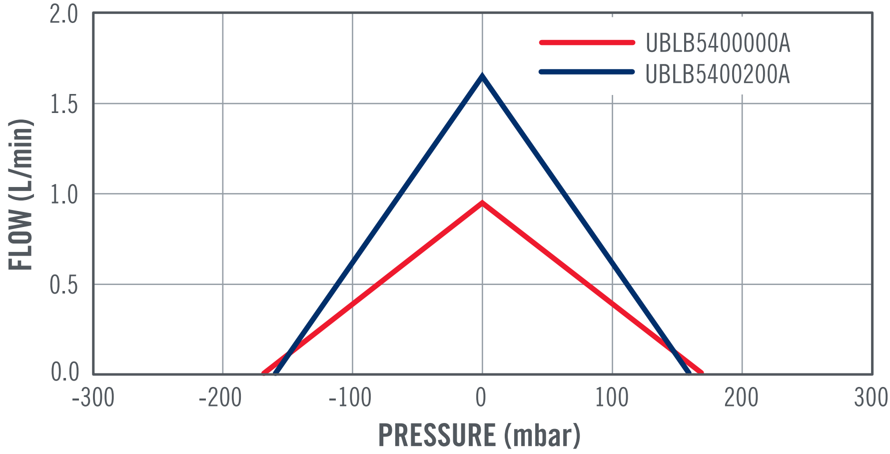
- **Pumping medium:** air. Liquids can be controlled indirectly.
- **Silent:** <10 dB
  Compact size: 29 mm diameter and lightweight (5 g)
- True pulsation-free, ultra smooth flow
- **Control precision:** <0.1%
- Ultra fast, millisecond response time
- **Power:** 0 to 1 W (continuous)
- **Operating temperature:** 41°F to 104°F (5°C to 40°C)
- **Recommended filtration:** 3 µm or less

Shown at actual size.

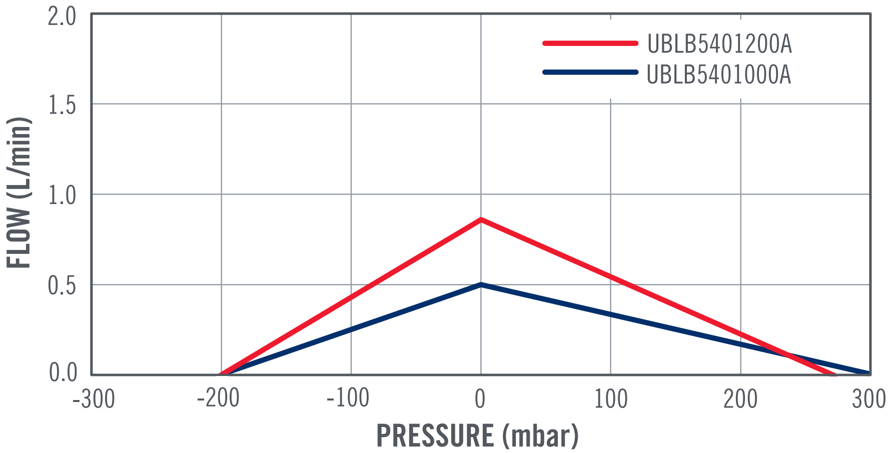
PART NUMBER	CONFIGURATION	STALL PRESSURE[2]	FREE FLOW[2]	STALL VACUUM[2]
UBLB5401000A	Series	300 mbar	0.50 L/min	200 mbar
UBLB5401200A	Series	270 mbar	0.80 L/min	200 mbar
UBLB5400000A	Parallel	170 mbar	0.95 L/min	170 mbar
UBLB5400200A	Parallel	160 mbar	1.65 L/min	150 mbar

(1) See pages J30-31 for additional information, including electrical characteristics, materials, and accessories.
(2) Continuous operation at 1 W drive power (into the pump). Performance data collected under normal temperature and pressure and ambient humidity conditions. Performance under other conditions may vary. In particular, note that performance decreases with altitude and may decrease at elevated temperature.

PARALLEL CONFIGURATION: PRESSURE VS. FLOW



SERIES CONFIGURATION: PRESSURE VS. FLOW



For dimensional views, mounting, and fluidic connections see pages J16-17.

Designed for conditions that maximize pump life, the LT Series Disc Pump can exceed 17,000 hours of continuous operation before the onset of performance degradation. The pump will continue to operate beyond this point at a reduced performance level. Reference Technical Guide TG005 "Wear Characteristics" for more information. The LT Series Disc Pump can be mounted as a Smart Pump Module that includes integrated drive electronics and pressure sensing.

FEATURES[1]:

- Long service life and exceptional power efficiency
- **Pumping medium:** air. Liquids can be controlled indirectly.
- **Silent:** <10 dB
- **Compact size:** 29 mm diameter and lightweight (5 g)
- True pulsation-free, ultra smooth flow
- **Control precision:** <0.1%
- Ultra fast, millisecond response time
- **Power:** 0 to 1 W (continuous)
- **Operating temperature:** -13°F to 104°F (-25°C to 40°C)
- **Recommended filtration:** 3 µm or less

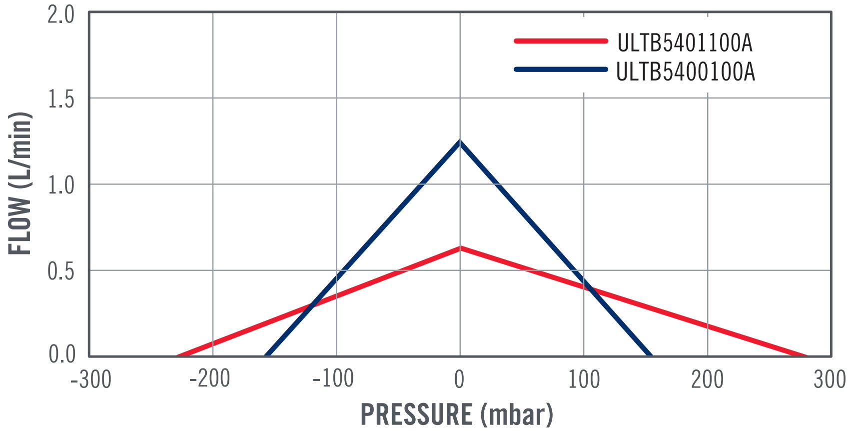
Shown at actual size.

PART NUMBER	CONFIGURATION	STALL PRESSURE[2]	FREE FLOW[2]	STALL VACUUM[2]
ULTB5401100A	Series	270 mbar	0.55 L/min	220 mbar
ULTB5400100A	Parallel	150 mbar	1.20 L/min	150 mbar

(1) See pages J30-31 for additional information, including electrical characteristics, materials, and accessories.

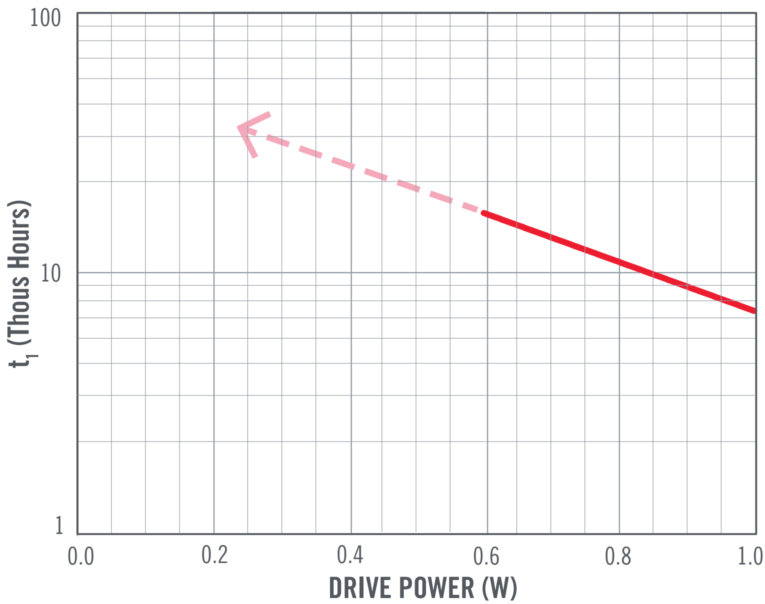
(2) Continuous operation at 1 W drive power (into the pump). Performance data collected under normal temperature and pressure and ambient humidity conditions. Performance under other conditions may vary. In particular, note that performance decreases with altitude and may decrease at elevated temperature.

PRESSURE VS. FLOW



The LT Series Disc Pump has no prevalent sudden failure mode. Instead, the operational wear processes in the pump eventually contribute to a gradual reduction in peak pressure capacity and efficiency. The Lee Company defines a point in time, t_1, at which these wear processes start to affect pump performance. In many cases, the pump continues to meet application requirements beyond t_1. t_1 varies with drive power (amongst other operational parameters).

TYPICAL LIFETIME CHARACTERISTICS



For dimensional views, mounting, and fluidic connections see pages J16-17.

XP SERIES DISC PUMP
PIEZOELECTRIC MICROPUMPS

The XP Series high performing piezoelectric disc pump offers the most power-efficient design and the widest operating temperature range. The XP Series Disc Pump can be mounted as a Smart Pump Module that includes integrated drive electronics and pressure sensing.

FEATURES[1]:

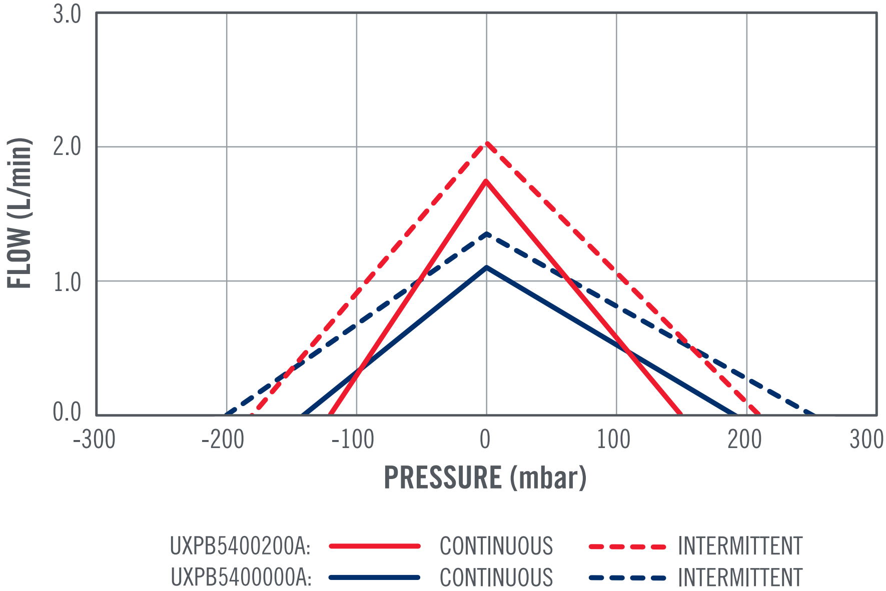
- **Pumping medium:** air. Liquids can be controlled indirectly.
- **Silent:** <10 dB
- **Compact size:** 29 mm diameter and lightweight (5 g)
- True pulsation-free, ultra smooth flow
- **Control precision:** <0.1%
- Ultra fast, millisecond response time
- **Power:** 0 to 1 W (continuous); up to 1.4 W (intermittent)
- **Operating temperature:** -13°F to 131°F (-25°C to 55°C)
- **Recommended filtration:** 3 µm or less

Shown at actual size.

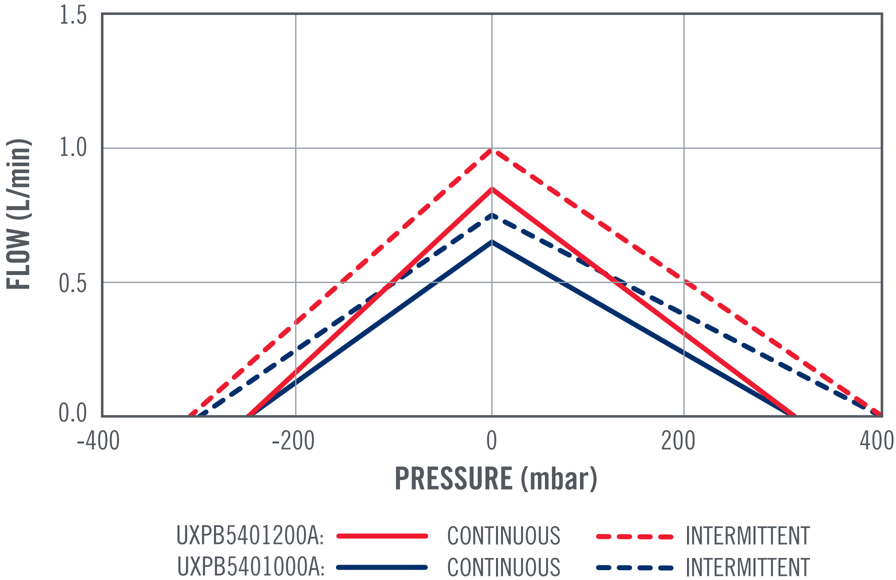
PART NUMBER	CONFIGURATION	OPERATION	STALL PRESSURE	FREE FLOW	STALL VACUUM
UXPB5401000A	Series	Intermittent [2,4]	400 mbar	0.75 L/min	300 mbar
		Continuous [3,4]	310 mbar	0.65 L/min	250 mbar
UXPB5401200A	Series	Intermittent [2,4]	400 mbar	0.96 L/min	295 mbar
		Continuous [3,4]	310 mbar	0.83 L/min	250 mbar
UXPB5400000A	Parallel	Intermittent [2,4]	250 mbar	1.35 L/min	200 mbar
		Continuous [3,4]	190 mbar	1.10 L/min	140 mbar
UXPB5400200A	Parallel	Intermittent [2,4]	210 mbar	2.00 L/min	180 mbar
		Continuous [3,4]	150 mbar	1.70 L/min	120 mbar

(1) See pages J30-31 for additional information, including electrical characteristics, materials, and accessories.
(2) Intermittent operation at 1.4 W drive power (into the pump). With intermittent operation, the mean power should be less than 1 W, with a duty cycle period of less than 20 s. Operational life may be shortened when the mean pump drive power exceeds 1 W.
(3) Continuous operation at 1 W drive power (into the pump).
(4) Performance data presented was collected under normal temperature and pressure and ambient humidity conditions. Performance under other conditions may vary. In particular, note that performance decreases with altitude and may decrease at elevated temperature.

PARALLEL CONFIGURATION: PRESSURE VS. FLOW

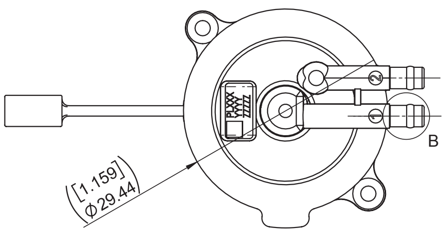


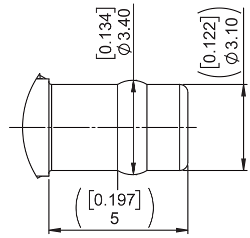
SERIES CONFIGURATION: PRESSURE VS. FLOW



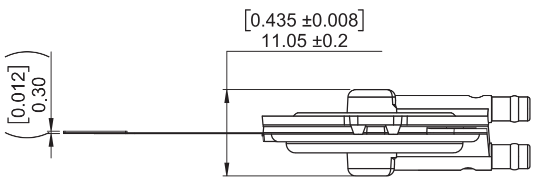
For dimensional views, mounting, and fluidic connections see pages J16-17.

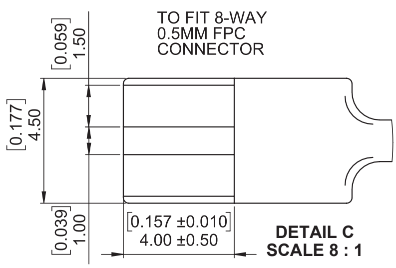
DIMENSIONAL VIEWS



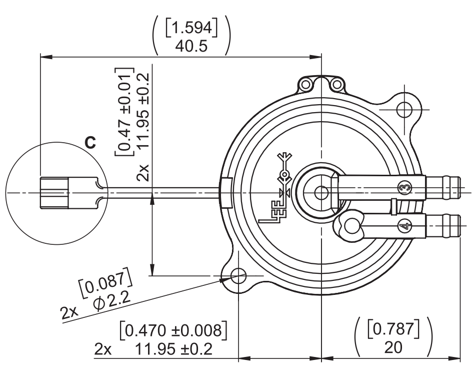


DETAIL B
SCALE 8 : 1





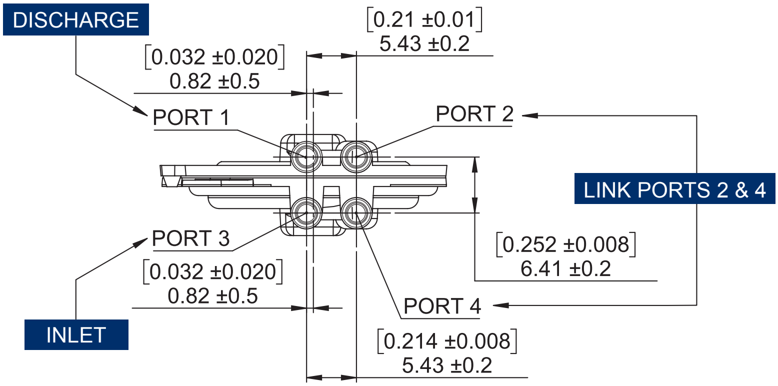
DETAIL C
SCALE 8 : 1



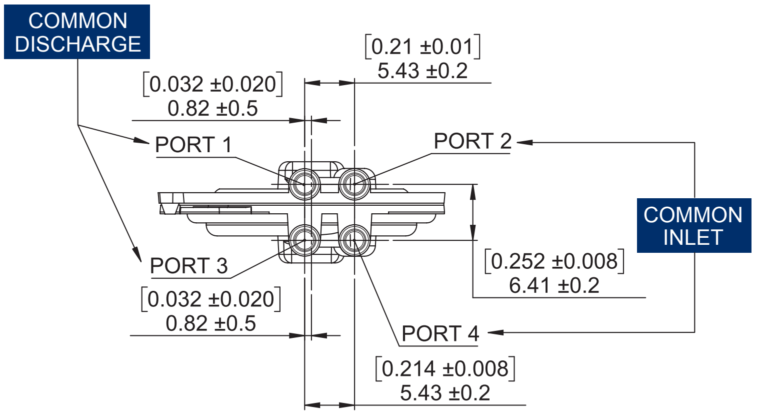
Unless otherwise specified, all dimensions are in millimeters [inches].

MOUNTING & FLUIDIC CONNECTIONS

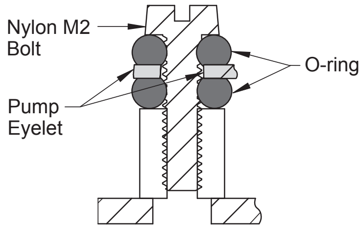
SERIES CONFIGURATION (SDC) PUMPS



PARALLEL CONFIGURATION (PDC) PUMPS



- Ports are designed for use with 2.0 mm (1/16") ID tubing.
- Mount in any orientation using compliant materials. If using mounting eyes on pump body, it is recommended to use four compliant O-rings (e.g. 1.42 ID x 1.78 CS nitrile 70 Shore A) with two O-rings per mounting eye (one above and one below the eye), and nylon M2 bolt and a 4.35 mm x 5 mm threaded mounting stud. This mounting scheme isolates high frequency vibration and prevents audible noise. Note that metal bolts are not recommended for this reason.



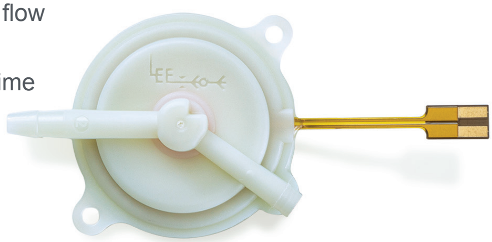
Unless otherwise specified, all dimensions are in millimeters [inches].

J

The HP Series Disc Pump offers the ability to generate higher pressures from a small, controllable, and non-pulsatile pump – opening up exciting opportunities in microfluidics through pressure driven flow. The HP Series Disc Pump can be mounted as a Smart Pump Module that includes integrated drive electronics and pressure sensing.

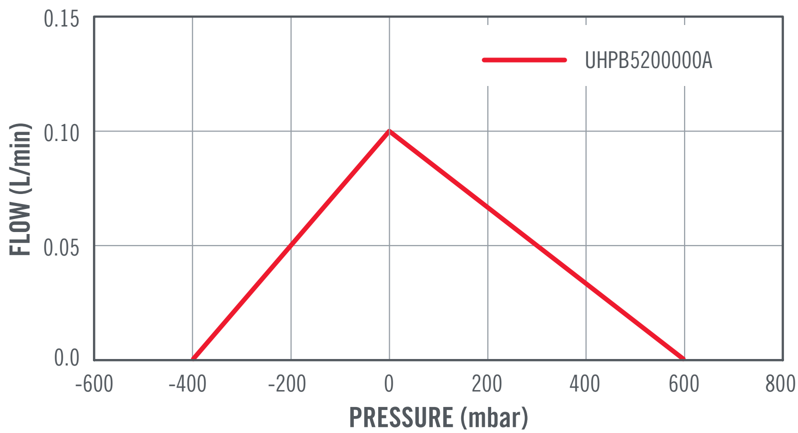
FEATURES[1]:

- **Stall pressure:** 600 mbar
- **Stall vacuum:** 400 mbar
- **Pumping medium:** air. Liquids can be controlled indirectly.
- **Silent:** <10 dB
- **Compact size:** 29 mm diameter and lightweight (5 g)
- True pulsation-free, ultra smooth flow
- **Control precision:** <0.1%
- Ultra fast, millisecond response time
- **Power:** 0 to 1 W (continuous)
- **Operating temperature:** 41°F to 104°F (5°C to 40°C)
- **Recommended filtration:** 3 µm or less



Shown at actual size.

PRESSURE VS. FLOW

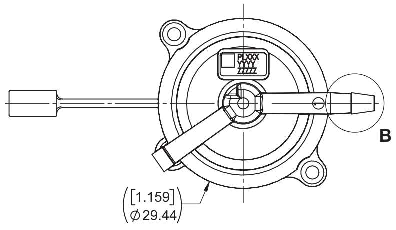


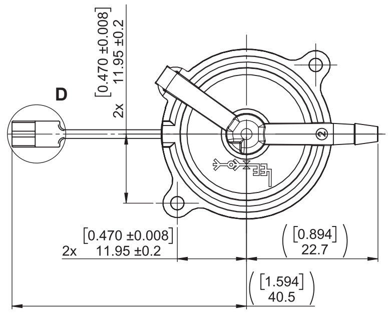
PART NUMBER	STALL PRESSURE[2]	FREE FLOW[2]	STALL VACUUM[2]
UHPB5200000A	600 mbar	0.10 L/min	400 mbar

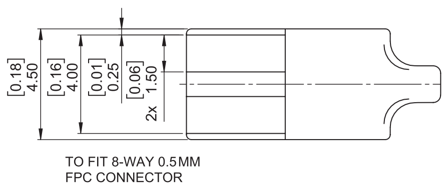
(1) See pages J30-31 for additional information, including electrical characteristics, materials, and accessories.

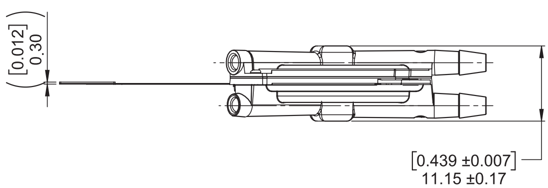
(2) Operation at 1 W drive power (into the pump). Performance data collected under normal temperature and pressure and ambient humidity conditions. Performance under other conditions may vary. In particular, note that performance decreases with altitude and may decrease at elevated temperature.

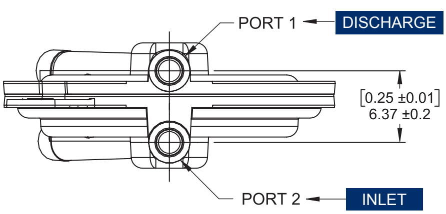
DIMENSIONAL VIEWS, MOUNTING, & FLUIDIC CONNECTIONS

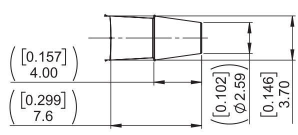






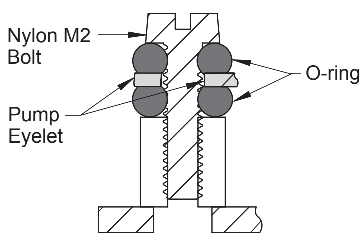






Unless otherwise specified, all dimensions are in millimeters [inches].

- Ports are designed for use with 2.0 mm (1/16") ID tubing.
- Mount in any orientation using compliant materials. If using mounting eyes on pump body, it is recommended to use four compliant O-rings (1.42 mm ID x 1.78 mm CS nitrile 70 Shore A) with two O-rings per mounting eye (one above and one below the eye), and nylon M2 bolt and a 4.35 mm x 5 mm threaded mounting stud. This mounting scheme isolates high frequency vibration and prevents audible noise. Note that metal bolts are not recommended for this reason.

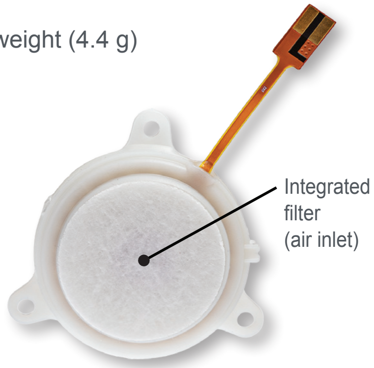


J

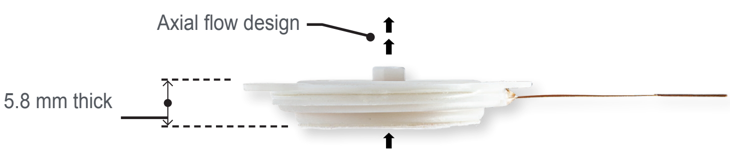
The Ultra Slim (US) Series Disc Pump offers exceptional performance and efficiency along with a narrow, manifold mount profile and integrated hydrophobic filter.

FEATURES[1]:

- **Integrated 3 µm filter:** hydrophobic ePTFE Membrane laminate, PFTE functional layer, polyester backer layer
- **Manifold mount:** compact system integration
- **Pumping medium:** air. Liquids can be controlled indirectly
- **Silent:** <10 dB
- **Compact size:** 29 mm diameter and lightweight (4.4 g)
- True pulsation-free, ultra smooth flow
- **Control precision:** <0.1% ultra fast, millisecond response time
- **Power:** 0 to 1 W (continuous); up to 1.4 W (intermittent)
- **Operating temperature:** 41°F to 104°F (5°C to 40°C)



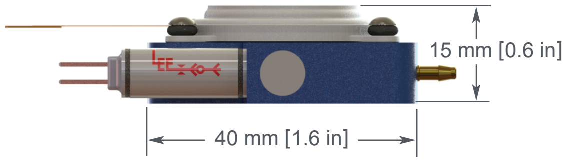
Shown at actual size.

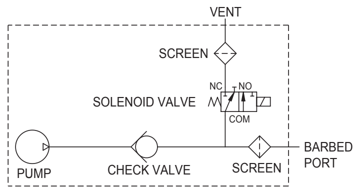


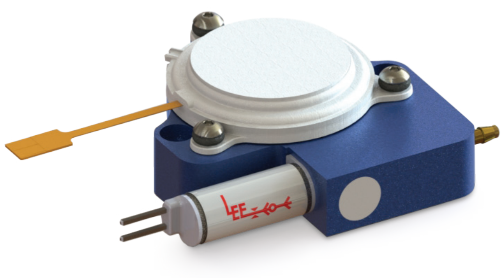
PART NUMBER	OPERATION	STALL PRESSURE	FREE FLOW
UUSB5101200A	Intermittent [2,4]	420 mbar	0.92 L/min
	Continuous [3,4]	310 mbar	0.80 L/min

(1) See pages J30-31 for additional information, including electrical characteristics, materials, and accessories.
(2) Intermittent operation at 1.4 W drive power (into the pump). With intermittent operation, the mean power should be less than 1 W, with a duty cycle period of less than 20 s. Operational life may be shortened when the mean pump drive power exceeds 1 W.
(3) Continuous operation at 1 W drive power (into the pump).
(4) Performance data presented was collected under normal temperature and pressure and ambient humidity conditions. Performance under other conditions may vary. In particular, note that performance decreases with altitude and may decrease at elevated temperature.

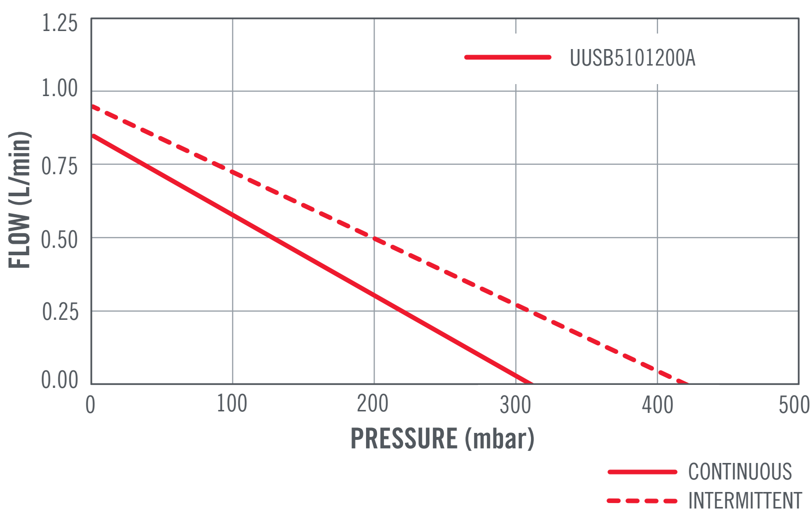
The US Series Disc Pump can be mounted on a manifold, making it ideal for compact integration with other components. In the example below, a charge vent application is realized with a pump, a solenoid valve, a check valve, and two screens, all in an extremely small package.







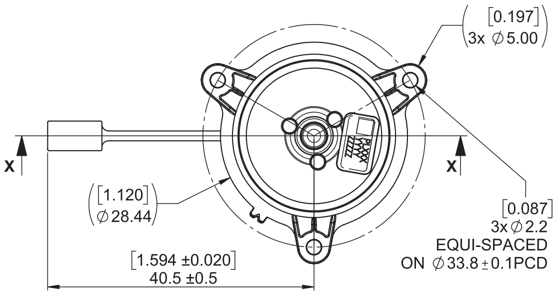
SERIES CONFIGURATION: PRESSURE VS. FLOW

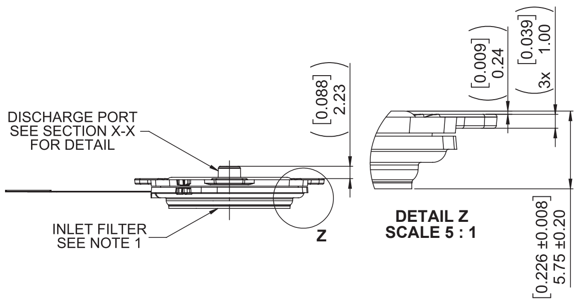


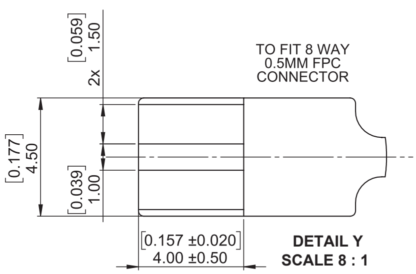
For dimensional views, mounting, and fluidic connections see pages J22-23.

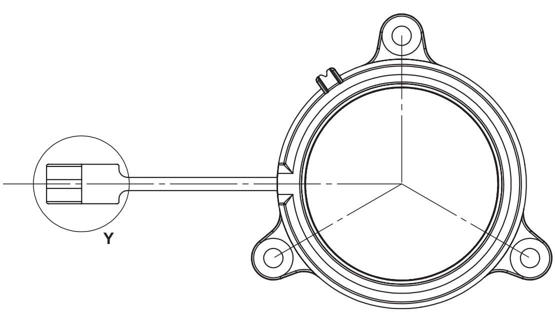
J

DIMENSIONAL VIEWS





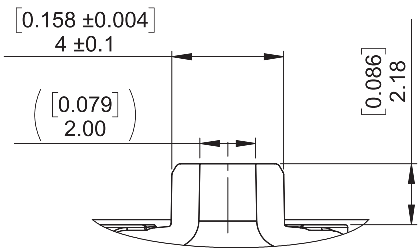




Unless otherwise specified, all dimensions are in millimeters [inches].

J

MOUNTING & FLUIDIC CONNECTIONS

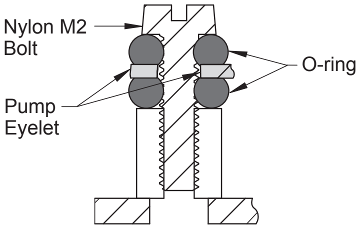


SECTION X-X
SCALE 5 : 1

Product is designed for axial seal on discharge port; product is not intended for direct connection to tubing. Please contact a Lee Sales Engineer for manifold mating boss guidance.

Unless otherwise specified, all dimensions are in millimeters [inches].

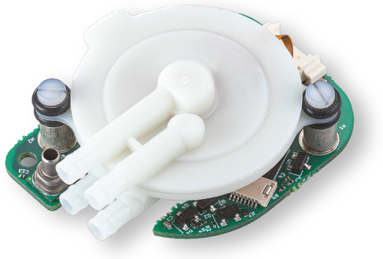
Mount in any orientation using compliant materials. If using mounting eyes on pump body, it is recommended to use four compliant O-rings (1.42 mm ID x 1.78 mm CS nitrile 70 Shore A) with two O-rings per mounting eye (one above and one below the eye), and nylon M2 bolt and a 4.35 mm x 5 mm threaded mounting stud. This mounting scheme isolates high frequency vibration and prevents audible noise. Note that metal bolts are not recommended for this reason.



J

The Smart Pump Module (SPM) combines our piezoelectric disc pumps with drive electronics and pressure sensing in a tightly integrated package, providing a miniature pump and pressure regulator solution all-in-one. This eliminates the need for a pump and proportional valve combination, ultimately reducing system complexity, size, and cost.

- Standalone pressure/vacuum regulation
- **Compact and lightweight:** 11 g
- Simple 5-wire interface for UART or I2C communication
- Digital and analog control options
- **Control modes:** power control, closed-loop pressure and vacuum control, and bang-bang pressure control
- See individual pump pages (J10-23) and part number table on following page (J26-J27) for performance specifications



Shown at actual size.

The SPM can be fitted with any of our BL, XP, LT, or HP Series pumps, resulting a micro pressure controller that can be controlled with either UART or I2C communication as well as an analog input, providing maximum flexibility. The module's closed-loop feedback from the pressure sensor allows for exceptional pressure and vacuum regulation, benefiting from the near infinite turndown ratio, pulsation-free output, wide dynamic range, and millisecond response time of the disc pump. This standalone pump module offers precision control that is not possible with conventional pumping technology, and it's plug and play operation ensures simple system integration.

Scan the QR code for more information on the SPM, including a link to download the Disc Pump Control App, a GitHub Code Snipped Library, application notes, and a link to the User Manual where you can find detailed instructions.

theleeco.com/smartpump

ELECTRICAL OPERATION

5-WIRE INTERFACE:

1. VCC - 3.5 to 5.5 V supply
2. UART RX or I2C SDA (3.3 V)
3. UART TX or I2C SCL (3.3 V)
4. Ground
5. 0 to 3.3 V analog in

The integrated pump drive electronics provide an AC drive waveform of 20-22 kHz. Power is limited between 0 and 1 W into pump (continuous operation) and up to 1.4 W (intermittent operation). Drive electronics also perform drive frequency optimization. Drive efficiency depends on operating use case.

SPM ACCESSORIES

PART NUMBER	ITEM	DESCRIPTION
UACX0500400E	USB Power and Communications Cable	Enables connection between module and host PC, providing power and enabling configuration, control, and data-logging via the Disc Pump Control App.
UACX0500600H	SPM Prototype Pneumatic Adapter Kit	These adapters, (C, Y, and L shaped couplers) simplify the prototype process by streamlining all port connections to/from the pump, including connection to the on-board pressure sensor. Adapters are intended for prototyping purposes; they are not suitable for use in end products.
UACX0500750H	1.2 µm Disc Filter	Low pressure drop filter to protect disc pumps from the ingress of contamination and debris.
UACX0500900H	L Coupler	Pack of 10 molded silicone couplers allows easy connection to the pressure sensor.

