USER MANUAL

For the

KLOEHN INLINE PUMP

1000 and 2000 Series

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NOTICE

Kloehn, Inc. maintains a continuous process of product evaluation and improvement. This is done through in-house engineering evaluations, market research and customer feedback. As a result of this process, Kloehn offers the most capable and sophisticated syringe pumps and valve drives in the world today at competitive prices. To sustain this effort, *Kloehn Inc. reserves the right to evolve and upgrade its standard products at Kloehn Inc.'s discretion*.

Kloehn Inc. has a policy of making every effort to ensure all upgrades are fully backward compatible with earlier versions of the same product. We have been successful in nearly all respects, producing better and more capable versions of our standard products that can be seamlessly integrated into existing system designs without significant price differences. However, differences may exist in internal parts and materials.

If such differences may impact your product certifications or if a unique configuration must be maintained over long production runs, contact Kloehn Customer Service to inquire about assigning a unique part number identification for your application. Alternately, you may request to add your name to the list of customers to be notified of changes prior to release of standard product upgrades.

Kloehn Customer Service: (702) 243-7727 or 1-800-358-4342

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1.0 INTRODUCTION

The Kloehn InLine pump, shown in Figure 1-1, is designed for accurate fluid dispensing at low pressures. It is a compact device that is offered in a variety of dispense volumes and in two different full-stroke resolutions. Some versions are available with an attached 3-way solenoid valve as depicted in Figure 1-1.

The basic InLine Pumps are designed with no electronic circuits for motor driving and control. This permits the motor to be controlled by the customer's method of choice. An InLine Pump has, at a minimum, a 4-lead bipolar stepper motor for the pump axis and an optical position detector for establishing a reference position from which other positions can be measured. It can be operated in any orientation.

The inline Pump comes in two resolutions, 10000 half steps full-stroke and 20000 half steps full-stroke. The motor can be operated in full step, half step or microstep modes, depending on the customer's motor driver design.

There are two models based upon the dispensing mechanism. One uses a positive displacement design and the other uses a syringe. The syringe-based design is recommended for use with aggressive reagents.

Various maximum displacements are available from 50ul to 5ml, depending on which model is selected. A product selection matrix is given in Section 4.

InLine Pumps can be ordered with and without attached 3-way solenoid valves.

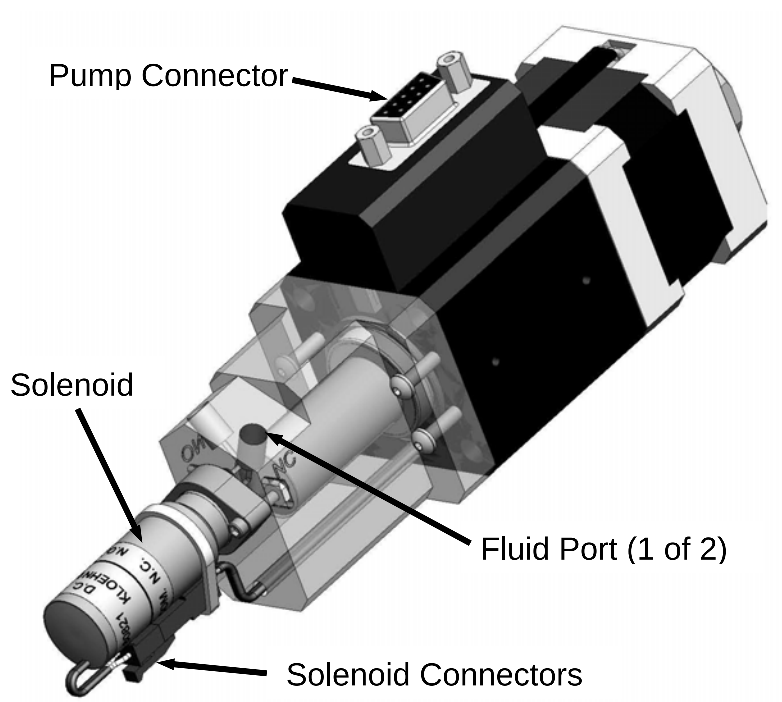


Figure 1-1 InLine Pump (2000 Series)

2.0 INSTALLATION

This section describes mechanical mounting of the pump and generally recommended system wiring practices.

2.1 MOUNTING

The pump can be mounted via a pair of threaded holes on each of two sides. It may also be mounted in groups of adjacent pumps, stacked together to a common supporting surface via a pair of non-threaded through holes in each pump adjacent to the connector assembly.