J

PUMP SERIES	SPM PART NUMBER	CONFIGURATION	OPERATION
BL SERIES	UBLC5401000A	Series	Continuous [2,3]
	UBLC5401200A	Series	Continuous [2,3]
	UBLC5400000A	Parallel	Continuous [2,3]
	UBLC5400200A	Parallel	Continuous [2,3]
XP SERIES	UXPC5401000A	Series	Intermittent [1,3]
			Continuous [2,3]
	UXPC5401200A	Series	Intermittent [1,3]
			Continuous [2,3]
	UXPC5400000A	Parallel	Intermittent [1,3]
			Continuous [2,3]
	UXPC5400200A	Parallel	Intermittent [1,3]
			Continuous [2,3]
LT SERIES	ULTC5401100A	Series	Continuous [2,3]
	ULTC5400100A	Parallel	Continuous [2,3]
HP SERIES	UHPC5200000A	N/A	Intermittent [3,4]

(1) Intermittent operation at 1.4 W drive power (into the pump). With intermittent operation, the mean power should be less than 1 W, with a duty cycle period of less than 20 s. Operational life may be shortened when the mean pump drive power exceeds 1 W.

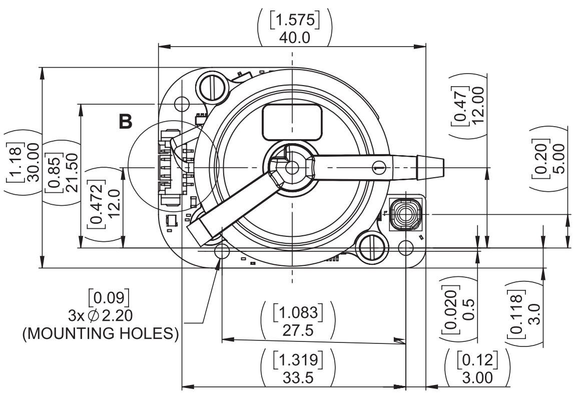
(2) Continuous operation at 1 W drive power (into the pump).

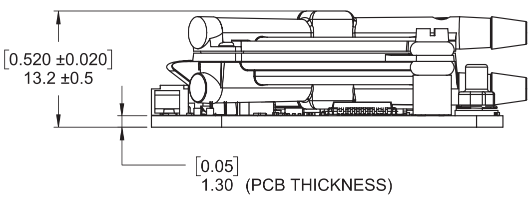
(3) Performance data presented was collected under normal temperature and pressure and ambient humidity conditions. Performance under other conditions may vary. In particular, note that performance decreases with altitude and may decrease at elevated temperature.

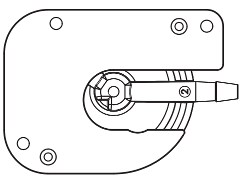
(4) Operation at 1 W drive power. It is recommended that the pump is operated at a duty cycle of less than 50% to manage temperature rise. Extended operation at higher duty cycles or elevated temperatures may require alternative drive protocols for optimal performance. Contact a Sales Engineer for more information.

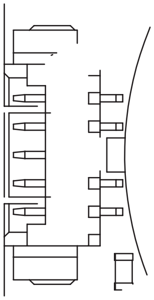
STALL PRESSURE[1]	FREE FLOW[1]	STALL VACUUM[1]
300 mbar	0.50 L/min	200 mbar
270 mbar	0.80 L/min	200 mbar
170 mbar	0.95 L/min	170 mbar
160 mbar	1.65 L/min	150 mbar
400 mbar	0.75 L/min	300 mbar
310 mbar	0.65 L/min	250 mbar
400 mbar	0.96 L/min	295 mbar
310 mbar	0.83 L/min	250 mbar
250 mbar	1.35 L/min	200 mbar
190 mbar	1.10 L/min	140 mbar
210 mbar	2.00 L/min	180 mbar
150 mbar	1.70 L/min	120 mbar
270 mbar	0.55 L/min	220 mbar
150 mbar	1.20 L/min	150 mbar
600 mbar	0.10 L/min	400 mbar

DIMENSIONAL VIEWS – HP PUMP

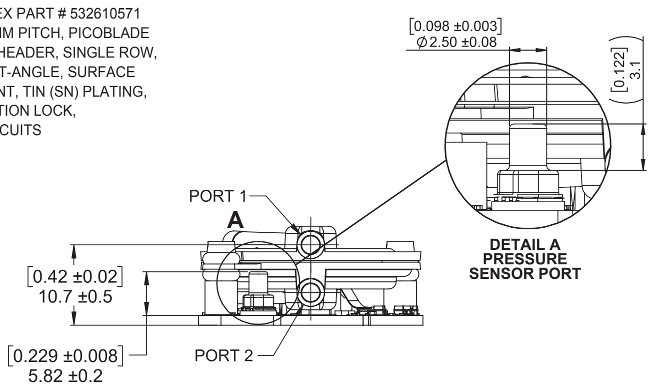






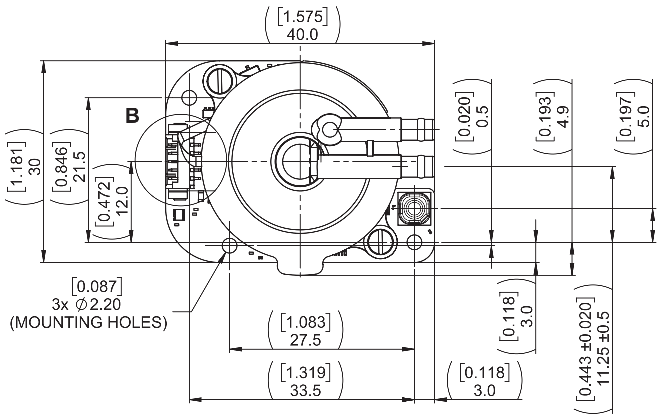


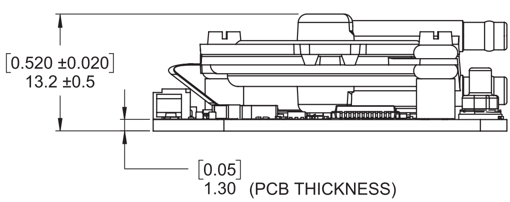
MOLEX PART # 532610571
1.25MM PITCH, PICOBLADE
PCB HEADER, SINGLE ROW,
RIGHT-ANGLE, SURFACE
MOUNT, TIN (SN) PLATING,
FRICTION LOCK,
5 CIRCUITS

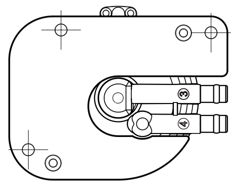


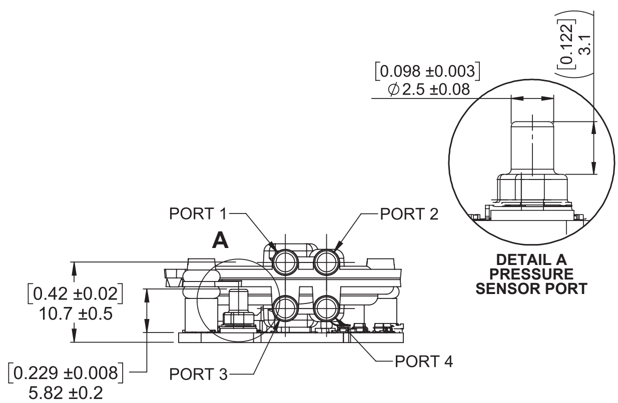
Unless otherwise specified, all dimensions are in millimeters [inches].

DIMENSIONAL VIEWS – BL/LT/XP PUMPS









Unless otherwise specified, all dimensions are in millimeters [inches].

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all disc pumps, unless otherwise noted.

PUMPING MEDIUM

Air. The pump cannot directly pump liquid. Liquid may be pumped indirectly in a pressure driven flow or air displacement regime.

SILENT

<10 dB per ISO 226:2003 and related studies; 30 cm equivalent measurement distance.

CONTROL PRECISION

< 0.1%. Pressure and flow: requires pump under closed-loop control with suitable sensor and drive electronics.

TURNDOWN RATIO AND RESPONSE TIME

The disc pump's piezoelectric drive actuator has no stall speed. The pump can be controlled continuously between 0 and 100% maximum output, resulting in an infinite turndown ratio and ultra fast response time.

COMPACT SIZE

29 mm diameter

LIGHTWEIGHT

5 g

RECOMMENDED FILTRATION

The use of an inlet filter with a pore size of 3 µm or less is strongly recommended to prevent the ingress of particulates that might otherwise limit the lifetime of the pump.

HUMIDITY RANGE

0 to 95%. Non-condensing; ingress of liquid-phase water will halt pump operation.

RoHS COMPLIANCE

All disc pumps and associated electronics are RoHS compliant.

ELECTRICAL CHARACTERISTICS

- Typical driver requires 3.5 to 5.5 V supply
- Pump requires AC drive waveform of 20 to 22 kHz
- Pump drive voltage must not exceed 48 Vrms (where for a typical square-wave drive Vrms ≈ Vpk)
- Power: 0 to 1 W (continuous)
- Pump efficiency is application dependent
- Drive PCB and evaluation electronics available (Ref. pages J6-9, and page J31)
- Reference circuits and firmware available to support product integration

CYCLE LIFE

Unlike the more traditional motor-driven pump technology, the disc pump very rarely suffers a catastrophic failure that causes it to stop pumping. Instead, pump performance remains flat for a period and then gradually reduces as the pump wears. Lee defines “t1” as the time it takes for the performance of the typical pump to drop by roughly 10% below that at start of its life. The exact value of t1 depends on how the pump is driven, the environment it is operated within, and varies model to model. Designed for conditions that maximize pump life, the LT Series can exceed 17,000 hours of continuous operation before the onset of performance degradation. The pump will continue to operate beyond this point at a reduced performance level. Reference Technical Note TN005 "Wear Characteristics" which explains this wear phenomenon in more detail and that the life of the BL, XP, LT, and US Series pumps can also reach many thousands of hours of operation when driven under certain conditions.

ACCESSORIES & ASSOCIATED ELECTRONICS

PART NUMBER	DESCRIPTION
UEKA0500300A	Development Kit (Ref. pages J6-9)
UACX0500850H	Y Coupler: pack of 10 molded silicone couplers allow for easy connection to parallel configuration (PDC) pumps.
UACX0500800H	V Coupler: pack of 10 molded silicone couplers to connect the two ports of series configuration (SDC) pumps.
UEKA0300100A	Development Motherboard
UEKA0300000A	General Purpose Driver Board
UACX0500950E	Mains Power Supply

MATERIALS	
Polyarylamide	Stainless steel
PET	Acrylated urethane
Polyimide	Gold
Nickel	Lead zirconium titanium oxide
Aluminum	Titanium
Silver	Copper tungsten
Epoxy	Nitrile

K

The Lee Company's fixed volume dispense pumps are **solenoid-driven**, chemically inert, **positive displacement pumps** that provide accurate and repeatable dispense volumes in a small, lightweight package. Requiring a simple square wave electrical signal for operation, the pumps **aspirate fluid when energized and dispense fluid when de-energized**. The normally closed design (with integrated check valves) prevents siphoning when the pumps are de-energized. Lee fixed volume dispense pumps are available in two different sizes to cover a wide range of dispense volumes:

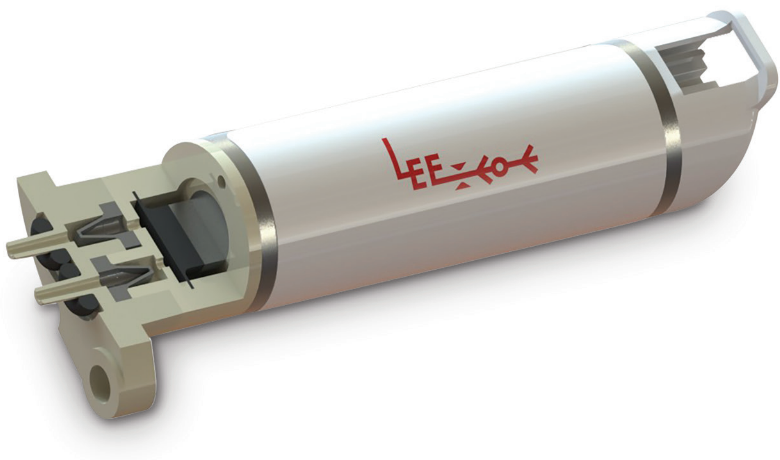
- LPL Series: 25 to 50 µL
- LPG Series: 100 to 175 µL

These pumps are generally used in medical and scientific applications, in markets such as in vitro diagnostics, genomics, and biotechnology.

FEATURES:

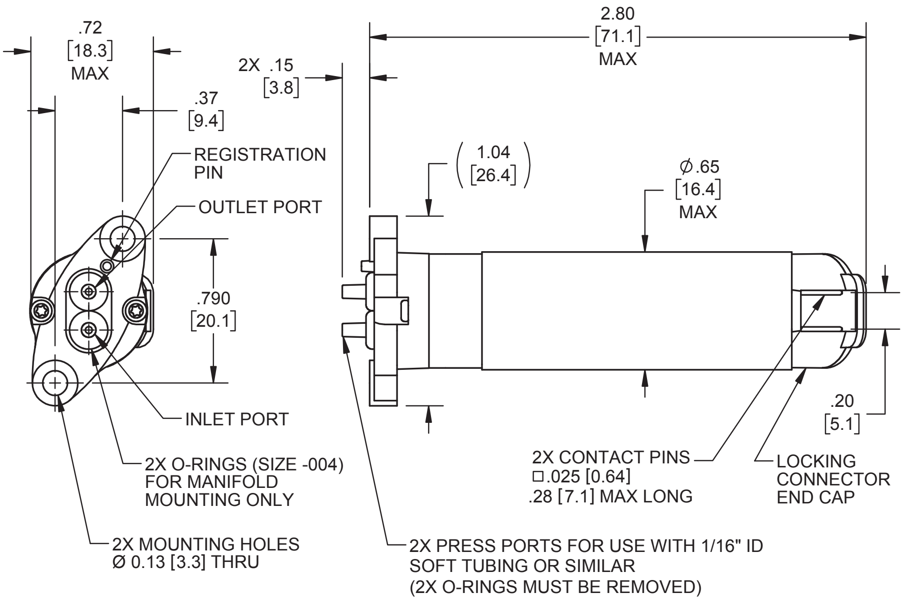
- Chemically inert
- Self-priming
- High dispense accuracy and repeatability
- Low power consumption

Each pump is 100% functionally tested and designed using materials that ensure consistent, long-term operation. The Lee Company also offers customization services to meet specific application requirements.



COMBINATION MANIFOLD / SOFT TUBE PORT-STYLE

The LPL Series dispense pump is available in 25 µL or 50 µL standard configurations. Other dispense volumes are available upon request. The combination port head allows you to press tubing directly onto the ports or mount the pump directly to a manifold. The locking end cap provides secondary retention and is compatible with TE Connectivity part number 104257-2 style connectors.



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

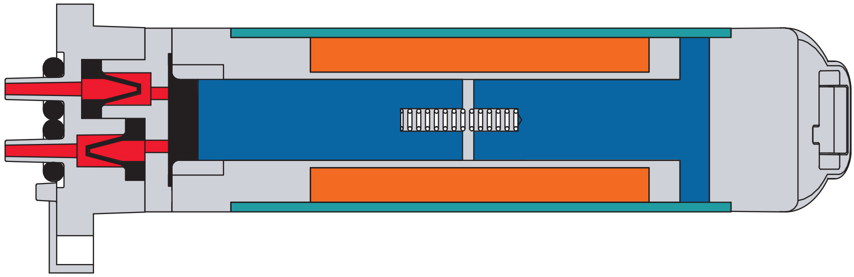
PART NUMBER [1]	DISPENSE VOLUME (µL)	ACCURACY [2] (%)	MAX FLOW RATE [3] (µL/sec)	POWER [4] (W)	WETTED MATERIALS [5]
LPLA _ _50650L	50 ±3	±6	100	3.3	PEEK/FKM
LPLA _ _51650L	50 ±3	±6	100	3.3	PEEK/EPDM
LPLA _ _50625L	25 ±3	±12	50	2.5	PEEK/FKM
LPLA _ _51625L	25 ±3	±12	50	2.5	PEEK/EPDM

(1) Pumps are available in 12 and 24 Vdc configurations

LPLA _ _50650L

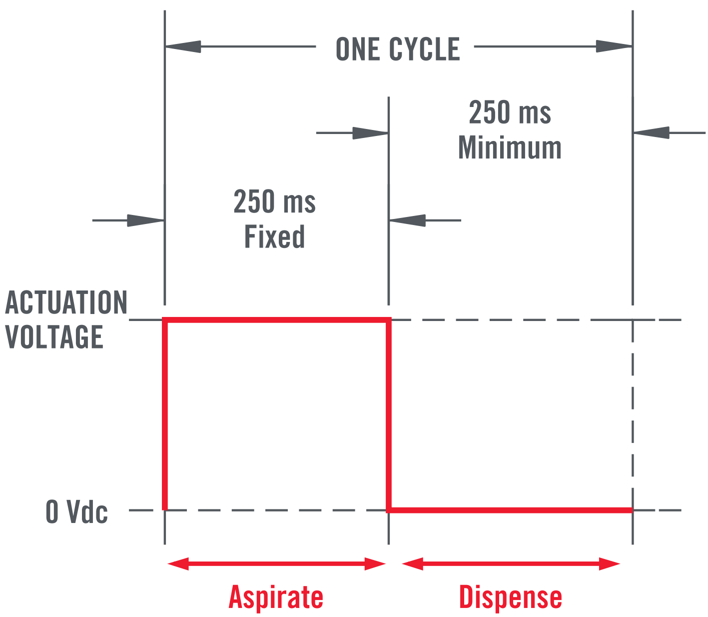
Actuation Voltage: 12 = 12 volts
24 = 24 volts

(2) Accuracy rated at zero head pressure on water at room temperature.
(3) Maximum flow rate at 2 Hz at zero head pressure on water at room temperature.
(4) Maximum power during aspiration. Average power while pumping will be half.
(5) Refer to pages Q62-63 for material information and abbreviations.



Flow Path
Elastomer (check valve/seal/O-rings)
Spring
Housing
Coil
Shield
Armature & Plunger Stop

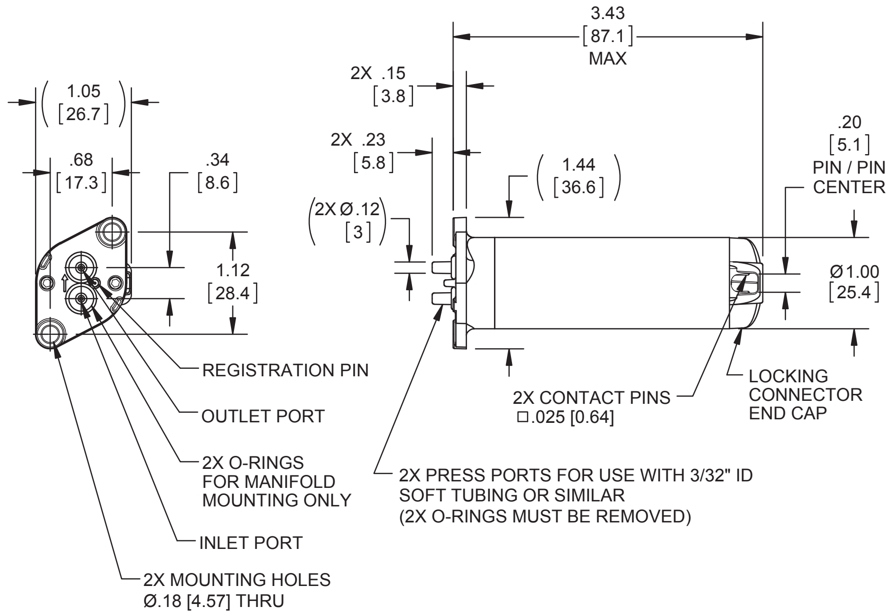
RECOMMENDED DRIVE FORM



The pump is intended for operation at the rated voltage, at a maximum frequency of 2 Hz.

COMBINATION MANIFOLD/SOFT TUBE PORTED STYLE

The LPG Series dispense pump is available in 100 µL or 175 µL standard configurations. Other dispense volumes are available upon request. The combination port head allows you to press tubing directly onto the ports or mount the pump directly to a manifold. The locking end cap provides secondary retention and is compatible with TE Connectivity part number 104257-2 style connectors.



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

PART NUMBER [1]	DISPENSE VOLUME (µL)	ACCURACY [2] (%)	MAX FLOW RATE [3] (µL/sec)	POWER [4] (W)	WETTED MATERIALS [5]
LPGA _ _ 50010D	100 ±10	±10	500	7	PEEK/FKM
LPGA _ _ 51010D	100 ±10	±10	500	7	PEEK/EPDM
LPGA _ _ 50618D	175 ±10	±6	875	7	PEEK/FKM
LPGA _ _ 51618D	175 ±10	±6	875	7	PEEK/EPDM

(1) Pumps are available in 12 and 24 Vdc configurations

LPGA _ _ 50010D

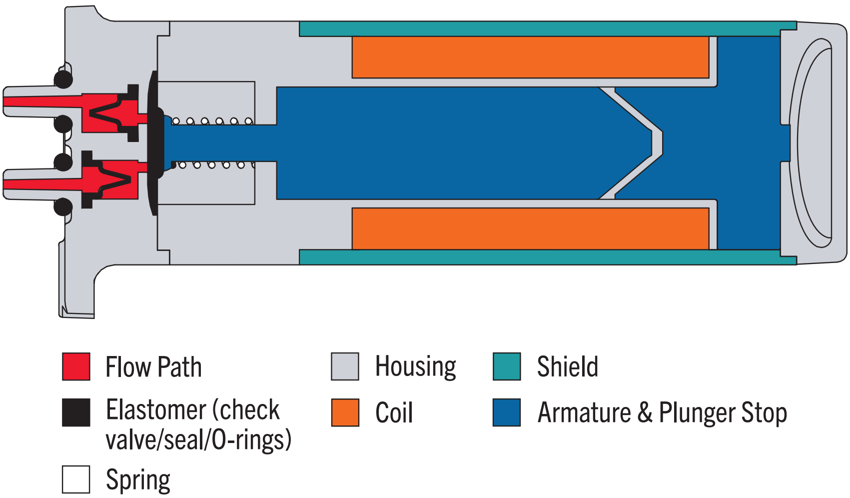
Actuation Voltage: 12 = 12 volts
24 = 24 volts

(2) Accuracy rated at zero head pressure on water at room temperature.

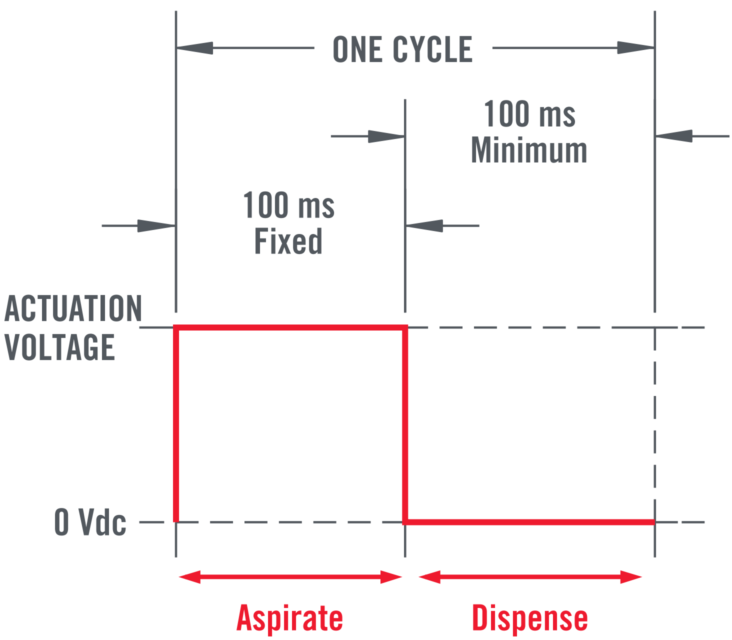
(3) Maximum flow rate at 5 Hz at zero head pressure on water at room temperature.

(4) Maximum power during aspiration. Average power while pumping will be half.

(5) Refer to pages Q62-63 for material information and abbreviations.



RECOMMENDED DRIVE FORM



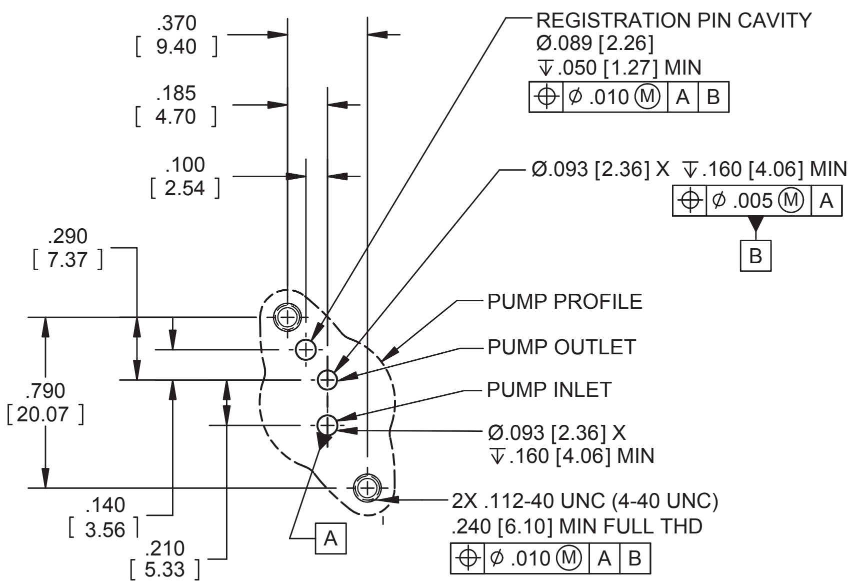
The pump is intended for operation at the rated voltage, at a maximum frequency of 5 Hz.

MOUNTING & FLUIDIC CONNECTIONS

Manifold mating boss geometries and dimensions shown are for reference only. Refer to drawing part numbers listed for complete specifications.

Soft Tube Port: The LPL Series dispense pump is designed to be manifold-mounted, or you can remove the O-rings and connect the ports directly to soft, flexible 1/16" (1.6 mm) tubing.

LPL SERIES BOSS



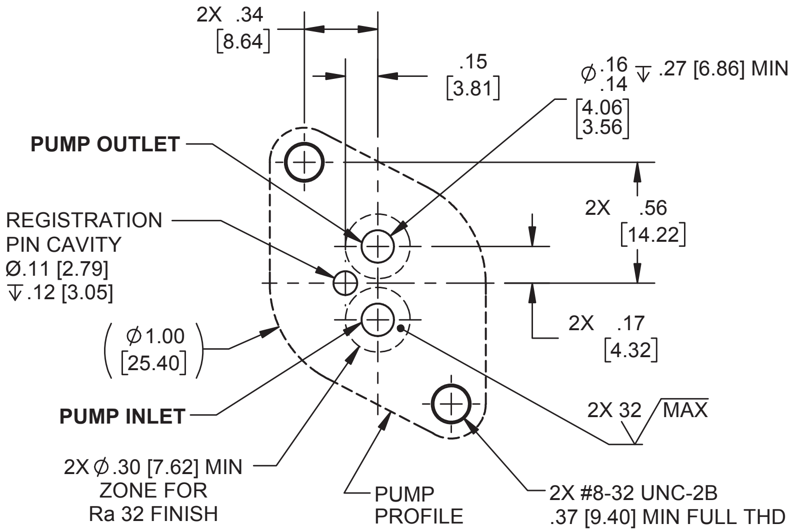
- Mount using two #4 screws tightened to 10 to 15 in-oz.
- Reference drawing number LSIX1001440A for full boss manufacturing details.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

MOUNTING & FLUIDIC CONNECTIONS

Soft Tube Port: The LPG Series pump is designed to be manifold-mounted, or you can remove the O-rings and connect the ports directly to soft, flexible 3/32" (2.4 mm) tubing.

LPG SERIES BOSS



- Mount using two #8 screws tightened to 90 in-oz.
- Reference drawing number LSIX1001490A for full boss manufacturing details.

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

STANDARD MANIFOLDS

Manifolds are available to adapt LPL and LPG pumps to threaded tubing.

SERIES	PORT CONNECTIONS	PART NUMBER [1]	
		PMMA	PEEK
LPL	¼-28	LSMX0517220B	LSMX0517210B
LPG	¼-28	LSMX0519120B	LSMX0519110B

(1) Part numbers are for the manifold and mounting screws only. Pumps are sold separately.

Refer to Manifold Assemblies (Section M) for custom design capabilities.

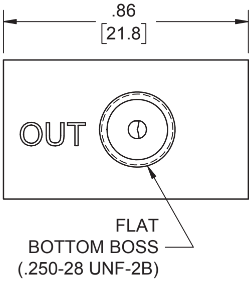
REPLACEMENT O-RINGS

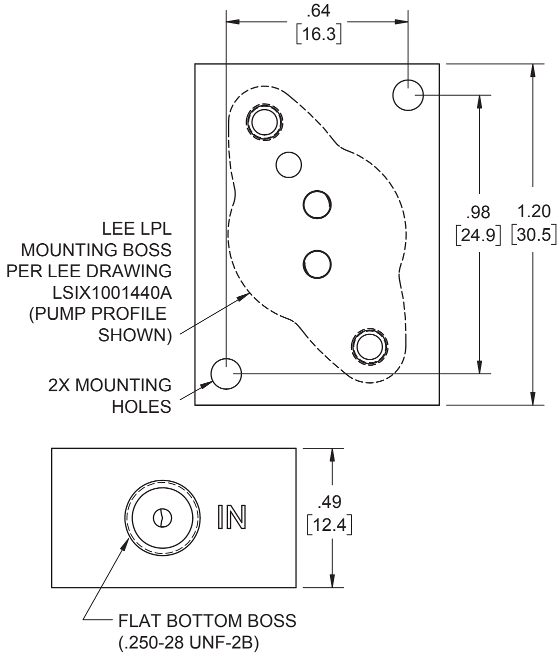
Fixed volume dispense pumps are shipped with two O-rings.

SERIES	PART NUMBER	
	EPDM	FKM
LPL	LSWX0508440A	LSWX0508430A
LPG	LSWX0508690A	LSWX0508680A

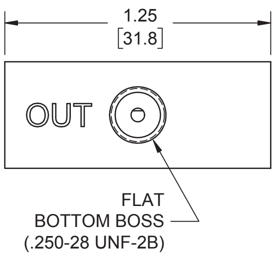
STANDARD MANIFOLDS

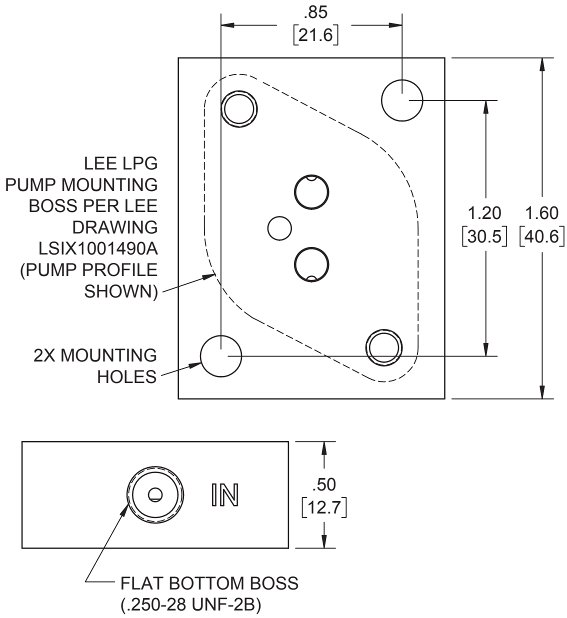
LPL SERIES





LPG SERIES





Unless otherwise specified, all dimensions are in inches [mm]. Drawings are not to scale.

K

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all fixed volume dispense pumps, unless otherwise noted.

CYCLE LIFE

The pumps will typically operate across a minimum of 10 million cycles on water, depending on application conditions.

OPERATING PRESSURE

The pumps will operate within the specified pressure range when supplied with the rated voltage ± 5%.

- Maximum case pressure: 5 psig
- Inlet and outlet port pressure range:
  - LPL Series:
    25 µL: ± 30 in. H_20
    50 µL: ± 60 in. H_20
  - LPG Series: ± 60 in. H_20
- Variations in pressure due to head or restriction can affect dispense volume accuracy.

OPERATING TEMPERATURE

- Ambient operating temperature range is dependent on the elastomer; reference table below for details.
- Maximum coil temperature not to exceed 200°F (90°C).
- Increasing the operating temperature tends to limit coil performance. The pump duty cycle and energized time must be evaluated for conformance with the maximum rated operating and coil temperatures.

ELASTOMER	AMBIENT OPERATING TEMPERATURE RANGE
EPDM	30°F to 120°F (-1°C to 49°C)
FKM	45°F to 120°F (7°C to 49°C)

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing
- Pumps should be stored completely wet or completely dried with nitrogen before prolonged periods of inactivity to avoid elastomeric stiction.

RESPONSE TIME

- Maximum operating frequency:
  - LPL Series: 2 Hz
  - LPG Series: 5 Hz
- Operating the pumps at higher frequencies will affect dispense accuracy and life expectancy.
- Response times are dependent upon system conditions, power, environment, etc. The response time will typically increase as the ambient operating temperature decreases. Extended periods of inactivity may also have an impact on the initial response time of the pump.

ELECTRICAL CONNECTIONS

Pins with locking end caps: Pumps are supplied with two 0.025" square electrical pins spaced 0.20" center to center. This design is compatible with most standard electrical connectors designed for 0.10" spacing. The locking end provides an added secondary retention clip that is compatible with TE Connectivity part number 104257-2 style connectors. The Lee Company also offers compatible lead-wire assemblies in two different lengths:

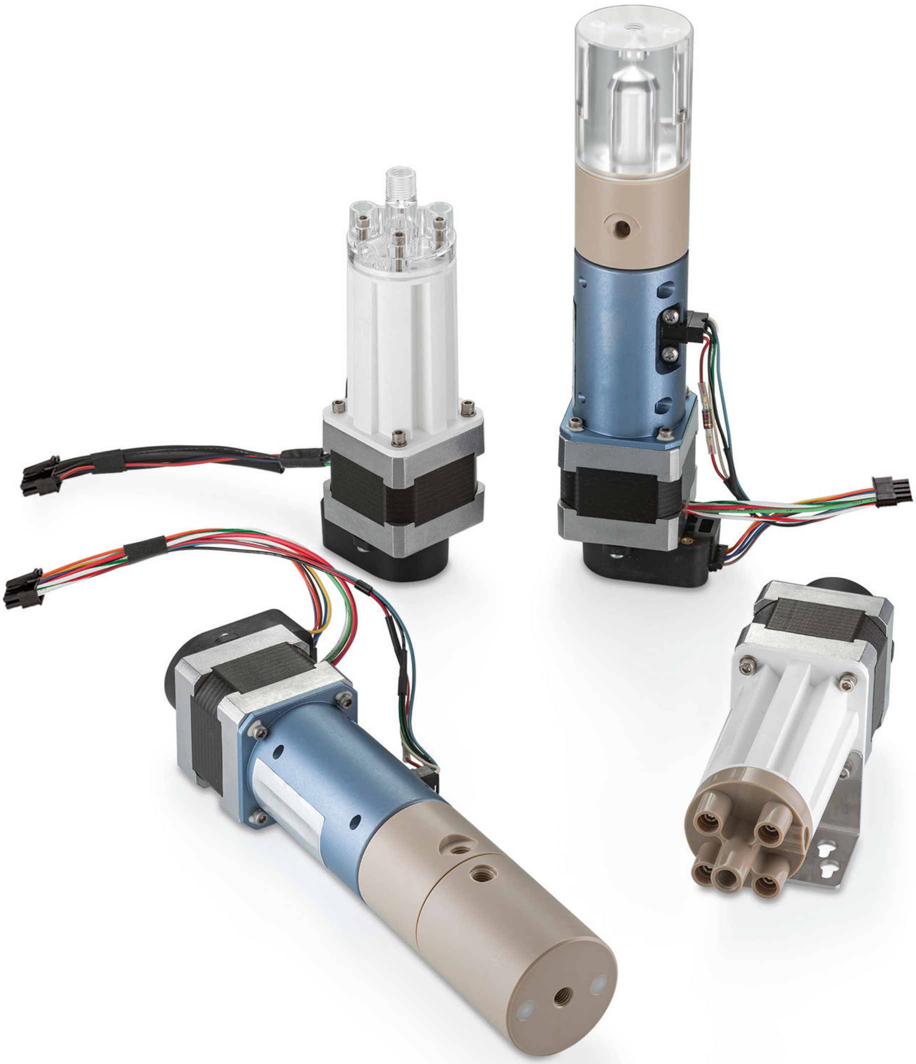
- Part number LSWX0504300A – Length, 6 inches
- Part number LSWX0606700A – Length, 24 inches

ELECTRICAL CHARACTERISTICS

- Standard operating voltages available: 12 and 24 Vdc (± 5%)
- Refer to individual part number tables on pages K2-5 for power consumption.
- Pumps are not rated for continuous electrical duty; 50% maximum duty cycle.

FILTRATION

Filtration of 35 microns or finer is recommended.



Variable volume dispense pumps are **stepper motor-driven, positive displacement pumps** providing full dispense volumes ranging from 50 to 3000 µL. Offering unparalleled reliability and performance, they use a highly reliable reciprocating drivetrain to aspirate a volume of fluid accurately and then dispense that fluid volume out in smaller, highly precise increments. Their size, weight, and maintenance-free design allow for the pumps to be positioned where the fluidic requirements dictate, regardless of accessibility. These pumps are available in a **single seal** (LPD Series) or a **dual seal configuration** for improved sealing performance when flowing aggressive fluids. Each pump is equipped with a home sensor to establish the end of stroke position. In some models, an optical encoder is included for applications requiring feedback on motor movement.

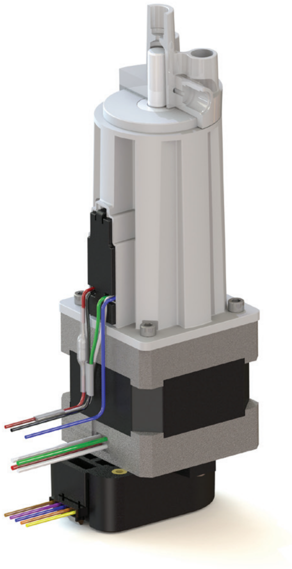
LPD SERIES:

- Single seal model
- Full dispense volumes: 50, 250, 1000, and 3000 µL
- Highly precise: CV ≤0.01% (certain models)
- Long cycle life: 10 million cycles
- Home sensor on all models
- Encoder and integrated backlash compensation (select models)
- Self-priming with valves
- Field-proven in vitro diagostics applications for reagent dispensing, aliquoting, and sample preparation.

DUAL SEAL:

- Utilizes two seals and two fluidic chambers to isolate the motor and extend pump life
- Great for more challenging fluids, such as surfactants prone to leakage or liquids prone to crystallization
- Home Sensor, Encoder, and Integrated Backlash Compensation included on all models
- Applications:
  - Lysing cells in DNA Sequencing and Synthesis, Immunoassay, and Hematology.
  - Pharmaceutical and Medical Manufacturing

Each pump is 100% functionally tested and designed using materials that ensure consistent, long-term performance. The Lee Company also offers customization services to meet specific application requirements.



STANDARD PERFORMANCE MODEL

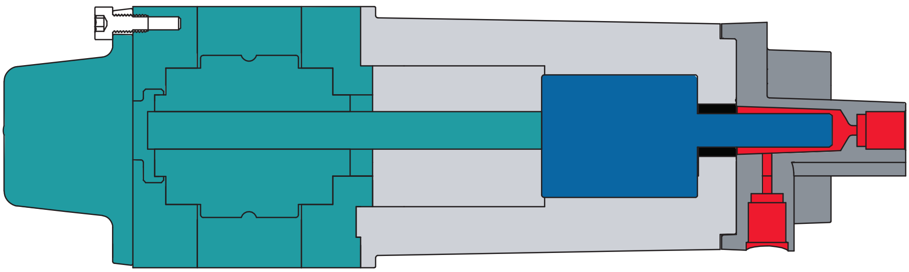
Our baseline precision dispense pump, the LPD Series Standard Performance model includes a home sensor and is available with a PMMA or PEEK port head.

- **Dispense accuracy** at 100% total volume: ± 0.6%
- **Precision CV%:**
  - **≤ 0.04%:** 100% total volume
  - **≤ 0.4%:** 10% total volume
- **Home sensor:** full dispense
- **Motor:** NEMA 17 bipolar stepper motor
- **Wetted materials:** TZP, port head (see table below), UHMW-PE, and 316 SS (3000 µL dispense volume only
- External valving required
- For additional specifications, see pages L10-13.

PART NUMBER	FULL DISPENSE VOLUME (µL)	PORT HEAD MATERIAL[1]	DISPENSE RESOLUTION (µL/full step)	MAXIMUM LENGTH "L"	CONFIGURATION
LPDA2720150L	50	PMMA	0.04	5.24" (133.1 mm)	A
LPDA2750150L	50	PEEK	0.04		B
LPDA2720125D	250	PMMA	0.2		A
LPDA2750125D	250	PEEK	0.2		B
LPDA2750110H	1000	PEEK	0.5	5.55" (141 mm)	B
LPDA2750130H	3000	PEEK	1.0	6.21" (157.7 mm)	B

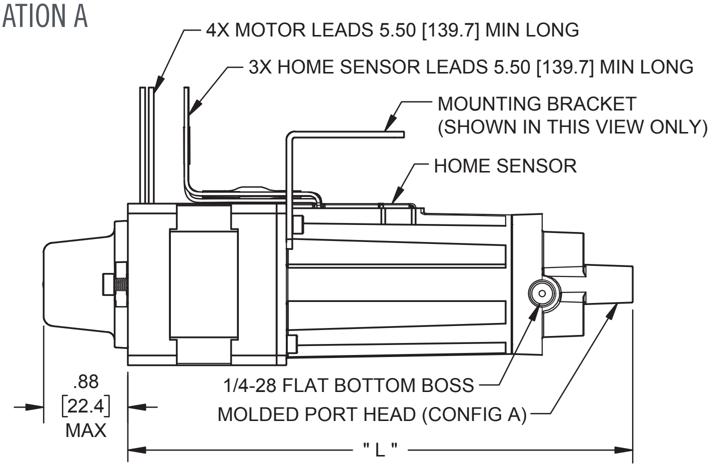
(1) Customized port heads are available upon request and may include alternative materials, valve mounted directly to the port head, or different fluidic ports. Refer to pages Q62-63 for material information and abbreviations.

STANDARD PERFORMANCE MODEL

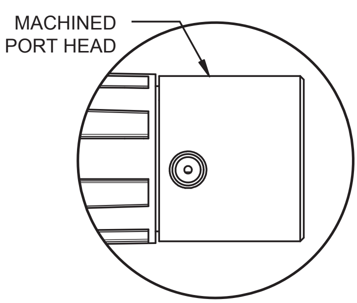


Flow Path | Pump Housing | Piston
Motor | Seal | Port Head

CONFIGURATION A



CONFIGURATION B



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

L

HIGH PERFORMANCE MODEL

The High Performance LPD Series precision dispense pump offers all the same benefits as the standard performance model, but with the addition of integrated backlash compensation (except 3000 µL pumps) and an encoder to provide feedback on motor movement.

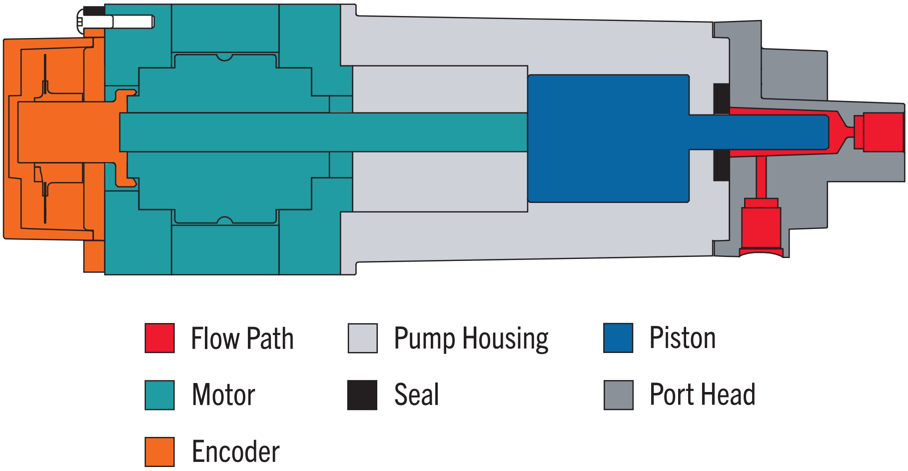
- **Dispense accuracy at 100% total volume:**
  - ± 0.5% (50 µL, 250 µL, and 1000 µL models)
  - ± 0.6% (3000 µL model)
- **Precision CV%:**
  - At 100% total volume:
    - ≤ 0.04%: 50 µL and 3000 µL models
    - ≤ 0.01%: 250 µL and 1000 µL models
  - At 10% total volume:
    - ≤ 0.4%: 50 µL and 3000 µL models
    - ≤ 0.1%: 250 µL and 1000 µL models
- **Home sensor:** full dispense
- **Rotary encoder:** optical, 2 channel quadrature
- **Motor:** NEMA 17 bipolar stepper motor
- **Backlash compensation:** integrated (except 3000 µL pumps)
- **Wetted materials:** TZP, port head (see table below), UHMW-PE, and 316 SS (3000 µL dispense volume only)
- External valving required
- For additional specifications, see pages L10-13.

PART NUMBER	FULL DISPENSE VOLUME (µL)	PORT HEAD MATERIAL[1]	DISPENSE RESOLUTION (µL/full step)	MAXIMUM LENGTH "L"	CONFIGURATION
LPDA1720350L	50	PMMA	0.04	5.24" (133.1 mm)	A
LPDA1750350L	50	PEEK	0.04		B
LPDA1720325D	250	PMMA	0.2		A
LPDA1750325D	250	PEEK	0.2		B
LPDA1750310H	1000	PEEK	0.5	5.65" (143.5 mm)	B
LPDA1750330H	3000	PEEK	1.0	6.21" (157.7 mm)	B

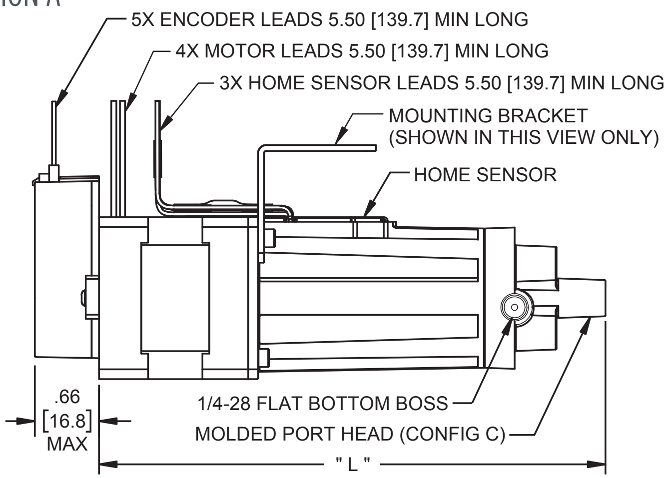
(1) Customized port heads are available upon request and may include alternative materials, valve mounted directly to the port head, or different fluidic ports. Refer to pages Q62-63 for material information and abbreviations.

L

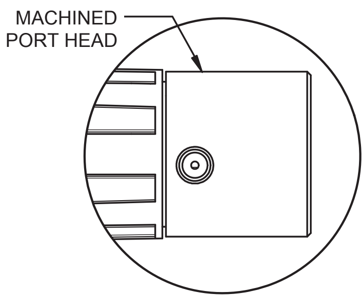
HIGH PERFORMANCE MODEL



CONFIGURATION A



CONFIGURATION B



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

DUAL SEAL MODEL

The Dual Seal Precision Dispense Pump is engineered to reliably control more challenging fluids, including those with high concentrations of surfactants and fluids prone to crystallization across an extensive cycle life. It utilizes two seals and two fluidic chambers to isolate the motor from the working fluid. The portion of the piston in contact with the working fluid does not retract past the second seal, and the isolation chamber can be plugged with air, filled with a barrier fluid, or actively flushed to dilute fluid residue on the piston. All designs are equipped with a home sensor to establish the end of stroke, integrated backlash compensation, and an optical motor encoder to provide feedback on motor movement.

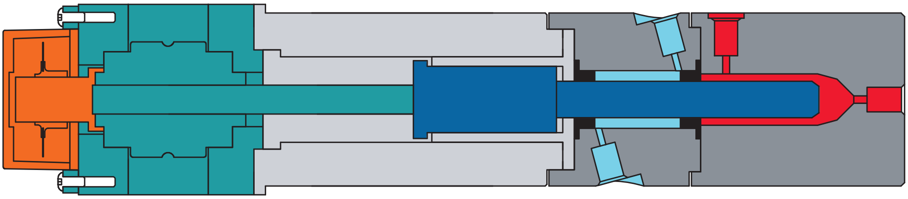
- **Dispense accuracy:** ± 0.5% (100% total volume)
- **Precision CV%:**
  - ≤ 0.03%: at 100% total volume
  - ≤ 0.3%: at 10% total volume
- **Home sensor:** full dispense
- **Rotary encoder:** optical, 2 channel quadrature
- **Motor:** NEMA 17 bipolar stepper motor
- **Backlash compensation:** integrated (except 3000 µL pumps)
- **Wetted materials:**
  - Port head chamber: port head (see table below), TZP, UHMW-PE
  - Seal isolation chamber: TZP, UHMW-PE, PEEK, 316 SS
- External valving required
- For additional specifications, see pages L10-13.

PART NUMBER	FULL DISPENSE VOLUME (µL)	PORT HEAD MATERIAL[1]	DISPENSE RESOLUTION (µL/full step)	MAXIMUM LENGTH "L"
LPVA1725350D	500	PMMA	0.469	5.86" (148.8 mm)
LPVA1755350D	500	PEEK	0.469	5.86" (148.8 mm)
LPVA1725310H	1000	PMMA	0.400	7.24" (183.9 mm)
LPVA1755310H	1000	PEEK	0.400	7.24" (183.9 mm)

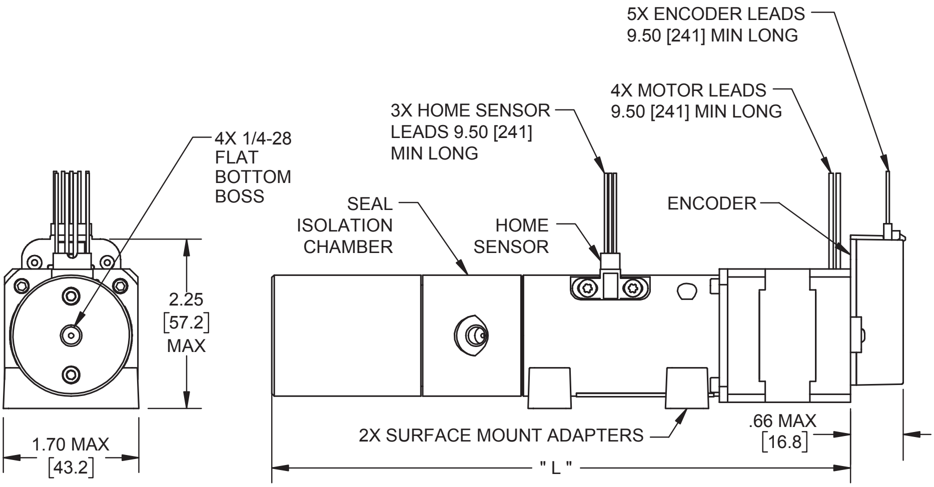
(1) Port head material varies by part number as described. The seal isolation chamber is PEEK on all models. Customized port heads are available upon request and may include alternative materials, valve mounted directly to the port head, or different fluidic ports. Refer to pages Q62-63 for material information and abbreviations.

L

DUAL SEAL MODEL



Flow Path (Working Fluid)	Pump Housing	Piston
Flow Path (Barrier Fluid)	Seal	Port Head & Seal Isolation Chamber
Encoder	Motor	



Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

Scan the QR code or type in the URL to view an animation demonstrating how the Dual Seal Pump operates.

theleeco.com/dualsealpumpanimation

STEPPER MOTOR

The Lee Company's Variable Volume Pumps are driven using a bipolar stepper motor. The stepper motor is a brushless DC electric motor characterized by the discrete number of steps in a rotation. This feature allows a motor to be held at a certain step without the need for any feedback, resulting in a very precisely controlled pump. Our pump's NEMA 17 stepper motor has 200 full steps per revolution and is characterized by high torque and precision.

Stepper motors can be driven in a variety of ways, so it is important to consider the operating current and voltage requirements when selecting a motor controller. While a stepper motor is limited by a certain number of discrete steps per revolution, a micro-stepping-enabled controller allows the motor to move only fractions of a step. A micro-step is generally defined as splitting a step into multiple component parts. This is accomplished by very carefully controlling the current in each stepper motor phase, which can effectively produce multiple partial steps within a single step, thereby increasing the dispense resolution.

HOME SENSOR / END OF STROKE SENSOR

The home sensor is used to indicate when the pump has reached a full dispense position (piston is fully extended). This "home" position is used as a reference so control systems do not accidentally drive the piston into a hard stop. The home sensor is an optical-electrical switch which uses an infra-red LED placed across from a detector. The pump drivetrain incorporates a flag to interrupt the optical path between LED and detector, which changes the electrical output from HIGH to LOW when the pump is in the home position.

To interface with the home sensor, a controller requires a digital input as well as a 5V output to power the sensor. Because the home sensor emitter is an LED, which is a current-driven device, an integrated resistor is included to limit current. Some stepper controllers include an integrated resistor which may need to be removed or modified to function properly. The Lee Company has the capability to provide a pump design with the resistor modified or removed if necessary.

ENCODER

Some of The Lee Company's Variable Volume Pumps include an encoder, which is an optical electronic device that provides a pulse output as the motor rotates. The encoder output is not intended as an indication of fluid dispense, but rather as verification that the stepper motor has completed the requested number of steps. The standard encoder used on our variable volume pumps has 200 pulses per revolution.

ADDITIONAL RESOURCES

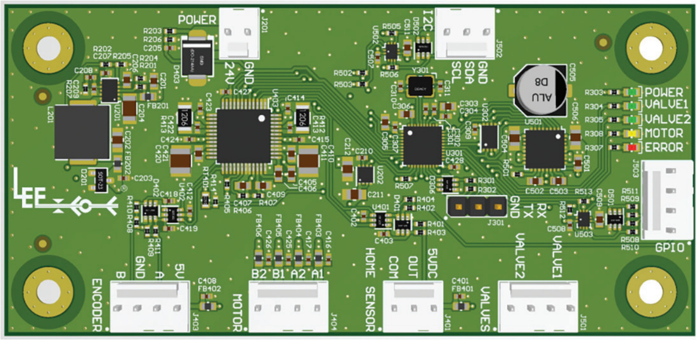
Refer to the Variable Volume Dispense Pump Technical Guide (available for download on our website or via the QR Code below) for further information on:

- Pump mechanics
- Pump operation
- Common fluidic circuits
- Best practices, getting started, troubleshooting, and more

theleeco.com/vvtechguide

VARIABLE VOLUME PUMP DRIVER

The Lee Company's Variable Volume Pump Driver is driven by the powerful Trinamic TMC5130 motion controller and motor driver, along with two Trinamic MAX22200 solenoid drivers. This comprehensive setup empowers the driver to effortlessly manage every aspect of the pumping system, from the precise control of the bipolar stepper motor, home sensor, and encoder to the management of two solenoid valves. The driver is optimal for expediting benchtop testing of Lee pumps and valves. The I2C and UART comms options also allow the driver to be integrated into end systems, streamlining system development. Crafting custom scripts and subroutines is a breeze with the TMCL IDE, allowing users to easily upload code to the driver for standalone operation. Moreover, the driver can function as a peripheral device, seamlessly receiving direct motion commands from another controller. For newcomers, a library of starter scripts is readily available to assist with simple pumping routines. Additionally, for those seeking advanced control options, a detailed firmware manual is available to get optimal performance for your application. Contact a Lee Sales Engineer for more information.



GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all Variable Volume Dispense Pumps, unless otherwise noted.

CYCLE LIFE

Unless otherwise specified, LPD pumps will typically operate across a minimum of 10 million cycles on water, depending on application conditions.

OPERATING TEMPERATURE

- Ambient operating temperature range is 40°F to 150°F (4°C to 66°C)

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing
- Pumps should be stored completely wet or completely dried with nitrogen before prolonged periods of inactivity.

MOTOR SPECIFICATIONS

All LPD and Dual Seal Pumps use a NEMA 17, bipolar stepper motor with 2 phases. The stepper motors have the following specifications:

- Resistance per phase: 2.4 Ω
- Coil inductance per phase: 5.9 mH
- Steps/revolution: 200 steps
- Stepper motor harmonic frequency: 150 to 170 Hz

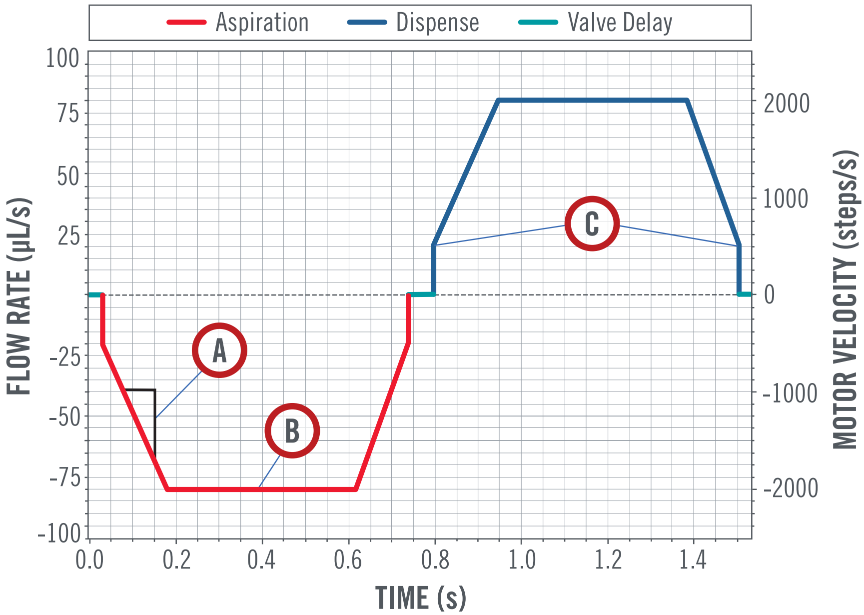
RECOMMENDED DRIVE PARAMETERS

When selecting a stepper motor driver, it is important to consider the motor specifications listed above. To get the best performance out of the variable volume pump and avoid stalling the motor, users should adhere to the following stepper motor drive parameters:

- Drive voltage: 24V
- Drive current:
    - 400-420 mA (RMS) per phase for all 50 µL, 250 µL, and 1000 µL standard and high performance LPD Series pumps.
    - 650-750 mA (RMS) per phase for the 3000 µL single seal LPD Series models and all Dual Seal models.
- Microstepping (optional): 1/2 step, down to 1/256 step
- Maximum recommended acceleration and deceleration (Ref. A in Pump Velocity Profile): 10,000 full steps/second^2
- Maximum speed (Ref. B in Pump Velocity Profile): 2000 full steps/second
- Maximum start/stop speed (Ref. C in Pump Velocity Profile): 500 full steps/second

PUMP VELOCITY PROFILE

The pump’s piston reciprocates back and forth to draw fluid into the pump and then dispense it out. An example of the 50 µL LPD pump's flow rate and motor step rate are depicted below in the velocity profile. This plot demonstrates a complete aspirate and dispense cycle utilizing the pump’s maximum recommended speed and acceleration. A 30 ms valve delay is included before and after each piston movement to switch flow paths as the pump's piston changes direction. This profile showcases just one application of the pump; it can also aspirate and dispense in finer increments and at varying speeds, depending on your application parameters.



Using the maximum recommended speeds, the variable volume pumps can complete one full aspirate and dispense cycle in the time indicated in the table below. Depending on use conditions, it may be possible to drive the pumps faster. Other applications may require slower operation to prevent motor stalling or fluid cavitation.

FULL DISPENSE VOLUME (µL)	PUMP TYPE	FULL CYCLE TIME (seconds)	AVERAGE DISPENSE RATE (mL/min)
50	LPD	1.595	1.9
250	LPD	1.595	9.4
1000	LPD	2.345	25.6
3000	LPD	3.345	53.8
500	Dual Seal	1.411	21.3
1000	Dual Seal	2.845	21.1

GENERAL SPECIFICATIONS (cont.)

MAXIMUM DISCHARGE PRESSURE:

Standard & High Performance Models:

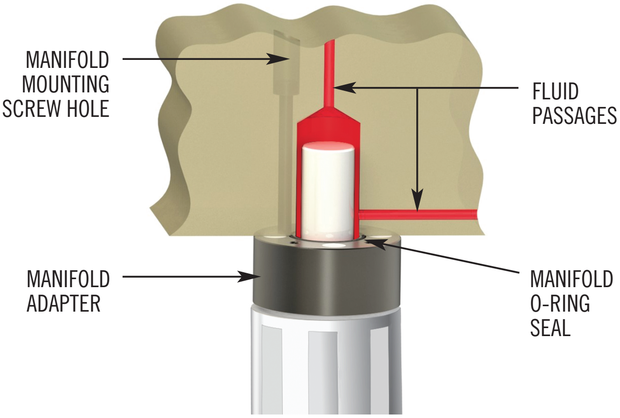
- 60 psig: 50 µL, 250 µL, and 1000 µL models
- 95 psig: 3000 µL models

Dual Seal Models:

- 30 psig: 500 µL and 1000 µL models

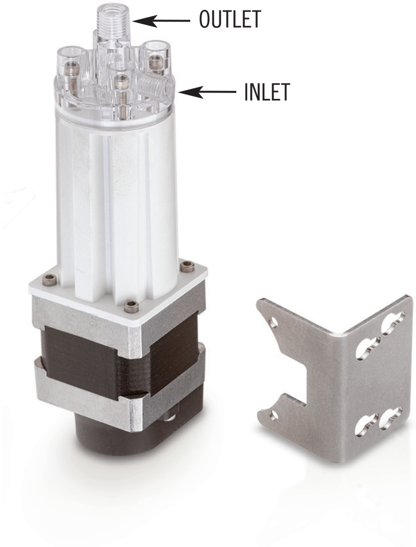
FLUIDIC CONNECTIONS

- All pumps require external valves for operation.
- ¼ - 28 Port: these ports are designed to be used with standard ¼-28 flat bottom fittings.
- Customized port heads are available upon request and may include alternative materials, valve mounted directly to the port head, or different fluidic ports.
- Manifold mount pumps are not offered as standards but are available upon request. The port head is replaced with a mounting adapter (shown below) and the fluid connections are dictated by the manifold.

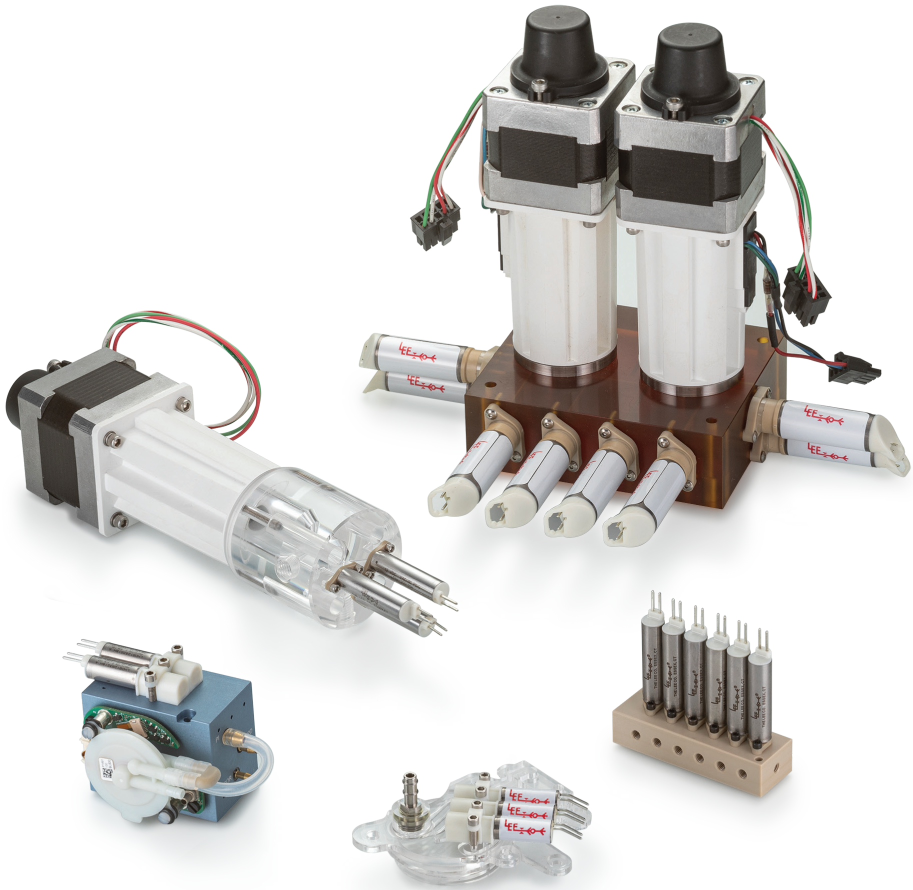


MOUNTING INFORMATION

- Pumps should be mounted with the port head up (motor down) to optimize bubble purging.
- Pumps come with a mounting bracket installed at the base of the white housing. The bracket can be removed and rotated to a different position. It is important to only remove two screws at a time when installing or uninstalling the bracket to ensure precision-aligned components do not shift. The mounting bracket has key-hole slots intended for #4 (2.5 mm) mounting screws.



MANIFOLD ASSEMBLIES

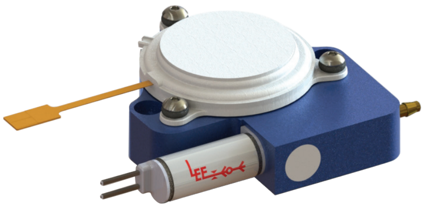


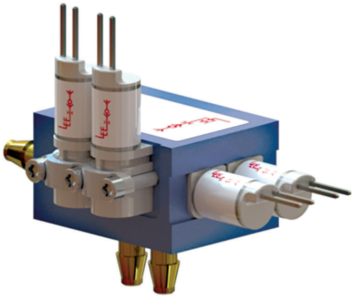
Integrated fluidic manifolds minimize size and internal volume, reduce the number of potential leak points, and offer the advantage of a drop-in, fully tested solution. At the system level, this reduces risk by decreasing assembly time, operator error, and streamlining preventative maintenance routines. However, designing a manifold with integrated active and passive fluid control components can be challenging.

Our expertise in fluidics, the components we supply, and the systems they go into, allow us to seamlessly incorporate our solenoid valves, pumps, check valves, restrictors, and a variety of outsourced components (PCBs, sensors, etc.) into a manifold subassembly with ease. We will work with you to select the optimal manifold manufacturing technique based on your application needs, then we will provide proposal drawings and CAD models for fit verification. Together, we will iterate through the prototype process with machined or 3D printed parts. Our engineering partnership carries through to production-ready assemblies that are 100% functionally tested and ready for install into your system.

CONVENTIONALLY MACHINED

Integrating miniature valves into a manifold using conventional cross-drilled machining is a major step towards reducing tubing and fluid volume. Drilled passages must be straight and construction passageways must be plugged in conventionally machined manifolds. This approach is typically chosen when the valve count is minimal and the flow paths are simple.





Conventional manifold designs shown above. At only 0.6 of an inch tall, 1.6 inches wide and 1.7 inches long, the left image showcases an ultra compact manifold with an integrated US Series Disc Pump and a 3-way LHD Series solenoid valve. The image on the right is populated with four 2-way LHL Series Latching solenoid valves.

MULTI-LAYER BONDED

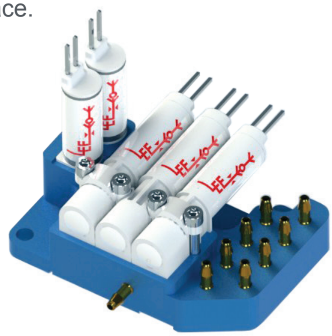
Multi-layer manifolds are ideal for applications with many valves, when the fluidic schematic is more complex, when integrated flow cells are required, or when the output pattern requires tighter spacing than other components allow (e.g., valve center-to-center spacing). These bonded manifolds stack multiple layers of plates containing different machined passages. The different plates are then bonded together either by epoxy, diffusion, or solvent weld.

The image above shows a multi-layer manifold design populated with LFV Series solenoid valves.

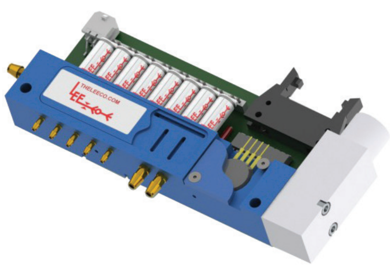
ANT FARM BONDED

The Ant Farm Technique involves machining a series of intricate flow paths or channels into a face of the manifold. After the machining operation, a plate is bonded over the flow passages to complete the circuit. In complex applications, the channels can be milled into more than one face of the manifold block. This manifold machining technique further reduces the overall manifold size compared to the other technologies.

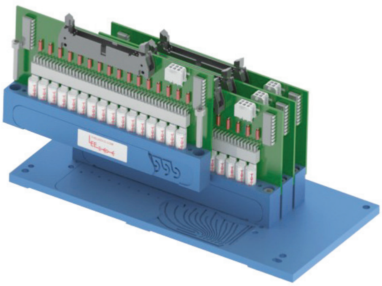
This technique also enables a modular design where modules of valve manifolds can be mounted onto a base plate via O-ring seals. This erector set approach to manifold construction offers design flexibility, especially if the application requires a distribution plate to redirect or prevent flow from one passage to another between sections. The designer can also implement a spacer plate to increase dimensions between sections when an oversized component or obstruction must be accommodated in the mounting surface.



This manifold design capitalizes on the use of our Ant Farm Technique, integrating multiple styles of HDI® Platform valves (plug-in and face mount) in order to accommodate specific space constraints and flow schematic requirements of a system. The intricate flow paths that complete the internal circuit are showcased in the image on the right, where the bond plate has been partially cut away.



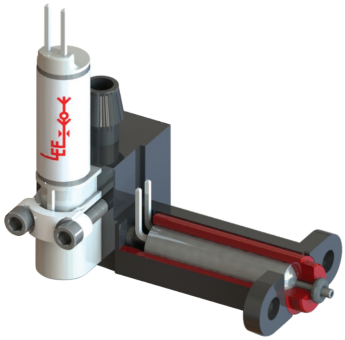
This manifold design exemplifies a higher degree of capability using our Ant Farm Technique, together with several HDI Platform solenoid valves and other critical components (pressure transducer and regulator).



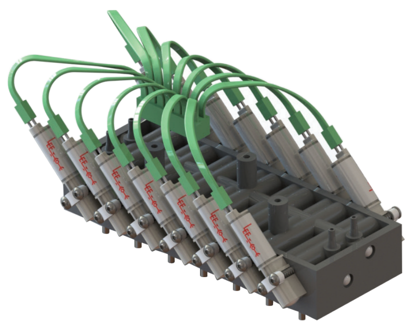
This complex manifold design takes a modular approach, while also employing our Ant Farm Technique. Four valve modules are mounted onto a distribution plate and O-rings with integrated screens are used to ensure a proper seal between the different manifold modules.

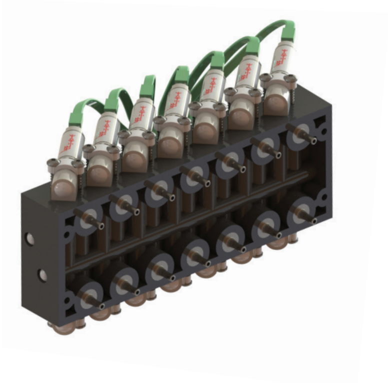
INJECTION MOLDED MANIFOLDS

Plastic injection molded manifolds can significantly reduce unit cost, reduce size and weight, and they enable unique geometries because they are not beholden to the straight drilled passage limitations of conventionally machined and bonded manifolds. The upfront costs associated with mold design and tooling typically make this option most appropriate for applications with high annual rates of production.