Figure 2-1 shows the mounting dimensions. The pump can be mounted and operated in any orientation. The figure shows the basic pump unit without an attached solenoid valve. A solenoid valve would mount to the left end of the pump and extend the overall length by about 2.60 inches (66 mm), including leads.

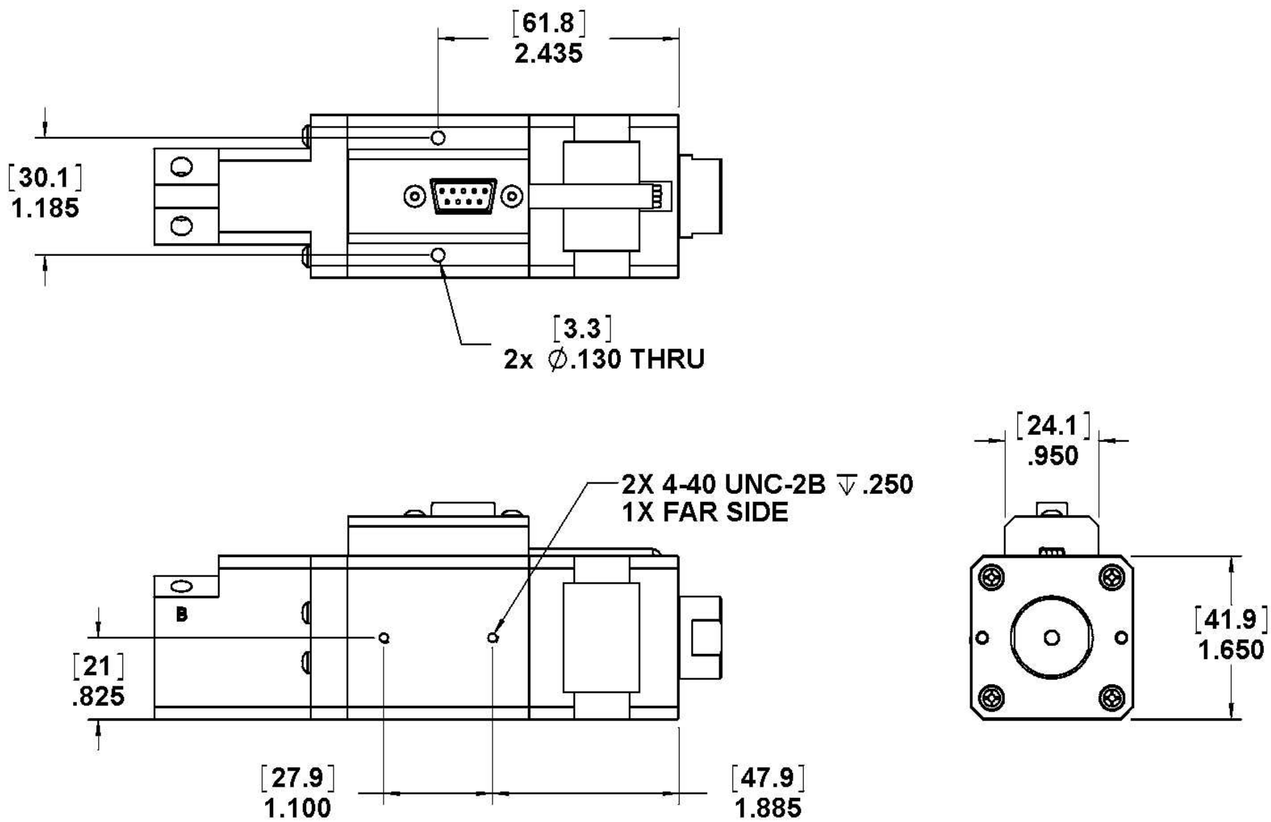
Mounting surfaces should be rigid to avoid coupling acoustic vibrations to the environment. Large, flat, thin surfaces can act as acoustic radiators to even small audible-range vibrations and should be avoided for mounting purposes. If such mounting surfaces are used, lossy coupling materials such as sorbothane should be considered as mounting gasket material to dampen possible acoustic coupling from the pump to the ambient via the mounting panel.

2.2 SYSTEM WIRING

All system wiring can be done with AWG #24 to #26 gauge wire. It is recommended that the opto detector wire on pin 5 of the DB-9 connector be a shielded wire if long cable runs between the pump and its electronics are used to prevent the motor driving signals from coupling into the detector signal.