Above design showcases a 3-way LHD Series solenoid valve with a cutaway view of a VHS Series dispensing valve mounted with a custom sleeve (red) for direct injection into a flow stream. Below is an ultra-light weight, compact solution for fluidically mounting twelve 3-way LHL Series valves. Electrically, flexible connectors enable the unique mounting angle, and the single ganged connector enables a simple, single connection to a PCB.





3D PRINTED MANIFOLDS

3D printed manifolds can aid in the prototyping phase by allowing you to quickly test various manifold design iterations. As an emerging technology, 3D printing is not yet a practical solution for long-term, robust, leak-proof, chemically inert, production-grade assemblies. However, as the technology continues to evolve, long-term options in a variety of materials – even metals – may become viable manifold solutions. 3D printing and Design For Manufacturability (DFM) considerations during the prototype phase ensure an easy transition to a production solution which uses the manifold technology best suited to your project.

MANIFOLD MATERIALS

The following is a list of typical materials used for each manufacturing technique. Other materials may also be available.

- **Conventional:**
  - Stainless steel
  - Aluminum (anodized or alodine)
  - PMMA
  - PEEK
  - PEI
  - PSU
  - PBT
  - PC
  - ABS
  - PVDF
- **Multi-layer:**
  - Aluminum (anodized)
  - PMMA
  - PC
  - PEI
- **Ant Farm:**
  - Aluminum
- **3D Printing:**
  - A wide range of common, industry-standard materials are available and are selected based on individual application requirements.

MANIFOLD ASSEMBLY AND TESTING

Once the manifold block is manufactured, it is populated with subcomponents in a dedicated cell. All Lee pumps and valves being assembled onto the manifold block are 100% tested prior to installation. Manifolds are typically outfitted with inlet and outlet ports. These ports can be brass barbs, stainless steel hypo tubes, or threaded fitting systems. To prevent contamination from rogue particles, screens are typically installed into all ports when space permits. The system as a whole is then tested to comply with specific application parameters to reduce installation time and eliminate start-up problems. After successfully passing all tests and inspection, the ports are sealed to prevent contamination during subsequent transit or handling.

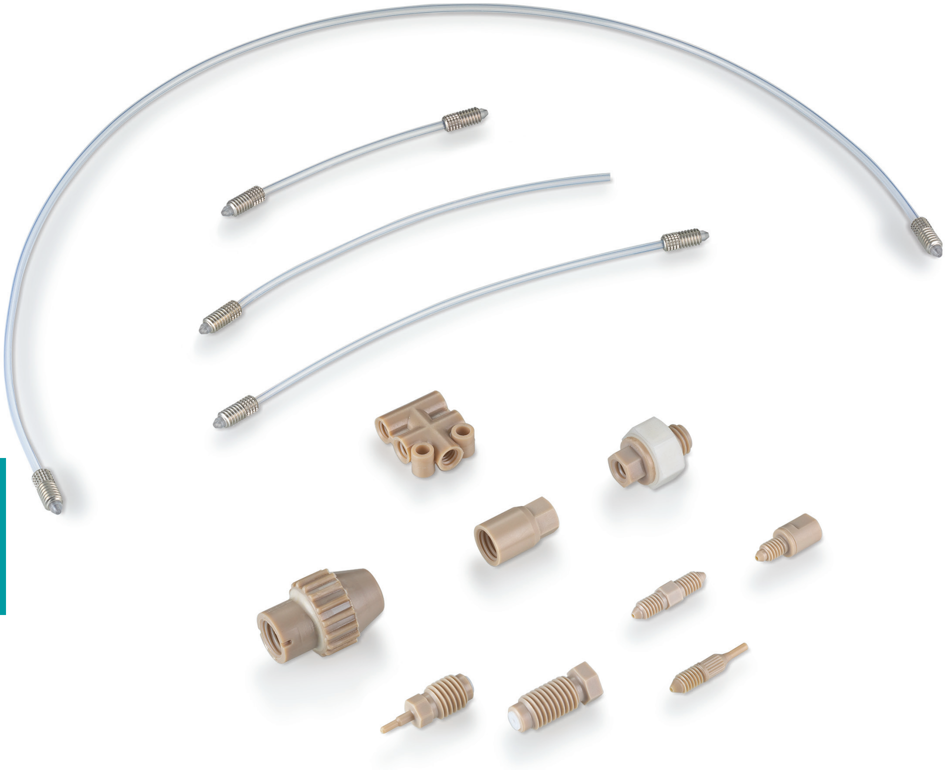
MANIFOLD ADVANTAGES

There are many advantages for using a manifold system, such as:

- Custom designed, manufactured, and 100% tested from a single source
- Reduced assembly and installation costs
- Space and weight savings
- **Manifold mountable components:**
  - Solenoid valves
  - Pumps
  - Check valves, single-orifice restrictors, and safety screen filters
  - Single fluid fittings and gang interface connections
- Integrated electrical components (pressure sensors, connectors, and circuit boards)
- Warranted as a single part number
- Maintenance and repair service available

Contact The Lee Company for additional technical assistance and application information.

MINSTAC®



The Lee Company's Miniature Inert System of Tubing and Components, or MINSTAC®, is a family of flow connection and control products that enable fast and efficient design of systems to handle critical and challenging fluids.

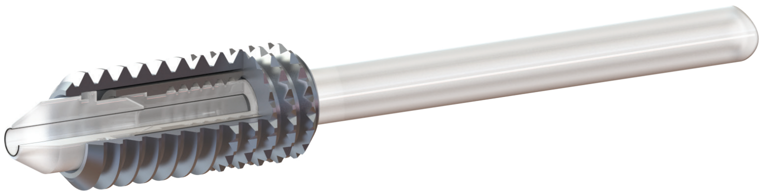
The MINSTAC family consists of a wide range of products including tubing and fitting ends, adapters and unions, as well as check valves, filters, and safety screens. Every component is optimized for miniaturization and constructed out of inert materials.

TUBE FITTINGS

FLUID CONTROL COMPONENTS

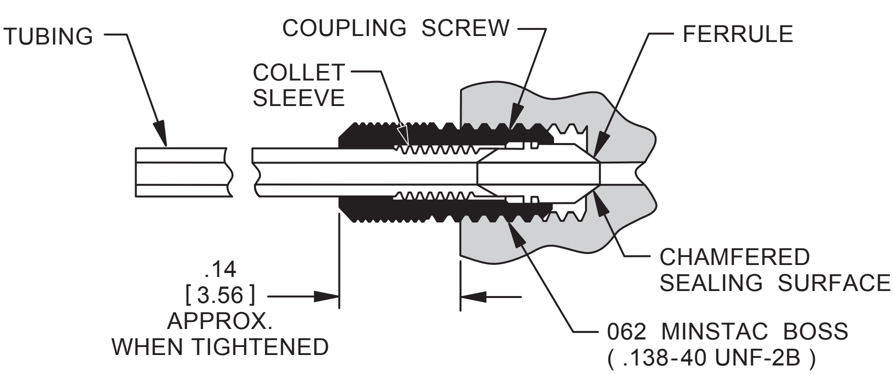
062 MINSTAC

The basis of the Lee 062 MINSTAC System is its unique collet-lock design which enables miniature, robust threaded connections for PTFE tubing. The assembled fittings may be connected and disconnected many times without adjustment. The assembled fitting ends consist of chamfered PTFE tubing, an internally threaded collet sleeve, externally threaded coupling nut, and sealing ferrule.



Cutaway view of 062 MINSTAC fitting

The 062 MINSTAC fitting system is for use with 0.062" (1.57 mm) OD PTFE tubing and uses a 0.138-40 UNF fitting end. The system utilizes an internally threaded collet sleeve that grips the outer diameter of the PTFE tubing end, preventing cold flow. The coupling screw acts as a compression fitting and presses the chamfered end of the tubing against one end of the PCTFE ferrule, as the other end of the ferrule is pressed against the sealing surface in the boss. This self-aligning fitting provides a reliable leak-proof system.



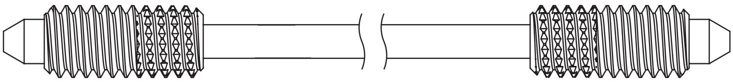
Cross section of installed assembly

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

062 MINSTAC TUBING ASSEMBLIES

Stock tubing assemblies come pre-assembled and are produced to The Lee Company's rigorous quality standards. These single and double-ended tubing assemblies simplify the prototype and design process. For OEM applications, customized tubing assemblies can be supplied including custom lengths, various tubing colors, and alternate materials. Contact a Lee Sales Engineer for assistance.

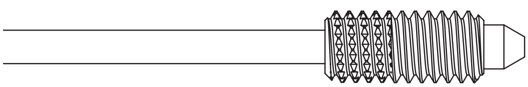
DOUBLE-ENDED TUBING ASSEMBLIES



INSTALLED LENGTH (cm)	0.012" ID	0.032" ID	0.040" ID
5	TUTC1226905L	TUTC3216905L	TUTC4012905L
10	TUTC1226910L	TUTC3216910L	TUTC4012910L
15	TUTC1226915L	TUTC3216915L	TUTC4012915L
20	TUTC1226920L	TUTC3216920L	TUTC4012920L
30	TUTC1226930L	TUTC3216930L	TUTC4012930L
40	TUTC1226940L	TUTC3216940L	TUTC4012940L
50	TUTC1226950L	TUTC3216950L	TUTC4012950L
60	TUTC1226960L	TUTC3216960L	TUTC4012960L
100	TUTC1226910D	TUTC3216910D	TUTC4012910D
200	TUTC1226920D	TUTC3216920D	TUTC4012920D
300	TUTC1226930D	TUTC3216930D	TUTC4012930D

SINGLE-ENDED TUBING ASSEMBLIES

Unterminated end compatible with most fitting systems specified for 1/16" (1.5 mm) OD tubing.



INSTALLED LENGTH (cm)	0.012" ID	0.032" ID	0.040" ID
10	TUTB1226910L	TUTB3216910L	TUTB4012910L
30	TUTB1226930L	TUTB3216930L	TUTB4012930L
100	TUTB1226910D	TUTB3216910D	TUTB4012910D
200	TUTB1226920D	TUTB3216920D	TUTB4012920D
300	TUTB1226930D	TUTB3216930D	TUTB4012930D

062 MINSTAC TOOLING & KITS

062 MINSTAC kits facilitate easy assembly of fitting ends, machining of 062 MINSTAC bosses, and include tools to enable easy installation.

062 MINSTAC FITTING END KITS

Each kit is specific to the inner diameter of tubing and includes everything needed to assemble up to 25 fitting ends. Tools are reusable; reorder more tubing, coupling screws, ferrules, and collet sleeves (one each per fitting end as needed).

DESCRIPTION	0.032" ID KIT TMZA3202010Z	0.040" ID KIT TMZA4001010Z	QTY.
Collet Tool	TTTA3201443A	TTTA4000143A	1
Chamfer Tool	TTTA3201543A	TTTA4000243A	1
Torque Wrench	TTTA3201243A		1
Tubing Cutter	TTTA6202327A		1
Rubber Tubing Grip	TTTX0500900A		1
Coupling Screw	TMAA3202079Z		25
Ferrule	TMBA3202910Z		25
Collet Sleeve	TMCA3202030Z		25
300 cm Tubing	TUTA3216930D	TUTA4012930D	1

BULK TUBING

LENGTH (cm)	0.012" ID	0.032" ID	0.040" ID
300	TUTA1226930D	TUTA3216930D	TUTA4012930D
3000	TUTA1226930H	TUTA3216930H	TUTA4012930H

062 MINSTAC BOSS MACHINING KIT

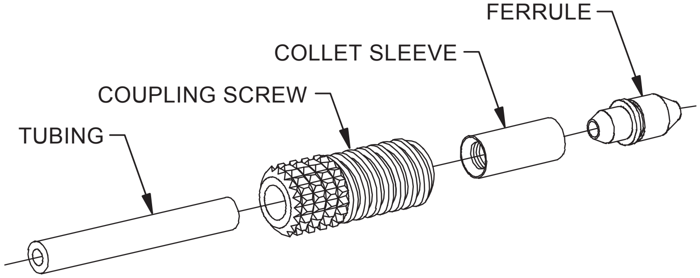
The 062 MINSTAC boss may be machined with commonly available CNC tooling, however, the tools below allow for boss manufacturing using equipment as simple as a drill press. For more information on producing the boss, reference page N9.

PART NUMBER	QTY.	DESCRIPTION
TTTA3200643A	1	Combination Boss Drill
TTTA3200743A	1	Plug Tap with Stop
TTTA3200843A	1	Bottoming Tap with Stop

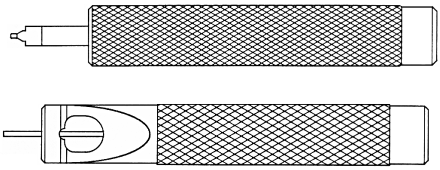
062 MINSTAC TUBING PREPARATION AND COUPLING ASSEMBLY

This section provides a step-by-step process and recommended guidelines for installing the 062 MINSTAC fitting ends onto PTFE tubing.

062 FITTING ASSEMBLY

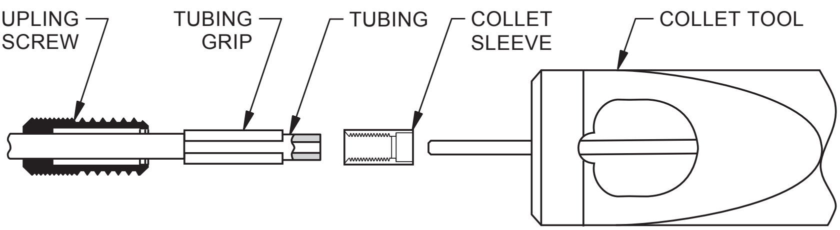


COUPLING ASSEMBLY TOOLS



PROCEDURE:

1. Cut the tubing to the desired length. The cut should be reasonably square.
2. Slide the Coupling Screw (part number TMAA3202079Z) over the end of the tubing, with the threaded end facing the tubing end. Place the Collet Sleeve into tool* (part number TTTA3201443A) counterbore end first.



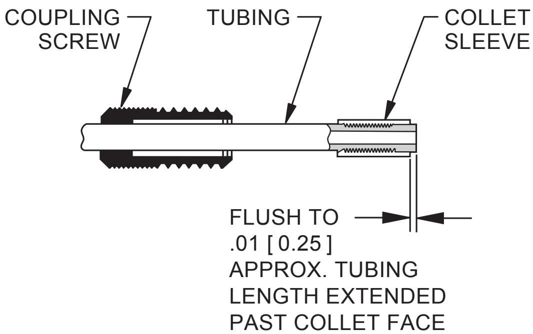
* Collet Tool (part number TTTA3201443A) is for use with 0.032" (0.81 mm) ID tubing. The following tools should be substituted for use with their respective tubing size:

TTTA3201743A: 0.012" (0.30 mm) ID tubing
TTTA4000143A: 0.040" (1.02 mm) ID tubing

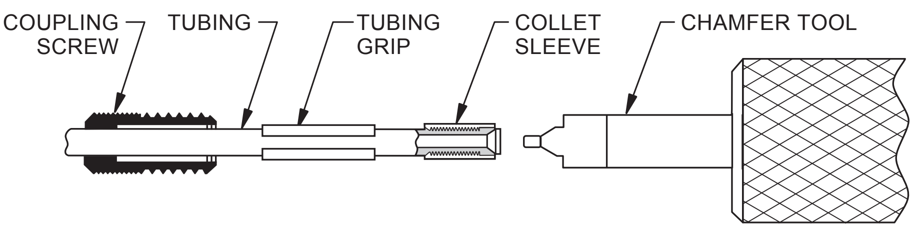
Drawings are not to scale.

PROCEDURE CONTINUED:

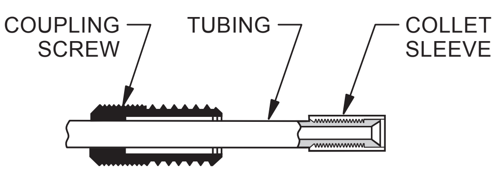
3. While holding the tubing with the Rubber Tubing Grip (part number TTTX0500900A), screw the Collet Sleeve onto the tubing end. This should require about 15-20 turns of the Collet Tool. Remove the tool from the coupling end and check that the tubing extends at least to the end of the Collet Sleeve.



4. Using the Chamfer Tool* (part number TTTA3201543A), place the pilot pin into the tubing assembly. Rotate the tool while applying a small axial force in a clockwise direction until it bottoms out against the Collet Sleeve (already installed on the tubing).



* The Chamfer Tool (part number TTTA3201543A) is for use with 0.032" (0.81 mm) ID tubing. The following tools should be substituted for use with their respective tubing size:



TTTA3201643A: 0.012" (0.30 mm) ID tubing

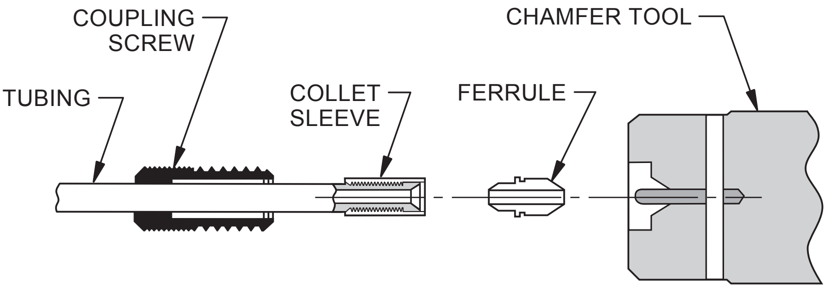
TTTA4000243A: 0.040" (1.02 mm) ID tubing

5. Slide the Coupling Screw over the Collet Sleeve.

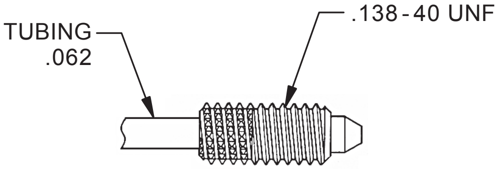
Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

PROCEDURE CONTINUED:

6. Push the Ferrule (part number TMBA3202910Z) onto the ferrule installation end of the Lee Chamfer Tool (part number TTTA3201543A).



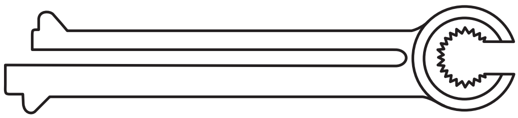
7. While holding the Coupling Screw, insert the Ferrule into the Coupling Screw and apply approximately 4 lbs (1.8 kg) of force. The Ferrule will "snap" in place. The coupling assembly is now complete.



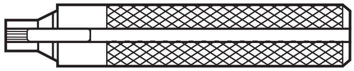
062 MINSTAC COUPLING INSTALLATION

COUPLING INSTALLATION TOOLS

This section will provide recommended practices and specifications to properly install the fittings into the 062 MINSTAC boss.



Torque Wrench
TTTA3201243A

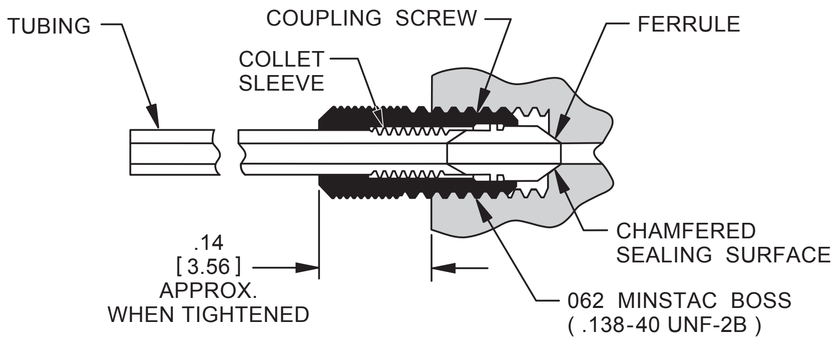


Spline Wrench
TTTA3200543C

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

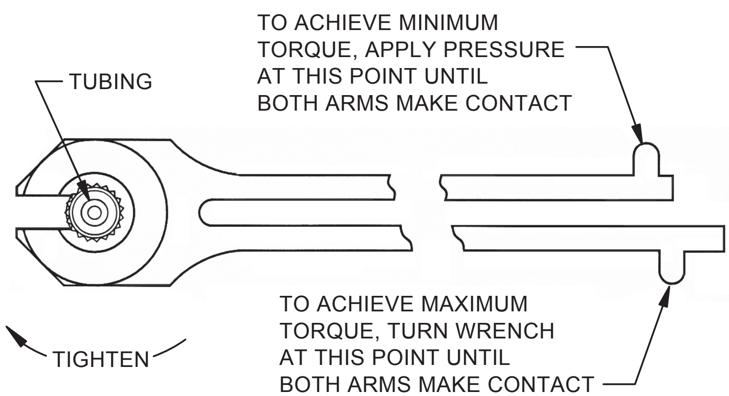
PROCEDURE:

1. Start threading coupling assembly into the 062 MINSTAC fitting boss by hand.



Cross section of installed assembly

2. Tighten the fitting between 5 to 10 ozf-in (0.035 to 0.07 N-m) by slipping the Torque Wrench (part number TTTA3201243A) onto the knurled Coupling Screw. The minimum torque is achieved by pressing the shorter torque arm clockwise until it just contacts the longer arm. To check that maximum recommended torque is not exceeded, invert the Torque Wrench and press the longer torque arm clockwise until the Coupling Screw begins to move. This should occur before the torque arms make contact. After gaining a feel for the proper torque, use of the Torque Wrench may be discontinued.

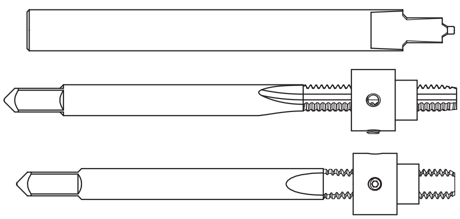


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

062 MINSTAC BOSS PREPARATION

The fitting boss required for the 062 MINSTAC coupling may be produced with the Combination Drill (part number TTTA3200643A). Dimensions shown below are for reference only; reference drawing number TMIX1300000A for complete 062 MINSTAC boss detail dimensions. The drill was designed for use in plastics and soft metals. It produces a boss (excluding the threads) with the proper configuration and dimensions. The boss may be produced as follows:

BOSS PREPARATION TOOLS

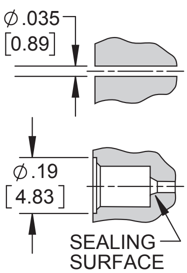


Combination Boss Drill: TTTA3200643A

Plug Tap: TTTA3200743A

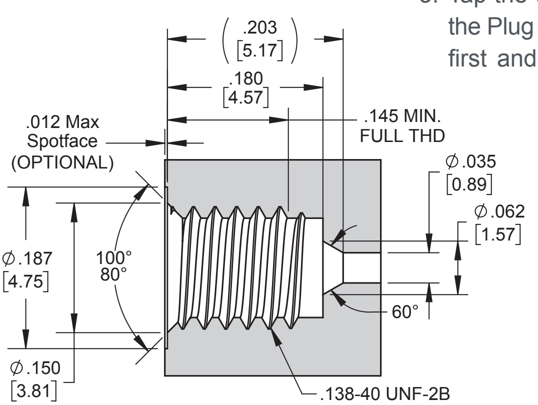
Bottoming Tap: TTA3200843A

PROCEDURE:



1. Drill a 0.035 of an inch (0.89 mm) diameter pilot hole in the desired boss location.
2. Insert the front of the Combination Boss Drill (part number TTTA3200643A) into the pilot hole and drill down until the 0.187 of an inch (4.75 mm) diameter spotface cleans up the surface of the boss. All diameters should be concentric within 0.006 of an inch (0.15 mm) T.I.R. The sealing surface should be smooth, with no burrs or tool marks.
3. Tap the 0.138-40 unfinished threads using the Plug Tap (part number TTTA3200743A) first and the Bottoming Tap (part number TTTA3200843A) second. These taps incorporate stops to avoid damaging the sealing surface. The boss is now complete.

NOTE: Care must be taken to ensure that the taps will follow true in the hole produced by the Combination Drill.



062 MINSTAC BOSS

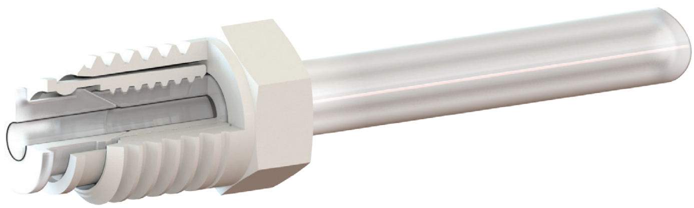
Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

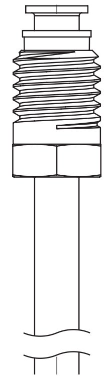
¼-28 FLAT BOTTOM MINSTAC

The Lee Company offers two different styles of ¼-28 flat bottom (FB) tubing assemblies: low profile and standard. Both connection types utilize an internally threaded collet that grips the outer diameter of the PTFE tubing to prevent cold flow and are highly reliable connections that never need adjustment after assembly.

LOW PROFILE

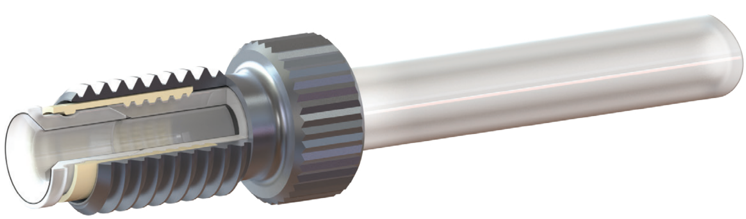
The economical, low profile tubing assembly is available in stock assemblies with 0.062" (1.6 mm) ID PTFE tubing and several different lengths. The fittings feature minimized fitting height above the installation boss and minimal allowed axial spacing between bosses, enabling tighter-spaced connections.

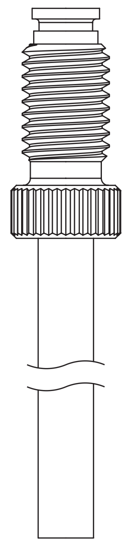




STANDARD

Our standard ¼-28 flat bottom tubing assemblies are available in stock with a 0.095" (2.4 mm) ID and several different lengths. The fittings feature an anodized aluminum finish and machined tubing grips for easy hand-installation.





¼-28 FB MINSTAC TUBING ASSEMBLIES

Stock tubing assemblies come pre-assembled and are produced to The Lee Company's rigorous quality standards. These tubing assemblies make the system design process a breeze. For OEM applications, customized tubing assemblies can be supplied. Contact a Lee Sales Engineer for assistance.

DOUBLE-ENDED TUBING ASSEMBLIES

INSTALLED LENGTH (cm)	STYLE	INNER DIAMETER	PART NUMBER
10	Low profile	0.060" (1.5 mm)	TNTC6230910L
15	Low profile	0.060" (1.5 mm)	TNTC6230915L
20	Low profile	0.060" (1.5 mm)	TNTC6230920L
30	Low profile	0.060" (1.5 mm)	TNTC6230930L
60	Low profile	0.060" (1.5 mm)	TNTC6230960L
100	Low profile	0.060" (1.5 mm)	TNTC6230910D
10	Standard	0.095" (2.4 mm)	TQTC9531910L
15	Standard	0.095" (2.4 mm)	TQTC9531915L
20	Standard	0.095" (2.4 mm)	TQTC9531920L
30	Standard	0.095" (2.4 mm)	TQTC9531930L
60	Standard	0.095" (2.4 mm)	TQTC9531960L
100	Standard	0.095" (2.4 mm)	TQTC9531910D

N

SINGLE-ENDED TUBING ASSEMBLIES

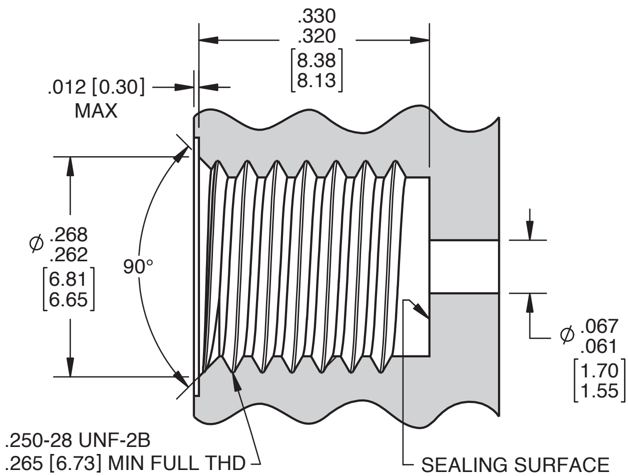
INSTALLED LENGTH (cm)	STYLE	INNER DIAMETER	PART NUMBER
10	Low profile	0.060" (1.5 mm)	TNTB6230910L
15	Low profile	0.060" (1.5 mm)	TNTB6230915L
20	Low profile	0.060" (1.5 mm)	TNTB6230920L
30	Low profile	0.060" (1.5 mm)	TNTB6230930L
60	Low profile	0.060" (1.5 mm)	TNTB6230960L
100	Low profile	0.060" (1.5 mm)	TNTB6230910D
10	Standard	0.095" (2.4 mm)	TQTB9531910L
15	Standard	0.095" (2.4 mm)	TQTB9531915L
20	Standard	0.095" (2.4 mm)	TQTB9531920L
30	Standard	0.095" (2.4 mm)	TQTB9531930L
60	Standard	0.095" (2.4 mm)	TQTB9531960L
100	Standard	0.095" (2.4 mm)	TQTB9531910D

¼-28 FB MINSTAC BULK TUBING

INSTALLED LENGTH (cm)	INNER DIAMETER	PART NUMBER
300	0.060" (1.5 mm)	TUTA6230930D
3000	0.060" (1.5 mm)	TUTA6230930H
300	0.095" (2.4 mm)	TUTA9531930D
3000	0.095" (2.4 mm)	TUTA9531930H

¼-28 FLAT BOTTOM MINSTAC BOSS

The ¼-28 flat bottom boss may be machined with commonly available CNC tooling. Boss geometries and dimensions shown below are for reference only. Refer to drawing number LSIX1001130A for complete specifications.

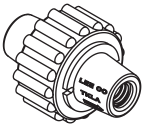
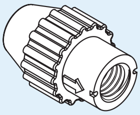


Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

INERT CHECK VALVES

MINSTAC components are constructed from inert materials for compatibility with reactive fluids. These components are designed to enable optimized fluid passageways, minimizing internal volume and ease of flushing. MINSTAC check valves offer simple threaded connections to allow easy system integration and provide backflow protection.

- **Cracking pressure:** 4 inches of water (1.0 kPa)
- **Chemically inert materials:** PEEK body, FFKM diaphragm, PTFE
- **Leakage:** 10 µL/min at 28 inches of water in the checked direction
- 35 microns (minimum) filtration recommended

PART NUMBER	CONNECTION	LOHM[1] RATE (NOMINAL)	MAXIMUM OPERATING PRESSURE	INTERNAL VOLUME[2] (µL)	ISOMETRIC VIEW[3]
TKLA3201112H	062 MINSTAC (0.138-40)	1200 Lohms	75 psig (517 kPa)	105	
TKLA9502130D	¼-28 flat bottom	300 Lohms	40 psig (276 kPa)	192	

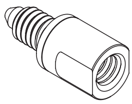
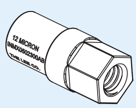
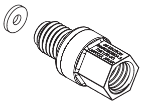
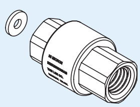
(1) Refer to Section Q for a full description of the Lohm Laws
(2) Internal volume is nominal; includes internal passages up to the bottom of fittings or the end of port connections.
(3) Isometric view is not to scale; refer to the inspection drawing for component dimensions.

INERT SAFETY SCREENS

MINSTAC safety screens are constructed of inert materials without the aid of any chemical bonding materials, making them ideal for applications with fluids.

Safety screens are designed to work in conjunction with a system filter and offer last-chance protection of sensitive fluidic components such as valves, sensors, and flow cells.

- **Flow direction:** bi-directional
- **Screen material:** woven mesh

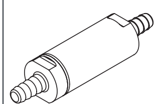
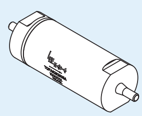
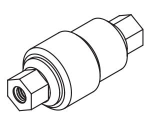
PART NUMBER & WETTED MATERIALS	NOMINAL PORE SIZE (MICRONS)	LOHMS[1]	INTERNAL VOLUME[2]	ISOMETRIC VIEW[3]	LEFT SIDE	RIGHT SIDE
INMX0350000A PEEK	12	1600	8 µL		062 MINSTAC (Male)	062 MINSTAC (Female)
INMX0350100A PEEK	35	1100				
INMX0504900A PEEK & 316 SS	75	1010				
INMX0502300A PEEK	12	1450	21 µL		062 MINSTAC (Female)	062 MINSTAC (Female)
INMX0350250A PEEK & PTFE	35	250	83 µL		¼-28 FB (Male)	¼-28 FB (Female)
INMX0350650A PEEK & PTFE	12	550				
INMX0503300A PEEK & PTFE	35	280	74 µL		¼-28 FB (Female)	¼-28 FB (Female)

(1) Refer to Section Q for a full description of the Lohm Laws
(2) Internal volume is nominal; includes internal passages up to the bottom of fittings or the end of port connections.
(3) Isometric view is not to scale; refer to the inspection drawing for component dimensions.

FILTERS

MINSTAC filters are constructed from inert materials and feature replaceable filter elements which can be easily and economically serviced.

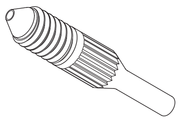
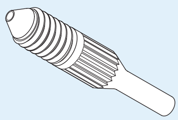
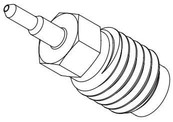
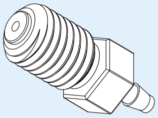
- **Flow direction:** unidirectional
- **Filter material:** formed UHMW-PE filter element

PART NUMBER & WETTED MATERIALS	NOMINAL PORE SIZE (MICRONS)	LOHMS[1]	MAX OPERATING PRESSURE (psig)	ISOMETRIC VIEW[2]	LEFT & RIGHT CONNECTOR	REPLACEMENT FILTER ELEMENT
TCFA1201035A UHMW-PE, FKM, & PC	35	350	30		Barb for 1/8" ID flexible tubing	TCFS0300210A
TCFA6202035A UHMW-PE, FKM, & PC	35	350	30		Barb for 1/16" ID flexible tubing	
TKFA3202135A PEEK, UHMW-PE, & PTFE	35	1300	100		062 MINSTAC (Female)	TCFS0300560A
TKFA3202110A PEEK, PTFE, & UHMW-PE	10					TCFS0301040A

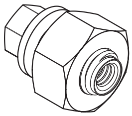
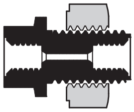
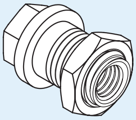
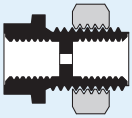
(1) Refer to Section Q for a full description of the Lohm Laws
(2) Isometric view is not to scale; refer to the inspection drawing for component dimensions.

MINSTAC adapters and unions enable connection to common industry tubing systems.

SOFT TUBING ADAPTERS

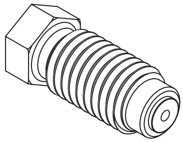
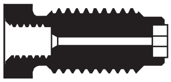
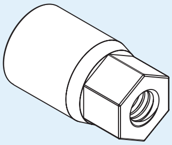
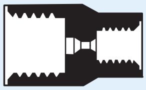
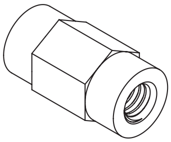
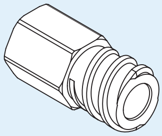
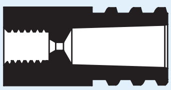
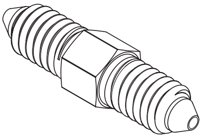
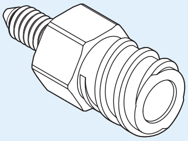
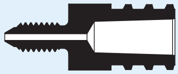
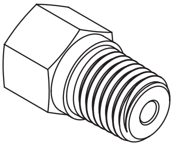
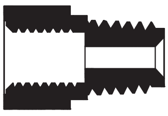
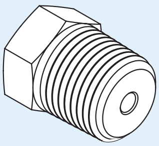
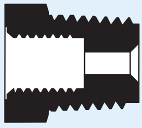
PART NUMBER & WETTED MATERIALS	ISOMETRIC[1] VIEW	CROSS SECTION	LEFT SIDE	RIGHT SIDE
TMDA3207950 PEEK			062 MINSTAC (Male)	For 0.042" ID soft tubing
TMDA3201950Z PEEK			062 MINSTAC (Male)	For 1/16" (0.062") ID soft tubing
TMDA2004910A PEEK & PTFE			Stepped interface for 0.020" and 1/32" (0.031") ID soft tubing	¼-28 FB (Male)
TMDA6201950A PEEK & PTFE			¼-28 FB (Male)	For 1/16" (0.062") ID soft tubing

BULKHEAD UNIONS

PART NUMBER & WETTED MATERIALS	ISOMETRIC[1] VIEW	CROSS SECTION	LEFT SIDE	RIGHT SIDE
TMUA3202950Z PEEK			062 MINSTAC (Female)	062 MINSTAC (Female)
TMUA9504950Z PEEK			¼-28 FB (Female)	¼-28 FB (Female)

(1) Isometric view is not to scale; refer to the inspection drawing for component dimensions.

THREADED ADAPTERS

PART NUMBER & WETTED MATERIALS	ISOMETRIC[1] VIEW	CROSS SECTION	LEFT SIDE	RIGHT SIDE
TMDA3204950Z PEEK & PTFE			062 MINSTAC (Female)	¼-28 FB (Male)
TMDA3212950Z PEEK			¼-28 FB (Female)	062 MINSTAC (Female)
TMUA3201950Z PEEK			062 MINSTAC (Female)	062 MINSTAC (Female)
TMRA3202950Z PEEK			062 MINSTAC (Female)	Luer Lock (Female)
TMUA3205950Z PEEK			062 MINSTAC (Male)	062 MINSTAC (Male)
TMRA3201950Z PEEK			062 MINSTAC (Male)	Luer Lock (Female)
TMGA9503950Z PEEK			¼-28 FB (Female)	1/16" NPT (Male)
TMGA9504950Z PEEK			¼-28 FB (Female)	1/8" NPT (Male)

(1) Isometric view is not to scale; refer to the inspection drawing for component dimensions.

N

GENERAL SPECIFICATIONS

All specifications listed within this handbook are for reference only. For full dimensions and specifications, refer to the inspection drawing for that particular part number. The following specifications apply to all MINSTAC products, unless otherwise noted.

OPERATING PRESSURE

MINSTAC components seal and are suitable for operating up to 120 psig (827 kPa) unless otherwise noted.

OPERATING TEMPERATURE

Ambient operating temperature range is 40°F to 120°F (4°C to 49°C).

STORAGE CONDITIONS

- Temperature: -40°F to 175°F (-40°C to 80°C)
- Relative humidity: 85% (max); non-condensing

INSTALLATION TORQUE

The torque required to seal varies based upon the material. Torque specifications noted below were developed for connection to PEEK bosses.

- 062 MINSTAC: 5-10 ozf-in (0.035-0.07 N-m)
- ¼-28 flat bottom boss: 7-21 ozf-in (0.05-0.15 N-m)

TUBING VOLUME & RESTRICTION

For MINSTAC tubing, the table below shows the nominal volume per centimeter of tubing.

INNER DIAMETER	VOLUME (µL per cm)
0.012" (0.3 mm)	0.7
0.032" (0.8 mm)	5.2
0.040" (1.0 mm)	8.1
0.062" (1.5 mm)	19.4
0.095" (2.4 mm)	45.6

NOTES

Medical and scientific equipment manufacturers need reliable, low-cost components that can be easily installed using manual or automated processes. Our line of metal check valves, pressure relief valves, single-orifice restrictors, and safety screen filters deliver on this requirement, performing as designed throughout the entire life of the product. Different models are available for either installation into metal manifolds or plastic tubing, fittings, or housings.

FEATURES:

- Low cost
- Small size: options as small as 2.5 mm
- Available in medical grade 316L
- Brass components for oxygen service
- Integrate into metal manifolds, plastic fittings, or tubing
- Customization available

APPLICATIONS:

- Disposable medical devices
- Microfluidics (lab-on-a-chip)
- Ambulatory hospital bed lifts
- Portable oxygen concentrators
- Prosthetics
- Surgical equipment
- Patient simulators
- Laboratory equipment
- Hearing protection
- Drug delivery and medication dispensing
- Wound therapy

CHECK & PRESSURE RELIEF VALVES

Our miniature check and pressure relief valves are designed to conform with existing automated and manual assembly workflows. The simple, cartridge-style design installs without threads, O-rings, or adhesive. Our integral retention features help to secure valves in place without the need for complex installation. All valves are 100% functionally tested before delivery, eliminating the need for additional inspections and guaranteeing they will meet your performance needs. Their high quality seats provide leak-tight operation, resulting in long life and superior system performance. Lastly, our guided ball designs provide fast response times and low hysteresis. We offer a variety of models of varying sizes and Lohm rates; some are available with or without integrated screens, elastomeric seals, and in a forward or reverse flow configuration.

- Standard sizes: Ø 2.5 mm to 8 mm
- Materials: all stainless steel construction. Some models feature medical grade 316L and ceramic balls for improved compatibility. Zero leak models feature a soft elastomeric seat for a more robust seal.

BODY MATERIAL	BALL MATERIALS	ELASTOMER MATERIALS *(ZERO LEAK MODELS)*
300 Series stainless steel	• 440C Series stainless steel • Ceramic	• FKM or EPDM: standard • FFKM, NBR, silicone: upon request

Selecting the right product begins with your installation material. If you plan to install the valves into metal, refer to our insert-style valves. If installing into plastic or tubing, refer to the press-in-style valves. The table below presents a general overview of standard offerings. Many can be made into a restrictor check valve, a flow control, or a vent valve. Please contact us for more information on customization opportunities.

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VALVE FAMILY	OPEN LOHM[1] RATE	INSERT INTO METAL	PRESS-IN TO PLASTIC
2.5 mm	750	–	✓
4.5 mm	250	–	✓
558 Series	250	✓	✓
558 LC Series	150	✓	✓
6 mm Zero Leak	250 or 700	✓	✓
6.5 mm	75	–	✓
855 Series	75	✓	✓
855 LC2 Series	45	✓	✓

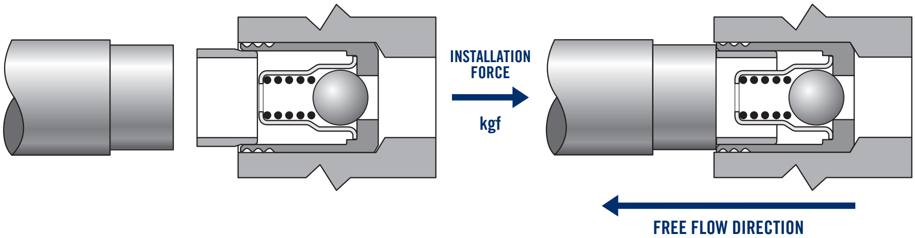
(1) Refer to Section Q for a full description of the Lohm Laws.

Scan the QR code or type in the URL to select a part number and receive more information on our various offerings.

theleeco.com/medicalcheckvalves

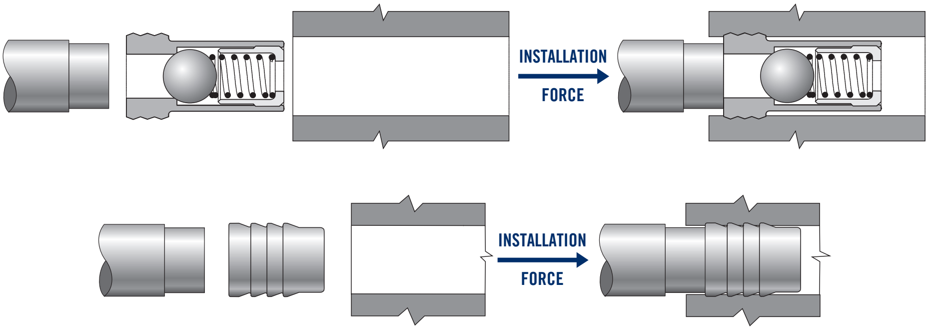
CHECK & PRESSURE RELIEF VALVES

INSERT INTO METAL



- Integrated locking end – an expansion pin is pre-installed and used to expand a grooved section of the insert's body into the metal housing.
- Forward and reverse flow configurations (reverse configuration shown above).
- Also available: side exit designs, medical grade 316L, ceramic ball designs, and integrated safety screen filters.

PRESS-IN TO PLASTIC



- Designed for installation into many compatible plastic manifolds, fittings, and soft tubing.
- Unique press-in design ensures retention via multiple sealing points and prevents bypass leakage.
- Compatible plastics with sufficient elongation: nylon, polypropylene, acetal, PEEK, and polyethylene. Please contact us for more information regarding installation and other material options.
- Medical grade 316L model with a ceramic ball is ideal for many medical applications.
- The 2.5 mm family fits into many common plastic medical fittings.
- See page O7 for standard products already installed into plastic or Tee fittings.

SINGLE-ORIFICE RESTRICTORS

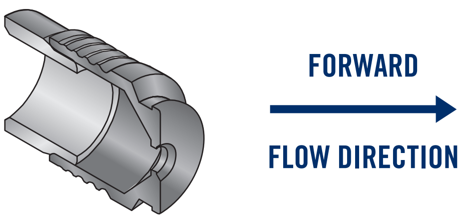
Our miniature, precision single-orifice restrictors are economical, highly accurate flow calibrated orifices designed to meter flow. Each flow restrictor is 100% flow tested to ensure that every part is within ± 5% of its nominal flow rate, providing consistent system performance. This provides far more flow accuracy than an orifice specified by hole tolerance. An ordinary hole held to a very tight tolerance will not result in a tight flow tolerance.

ACTUAL SIZE

2.5 mm for plastic

(As Installed)

To improve accuracy, we offer models that are intended for gas or liquid applications. Gas restrictors are flow tested on clean, dry nitrogen and liquid restrictors are tested on distilled water. Acceptance criteria are very high and each orifice is tested in the direction of use to increase accuracy.



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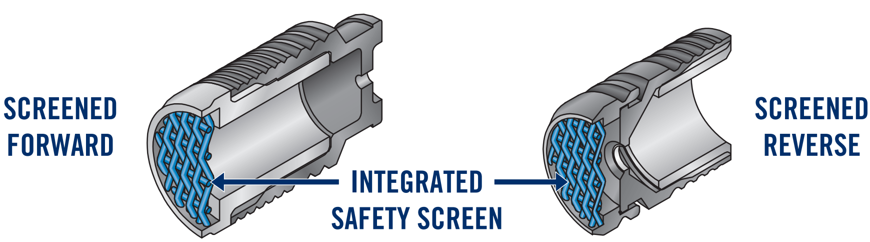
Because our components are used in such a large variety of applications, they're available in a range of sizes, configurations, and materials. Each configuration is easy to install and guaranteed to provide consistent flow performance with every part.

- 100% flow tested for accurate, consistent system performance
- Liquid and gas-tested, forward or reverse flow versions available
- Customizable Lohm Rate: 500 to 1 M Lohms or higher
- Reference hole sizes down to 0.0004" and (0.01 mm)
- Integrated safety screen filters available



Selecting the right product begins with your installation material. If you plan to install the restrictors into metal, refer to our insert-style models. If installing into plastic or tubing, refer to the press-in-style models. The tables below present a general overview of standard offerings. Please contact us for more information on customization opportunities.

INSERT INTO METAL

<table>
<tr><th>BODY DIAMETER</th><th>METERED FLOW RANGE[1]</th><th>MATERIALS</th></tr>
<tr><td>2.5 mm</td><td>• Screened:
40 micron: 8k to 45k Lohms
• Unscreened: 1.2k to 6k Lohms</td><td rowspan="3">Body: 303 stainless steel
Pin: 303 or 416 stainless steel
Screen: 316 stainless steel</td></tr>
<tr><td>5.5 mm</td><td rowspan="2">• Screened:
40 micron: 20k to 45k Lohms
75 micron: 6k to 15k Lohms
125 micron: 2k to 5k Lohms
• Unscreened: 500 to 1.5k Lohms</td></tr>
<tr><td>8.0 mm</td></tr>
</table>

(1) Refer to Section Q for a full description of the Lohm Laws.

PRESS-IN TO PLASTIC

BODY DIAMETER	METERED FLOW RANGE[1]	MATERIALS
2.5 mm	Unscreened: 500 to 45k Lohms	Body (3 options): • 303 stainless steel • 316 stainless steel • Brass C36000

(1) Refer to Section Q for a full description of the Lohm Laws.

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Scan the QR code or type in the URL to select a part number and receive more information on our various offerings.

theleeco.com/medicalflowrestrictors

SAFETY SCREEN FILTERS

Safety screen filters are designed to protect critical fluid control components from rogue contamination. Safety screen filters are available in a wide range of installation configurations and sizes to meet various system requirements.

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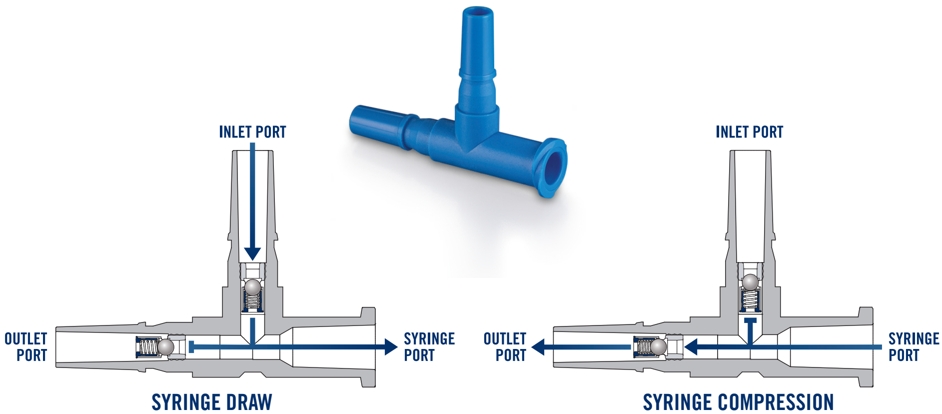
Stainless steel woven wire mesh designs offer a reliable and economical solution. Etched safety screens provide maximum open area to reduce pressure drop across the component and increase resistance to clogging. Drilled screens have high pressure capability, can be easily flushed, and are offered in a variety of materials such as PEEK for resistance against harsh chemicals and brass for use in oxygen systems.

- Maximum contamination protection (micron ratings from 4 to 500 microns) without unnecessary clogging
- Variety of configurations and sizes available for design flexibility
- Multiple material options for compatibility with a wide range of liquids and gases
- Diameters ranging from 2.5 mm to 16 mm
- For installation into metal or plastic

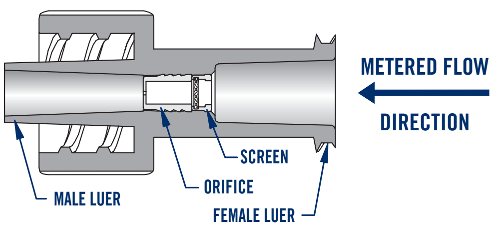
Scan the QR code or type in the URL to select a part number and receive more information on our various offerings.

theleeco.com/medicalsafetyscreens

Our check valves, pressure relief valves, single-orifice restrictors, and safety screen filters are also offered installed into various plastic fittings, including barb-to-barb unions, male to female luer adapters, and luer tee fittings. Some standard examples are shown below; please contact us or visit our website for more information on these standard offerings.



Above: the Pump Head Syringe T-Connector contains two 2.5 mm press-in check valves, one installed in each branch configured as inlet and outlet valves for a hand syringe-driven system. Each check valve has a cracking pressure of 4 kPa to provide positive shutoff.



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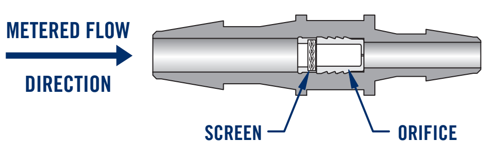
Above: a 300 Series stainless steel single-orifice restrictor shown installed into a medical grade polypropylene male to female luer adapter.

Below: orifices with Lohm rates as high as five million Lohms (equivalent to as small as a 0.0004 of an inch diameter orifice), can be incorporated into a barb-to-barb union with an integrated safety screen filter.



Scan the QR code or type in the URL to select a part number and receive more information on our various offerings.

theleeco.com/productsinplasticfittings

VISCO JET® MIXERS

The Lee *Visco Jet* Mixer uses aerospace technology to provide the ultimate in static mixing efficiency. A series of 36 critically-controlled spin chambers subject the incoming liquids to a vigorously repeated mixing process. No electrical or mechanical input is required – the mixing energy is drawn from the liquids themselves.

Two sizes are currently offered, differing primarily in their internal volume to optimize system performance.

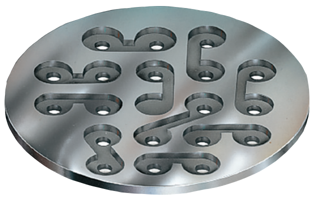
FEATURES:

- Low internal volume: 10 µL and 250 µL models
- Special sizes: as small as 3 µL available
- Material: 316 stainless steel
- Maximum flow: 45 mL/min at 70°F, 6000 psid water
- Screen protected passages
- Zero dead volume
- Proof-tested to 10,000 psi

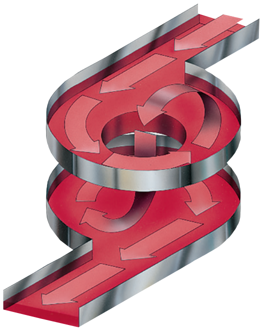
Each mixing chamber induces tangentially spinning fluids to reduce their radius of rotation to allow passage into the next chamber, thus increasing angular velocity.

This rapidly spinning column of liquid must then reverse its own direction of rotation in order to progress to subsequent spin chambers.

The result is a vigorously repeated mixing process.



SPIN CHAMBER



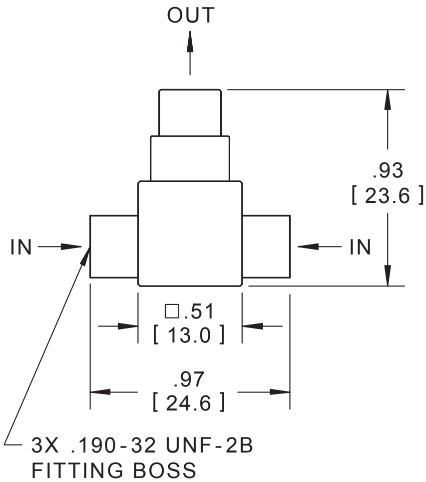
MIXING ACTION

Mixing in a Lee *Visco Jet* Mixer is a relatively brief process. As shown in the table below, the throughput time of the mixer is directly related to the flow rate. The more flow, the briefer the throughput time. It is during this throughput time that the two input flows are combined together for mixing.

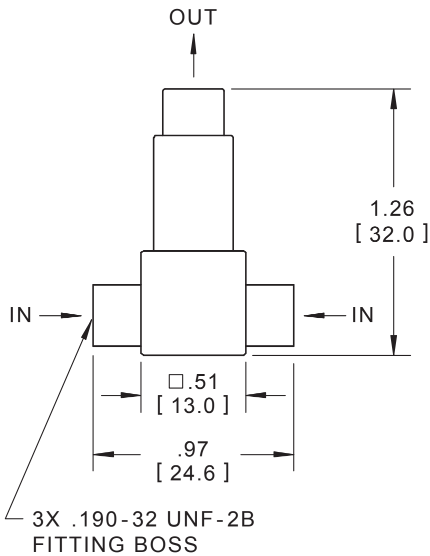
FLOW (μL/min)	THROUGHPUT TIME (SEC.)		PRESSURE DROP (psi)
	10 μL MIXER	250 μL MIXER	
50	12.0	300	0.01
100	6.0	150	0.04
200	3.0	75	0.1
500	1.2	30	1.0
1000	0.6	15	4.0
2000	0.3	7	16.0
4000	0.15	3	64.0

Any irregularities in either of the input flows will tend to be time-averaged during the throughput time of the mixer.

10 µL MODEL PART NUMBER TCMA0120113T



250 µL MODEL PART NUMBER TCMA2520113T



- **Wetted materials:** 316 stainless steel Au/Ni braze per AMS 4787
- **Proof pressure:** tested to 10,000 psi
- **Passage size:** 130 microns nominal
- **Internal protective filtration:** 17 µ nominal, 45 µ absolute
- **Lohm rate:** 130,000 Lohms ± 15%
- **Internal volume:** 10 µL and 250 µL
- **Fittings:** compatible with 10-32 threaded, 38° nominal coned port for 1/16" OD tubing (nuts, ferrules, and tubing are customer-supplied)

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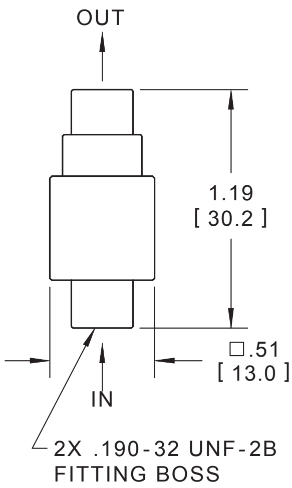
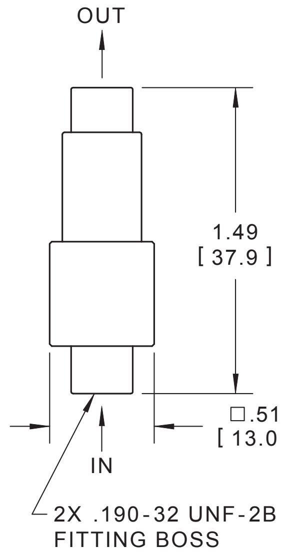
Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

IN-LINE 10 µL MODEL
PART NUMBER TCMA0110113T



IN-LINE 250 µL MODEL
PART NUMBER TCMA2510113T



PART NUMBER	INTERNAL VOLUME	MATERIAL
TCMA0120113T	10 µL	316 stainless steel
TCMA2520113T	250 µL	316 stainless steel
TCMA0110113T	10 µL	316 stainless steel
TCMA2510113T	250 µL	316 stainless steel

Unless otherwise specified, dimensions are in inches [mm]. Drawings are not to scale.

THE LEE COMPANY'S LOHM LAWS

Over the years, The Lee Company has developed the Lohm Laws for defining and measuring resistance to fluid flow. Just as the “Ohm” defines electrical resistance, the “Lohm” or “liquid Ohm” can be used as a measure of fluid resistance.

The Lohm is defined such that 1 Lohm will flow 100 gallons per minute of water with a pressure drop of 25 psi at a temperature of 80°F. Since resistance is inversely proportional to flow, by definition:

$$\text{Lohms} = \frac{100}{\text{flow (gal/min } H_2O \text{ @ 25 psid)}}$$

For example: 1000 Lohms will flow 0.1 GPM (378.5 mL/min)

378,500 Lohms will flow 1 mL/min

By using Lohms, one can specify performance without concern for coefficients for discharge, passageway geometrics, physical dimensions, or tolerances. The resistance of any flow can be expressed in Lohms and confirmed by actual flow tests.

Lohm Laws generalize the Lohm definition and allow the system designer to specify Lohm requirements for a particular application based on the desired pressures and flow rates.

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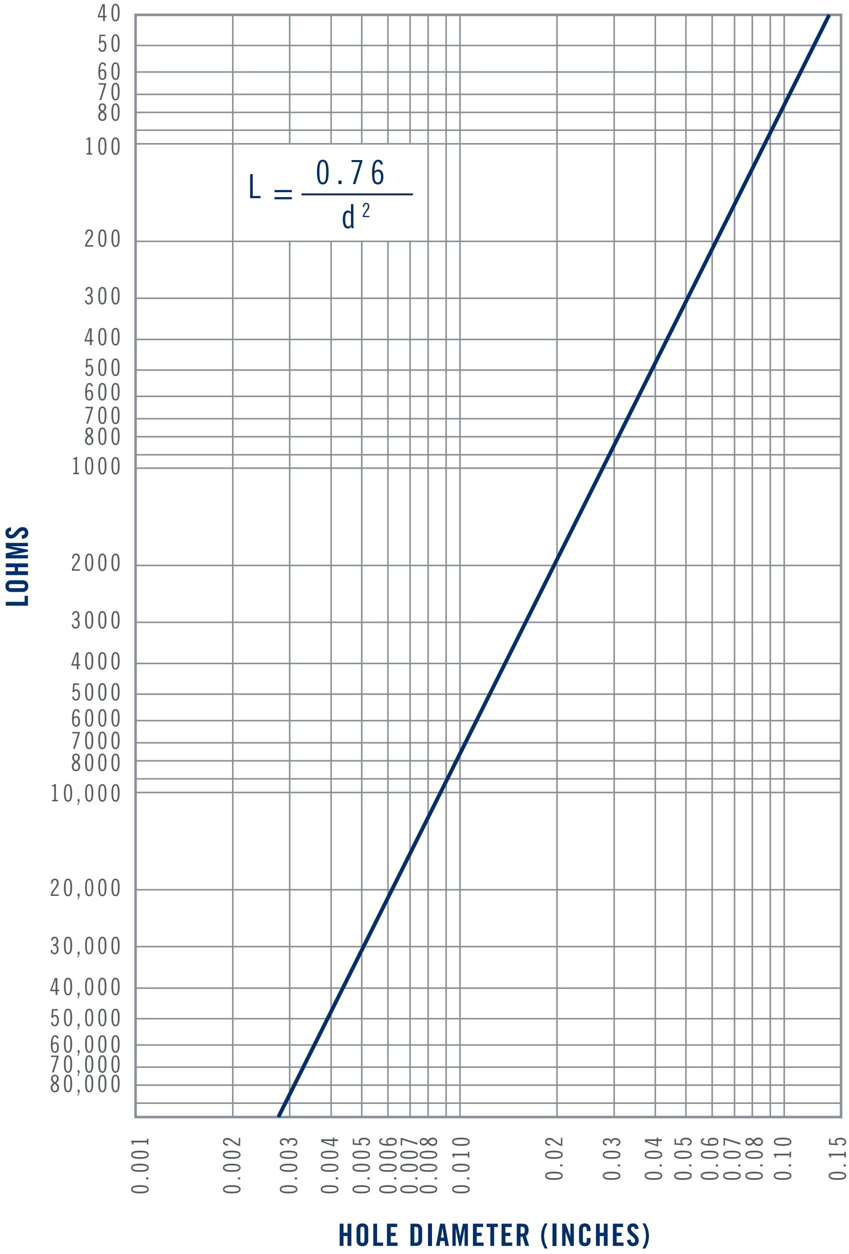
Scan the QR Code or visit theleeco.com/lohm-calculator to access the Lohm Calculator.

theleeco.com/lohm-calculator

HOW TO CALCULATE FLOW RESISTANCE FOR LIQUIDS

LOHM RATE VERSUS ORIFICE DIAMETER



HOW TO CALCULATE FLOW RESISTANCE FOR LIQUIDS

WATER FLOW – LOHM RATE FORMULA

The Lohm has been selected so that a 1 Lohm restriction will permit a flow of 100 gallons of water per minute with a pressure drop of 25 psi at a temperature of 80°F.

$$L = 20\,\frac{\sqrt{H}}{I}$$

$$I = 20\,\frac{\sqrt{H}}{L}$$

$$H = \frac{I^2 \times L^2}{400}$$

Where:

I = Flow rate (gallons per minute)

H = Differential pressure (psi)

L = Lohm rate, a measure of resistance to liquid flow. It includes all density, viscosity, Reynolds number, coefficient of discharge, and area units (Lohms).

When testing on water at 25 psi, ΔP, $\sqrt{H} = 5$ and the above formulas simplify as follows:

$$L = \frac{100}{I}$$

and

$$I = \frac{100}{L}$$

Some useful relationships:

1. 1000 Lohms will permit flow of 50 lb/hr water at 25 psi ΔP.
2. Convert Lohms to Flow Coefficient:

$$C_V = \frac{20}{L}$$

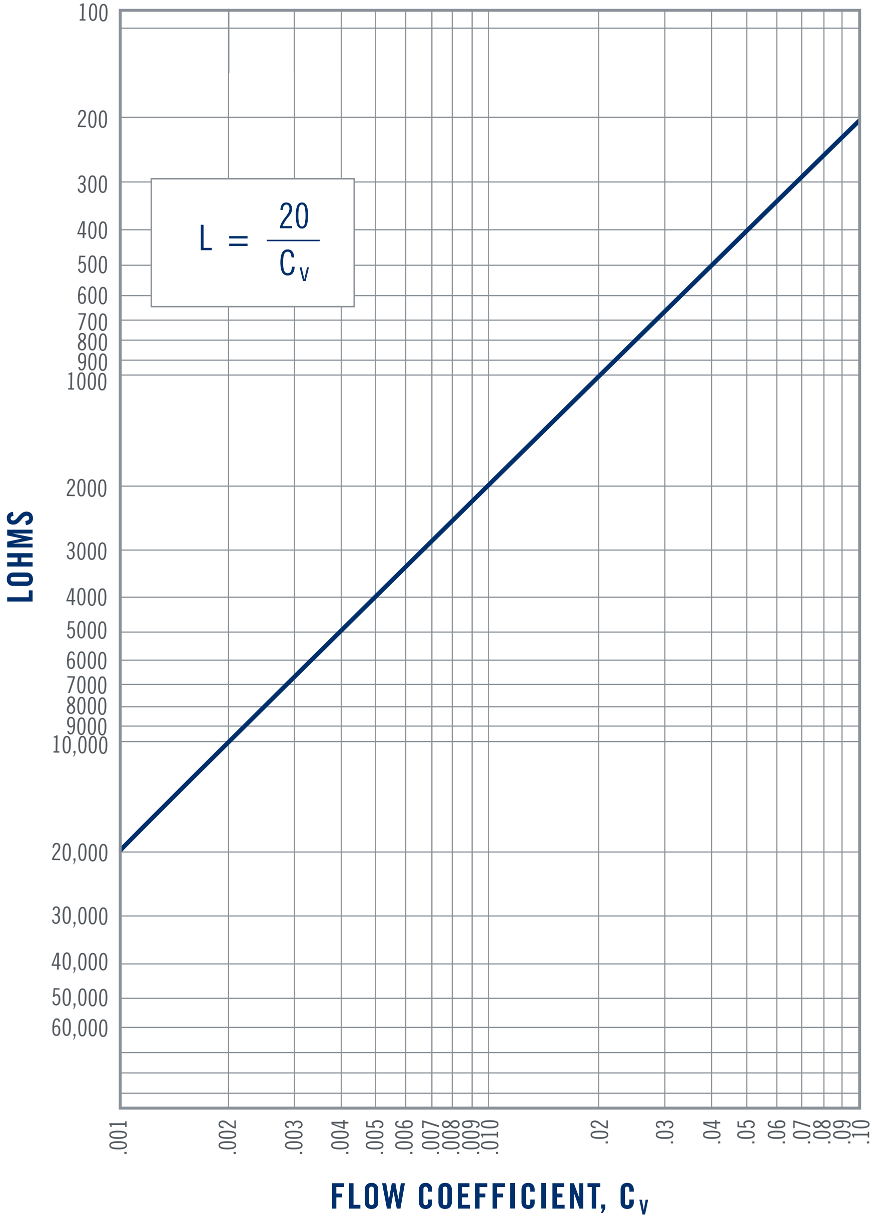
3. Convert Orifice Diameter (in) to Lohms:

$$L = \frac{0.76}{d^2}$$

4. Convert Coefficient of Discharge to Lohms:

$$L = \frac{0.527}{C_d A}$$

LIQUID LOHM RATE VERSUS HOLE DIAMETER (SINGLE ORIFICE RESTRICTOR)



APPROXIMATE HOLE DIAMETER (INCHES)

GRAPHICAL EXTENSION

.500 DIA. -3 LOHMS, .250 DIA. -12 LOHMS, .025 DIA. -1200 LOHMS

HOW TO CALCULATE FLOW RESISTANCE FOR LIQUIDS, cont.

WATER FLOW – EXAMPLES

Example 1. What restriction will permit a flow of 1 gallon of water per hour at 50 psi ΔP?

$\mathrm{I} = 1/60 = 0.0167$ GPM

$$L = \frac{20\sqrt{H}}{\mathrm{I}} = \frac{20\sqrt{50}}{0.0167} = 8500 \text{ Lohms}$$

Example 2. A jet with an approximate hole diameter of 0.012 of an inch flows 18 lb/hr of water at 100 psi ΔP. What is the restriction?

$$\mathrm{I} = \frac{18}{60 \times 8.345} = 0.036 \text{ GPM}$$

$$L = \frac{20\sqrt{H}}{\mathrm{I}} = \frac{20\sqrt{100}}{0.036} = \frac{200}{0.036} = 5500 \text{ Lohms}$$

Example 3. What ΔP will be required to flow 20 gallons of water per hour through a 2000 Lohm Jet?

$$\mathrm{I} = \frac{20}{60} = 0.333 \text{ GPM}$$

$$H = \frac{\mathrm{I}^2 \times L^2}{400} = \frac{0.333^2 \times 2000^2}{400} \quad \frac{0.111 \times 4{,}000{,}000}{400}$$

Example 4. What water flow will result from a restriction of 500 Lohms and a ΔP of 500 psi?

$$\mathrm{I} = \frac{20\sqrt{H}}{L} = \frac{20\sqrt{500}}{500} = 0.894 \text{ GPM}$$

NOTE: For special flow requirements, contact your local Lee Sales Engineer to determine the required Lohm rating.

LIQUID FLOW – LOHM RATE FORMULA

The following formulas are presented to extend the use of the Lohm Laws to many different liquids, operating over a wide range of pressure conditions. These formulas introduce compensation factors for liquid density and viscosity. They apply to any liquid of known properties, with minimum restrictions on pressure levels or temperature. The units constant “K” eliminates the need to convert pressure and flow parameters to special units.

VOLUMETRIC FLOW UNITS

$$L = \frac{KV}{I}\sqrt{\frac{H}{S}}$$

GRAVIMETRIC FLOW UNITS

$$L = \frac{KV}{w}\sqrt{HS}$$

Where:

L = Lohm rate (Lohms)
H = Differential pressure
I = Liquid flow rate: volumetric
S = Specific gravity*
V = Viscosity compensation factor** (view viscosity compensation factor on page Q10)
K = Units constant – liquid (see volumetric and gravimetric flow units on page Q9)
w = Liquid flow rate: gravimetric

*S = 1.0 for water at 80°F
**V = 1.0 for water at 80°F

LIQUID FLOW – EXAMPLES

Problem 1. A restrictor is required to flow 0.1 psid GPM of 50/50 ethylene glycol/ water blend (specific gravity = 1.07) at 45°F and 6 psid.

How many Lohms are required?

Solution:

1. Read kinematic viscosity; ν = 5.0 cs from curve on pages Q56-57.
2. Use v and ΔP to determine viscosity correction factor, V = .87, from curve on page Q10.
3. Select units constant K from table on page Q9.
4. Compute Lohms required.

$$L = 20 \frac{V}{I} \sqrt{\frac{H}{S}} = 20 \frac{.87}{.1} \sqrt{\frac{6}{1.07}} = 412 \text{ Lohms}$$

Problem 2. What pressure drop will result from a flow of 57 mL/min of 50/50 ethylene glycol/water mixture (specific gravity = 1.07) at 45°F, flowing through a 1000 Lohm restrictor?

Solution:

1. Find viscosity from pages Q56-57. ν = 5 cs
2. Use knowledge of system to assume initial solution.
   H = 4 psid
3. Use assumed H to determine V = 0.75 from chart on page Q10.
4. Select units constant K from table on page Q9.
5. Compute trial ΔP

$$H = S \frac{I^2 L^2}{K^2 V^2} = 1.07 \cdot \left(\frac{57 \cdot 1000}{75700 \cdot .75} \right)^2 = 1.08 \text{ psid}$$

6. Make trials as required to find correct solution.
   H = 2 psid V = .55

LIQUID FLOW – UNITS CONSTANT K

To eliminate the need to convert pressure and flow parameters to specific units such as PSI and GPM, the units constant K may be used in the Lohm formula:

$$L = \frac{KV}{I}\sqrt{\frac{H}{S}}$$

FLOW UNITS	PRESSURE UNITS						
	psi	bar	kPa	N/m^2	kg/cm^2	ft H_2O	mm/Hg
GPM	20	76.2	7.62	.24	75.4	13.2	2.78
L/min	75.7	288	28.8	.91	285	50	10.5
mL/min	75,700	288,000	28,800	911	285,000	50,000	10,500
in^3/min	4620	17,600	1760	55.6	17,400	3040	642
ft^3/min	2.67	10.2	1.02	.032	10	1.76	.372

Problem: An orifice must flow 43 in^3/min of water at a head of 300 kPa. What Lohm rate is required?