The shield ground for the detector wire should be connected at one end of the wire run, preferably at the controlling electronics end. This will prevent ground loops in the detector circuit. The sensor ground lead on pin 4 of the connector should also be connected by a separate lead to the same controlling electronics ground connection as the shield.

If the wire bundle from the pump should be included into a general system wiring bundle containing sensitive control or analog signals, those signals or the motor leads should be shielded as well. The motor leads contain strong signals having significant frequency components into the hundreds of kilohertz. These spectral components could cause interference with other signals or could radiate beyond the enclosure and present problems with EMC testing.



[Measurements are given in inches; measurements in brackets are in mm.]
Figure shows acrylic pump unit without optional solenoid valve. See Section 5.2.

FIGURE 2-1 Pump Mounting Dimensions

2.3 VALVE INSTALLATION

The solenoid valve supplied with some versions of the pump can be replaced at the field level. To remove a valve, first remove the valve connector from the back of the valve. Then remove the two valve mounting screws and pull the valve off the manifold.

Note: The installation hardware is not provided with an individual valve assembly Insure initial mounting hardware is retained for valve replacement.

To install a valve, replace the seal provided with the replacement valve, set the new valve onto the manifold, re-install the two valve mounting screws with hex nuts, and torque to 36oz-in max. Finally, place the valve connector onto the pins of the new valve.

2.4 SAFETY

This section describes precautions to be considered in the use of the InLine Pump units during design and operation of various applications.

2.4.1 Operator Protection

The InLine valve and pump motors can each exceed 70 °C during extended operation. It is recommended to shield these parts from inadvertent operator contact.

2.4.2 Flammable Liquids

Care should be taken in instrument design and usage to prevent the exposure of flammable fluids to the motor or the valve during operation or service due to the elevated temperatures at which these devices may operate. Fluid lines should be routed to minimize any such risk.

Misuse or use in a manner not consistent with the User's Manual is not authorized and may result in a loss of warranty coverage.

2.5 Cleaning

When dispensing fluids other than water, cleaning procedures are recommended. Solutions that produce or contain particulates, such as saline solutions or the products of reactions between different solutions should not be allowed to stand for extended periods of time. As sharp-edged particulates accumulate on the inner surfaces of the valve and syringe parts, damage to diaphragms or syringe piston seal materials may occur, greatly shortening their operating life. Saline solutions should never be allowed to stand long enough for salt crystals to come out of solution.

To preclude a problem with particulate accumulation, flush the pump with a buffer solution or DI water after each use. This is also advised between different solutions if cross-contamination is a potential issue. Sufficient buffer or DI water should be used to adequately dilute the possible residues from previous solutions.

Do not attempt to disassemble the pump or its valve and syringe parts for cleaning. This is a factory-level operation.

3.0 INTERFACING AND CONTROLLING

This section describes the external electrical connections provided on the InLine Pump. The interfaces are the Motor, the Opto, and the Solenoid Valve. These connections are available at the DB-9 connector as shown in Figure 3-1.

Connector Pin	Function
1	Motor phase A1
6	Motor phase A2
2	Motor phase B1
7	Motor phase B2
3	Solenoid Valve
8	Solenoid Valve
4	Opto sensor ground
9	Opto sensor emitter LED anode
5	Opto sensor detector output

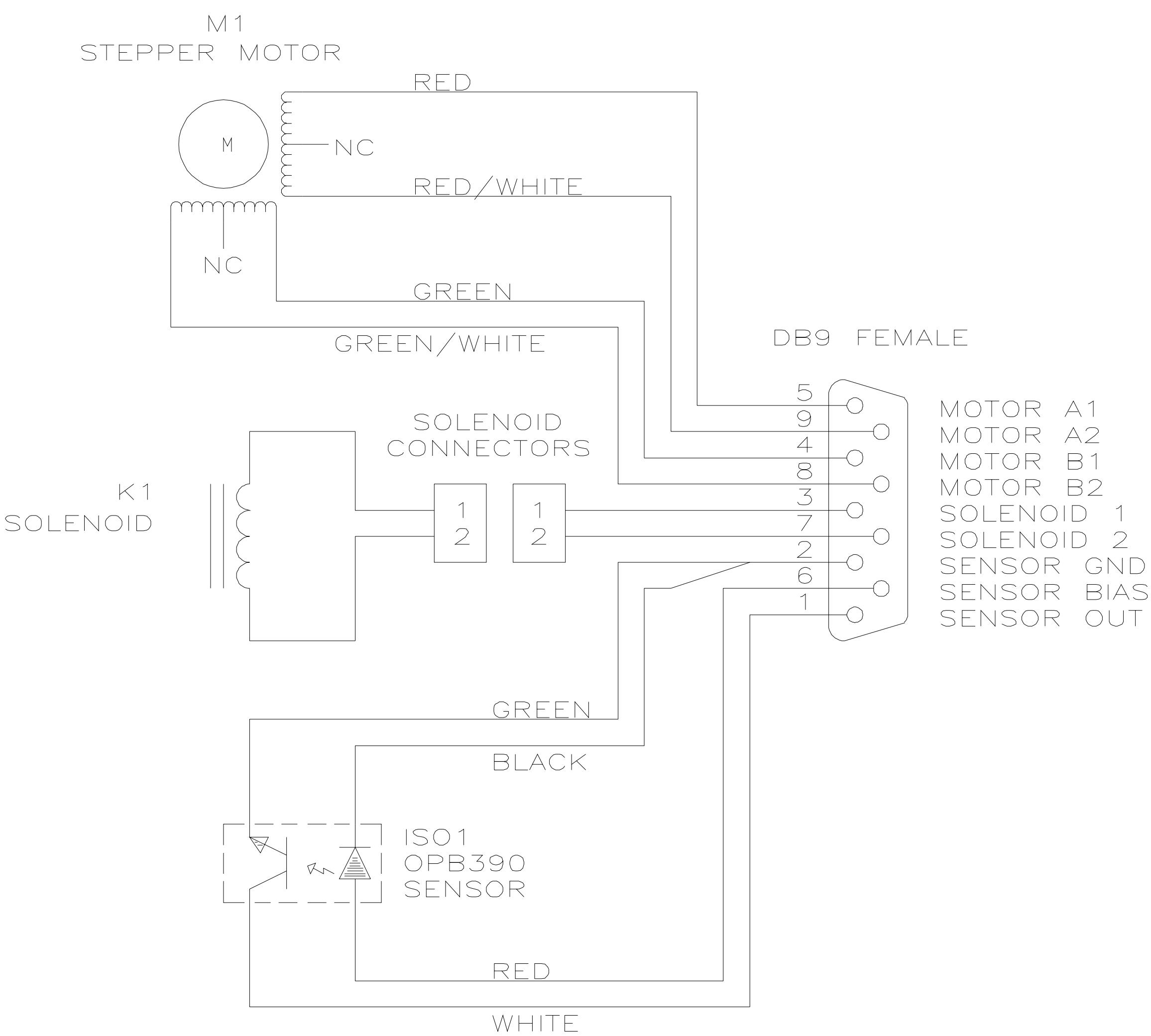


Figure 3-1 InLine Pump Electrical Schematic

3.1 DRIVING THE PUMP MOTOR

The InLine Pump uses a two-phase, bipolar stepper motor. Referring to Figure 3-1, the motor has four leads for the two motor phases. One phase is connected to pins 1 and 6 on the 9-pin connector and the other phase is connected to pins 2 and 7. The rated dispense volume for all pumps is set for a 30mm stroke.

3.1.1 Motor Lead Connections

The choice of order for the two leads for any one phase of user's driver circuits is arbitrary, but should be consistent. If the order of the two leads for one phase is reversed, the direction of rotation of the motor will also be reversed. It is critical to ensure the motor leads for each of the two phases are properly connected to the driver. Connecting a lead of one phase and a lead from the other phase to one driver phase output can result in damage to the driver, the motor or both.

3.1.2 Motor Drivers

The stepper motor uses a four-lead configuration intended for bipolar motor drivers. The motor is rated for 0.70 Amps, two phases on. This driving current level was selected as the maximum that would allow the motor to be driven by several popular surface-mount, bipolar stepper motor driver integrated circuits (ICs) without exceeding their thermal limitations.

The constant-current, bipolar chopper drive is recommended for the best performance. Driver supply voltages can be up to the maximum allowed for any of the commercially available motor driver chips.

3.1.3 Motor Resonance

Stepper motors can exhibit a resonance phenomenon at low speeds. This results in a loss of torque at the resonant frequencies and possible mechanically noisy operation near the resonances. The magnitude of this effect varies with the motor excitation method and the effective inertia and friction of the load as reflected at the motor. The speed range of 200 to 300 ½-steps per second results in noisy operation and has a resonance at approximately 225 ½-steps per second.