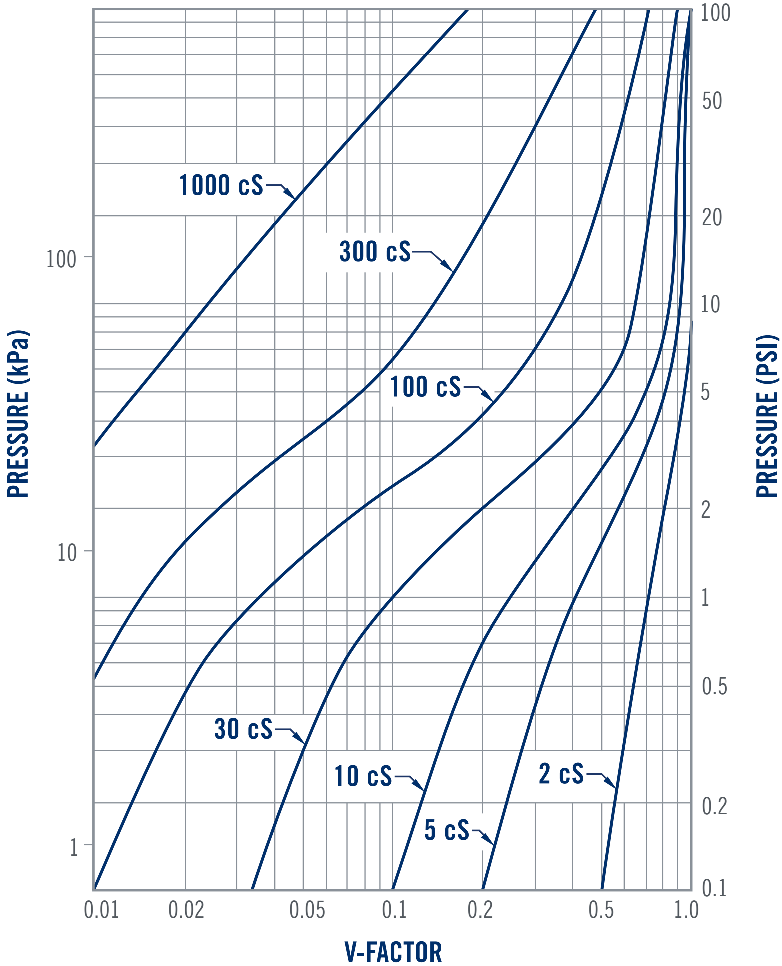
Solution: First, the appropriate K is selected from the table: K = 1760. Second, the Lohm formula is solved using the K value:

$$L = \frac{1760\sqrt{300}}{43} = 709 \text{ Lohms} \quad (S = V = 1.0)$$

VISCOSITY COMPENSATION FACTOR "V" FOR A SINGLE ORIFICE

V-FACTOR

The Viscosity Compensation Factor (V-Factor) was developed for use with single-orifice restrictors. If you know your V-Factor when using our online Lohm Calculator (see page Q2), you can check the box and manually enter the value. Otherwise, the online calculator will compute it for you. Since V-Factor is an approximation for single orifice restrictions, its accuracy diminishes when applied to other geometries, with accuracy further diminished in applications where fluid viscosity is greatly increased. It should therefore only be used as a general guide if the resistance flow path is anything other than a single orifice.



NOTE: V-Factor Curve may vary depending on specific geometry of the device.

TWO FORMULAS FOR COMBINATIONS OF RESTRICTORS

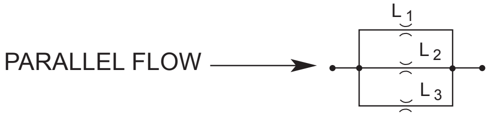
LIQUID FLOW – COMBINATIONS OF RESTRICTORS

For parallel flow, the total Lohm rating is:

$$\frac{1}{L_T} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_N}$$

Please note that this relationship is identical to the electrical equation.

Example 1: Parallel Flow



L_1 = 2000 Lohms
L_2 = 3000 Lohms
L_3 = 5000 Lohms

$$\frac{1}{L_T} = \frac{1}{2000} + \frac{1}{3000} + \frac{1}{5000} = 0.00103$$

and therefore L_T = 970 Lohms

For series flow, the total Lohm rating is:

$$L_T = \sqrt{L_1^2 + L_2^2 + L_3^2 + \cdots + L_N^2}$$

Please note that this relationship is not the same as in electrical problems. The difference is due to the non-linearity of:

$$H = \frac{I^2 L^2}{400}$$

Example 2: Series Flow

$$L_T = \sqrt{2000^2 + 3000^2 + 5000^2} = 6160 \text{ Lohms}$$

When $L_1 = L_2 = L_3$, then $L_T = L\sqrt{N}$

N = Number of equal resistors in series

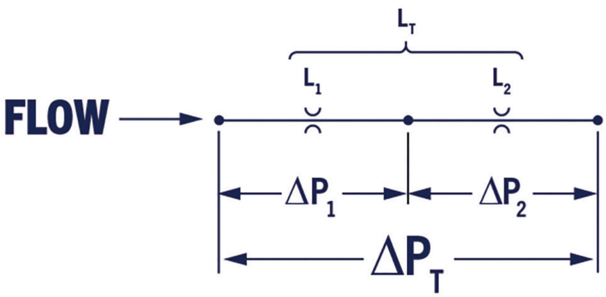
For passageway size: $D_T = D/N^{1/4}$

D_T = Diameter of a single equivalent orifice, with a Lohm rate = L_T

D = Diameter of the actual orifices, each with a Lohm rate = L_1

LIQUID FLOW – SERIES FLOW

One of the reasons for using two restrictors in series is to allow fine-tuning of a total resistance value. If L1 is known and is more than 90% of LT, then L2 may vary by ±5% without altering the value of LT by more than ±1%, even though the value of L2 may be as high as 40% of LT. This effect becomes even more pronounced as L1 approaches LT.



To determine the intermediate pressure between two restrictors in series, the following formulas may be used.

$$\Delta P_1 = \frac{\Delta P_T}{1 + \left(\frac{L_2}{L_1}\right)^2}$$

$$\Delta P_2 = \frac{\Delta P_T}{1 + \left(\frac{L_1}{L_2}\right)^2}$$

$$\left(\frac{L_1}{L_2}\right)^2 = \frac{\Delta P_1}{\Delta P_2}$$

GAS VS. LIQUID CALIBRATION

The majority of our health and science products are calibrated on gas for both gas and liquid service. Should it be necessary to use a gas calibrated component for liquid service, or a liquid calibrated component for gas service, the following factors should be considered.

Allowance should be made for variations in liquid/gas correlation of up to ±15%. This is caused by the response of different fluids to the orifice geometry.

Single-orifice restrictors will correlate directly from gas to liquid service, subject to the ±15% normal variation.

Multi-orifice restrictors will correlate directly only when the pneumatic pressure ratio is very low ($P_1 / P_2 < 1.2$).

When multi-orifice restrictors are used at higher pressure ratios, the gas flow will be up to 30% higher than expected from a liquid calibration. This is caused by gas compressibility which results in a non-uniform distribution of pressure drops through the restrictor.

WARNING: Do not substitute hydraulic restrictors in gas applications, or vice versa, without first considering the application and correlation accuracy.

STANDARD CONDITIONS

U.S. Standard Conditions at sea level are per ICAO STD ATMOSPHERE

Pressure .... 14.70 psia (29.92 in. Hg)

Temperature .... 59°F (518.7°R)

Other references may use somewhat different conditions.

ACFM TO SCFM CONVERSION

It is frequently convenient to express gas flow in terms of flow at standard conditions. This is useful for calculation purposes or for the application of flow measuring instruments.

However, since most applications are not occurring under standard conditions, it may be necessary to convert the actual conditions to standard. The following formula can be used to convert the actual flow rate to the standard flow rate in cubic feet per minute. The flow rate in other units can be determined by converting them into cubic feet per minute before and after using the formula.

$$\text{SCFM} = \text{ACFM}\left(\frac{P}{14.7}\right)\left(\frac{519}{460+T}\right)$$

Where:

T = Gas temperature (°F)
P = Gas pressure (psia)
ACFM = Gas flow (actual cubic feet/minute)
SCFM = Gas flow (standard cubic feet/minute)

EXAMPLE: What is SCFM corresponding to 0.032 ACFM at 300 psia and at 240°F?

SOLUTION:

$$\text{SCFM} = 0.032\left(\frac{300}{14.7}\right)\left(\frac{519}{700}\right) = 0.48$$

WORKING WITH GASES

The Lee Company has developed the Lohm Laws, a simple method of defining and measuring resistance to fluid flow for pneumatic components. Just as the Ohm is used in the electrical industry, we find that we can use a liquid Ohm or "Lohm" as an advantage when performing fluidic computations.

The benefit of using the Lohm Laws is that you can forget about coefficients of discharge and dimensional tolerances on drilled holes. These factors are automatically compensated for in the Lohm calculations and confirmed by our testing of each component to establish flow tolerances. The resistance to flow of any fluid component can be expressed in Lohms.

When using the Lohm system for pneumatics, the effect of flow in the subsonic region and the compressibility of gases is corrected for in the Lohm calculations. The resistance to flow of any component can be expressed in Lohms.

The Lohm has been selected so that a 100 Lohm restrictor will permit a flow of 250 standard liters per minute of nitrogen at a temperature of 59°F, and an upstream pressure of 90 psia discharging to atmosphere.

Due to the differences in fluid properties between gases and liquids, the equations for calculating the relationship between flow restriction, pressure differential, and flow rate are different.

HOW TO CALCULATE FLOW RESISTANCE FOR GASES

GAS FLOW - LOHM RATE FORMULA

The Lohm Laws extend the definition of Lohms for gas flow at any pressure and temperature, and with any gas. The formulas work well for all gases because they are corrected for the specific gas and for the flow conditions caused by the compressibility of gases due to pressure.

The steps for using the gas Lohm rate formula are below.

Sonic condition:

i.e. $P_1/P_2 \geq 1.9$

$$L = \frac{K\, f_T\, P_1}{Q}$$

Subsonic condition:

i.e. $P_1/P_2 \leq 1.9$

$$L = \frac{2\, K\, f_T \sqrt{\Delta P\, P_2}}{Q}$$

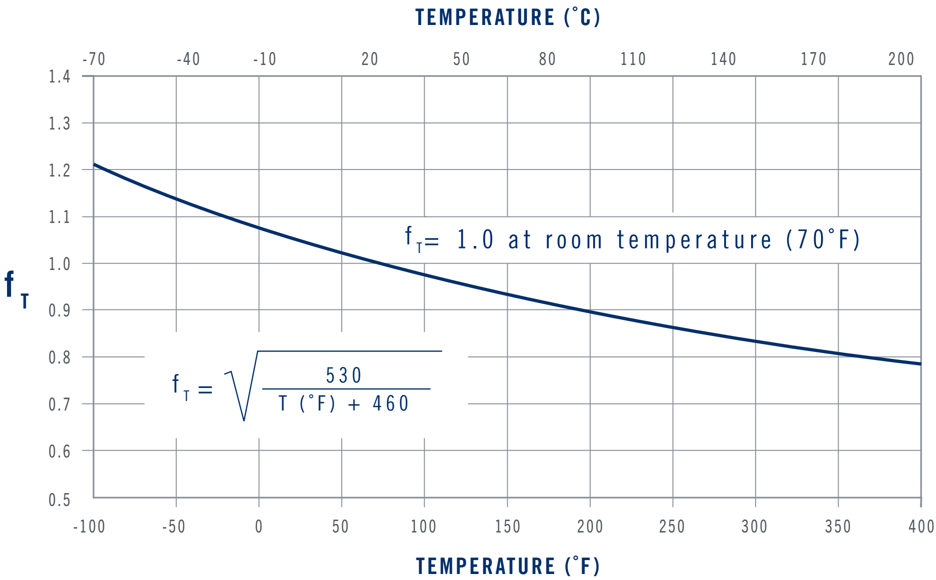
Where:

- L = Lohm rate (Lohms)
- K = Gas flow – Units Constant (see volumetric and gravimetric flow units in tables on next page)
- f_T = Temperature correction factor (see "Temperature Correction Factor f_T" chart on next page)
- P1 = Upstream absolute pressure
- P2 = Downstream absolute pressure
- Q = Gas flow rate
- ΔP = P1 – P2

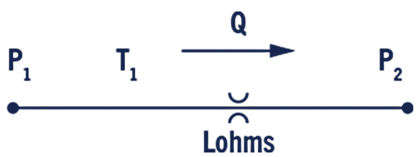
Steps for using the gas Lohm rate formula:

1. Compute the P1 / P2 pressure ratio.
2. Select the correct formula for the flow condition.
3. Look up the value of "K" for the gas.
4. Determine the temperature correction factor, "f_T".
5. Use the formula to solve for the unknown.

TEMPERATURE CORRECTION FACTOR f_T



GAS FLOW - EXAMPLE



EXAMPLE: What restriction will permit a flow of 1.00 SLPM of nitrogen at 90°F with a supply pressure of 5 psig discharging to the atmosphere?

K = 276 (see pages Q18-19)

T_1 = 90 f_T = 0.98 (see chart above)

P = 5.0 + 14.7 = 19.7 psia, P_2 = 14.7 psia

P_1/P_2 = 19.7/14.7 = 1.34 (subsonic)

ΔP = 5.0 psid

Q = 1.00 SLPM

$$L = \frac{2\,(276)\,0.98\sqrt{5.0\,(14.7)}}{1.00} = 4640 \text{ Lohms}$$

GAS FLOW - UNITS CONSTANT K

VOLUMETRIC

To eliminate the need to convert pressure and flow parameters into specific units such as psia and standard liters per minute, the tables below list the values of the units constant K, which is used in the gas flow Lohm formulas. Depending on your application, it may be more appropriate to use the volumetric or gravimetric flow units.

REFERENCE TABLE

VOLUMETRIC FLOW UNITS							
Abs. Pressure	psia			bar		kPa	mm Hg
FLOW	SLPM	SCFM	in^3/min	SLPM	SCFM	SLPM	mL/min
H_2	1030	36.3	62,700	14,900	526	149	19,900
He	771	27.2	47,100	11,200	395	112	14,900
Neon	343	12.1	20,900	4980	176	49.8	6640
Nat. Gas	319	11.3	19,400	4620	163	46.2	6160
N_2	276	9.73	16,800	4000	141	40.0	5330
CO	274	9.69	16,700	2980	141	39.8	5300
Air	271	9.56	16,500	3930	139	39.3	5230
Ethane	251	8.86	15,300	3640	129	36.4	4850
O_2	257	9.08	15,700	3730	132	37.3	4970
Argon	245	8.65	14,900	3550	125	35.5	4730
CO_2	213	7.52	13,000	3090	109	30.9	4110
N_2O	214	7.56	13,100	3100	110	31.0	4140
SO_2	176	6.21	10,700	2550	90.1	25.5	3400
Freon-12	123	4.34	7510	1780	63.0	17.8	2380
Xe	135	4.77	8253	1956	69.1	19.6	2605

GAS FLOW - UNITS CONSTANT K

GRAVIMETRIC

See examples on page Q20 of using the Units Constant K with flow specified in either volume or weight units.

REFERENCE TABLE

GRAVIMETRIC FLOW UNITS							
Abs. Pressure	psia			bar		kPa	mm Hg
FLOW	PPH	lbm/s	kg/min	PPH	kg/min	kg/min	gm/min
H_2	11.6	0.00322	0.0876	168	1.27	0.0127	1.69
He	17.6	0.00479	0.131	250	1.89	0.0189	2.52
Neon	38.7	0.0108	0.293	561	4.25	0.0425	5.66
Nat. Gas	34.8	0.00966	0.263	505	3.82	0.0382	5.09
N_2	43.2	0.0120	0.326	626	4.73	0.0472	6.31
CO	43.0	0.0119	0.325	623	4.71	0.0471	6.28
Air	43.8	0.0122	0.331	636	4.81	0.0481	6.41
Ethane	42.2	0.0117	0.319	611	4.62	0.0462	6.16
O_2	46.0	0.0128	0.348	667	5.04	0.0504	6.72
Argon	54.6	0.0152	0.413	792	5.99	0.0599	7.99
CO_2	52.4	0.0145	0.396	759	5.74	0.0574	7.65
N_2O	52.7	0.0146	0.398	764	5.77	0.0577	7.70
SO_2	62.0	0.0175	0.476	914	6.91	0.0691	9.21
Freon-12	83.2	0.0231	0.629	1210	9.12	0.0912	12.2
Xe	97.6	0.0271	0.738	1415.6	10.7	0.1070	14.24

Gravimetric Example:

If a Lohm rate is being calculated for an argon application using pounds per hour and bar as the flow and pressure units, the unit constant is 792.

GAS FLOW EXAMPLE

EXAMPLE: A restrictor must flow 8.20 SLPM of helium at room temperature (70°F), with an inlet pressure of 1500 kPa, discharging to atmosphere. What Lohm rate is required?

K = 112 (see pages Q18-19)
T_1 = 70°F, f_T = 1.00 (see page Q17)
P_1 = 1500 kPa, P_2 = 101 kPa
P_1/P_2 = 14.9 (sonic)
Q = 8.20 SLPM

$$L = \frac{112 \times 1{,}500 \times 1.00}{8.20} = 20{,}500 \text{ Lohms}$$

EXAMPLE: A restrictor must flow 0.0015 lb_m / s of oxygen at room temperature (70°F), with an inlet pressure of 1200 psia, discharging to 850 psia. What Lohm rate is required?

K = 0.0128 (see pages Q18-19)
T_1 = 70°F , f_T = 1.00
P_1 = 1200 psia, P_2 = 850 psia
P_1/P_2 = 1.41 (subsonic)
ΔP = 350 psid
w = 0.0015 lb_m / s

$$L = \frac{2 \times 0.0128 \times 1.00 \times \sqrt{350 \times 850}}{0.0015} = 9300 \text{ Lohms}$$

ABSOLUTE PRESSURE MEASUREMENT

Gas flow is a function of upstream absolute pressure, and of the ratio of upstream to downstream pressures. Lohm testing done at The Lee Company is performed at an upstream pressure that is high enough so that downstream pressure does not affect the flow rate. To accurately determine the upstream absolute pressure, it is necessary to measure atmospheric pressure with a suitable barometer. This measurement will normally be in units of in. Hg, while the gauge pressure reading is in units of psig. Thus, the barometer reading must be converted to psia, and added to the gauge reading to get the value of pressure in psia.

$$\boxed{\text{Pres. (psia)} = \text{Pres. (psig)} + 0.4912 \times \text{Pres. (in. Hg)}}$$

EXAMPLE: What single-orifice restriction will permit a flow of 2.00 SLPM of nitrogen at 70°F, with supply pressure at 10 psig, discharging to an atmospheric pressure of 29.5 in. Hg?

K = 276 (see pages Q18-19)
T_1 = 70°F, f_T = 1.00 (see page Q17)
P_2 = 0.4912 x 29.5 = 14.5 psia
P_1 = 10.0 + 14.5 = 24.5 psia
P_1/P_2 = 24.5/14.5 = 1.69 (subsonic)
ΔP = 24.5 - 14.5 = 10.0 psid
Q = 2.00 SLPM

$$L = \frac{2\,(276)\,1.0\,\sqrt{10.0\,(14.5)}}{2.00} = 3320 \text{ Lohms}$$

GAS FLOW CHARACTERISTICS

When selecting components for use in a gas system, certain factors must be considered which arise only because of the compressibility of gases. The nature of this compressibility is defined by the following two rules.

Boyle's Law: The pressure and specific volume of a gas are inversely proportional to each other under conditions of constant temperature.

Charles' Law: The pressure and temperature of a gas are directly proportional to each other when the volume is held constant, and the volume and temperature are directly proportional when the pressure is held constant.

Thus, a gas will expand to fill any container, and pressure and temperature will adjust to values consistent with the above rules. Gas flowing through valves and restrictors will be subject to an increasing specific volume as pressure drops take place, and temperatures will change as determined by the Joule-Thomson effect.

The combination of the above rules forms the basis for the "Equation of State" for perfect gases. This allows either pressure, temperature, or volume to be calculated for a known quantity of gas when the other two variables are known.

$$pV = mRT$$

(For values of the gas constant R see page Q27)

In general, the following comments apply to gas flow:

1. Gas flow at high pressure ratios ($P_1/P_2 > 1.9$) is directly proportional to the upstream absolute pressure.
2. Gas flow at moderate pressure ratios ($P_1/P_2 < 1.9$) is proportional to the downstream absolute pressure, and to the pressure differential (see page Q16).

GAS FLOW CHARACTERISTICS (CONTINUED)

3. Gas flow at low pressure ratios ($P_1 / P_2 < 1.1$) is proportional to the pressure differential, similar to hydraulic flow.
4. When restrictors appear in series, the most downstream restrictor dominates in the determination of flow rate.
5. When the absolute pressure ratio across a restrictor is above 1.9, the gas velocity will reach the speed of sound (sonic flow) in the restrictor's throat. When restrictors appear in series, the overall pressure ratio must be higher to achieve sonic flow.
6. When equal restrictors appear in series, sonic flow can only occur in the most downstream restrictor.
7. The velocity of a gas stream cannot exceed the speed of sound in either a constant area duct or a converging section.

The Rule of Forbidden Signals:

“The effect of pressure changes produced by a body moving at a speed faster than the speed of sound cannot reach points ahead of the body.” (Von Karman, 1947).

This rule can be applied to pneumatic flow restrictors where the body is not moving but the flow velocity relative to the body can reach or exceed the speed of sound. Whenever the downstream pressure is low enough to produce Mach 1 at the restrictor throat, any effect of changes in the downstream pressure cannot reach points upstream of the throat. Thus, the flow rate will be independent of downstream pressure. This situation applies to a single orifice restrictor flowing air when the overall pressure ratio exceeds 1.89/1.

Source Cited: Von Karman, T. (1947). Supersonic Aerodynamics - Principles and Applications The Tenth Wright Brothers Lecture. *Journal of the Aeronautical Sciences*, 14(7), 373-402.

MOMENTUM FORCES – GAS FLOW

When a flowing stream of gas is subject to a change in velocity (either speed or direction), forces arise which are the reaction to the change in momentum of the stream. This is particularly important in valve design where the position of a moving element may be affected.

The direction in which the momentum force acts is always opposite to the acceleration which is imparted to the flow stream. The magnitude of the force may be calculated by using the momentum Lohm Laws, which apply to air at near room temperature.

SONIC FLOW

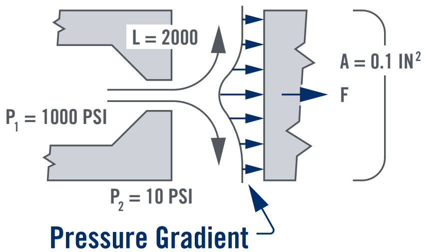
$$F = \frac{0.42 \times P_1}{L} \qquad F = \frac{Q}{645}$$

L = Orifice Lohm Rate (Lohms)

Q = Flow Rate (SLPM)

EXAMPLE: Where a gas changes direction.

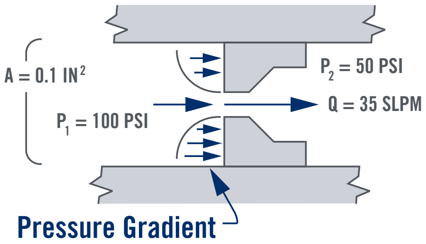
$$F = \frac{0.42 \times P_1}{L} = \frac{0.42 \times 1000}{2000} = 0.21 \text{ lbf}$$



The momentum force of 0.21 of a pound in this example must be added to the force produced by static pressure on the plate (0.1 in^2 x 10 psi = 1 lb) to give the total force on the plate.

EXAMPLE: Where a gas changes speed.

$$F = \frac{Q}{645} = \frac{35}{645} = 0.05 \text{ lbf}$$



The momentum force of 0.05 of a pound in this example must be subtracted from the force produced by static pressure on the plate (0.1 in^2 x [100-50] = 5 lbs) to give the total force on the piston.

PNEUMATIC POWER

A gas flowing through an orifice is throttled (causing turbulence and heating) and expanded (causing cooling). Therefore, it is subject to energy conversions that reduce the amount of energy available to do work. The rate at which available energy is lost can be termed the pneumatic power — a function of the pressures, the Lohm rate of the orifice, and the flow. The graph on the next page shows the relationship for nitrogen.

The power consumption can be determined from the graph when the flow rate and the pressure ratio are known. If the flow rate is not known, it can be calculated from the Lohm rate using the gas Lohm Law. Plot a point on the graph at the appropriate pressure ratio (X-axis), and follow the vertical line to the point of intersection corresponding to the applicable flow rate. The resulting power may be read via the horizontal line intersecting the Y-axis. Note that the pressure ratio is the ratio of the absolute pressures.

The following formula may be used for nitrogen or air for more precise calculations or to extend the range of the pneumatic power graph.

$$HP = \frac{2.2\,P_1}{L}\left[\left(P_1 / P_2\right)^{1/4} - 1\right]$$

WHERE:

HP = Pneumatic power (Horsepower)

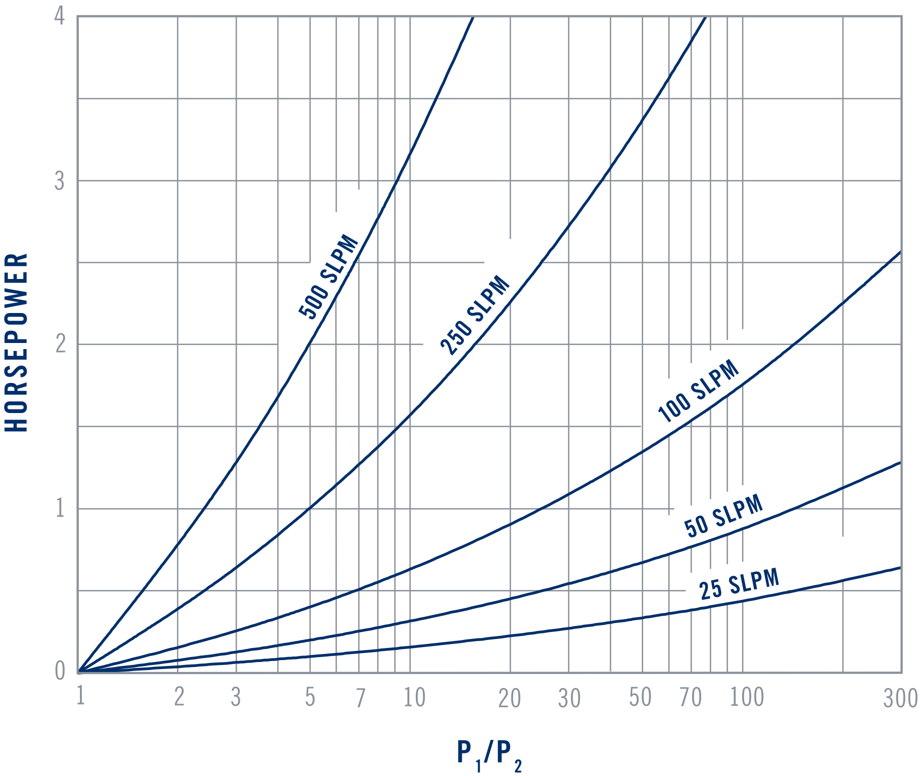
P_1 = Absolute pressure upstream of orifice (psia)

P_2 = Absolute pressure downstream of orifice (psia)

L = Lohm rate of orifice (Lohms)

Due to compressor inefficiencies, more power will be needed to compress the gas than will be expended when it flows through an orifice.

POWER LOSS FOR NITROGEN



EXAMPLE:

For a 500 Lohm restrictor flowing nitrogen at 750 psia exhausting to 75 psia, the flow can be easily calculated from the gas Lohm Law.

$$Q = \frac{270\ P_1}{L} = \frac{270\ (750)}{500} = 405\ \text{SLPM}$$

Next, determine the pressure ratio, P_1/P_2, which in this example is 750/75 = 10. Then, from the graph:

Pneumatic power = 2.5 HP

GAS PROPERTIES

FLUID MECHANICS FOR GASES

GAS	k	R ft-lb/lb° R	DENSITY		C_P* Btu/lb° R	C_V* Btu/lb° R
			lb_m/ft^3	lb_m/std L		
H_2	1.40	766.6	0.00532	0.000188	3.420	2.435
He	1.66	386.1	0.01056	0.000373	1.250	0.754
Neon	1.66	76.6	0.0533	0.00188	0.248	0.150
Nat. Gas	1.22	79.2	0.0516	0.00182	0.560	0.45
N_2	1.40	55.2	0.0739	0.00261	0.247	0.17
CO	1.41	55.2	0.0739	0.00261	0.243	0.172
Air	1.40	53.3	0.0764	0.00270	0.241	0.173
Ethane	1.21	51.4	0.0793	0.00280	0.386	0.320
O_2	1.40	48.3	0.0845	0.00298	0.217	0.155
Argon	1.67	38.7	0.1053	0.00372	0.124	0.074
CO_2	1.28	35.1	0.1162	0.00410	0.205	0.160
N_2O	1.26	35.1	0.1162	0.00410	0.221	0.176
SO_2	1.25	24.1	0,1691	0.00597	0.154	0.123
Freon-12	1.13	12.8	0.319	0.01127	0.145	0.129
Xe	1.68	11.74	0.3427	0.0121	0.0383	0.0228

*Values at 68°F and 14.7 psia

C_P = Specific heat at constant pressure

C_V = Specific heat at constant volume

k = Ratio of specific heats: $\frac{C_P}{C_V}$

R_O = Universal gas constant

R = Gas constant: $\frac{R_O}{\text{Molecular Weight}}$

Q

TRANSIENT GAS FLOW

This type of flow normally concerns the charging of a volume through a fixed resistance such as an orifice. Use of the Lohm system simplifies the calculation of the time required to blow down or charge up a vessel.

The first step is to calculate system time constant, τ, which takes into consideration the volume of the pressure vessel, the absolute temperature, and the Lohm rate of the orifice. The system time constant is given by:

$$\tau = \frac{4\, f_T\, V\, L}{K}$$

WHERE:

- K = Volumetric units correction factor
- L = Orifice Lohm rate (Lohms)
- f_T = Temperature factor
- V = Pressure vessel volume
- τ = System time constant (sec)

Note: Select "K" from the appropriate "psia" column of the table of volumetric flow units on *page Q18**. Keep the units of pressure vessel volume "V" consistent with the volumetric flow units.*

The larger the value of τ, the more sluggish the system.

Once τ has been calculated, the ratio of upstream pressure to downstream pressure for both the initial and final conditions must be computed. Then, from the pressure–ratio graph, initial and final values for "N" can be found. "N" is the number of system time constants required for the system to reach equilibrium.

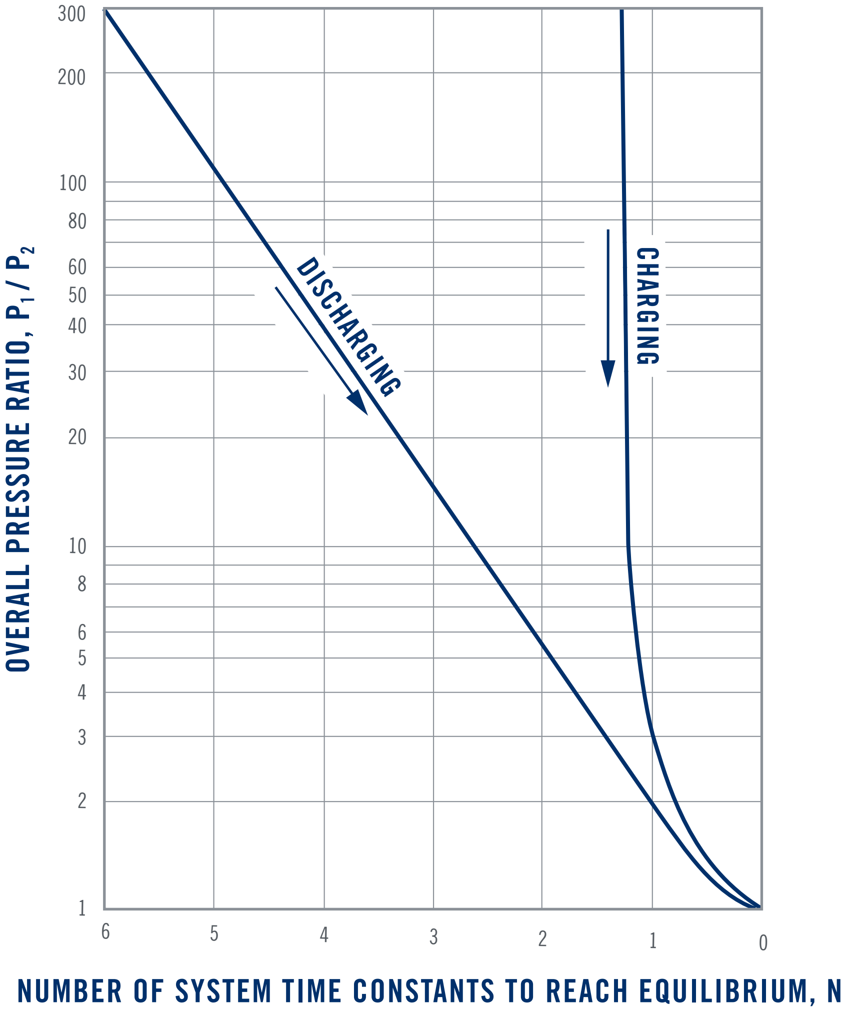
If the final condition is equilibrium, where upstream and downstream pressures are equal, the final pressure ratio is 1 and the final value of "N" is 0. With these values, the time for the system to blow down or charge up can be calculated from:

$$t = \tau \left(N_i - N_f\right)$$

WHERE:

- N_i = Initial number of system time constants
- N_f = Final number of system time constants
- P_1 = Upstream gas pressure
- P_2 = Downstream gas pressure
- t = Time to charge up or blow down a pressure vessel (sec.)

TRANSIENT GAS FLOW



TUBING FLOW

RESISTANCE TO FLOW IN TUBING

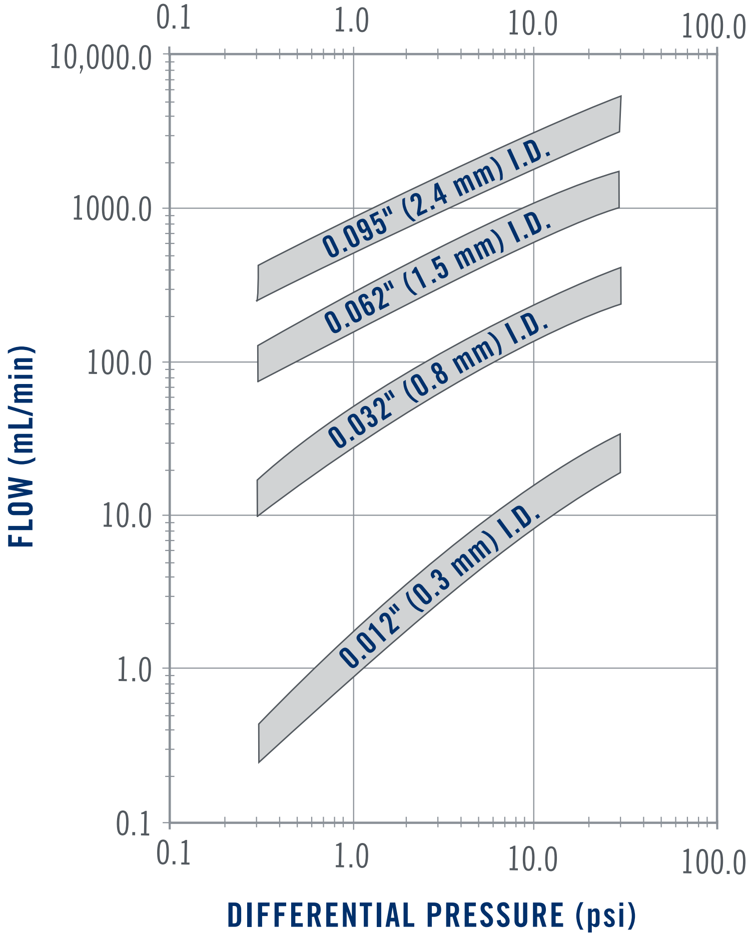
The Lohm Laws, described in the preceding pages, accurately relate flow, pressure drop, and Lohm rating for individual components. For tubing, however, these variables are best related in graph form. The following graphs show pressure drop and flow rate for four different standard sizes of tubing offered by The Lee Company. A 10 cm length of tubing is used in the graphs. If your flow problem involves longer tubing length, increase the pressure drop proportionately.