3.1.4 Stepping Modes

Stepper motors can be driven in several different excitation modes depending on the phase current sequencing. These modes are generally divided into full stepping, half stepping and microstepping.

Full stepping in both one-phase-on and two-phase-on excitation modes produces the strongest resonances, while half stepping substantially reduces this effect. At low speeds, microstepping can all but eliminate resonance. Half-stepping can produce a torque ripple unless the one-phase-on excitation current is adjusted to generate the same torque as the two-phase-on steps. Microstepping results in the smoothest motion, but reduces the available torque to about 71% of the values obtained in two-phase-on, full-step mode.

3.1.5 Start and Stop Speeds

The stepper motor used in the Kloehn InLine pump can be started and stopped without error at speeds up to a maximum stepping rate. Testing has found this rate to be not more than 1200 ½-steps per second (pps). The equivalent full-step speed is half this figure. If the maximum start speed for a given load is exceeded, the motor may begin rotation, but the actual position will not correspond to the number of step commands. See the last paragraph of Section 3.1.6 for a more complete explanation of this phenomenon. A start speed of 500 to 1000 ½-steps per second is recommended.

Stopping speeds may be any value up to the actual running stepping rate but should generally be limited to the start speed range to avoid missed steps due to system inertia causing an overshoot in the syringe travel.

3.1.6 Acceleration and Deceleration

The acceleration from the start speed to the running speed is limited by the available thrust. The available thrust is a function of speed and pump resolution. During acceleration, part of the total available thrust is consumed by accelerating the inertia of the pump and fluid, while the remainder of the total thrust is available to overcome fluid flow resistance. Higher accelerations use a larger fraction of the available thrust. For high fluid flow resistances, lower accelerations should be considered. The maximum acceleration should be not more than 50,000 ½-steps/sec^2. A value of 25,000 is recommended as a starting point. This is calculated as

Acceleration = (running speed – start speed) / (time from start to running speed)

Deceleration is aided by system load and friction and can be made very rapid at rates exceeding the allowable acceleration.

The result of too rapid an acceleration or deceleration can be missed steps, which produces errors in position tracking algorithms. This results when the motor loses synchronism between step commands and its actual position due to an inability to overcome load inertia at the commanded acceleration or deceleration rate. As the commanded rotation sequence from the driver outputs repeats due to continuing step commands, the motor attempts to restore synchronization. If successful, the motor continues to visibly move, but the actual position no longer corresponds to the number of step commands that were sent. This phenomenon can also occur with a start speed that is slightly too high for a given load.

3.1.7 Running Speed

The thrust demands of the fluid load, the pressure limits of any valves in the fluid path and the diminishing of thrust with speed limit the maximum running speed. The thrust demand varies considerably with the fluid path variables viscosity, velocity, fluid path diameter and fluid path length. See Section 3.1.10 for system pressure considerations.

Thrust demand varies in direct proportion to the fluid viscosity. Viscosity can vary considerably with temperature for any fluid, so the worst-case temperature should be considered when setting pump speeds.

The thrust demand varies as the square of the fluid velocity. Thus doubling of velocity requires four times the thrust. When selecting speeds, the maximum speed for an application should be not more than 70% of the lowest speed that causes the pump to stall under load.

Thrust demand varies with the fourth power of fluid path diameter. Thus increasing diameter by just 19% reduces path flow resistance by half. Careful consideration of the tradeoff between path volume and flow resistance should be done for any system design. This consideration applies to path constrictions as well. Kinking in tubing due to bends can create such flow restrictions.

Thrust demand varies directly with fluid path length. In general, keeping path lengths to a minimum enhances system performance and design margins.

The combined effects of these factors on thrust demand cannot be overestimated. It is not uncommon for a dispensing system to vent to ambient pressure, yet cause 10 bar or more at the syringe due to flow path pressure rises when flow variables are not considered. It is recommended that system speeds be optimized by empirical means, accounting for the effects of temperature.

The table below summarizes the smoothness of operation for full stepping, one phase on for a bipolar drive at 24Vdc.

Preferred	audible stepping	resonance
	50 – 150	200 – 300
400 – 950	1000 – 1200	

Using a torque-compensated ½-step mode of operation results in considerable improvement. The maximum speed becomes approximately 5000 ½-steps per

second, better than twice the linear rate as for full stepping, one phase on. The resonance range is unchanged for ½-stepping.
Microstepping will produce substantially quieter operation in the audible stepping ranges and will eliminate resonances at the cost of about 30% less available thrust than two-phase full stepping or torque-compensated ½-stepping.