Example:
To find the pressure drop for a 30 cm length of Lee standard 0.032" ID tubing flowing 100 mL/min of water, begin by consulting the water flow graph. The graph shows that the pressure drop is 4 psia for a 100 mL/min flow rate. Adjust this to your length of 30 cm by the ratio:

(30 cm / 10 cm) x 4 psid = 12 psid

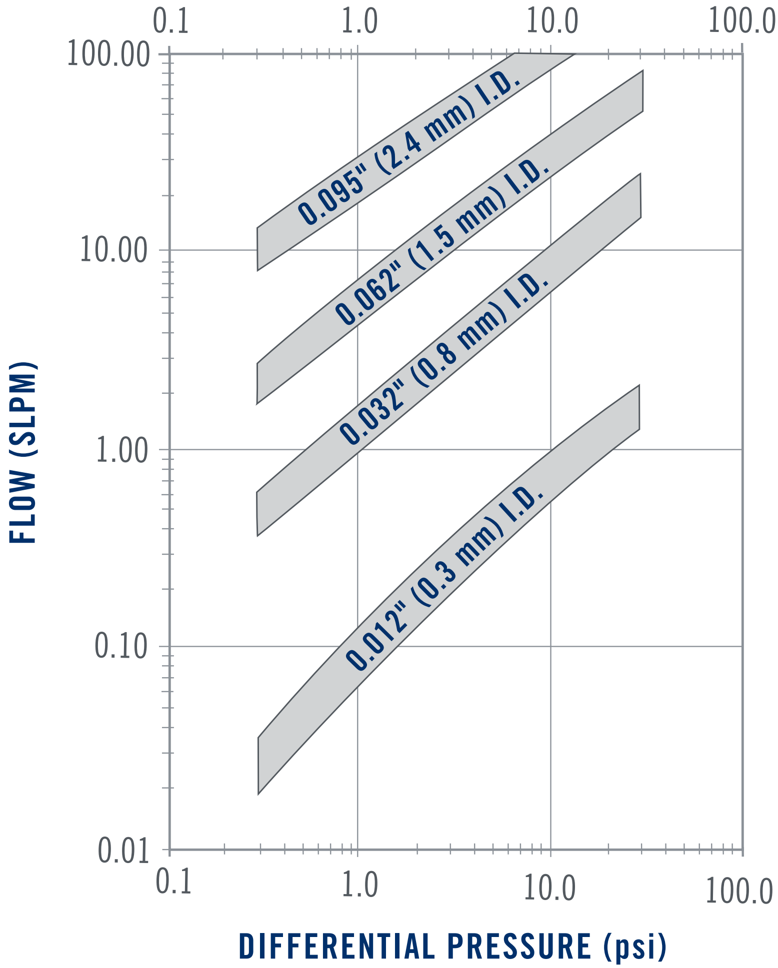
Due to slight variations that normally occur in the tubing ID, these flow calculations for tubing are not exact, but are useful for most design work.

TUBING FLOW CURVES – WATER FLOW
FOR 10 CM TUBE LENGTH

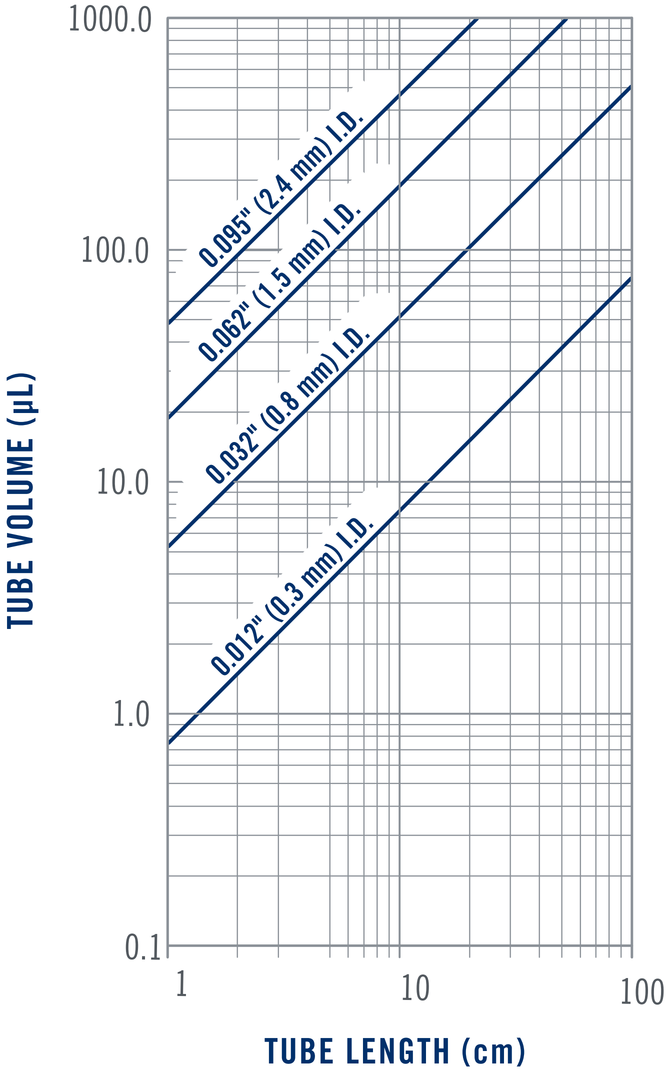


TUBING FLOW CURVES – AIR FLOW

FOR 10 CM TUBE LENGTH



TUBING VOLUME VS. LENGTH



CONTAMINATION CONTROL

Contamination can cause a wide range of problems, including damage to valves or pumps, clogging, or complete system failure. The source of contamination can originate from many places, such as dirty fluid, manufacturing debris, or even defective components during operation. Maintaining fluidic system performance requires cleanliness and tight control of potential contamination.

SYSTEM CLEANLINESS

Fluidic systems are typically comprised of components that have varying degrees of sensitivity to contamination, mostly determined by the minimum passage size and clearances throughout the flow path. Several attributes of contamination must be considered beyond just size, such as the shape, length, texture, and hardness of a particulate. Some critical steps to consider are:

1. Working in a clean environment.
2. Properly flushing components before system assembly.
3. Incorporating proper system level filtration.

The first step ensures the system is free from manufacturing debris prior to installing components. The second step removes contamination to protect individual components and extend their operational life. However, since contamination can also originate from within the system due to the normal wear of components, step three of incorporating safety screen filters immediately upstream from components is a prudent design practice. The added benefit of using safety screens is to protect the components during any maintenance of the system.

CONTAMINATION LEVEL CORRELATION

There is a direct correlation between fluid cleanliness and the level of filtration required in your system. Fluid contamination can be described using different techniques:

- **The Gravimetric Method:** The contaminant level is expressed as the mass of contaminant per unit volume of fluid.
- **Parts Per Million:** The degree of contamination is based on mass or volume per million units (e.g. grams/106 grams).

The above techniques describe bulk or total contamination but give little information regarding the size of the contaminant. For example, unless the size and density of the contaminating particles is known, no conclusions may be drawn relative to the number of particles.

Other techniques look at the number of particles, describing contamination in terms of its size and concentration. These may be an interval concentration, for example, the number of contaminant particles (per unit volume) between 5 and 15 μ in size. Additionally, contamination may be expressed as a cumulative concentration. In this case, contamination levels are described by the total number of particles per unit volume above a given size. For example, the number of particles above 25 μ in size per 100 mL.

The more common cleanliness specifications are based on the number of particles rather than gravimetric techniques. However, particle distributions which were determined to be representative of service distributions (e.g. NAS 1638 distributions) correlate reasonably with those obtained gravimetrically with AC test dust. The table below (from An Encyclopedia of Fluid Contamination Control by E.C. Fitch) provides a correlation of some different cleanliness specifications.

NAS 1638 TABLE

NAS* 1638	NUMBER OF PARTICLES PER 100 mL MICRON RANGE					ISO 4406
CLASS	5-15 μ	15-25 μ	25-50 μ	50-100 μ	>100 μ	CLASS
00	125	22	4	1	—	8/5
0	250	44	8	2	—	9.6
1	500	89	16	3	1	10/7
2	1K	178	32	6	1	11/8
3	2K	356	63	11	2	12/9
4	4K	712	126	22	4	13/10
5	8K	1425	253	45	8	14/11
6	16K	2.8K	506	90	16	15/12
7	32K	5.7K	1012	180	32	16/13
8	64K	11.4K	2.0K	360	64	17/14
9	128K	22.8K	4.1K	720	128	18/15
10	256K	45.6K	8.1K	1440	256	19/16
11	512K	91.2K	16.2K	2.8K	512	20/17
12	1M	182K	32.4K	5.8K	1024	21/18

* SAE standard AS 4059 also applies and lists fluid particulate contamination cumulatively for 5 ranges for contamination classes from 00 to 12 (>2 μ; >5 μ; >15 μ; >25 μ; >50 μ).

CONTAMINATION CONTROL

ISO 4406 TABLE

ISO 4406 CODE	PARTICLES PER mL >10 µ	ACFTD GRAVIMETRIC, LEVEL mg/L	MIL-STD 1246 LEVEL	NAS 1638 CLASS
6/23	140,000	1000		
25/23	85,000		1000	
23/20	14,000	100	700	
21/18	4500			12
20/18	2400		500	
21/17	2300			11
20/16	1400	10		
19/16	1200			10
6/23	140,000	1000		
25/23	85,000		1000	
23/20	14,000	100	700	
21/18	4500			12
20/18	2400		500	
21/17	2300			11
20/16	1400	10		
19/16	1200			10
6/23	140,000	1000		
25/23	85,000		1000	
23/20	14,000	100	700	
21/18	4500			12
20/18	2400		500	
21/17	2300			11
20/16	1400	10		
19/16	1200			10
6/23	140,000	1000		
25/23	85,000		1000	

CONTAMINATION CONTROL

PARTICLE SIZE COMPARISON

SIZES OF FAMILIAR OBJECTS		
U.S. SIEVE NUMBER	OPENING IN INCHES	OPENING IN MICRONS
Grain of Table Salt	100	0.0039
Human Hair	70	0.0028
Lower Limit of Visibility	40	0.0016
White Blood Cells	25	0.0010
Talcum Powder	10	0.0004
Red Blood Cells	8	0.0003
Bacteria (Average)	2	0.00008

SCREEN SIZES		
U.S. SIEVE NUMBER	OPENING IN INCHES	OPENING IN MICRONS
50	0.0117	297
60	0.0090	228
70	0.0083	210
100	0.0059	149
140	0.0041	105
200	0.0029	74
270	0.0021	53
325	0.0017	44
Paper	0.00039	10
Paper	0.00020	5

OHM'S LAW

Ohm's Law can be used to calculate the relationship between voltage, current, and resistance:

$$V = I \times R$$

WHERE:

V = electric potential (volts)
I = current (amperes)
R = resistance (Ohms)

When current passes through a resistance, power is dissipated in the form of heat. Power is calculated by the following:

$$P = V \times I$$

DC ELECTRICAL EQUATIONS			
VOLTAGE	**CURRENT**	**RESISTANCE**	**POWER**
$I \times R$	$\frac{V}{R}$	$\frac{V}{I}$	$V \times I$
$\frac{P}{I}$	$\frac{P}{V}$	$\frac{V^2}{P}$	$\frac{V^2}{R}$
$\sqrt{(P \times R)}$	$\sqrt{\left(\frac{P}{R}\right)}$	$\frac{P}{I^2}$	$I^2 \times R$

DRIVE CIRCUITS

Solenoid-operated valves or pumps require an electrical signal to actuate. There are numerous methods to deliver this signal and therefore, countless options to consider when designing the necessary electrical drive circuitry; among them are several off-the-shelf options such as PWM chips and mechanical relays.

The Lee Company provides circuit schematics that may be used to drive many of our solenoid-operated valves and pumps. The next few pages contain a few specific circuit schematics that may serve as general guidelines; they may be reproduced or modified by the end-user to meet specific application requirements. Contact a Lee Sales Engineer with questions about which circuit is best suited for your application.

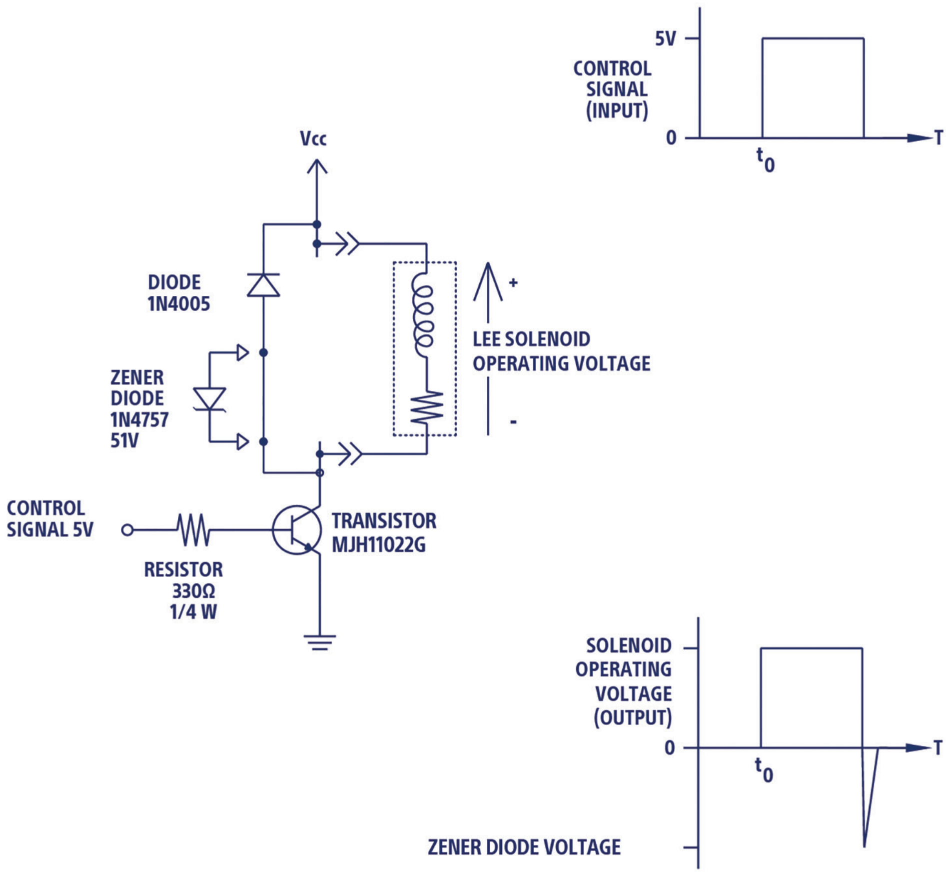
BASIC TRANSISTOR / FAST RESPONSE CIRCUIT

This schematic demonstrates the simplest form of solenoid drive circuitry, and it may be used to actuate most solenoid-operated valves and pumps. The circuit requires an input voltage (Vcc) to actuate the solenoid and a control signal input (from a controller, function generator, or timing circuit), that switches a transistor. This sequence allows the drive current to energize the solenoid. A diode is placed in parallel with the solenoid to protect the transistor from the inductive voltage spike that occurs as the solenoid de-energizes. A significant voltage drop between the power supply and solenoid may occur if there is unexpected resistance, such as long lead wires or other electrical components. Once the circuit is built, it is important to verify that the solenoid is receiving its rated actuation voltage by measuring the voltage directly across the solenoid's pins. This circuit may be configured for two different operating modes, depending upon your application requirement:

1. **Basic Driver** – In the simplest operating mode, this basic solenoid drive schematic does not require the 51V Zener diode.

2. **Fast Response Driver** – A 51V Zener diode placed in series with a flyback protection diode improves the latch-out response (time to close) of the solenoid when power is removed.

BASIC TRANSISTOR/FAST RESPONSE CIRCUIT SCHEMATIC



This circuit schematic is incomplete and is offered as a basic reference. Contact a Lee Sales Engineer to obtain drawing LFIX1002200A; it includes additional notes and operating instructions.

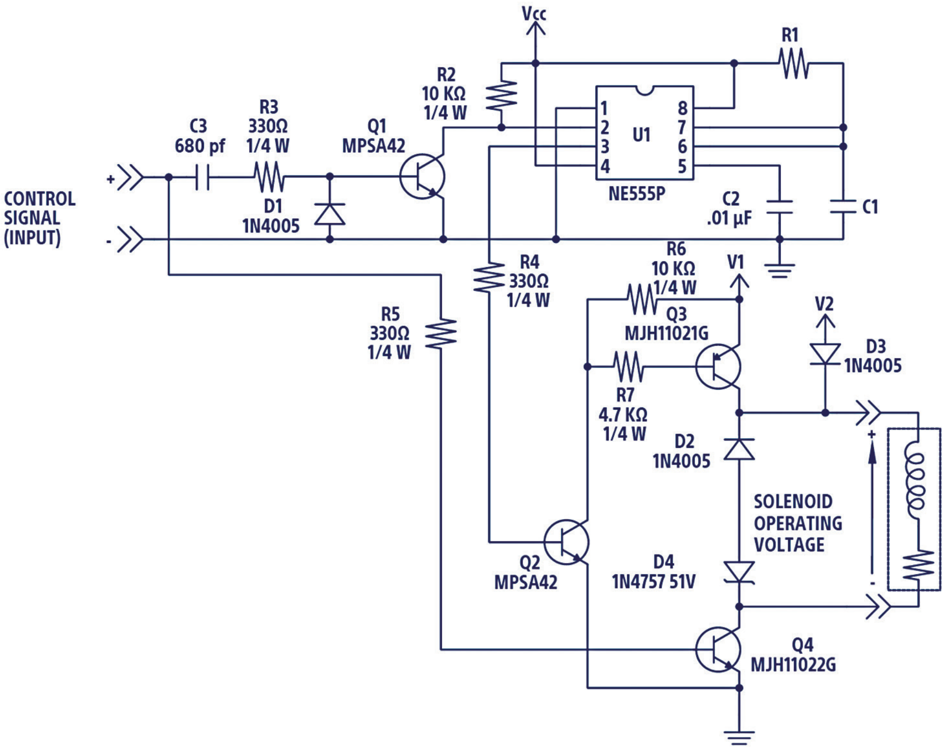
SPIKE & HOLD CIRCUIT

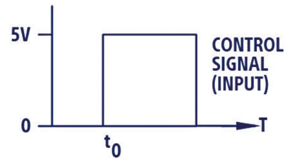
This circuit can be used as either an enhanced response time driver or as a low power consumption driver. The circuit initially supplies a brief actuation voltage (V1, “Spike” Voltage) for a period of time (ts); then switches to a lower voltage (V2, “Hold” Voltage), to keep the solenoid in an energized state for an extended period of time. The duration of the spike (ts) is determined by a resistor and capacitor (R1 and C1 indicated on LFIX1002250A, Note 4), connected to a 555 timer chip. Typically, the spike duration is slightly longer than the response time of the solenoid. A control signal input (from a controller, function generator, or timing circuit) is required to actuate the solenoid. The solenoid will remain actuated for as long as the control signal is applied. A significant voltage drop between the power supply and solenoid may occur if there is unexpected resistance, such as long lead wires or other electrical components. Once the circuit is built, it is important to verify that the solenoid is receiving its rated actuation voltage by measuring the voltage directly across the solenoid's pins. Be sure to employ a differential probe when you use an oscilloscope to measure the signal between the solenoid pins.

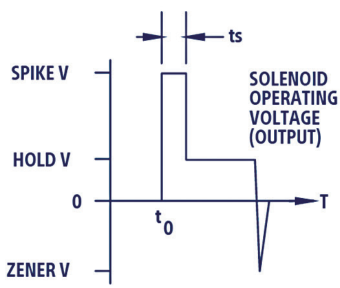
This driver may be configured for two different operating modes depending upon whether you require lower power or a faster response.

1. **Fast response spike & hold driver** – Solenoid response time can be improved for both actuation (time to open), and latch-out (time to close) of the solenoid. This may be accomplished by applying an “over-drive” voltage greater than the rated actuation voltage to V1 and adding a 51V Zener Diode (D4, indicated on LFIX1002250A, Note 5.1). After quickly actuating the solenoid, the driver switches to a lower holding voltage applied at V2 to reduce resistive heating and to avoid damage to the solenoid. When power is removed, a 51V Zener diode placed in series with a flyback protection diode improves the latch-out response (time to close) of the solenoid.
2. **Low power consumption driver** – Overall power consumption can be significantly reduced (typically 75-90%), by applying the rated solenoid voltage to V1 and a lower hold voltage to V2. For most solenoids, the hold voltage is half of the rated actuation voltage; be sure to check the valve's inspection drawing for requirements related to a particular part number. Contact a Lee Sales Engineer for more specific recommendations regarding the voltage or spike duration.

SPIKE & HOLD CIRCUIT SCHEMATIC







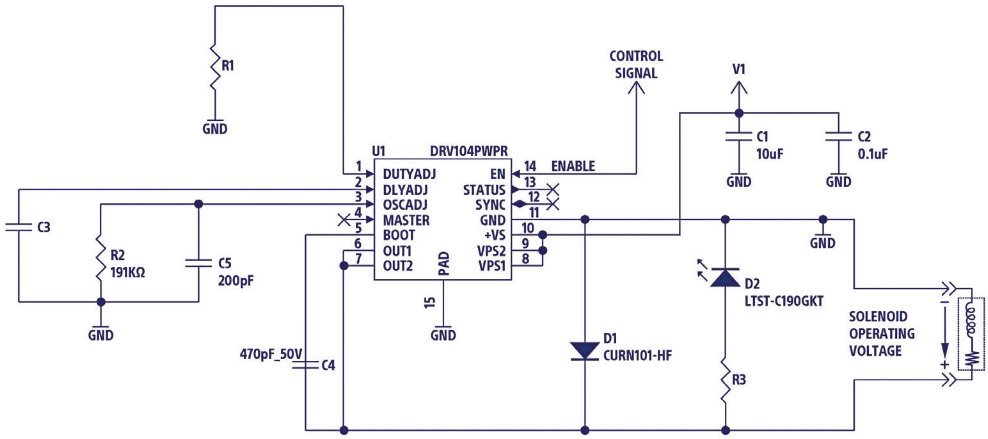
This circuit schematic is incomplete and is offered as a basic reference. Contact a Lee Sales Engineer to obtain drawing LFIX1002250A; it includes additional notes and operating instructions.

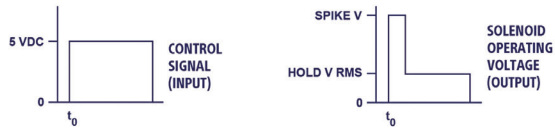
Q

PULSE WIDTH MODULATION (PWM)

Another method for applying spike & hold voltages to a valve is with a pulse width modulation (PWM) driver. With this circuit, a simple TTL signal controls the valve's state. While the control signal is high, the PWM driver, DRV104PWPR, applies a brief actuation voltage (V1, "spike" voltage) for a period of time then switches to a pulse-width-modulated signal, effectively lowering the voltage to the solenoid valve to a "hold" voltage. Typically, the spike duration is longer than the valve's response time. High spike voltages are advantageous to improve response speed and consistency. Hold voltages help lower power consumption and valve heating. Using DRV104PWPR, V1 values can range from 8V to 32V and hold voltages can be as low as 10% of V1. Please refer to each valve's inspection drawing for recommended drive voltages and response time information.

PWM CIRCUIT





Circuit schematic for reference only. Contact a Lee Sales Engineer for drawing LFIX1002600B which includes additional notes and operating instructions.

The spike time is configured using C3. The PWM frequency is set using R2. R1 is used to set the duty percentage, and therefore the hold voltage. It is recommended to select a PWM frequency and duty that result in signal-off times that are 100x shorter than the valve's latch-out time to prevent any plunger movement. Please refer to the DRV104PWPR data sheet for recommended C3, R2, and R1 values.

LATCHING VALVE CIRCUIT

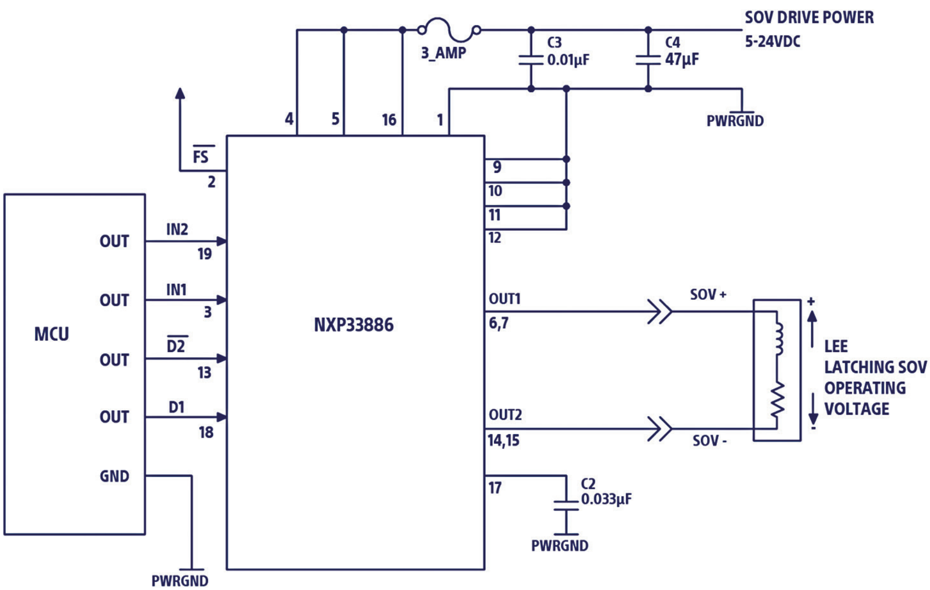
The primary advantage of a latching solenoid valve is that power is not required to maintain the valve's flow state (either open or closed) between actuations. That is, a de-energized latching valve will hold its current flow state. Because of this magnetically latched feature, latching solenoid valves have polarized leads that require a different type of drive circuitry. The flow state of the solenoid is determined by a negative or positive voltage pulse; this requires a circuit capable of bi-directional current flow. The recommended LFIX1002350A schematic includes an H-bridge chip that reverses the direction of current flow, allowing for effective latching solenoid valve switching. A significant voltage drop between the power supply and the solenoid may occur if there is unexpected resistance, such as long lead wires or other electrical components. Once the circuit is built, it is important to verify that the solenoid is receiving its rated actuation voltage by measuring directly across the solenoid's pins.

This schematic requires the rated input voltage to actuate the solenoid and to switch commands provided by a micro-controller (MCU), or other programmable logic controller (PLC). Switching commands should be provided as a 5 Vdc "HIGH" or "LOW" signal – four are required. Two pins are required to enable the H-bridge chip, and two others are required to trigger either a positive or negative pulse to the solenoid. A description of each pin is included below along with a state diagram. The inspection drawing for each latching solenoid valve provides information about solenoid pin assignments and the porting arrangements.

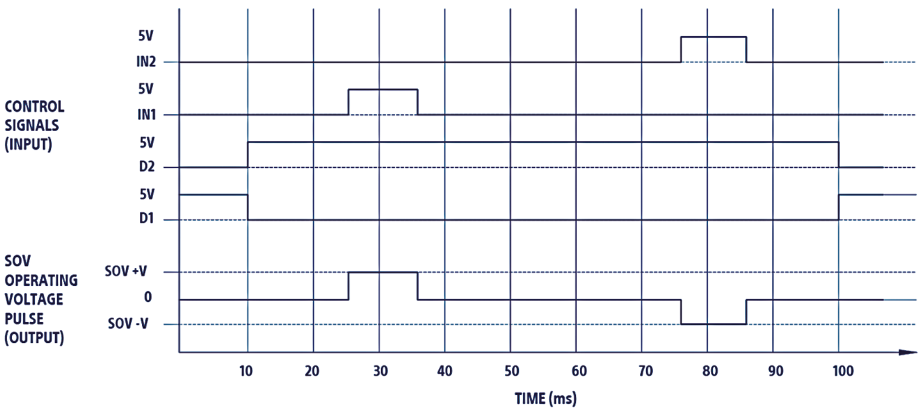
MCU Pin Assignments (Waveform Graph)

- IN1 – HIGH provides a +5 Vdc pulse. The pulse length (time) should be slightly longer than response time of the solenoid.
- IN2 – HIGH provides a -5 Vdc pulse. The pulse length (time) should be slightly longer than response time of the solenoid.
- D1 - Enables NXP33886 (H-Bridge Chip), should be HIGH when actuating (in either direction).
- D2 - Enables NXP33886 (H-Bridge Chip), should be LOW when actuating (in either direction).

LATCHING VALVE CIRCUIT SCHEMATIC



WAVEFORM GRAPH



The circuit schematic is incomplete and is offered as a basic reference. Contact a Lee Sales Engineer to obtain drawings LFIX1002350A (5-24 Vdc latching valves) or LFIX1002500A (2-6 Vdc latching valves), they include additional notes and operating instructions.

PRIMARY/EXACT STANDARDS & EXACT/DERIVED CONVERSIONS

PRIMARY STANDARDS*

Meter Length equal to 1,650,763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2 p_{10} and 5 d_5 of the krypton-86 atom.

Kilogram Mass equal to the mass of the international prototype of the kilogram. This is a particular cylinder of platinum-iridium alloy that is preserved in a vault at Sèvres, France by the International Bureau of Weights and Measures.

Second Time duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom.

DERIVED STANDARD

Newton The force that gives to a mass of 1 kilogram an acceleration of 1 meter per sec. per sec.

EXACT CONVERSIONS*

1 pascal	=	1 newton/meter ^{2}
1 atmosphere	=	101,325 pascals
1 bar	=	100,000 pascals
1 centipoise	=	0.001 of a newton-second/meter ^{2}
1 centistoke	=	1 x 10^{-6} meter ^{2} /second
1 fluid ounce (U.S.)	=	2.95735295625 x 10^{-5} meter ^{3}
1 foot	=	0.3048 of a meter
1 gallon (U.S.)	=	3.785411784 x 10^{-3} meter ^{3}
1 gram	=	0.001 of a kilogram
1 inch	=	0.0254 of a meter
1 kilogram force	=	9.80665 newtons
1 liter	=	0.001 of a meter ^{3}
1 micron	=	1 x 10^{-6} meter
1 milliliter	=	1 x 10^{-6} meter ^{3}
1 ounce mass (avdp)	=	0.028349523125 of a kilogram
1 pound force (avdp)	=	4.4482216152605 newtons
1 pound mass (avdp)	=	0.45359237 of a kilogram

* Exact by National Bureau of Standards definition

DERIVED CONVERSIONS:

1 foot of H_2O at 4°C	=	2988.98 pascals
1 gram/centimeter^3	=	1000 kilograms/meter^3
1 inch of H_2O at 4°C	=	249.082 pascals
1 inch of Hg at 0˚C	=	3386.389 pascals
1 pound$_F$ / inch^2	=	6894.7572 pascals
1 pound$_M$ / inch^3	=	27,679.905 kilograms/meter^3
1 quart (U.S.)	=	9.4635295 x 10^{-4} meter^3
1 drop	=	50 microliters
1 bar	=	14.503774 pound$_F$ /inch^2

MASS/VOLUME CONVERSION FACTORS

MASS

INTO → / TO CONVERT ↓	LB.$_M$ (avdp)	OZ.$_M$ (avdp)	SLUG	gram	kg$_m$
LB.$_M$ (avdp)	—	16.00	3.108 x 10^{-2}	453.6	0.4536
OZ.$_M$ (avdp)	6.250 x 10^{-2}	—	1.943 x 10^{-3}	28.35	2.835 x 10^{-2}
SLUG	32.17	514.8	—	1.459 x 10^{4}	14.59
gram	2.205 x 10^{-3}	3.527 x 10^{-2}	6.852 x 10^{-5}	—	1.000 x 10^{-3}
kg$_m$	2.205	35.27	6.852 x 10^{-2}	1000	—

MULTIPLY BY

MASS/VOLUME CONVERSION FACTORS

VOLUME

INTO → / TO CONVERT ↓	FT.^{3}	IN.^{3}	GAL (U.S.)	QUART (U.S.)	FL. OZ. (U.S.)	liter	mL	m^3
FT.^{3}	—	1728	7.481	29.92	957.5	28.32	2.832×10^{4}	2.832×10^{-2}
IN.^{3}	5.787×10^{-4}	—	4.329×10^{-3}	1.732×10^{-2}	0.5541	1.639×10^{-2}	16.39	1.639×10^{-5}
GAL (U.S.)	0.1337	231.0	—	4.000	128.0	3.785	3785	3.785×10^{-3}
QUART (U.S.)	3.342×10^{-2}	57.75	0.2500	—	32.00	0.9464	946.4	9.464×10^{-4}
FL. OZ. (U.S.)	1.044×10^{-3}	1.805	7.813×10^{-3}	3.125×10^{-2}	—	2.957×10^{-2}	29.57	2.957×10^{-5}
LITER	3.531×10^{-2}	61.02	0.2642	1.057	33.81	—	1000	1.000×10^{-3}
mL	3.531×10^{-5}	6.102×10^{-2}	2.642×10^{-4}	1.057×10^{-3}	3.381×10^{-2}	1.000×10^{-3}	—	1.000×10^{-6}
m^3	35.31	6.102×10^{4}	264.2	1057	3.381×10^{4}	1000	1.000×10^{6}	—

MULTIPLY BY

PRESSURE CONVERSION FACTORS

PRESSURE

INTO → / ↓ TO CONVERT	LB./in^2	IN. Hg at 0°C	IN. H_2O at 4°C	FT. H_2O at 4°C	ATM	kg_f/cm^2	kg_f/m^2	kPa
LB./IN.^{2}	—	2.036	27.68	2.307	6.805 x 10^{-2}	7.032 x 10^{-2}	703.1	6.895
IN. HG at 0°C	0.4912	—	13.60	1.133	3.342 x 10^{-2}	3.453 x 10^{-2}	345.3	3.386
IN. H_2O at 4°C	3.613 x 100^{-2}	7.355 x 100^{-2}	—	8.333 x 100^{-2}	2.458 x 100^{-3}	2.540 x 100^{-3}	25.40	0.2491
FT. H_2O at 4°C	0.4335	0.8826	12.00	—	2.950 x 10^{-2}	3.048 x 10^{-2}	304.8	2.989
ATM	14.70	29.92	406.8	33.90	—	1.033	1.033 x 10^4	101.3
kg_f/cm^2	14.22	28.96	393.7	32.81	0.9678	—	1.000 x 10^4	98.07
kg_f/m^2	1.422 x 10^{-3}	2.896 x 10^{-3}	3.937 x 10^{-2}	3.281 x 10^{-3}	9.678 x 10^{-5}	1.000 x 10^{-4}	—	9.807 x 10^{-3}
kPa	0.1450	0.2953	4.015	0.3346	9.869 x 10^{-3}	1.020 x 10^{-2}	102.0	—

MULTIPLY BY

CONVERSION FACTORS - VOLUME TO MASS OF WATER AT 39.2°F (4°C)

MASS

INTO → / TO CONVERT ↓ (VOLUME)	LB.M (avdp)	OZ.M (avdp)	SLUG	gram	kg m
FT.^{3}	62.43	998.8	1.940	2.832 x 10^4	28.32
IN.^{3}	3.613 x 10^{-2}	0.5780	1.123 x 10^{-3}	16.39	1.639 x 10^{-2}
GAL (U.S.)	8.345	133.5	0.2594	3785	3.785
QUART (U.S.)	2.086	33.38	6.484 x 10^{-2}	946.3	0.9463
FL. OZ. (U.S.)	6.520 x 10^{-2}	1.043	2.026 x 10^{-3}	29.57	2.957 x 10^{-2}
LITER	2.205	35.27	6.852 x 10^{-2}	1000	1.000
mL	2.205 x 10^{-3}	3.527 x 10^{-2}	6.852 x 10^{-5}	1.000	1.000 x 10^{-3}
m^3	2205	3.527 x 10^4	68.52	1.000 x 10^6	1000

MULTIPLY BY

To apply these factors to fluids with specific gravity other than 1.0, these factors must be multiplied by the actual specific gravity.

EXAMPLE: Determine flow rate in lb/hr of acetone at 40°F and 2 mL/min

SOLUTION: Specific Gravity S of acetone at 40°F = 0.80

$$I = \frac{\text{lbs}}{\text{hr}} = \left[I \frac{\text{mL}}{\text{min}}\right]\left[\begin{matrix}\text{conversion}\\ \text{factor mL – lbs}\end{matrix}\right]\left[\begin{matrix}\text{conversion}\\ \text{factor min – hrs}\end{matrix}\right]\left[S\right]$$

$$= \left[2 \frac{\text{mL}}{\text{min}}\right]\left[2.205 \times 10^{-3} \frac{\text{lbs}}{\text{mL}}\right]\left[\frac{60 \text{ min}}{1 \text{ hr}}\right]\left[0.80\right]$$

$$= .21 \frac{\text{lb}}{\text{hr}}$$

CONVERSION FACTORS - MASS TO VOLUME OF WATER AT 39.2°F (4°C)

MASS

TO CONVERT → / INTO ↓ (VOLUME)	LB. M (avdp)	OZ. M (avdp)	SLUG	gram	kg m
FT.^{3}	1.602 x 10^{-2}	1.001 x 10^{-3}	0.5154	3.532 x 10^{-5}	3.532 x 10^{-2}
IN.^{3}	27.68	1.730	890.6	6.103 x 10^{-2}	61.03
GAL (U.S.)	0.1198	7.489 x 10^{-3}	3.855	2.642 x 10^{-4}	0.2642
QUART (U.S.)	0.4793	2.996 x 10^{-2}	15.42	9.464 x 10^{-4}	0.9464
FL. OZ. (U.S.)	15.34	0.9586	493.5	3.381 x 10^{-2}	33.81
LITER	0.4536	2.835 x 10^{-2}	14.59	1.000 x 10^{-3}	1.000
mL	453.6	28.35	1.459 x 10^{4}	1.000	1,000
m^3	4.536 x 10^{-4}	2.835 x 10^{-5}	1.459 x 10^{-2}	1.000 x 10^{-6}	1.000 x 10^{-3}

MULTIPLY BY

To apply these factors to fluids with specific gravity other than 1.0, these factors must be divided by the actual specific gravity.

EXAMPLE: Determine the volume in gallons which would be occupied by 3.0 kg of sea water (specific gravity is 1.02).

SOLUTION:

$$3.0 \text{ kg} \times \frac{0.2642}{1.02} \frac{\text{gal}}{\text{kg}} = 0.78 \text{ gal}$$

1 ft^2 / sec = 92,903 centistoke and

1 centistoke = 1.076 x 10-5 ft^2 / sec

VISCOSITY DEFINITIONS

Absolute viscosity: the ratio of the shear stress in a fluid to the rate of shearing strain.

Unit of absolute viscosity in the metric system:

poise and centipoise

1 poise = 1 gram / (cm) (sec) and
1 centipoise = 1/100 poise

Unit of absolute viscosity in the imperial system:

slug / (ft) (sec):
1 slug / (ft) (sec) = 1 / 0.002089 of a poise

Kinematic viscosity: the absolute viscosity divided by density.

Unit of kinematic viscosity: in the metric system and commonly used in the countries using the imperial system:

stoke and centistoke

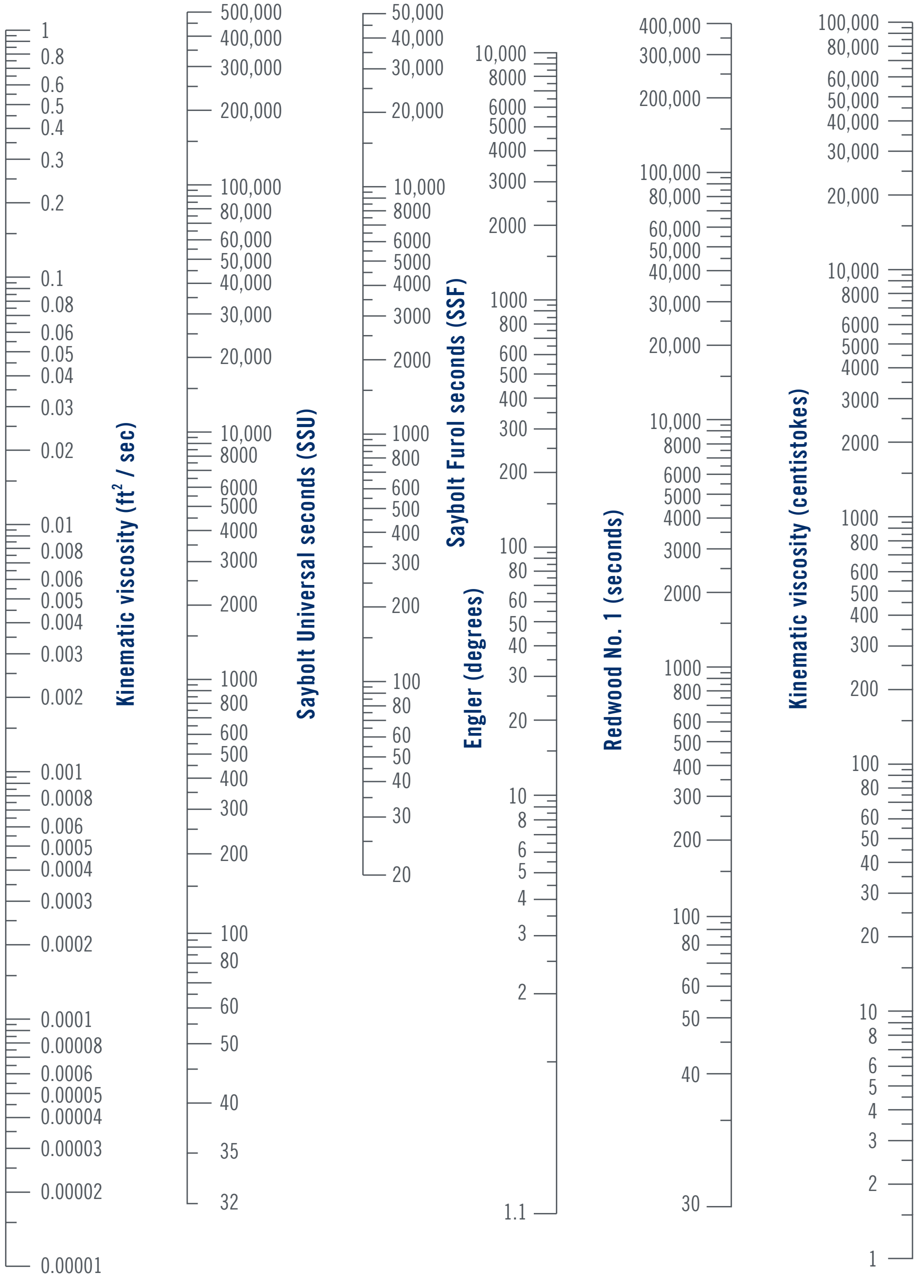
1 stoke = 1 poise / density (g / mL)
1 centistoke = 1/100 stoke

Other units of kinematic viscosity: in the imperial system, the most practical unit for making calculations is ft^2 / sec; 1 ft^2 / sec:

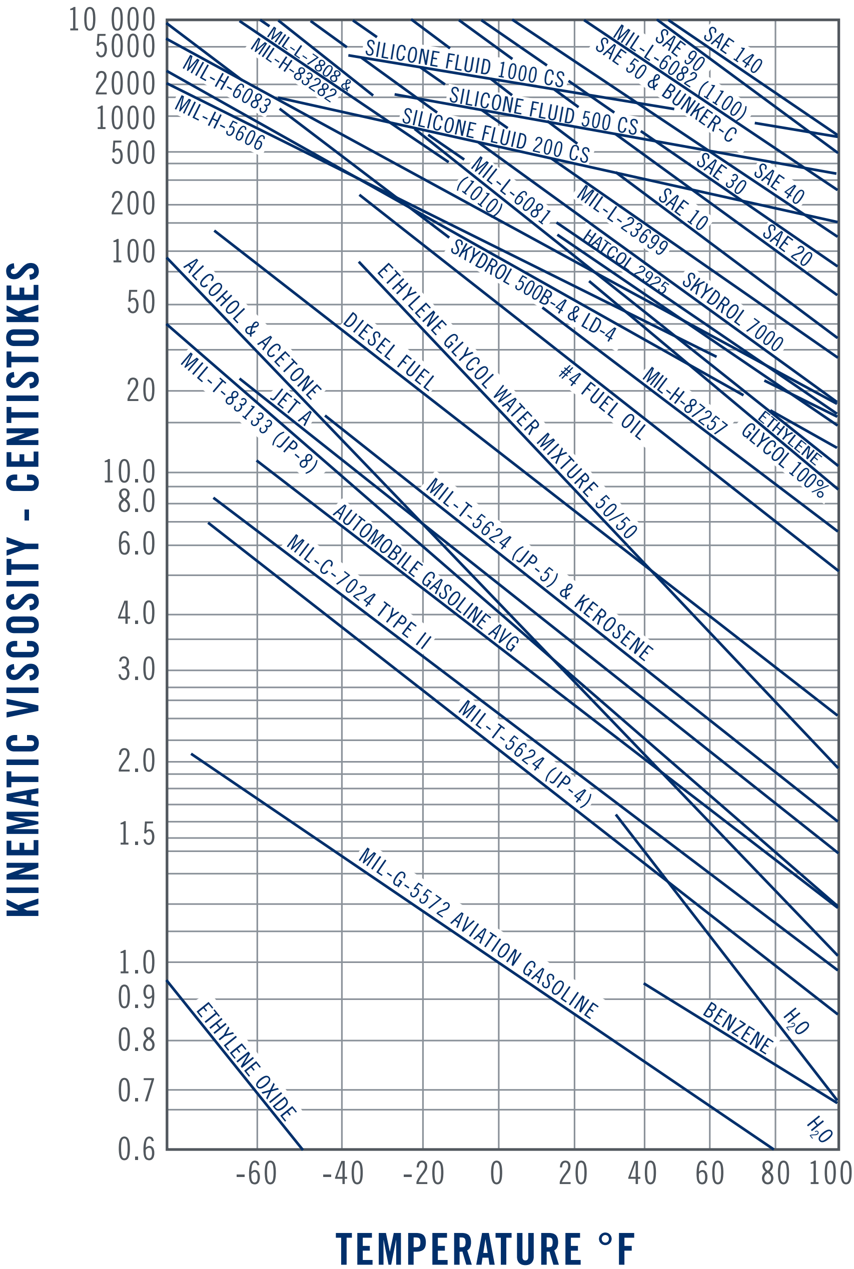
1 ft^2 / sec = 92,903 centistoke and
1 centistoke = 1.076×10^{-5} ft^2 / sec

VISCOSITY CONVERSIONS

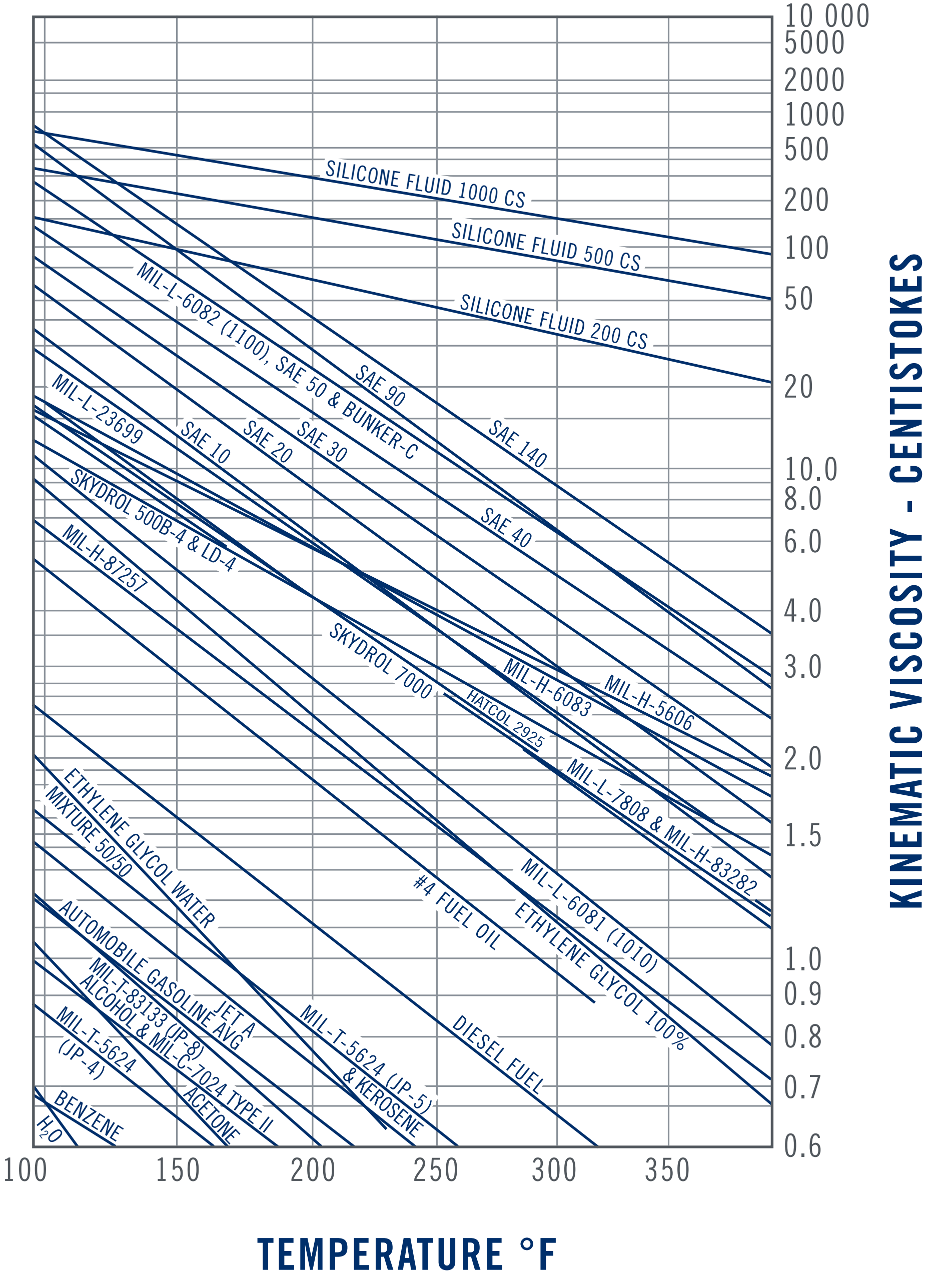
To convert between different viscosity units, simply connect horizontally across the chart.



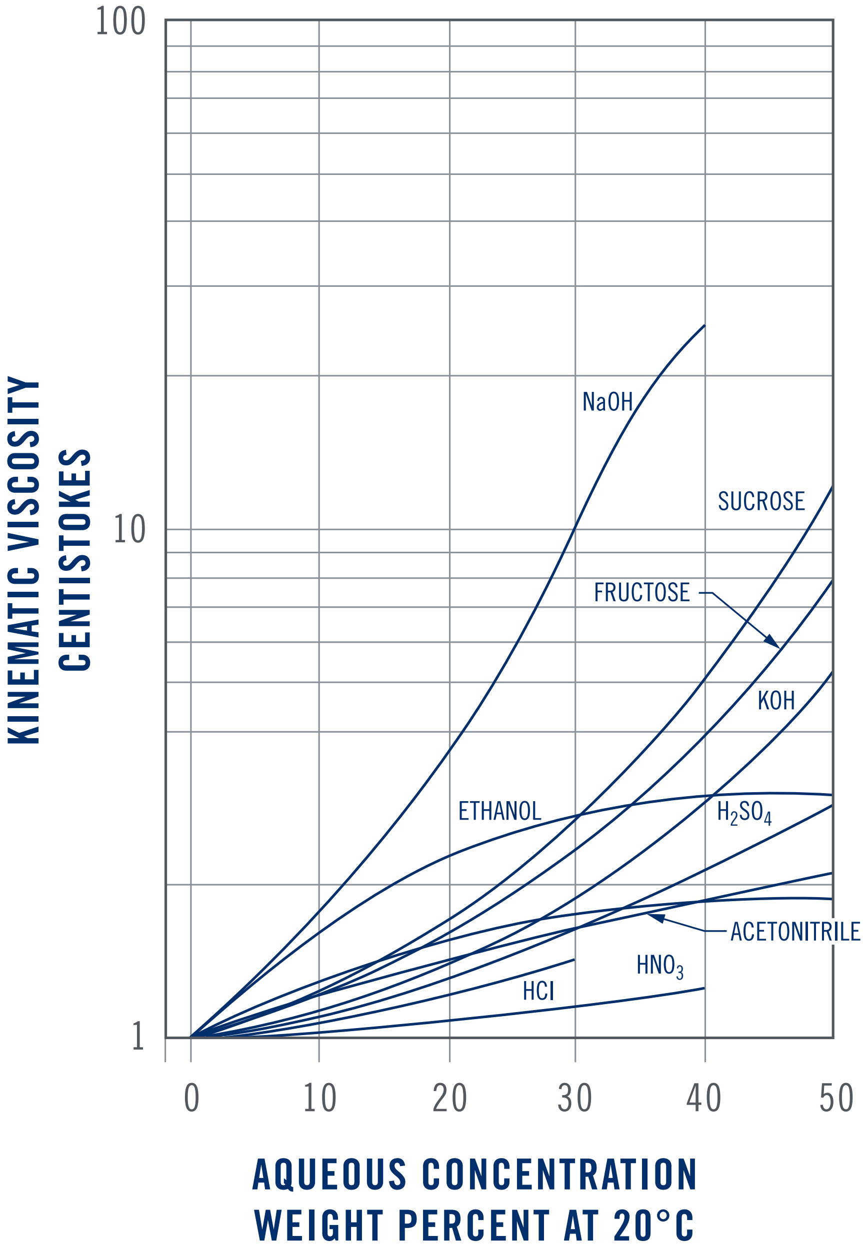
VISCOSITY OF TYPICAL FLUIDS VS. TEMPERATURE



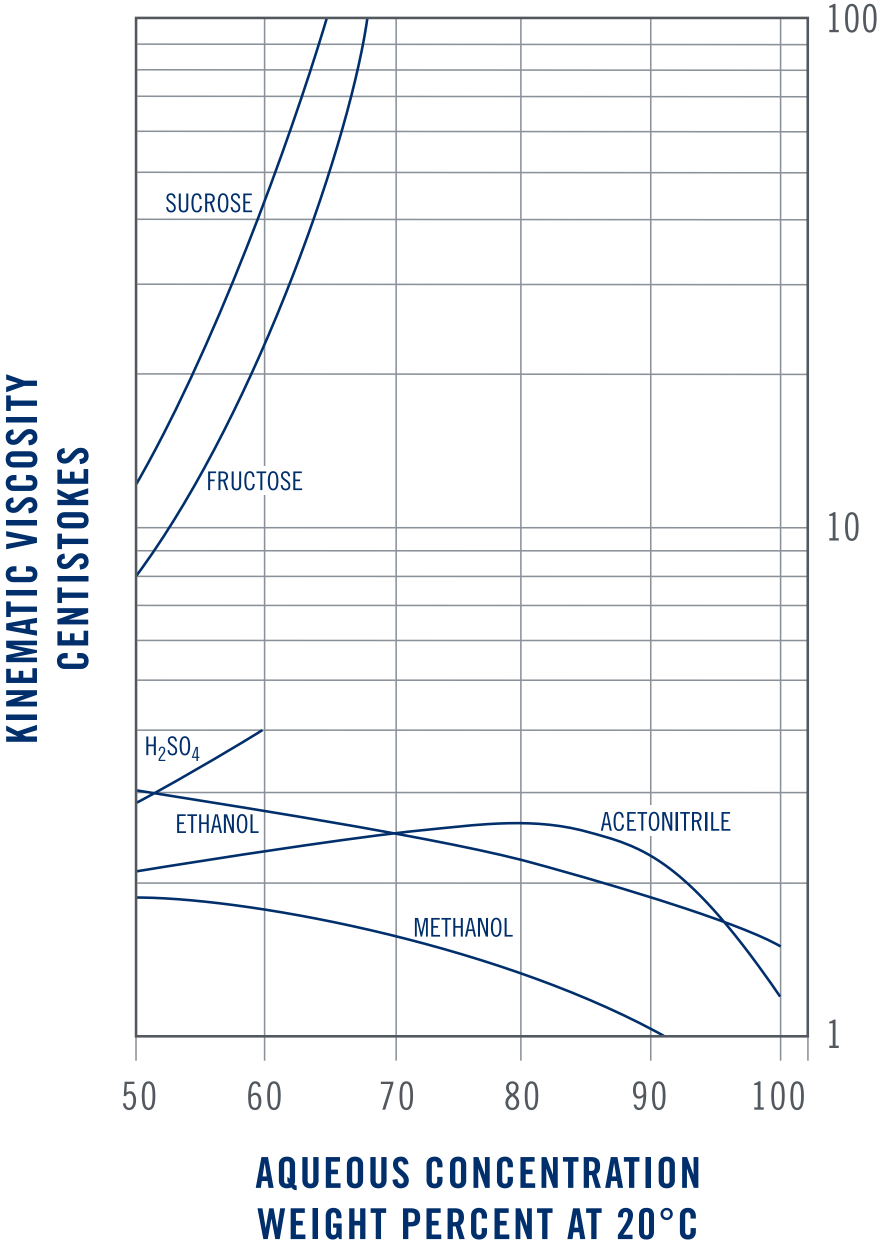
VISCOSITY OF TYPICAL FLUIDS VS. TEMPERATURE



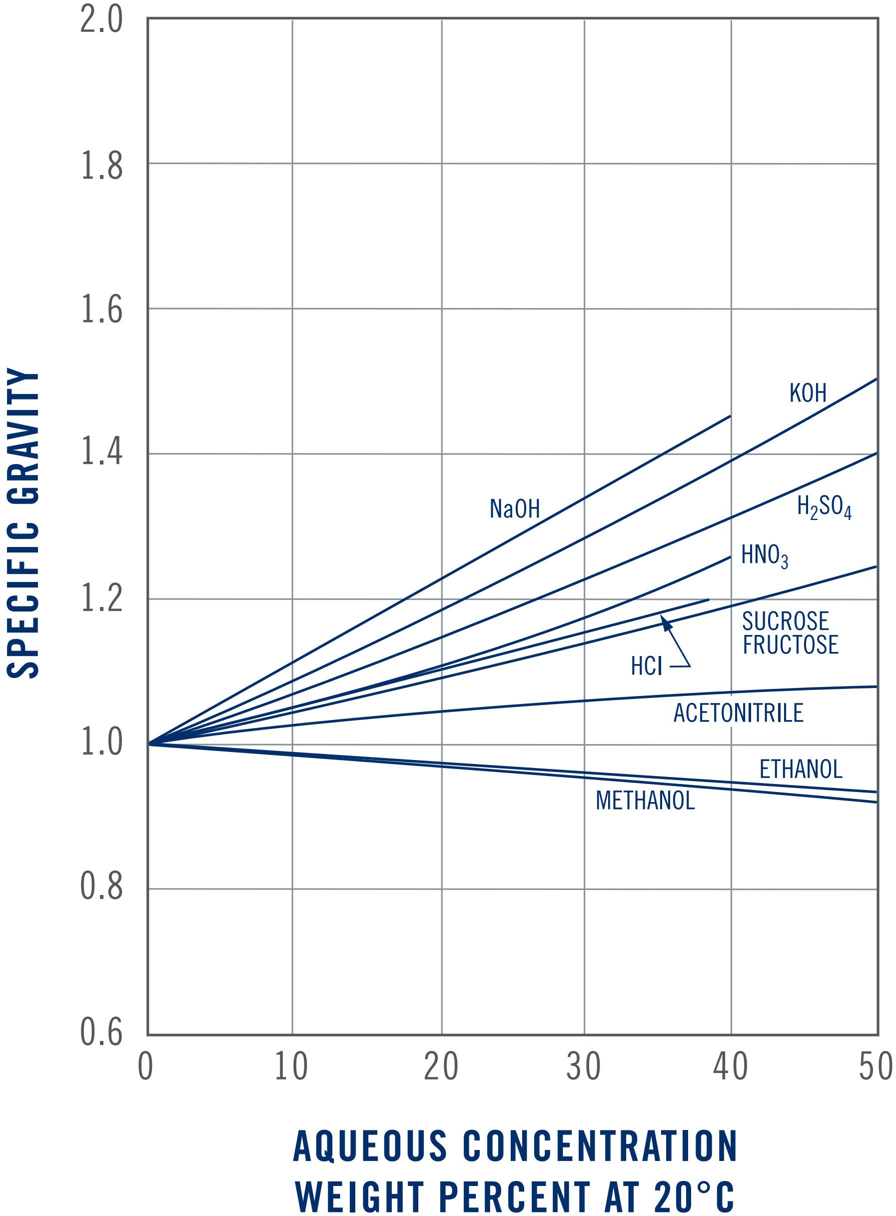
VISCOSITY VS. CONCENTRATION



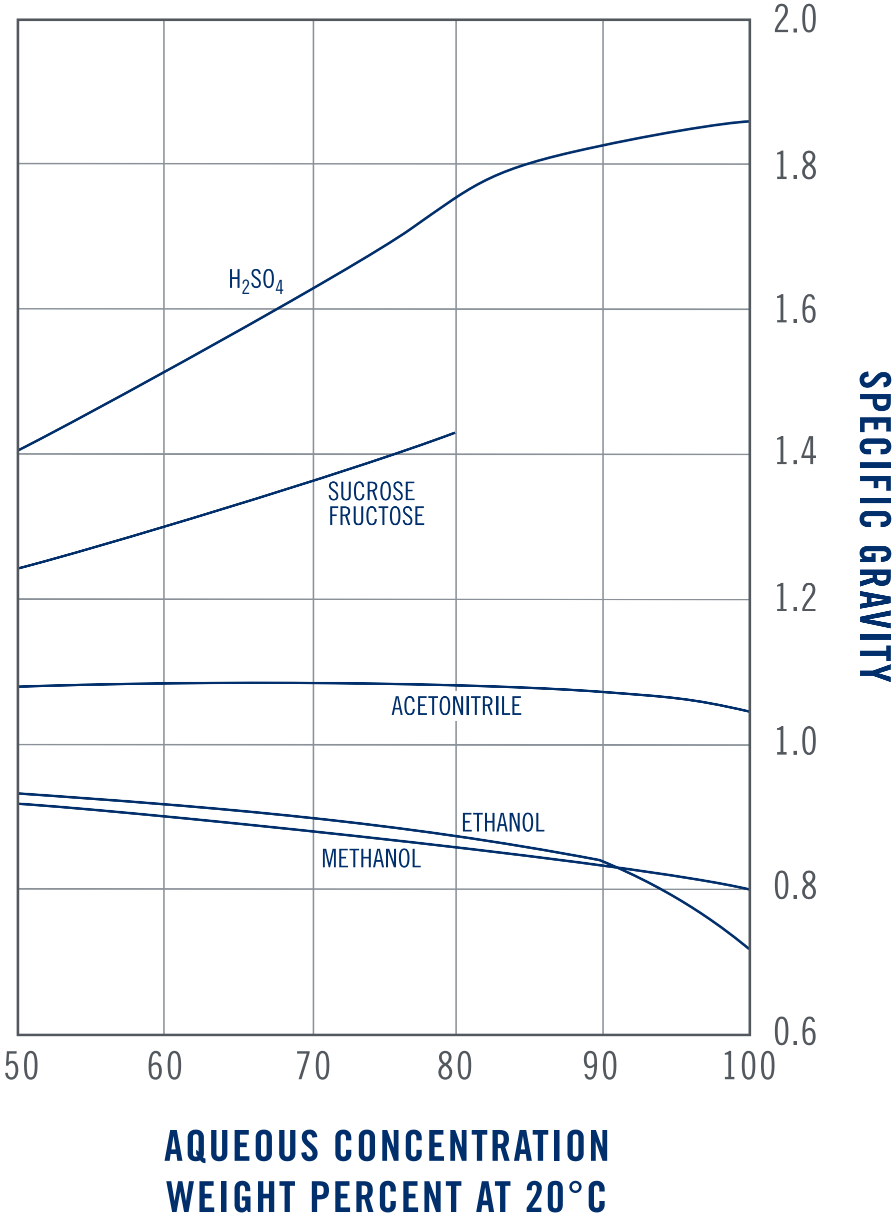
VISCOSITY VS. CONCENTRATION



SPECIFIC GRAVITY VS. CONCENTRATION



SPECIFIC GRAVITY VS. CONCENTRATION



MATERIALS – The chemical compatibilities listed are meant as guidelines only. Material samples for immersion testing can be requested from The Lee Company. This is the most accurate method of determining the chemical compatibility of our materials and our customers' specific fluids.

RATING	5	4	3	2
Compatibility	Superior	Excellent	Good	Fair

PLASTIC	MECHANICAL STRENGTH	GENERAL CHEMICAL RESISTANCE	THERMAL RESISTANCE	FEATURED PROPERTIES
EVA *Ethylene-vinyl acetate*	3	3	2	Physically conformable
LCP *Liquid crystal polymer*	5	4	4	Superior balance of all properties
PBT *Polybutylene terephthalate*	3	3	3	Good balance of all properties
PC *Polycarbonate*	3	3	3	Optical clarity
PCTFE *Polychlorotrifluoroethylene*	3	4	3	Resists most chemicals, zero water absorption
PEEK *Polyetheretherketone*	4	4	5	Thermal stability & good solvent resistance
PEI *Polyetherimide*	3	4	4	Translucent, amber color. Good solvent resistance
PES *Polyethersulfone*	3	3	4	Dimensionally stable
PFA *Perfluoroalkoxy resin*	2	5	2	Chemical & solvent resistant
PMMA *Polymethyl methacrylate*	3	3	3	Transparent, good general properties
POM *Polyoxymethylene*	3	3	2	Wear resistance
PPA *Polyphthalamide*	3	3	4	Thermal and dimensional stability
PPS *Polyphenylene sulfide*	4	3	4	Very good mechanical strength
PSU *Polysulfone*	3	3	4	Low moisture absorption, transparent

MATERIALS (CONTINUED)

PLASTIC	MECHANICAL STRENGTH	GENERAL CHEMICAL RESISTANCE	THERMAL RESISTANCE	FEATURED PROPERTIES
PTFE *Polytetrafluoroethylene*	2	5	2	Unsurpassed chemical resistance
PVC *Polyvinylchloride*	3	3	3	High flexibility
PVDF *Polyvinylidene fluoride*	3	4	3	Chemical & solvent resistant, porous form
UHMW PE *Ultra-high molecular weight polyethylene*	3	3	3	Porous form, solvent resistant

ELASTOMER	WEAR RESISTANCE	GENERAL CHEMICAL RESISTANCE	THERMAL RESISTANCE	FEATURED PROPERTIES
EPDM *Ethylene/propylene rubber*	3	4	3	Very good solvent resistance
FKM *Fluoroelastomer*	5	4	4	Superior balance of properties
CR *Polychloroprene*	3	3	3	Good balance of properties
FFKM *Perfluoroelastomer*	3	5	5	Unsurpassed chemical resistance
VMQ *Silicone*	3	3	4	Good balance of properties

OTHER MATERIALS	MECHANICAL STRENGTH	GENERAL CHEMICAL RESISTANCE	THERMAL RESISTANCE	FEATURED PROPERTIES
TZP *Tetragonal zirconia polycrystal*	5	5	5	Superior surface finish and excellent dimensional stability
Sapphire *(Aluminum oxide)*	5	5	5	Superior surface finish and excellent dimensional stability

ADHESIVES	FEATURED PROPERTIES
Epoxy	Good adhesive strength to many materials, good chemical resistance
Cyanoacrylate	Quick set, high strength
Anaerobic	Very high strength, very good chemical resistance

METALS	FEATURED PROPERTIES
316 CRES	Superior corrosion resistance
430 CRES	Good magnetic properties, good corrosion resistance
303, 304 CRES	Good machinability, good corrosion resistance
17-4, 17-7 CRES	High modulus, good corrosion resistance
FeCr Alloy	Excellent corrosion resistance, good magnetic properties
Aluminum	Can be colored, low cost

GLOSSARY

This glossary serves to introduce the user to some of the terminology used throughout this handbook. These descriptions are proposed to serve as a reference point in product discussions to eliminate problems with definition.

Accuracy: The degree of closeness of a measured value to the intended, specified, or actual value. Compare to PRECISION.

Ambient Temperature: Temperature of the media surrounding external surfaces of a part.

Burst Pressure: The maximum pressure a part can endure before it will break.

Coefficient of Variation (CV): This value, expressed in terms of percentage, reflects the dispersion of data used to help define consistency of performance. It is calculated by taking the standard deviation of a distribution and dividing it by the mean value.

Coil Voltage (Actuation or Spike Voltage): The voltage supply required to actuate (energize) the coil sufficiently such that the valve is able to switch its flow state and perform as stated in the specifications.

Continuous Duty: Coils rated for continuous duty are designed to be energized continuously without overheating to failure.

Crossover Volume (Carryover Volume): Inherent to most 3-way valve designs, this is the leftover slug of fluid between one flow path and the closed seal of the second flow path. Volume carried over can mix with other fluids and is subsequently wasted when it is flushed out. See page G1 for an illustration of carryover volume.

Crosstalk (Intra-port Flow): Any response time dependent flow or pressure variation between any two valves or two ports of a 3-way valve. For example, this term refers to the flow that takes place between the normally closed and normally open ports of the 3-way valve in the time between the beginning of actuation and the end of actuation, when both ports are partially open.

Dead Volume: The actual non-flushable volumes of any component or system flow passages, where a dead-end passageway or cavity could retain materials to contaminate subsequent sample or flow media. The dead volume is not easily swept or flushed out regardless of valve actuation state. This value is highly subjective, as many factors come into play to determine the actual dead volume such as miscibility, viscosity, binding energy, etc. The quantity of the former sample still retained inside the component after flushing with some specified volume is defined as dead volume.

De-energized: No power applied to the coil. A normally closed solenoid valve is closed when the coil is de-energized.

Duty Cycle: The ratio, expressed in terms of percentage, of the energized period to the total period. Example: if a solenoid valve is on for 8 seconds and off for 12 seconds, the total cycle time is 20 seconds and therefore the duty cycle is 40%.

Energized: Power applied to the coil causing the solenoid valve to change state. A normally closed valve will open when energized.

Filter: A device used to remove contaminants from the fluid media.

Flow Coefficient (Cv): Indicates a valve's capacity for a liquid or gas to flow through it at a given pressure drop. The larger the opening in a valve, the larger the Cv, which indicates a higher flow capacity. See page Q4-5 for the relationship between Cv and Lohms.

Internal Volume: the total wetted fluid volume within the fluidic component. This includes the dead volume, carryover volume, and swept volume.

Normally Closed: A normally closed solenoid valve is closed when de-energized, preventing flow. When energized, the valve opens, allowing flow.

Normally Open: A normally open solenoid valve is open when de-energized, allowing flow. When energized, the valve closes, preventing flow.

Operating Pressure: The pressure specified for normal operation.

Precision: The degree of closeness of two or more measurements to each other. Compare to ACCURACY.

Pressure Differential: The pressure difference between the inlet and outlet pressure.

Proof Pressure: The level of pressure that may be applied to the part without causing permanent damage.

Response Time: This term defines the lag time between the input of a control signal, and the resulting response of the system or component being monitored. Typical use of the response time with a passive component could define the time lag between a pressure pulse input to a check valve, and the time to close or open the valve seat in response to that pulse. The more common usage is in reference to active components, such as solenoid valves. This term then typically defines the time from beginning of a normal voltage step-input drive signal, and the pneumatic output from the valve port that is opening or closing as a result of that signal.

The dimensions and configurations in this handbook are for reference purposes only, and may be updated at any time. Contact The Lee Company for current inspection drawings.

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TRADE NAME	TRADEMARK
THE LEE COMPANY	

PRODUCT NAME	TRADEMARK
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HDI	**HDI®**
XOVER	**XOVER®**
VHS	**VHS®**
Visco Jet Mixer	**VISCO JET®**

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The Lee Company is proud to warrant that, during the applicable warranty period, all products described in this handbook are free from defect in design, workmanship and materials and that they conform to any applicable specifications, drawings or approved samples.

Our products will only operate as well as the systems in which they are installed. We therefore expect the buyers of our products to be responsible for the proper design and fabrication of the systems in which our products are used. In order to assist our customers, we maintain a staff of sales engineers that can recommend the proper products to satisfy a particular system requirement. However, the buyer assumes sole responsibility of verifying the compatibility of our products with the fluid media.

The warranty period for all disc pump products, disc pump accessories, and any products with integrated disc pumps is six (6) months from the date of delivery. The warranty period for all other goods is four (4) years from the date of delivery, or the product's published life cycle, whichever is shorter.

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