Higher speeds are achievable with higher voltage drives and a 48Vdc or 60Vdc drive can provide very significant improvements in the maximum speed, although the low-speed thrust is not affected by a higher voltage drive..

3.1.8 Anti-backlash

When the syringe is aspirated to take in fluid and then reversed, a small mechanical play exists in the drive mechanism that causes the first part of a subsequent dispense move to fail to move the syringe. Thus the commanded dispense is slightly short. This can be compensated by an anti-backlash move.

An anti-backlash move consists of an aspirate move that slightly exceeds the intended target volume. The amount *delta* by which the move exceeds the target is then removed by reversing direction and moving the distance *delta* in the dispense direction. This takes up the slack in the drive mechanism so the dispense begins without error. The distance *delta* is chosen to be not less than the maximum mechanical play in the drive. A typical value is less than 0.05mm.

3.1.9 Initialization

When a system using the InLine pump is initially powered on or when a recovery from an unknown pump piston position is required, an *initialization* is required. This is the process of placing the pump piston into a mechanically known reference position from which all other positions may be determined by the user's controlling software.

The initialization process must begin by determining on which side of the reference position the piston is located. Such a determination must consider that the opto signal will be low on both sides of the reference position and transition from low to high when encountering the internal reference flag from both the dispense direction and the aspirate direction.

A recommended procedure is to begin a move in the aspirate direction at a low speed of not more than 1 mm/sec. Since the opto signal transition is about 2 mm from the dispense direction maximum stroke position, if the opto signal does no transition to a high level within 2 mm of travel, the piston must be on the aspirate side of the reference position. If the opto low-to-high transition is seen within that distance, it was approached from the dispense end.

If the opto is seen from the dispense direction, continue moving until the opto signal returns low and move not less than 0.10 mm more in the aspirate direction. When this move is complete, reverse direction to the dispense direction and move until the low-to-high transition is seen again, then stop. This is the reference position and an anti-backlash move has been included in the initialize move.

If the opto transition from low-to-high is not seen within 2 mm, reverse direction to the dispense direction and proceed until the opto transition occurs. Stop when the transition is detected. This is the reference position and an anti-backlash move has been accomplished.

When the reference position has been located, a position counter in the controlling software should be set to a reference value. This value may be zero or some number corresponding to the desired distance from the reference position to the zero position. As the total possible piston travel is about 33 mm and a full stroke for the pump's rated displacement volume is 30 mm, there is 3 mm total travel available for both ends combined in excess of a full stroke. Since the reference position is about 2 mm from the extreme dispense end, this leaves 1 mm of excess travel in the aspirate direction beyond a full stroke. By assigning a non-zero value to the reference position, a zero position can be located on the dispense side of the reference position and the locations of the full-stroke end points can be adjusted so that the entire position range along a stroke remains a positive integer number.

While other methods of initializing the position tracking software can be derived, the preceding method is perhaps the simplest to implement.

3.1.10 Pump Pressures

System parameters as discussed in Section 3.1 will determine the actual operating system pressures in any given user system, subject to two limitations: the maximum available pump pressure and the weakest element in the fluid path.

In systems using a pump with an integral solenoid valve, the maximum practical pressure may be the pressure rating of the valve itself. Consult the Product Data Sheet for the actual pressure for a given model. The basic valve pressure limit for the standard Kloehn valve is listed in Section 5.2. If the valve limit pressure is exceeded, the seal between valve ports will not contain the fluid and leakage between valve fluid paths will result. Contact Kloehn Inc. if special valve designs are required for a system application.

The source of pressure in the fluid path is the pump itself. The system parameters such as path geometry, fluid properties and fluid velocities will determine the pressure rise from the final fluid destination to the pump piston. The pump must provide the thrust force to meet the system pressure demand at the pump piston. If the pressure demand exceeds the thrust available, the pump motor will stall.

The Kloehn pump piston is driven by a stepper motor that is designed to withstand a stalled condition indefinitely without damage if the motor driver circuit limits the peak current delivered to the motor to the values listed in Section 5.3.1.

The pressure at which the motor will stall is determined by the rated fluid volume for the pump, the speed at which the motor is driven and the design of the motor driver circuit. Pressure is defined as force per unit area. The pressure value is therefore determined by the piston area, which depends rated volume, and the thrust force delivered by the motor. The following relation determines these variables for the Kloehn Inline pump:

Psi = (38.7 x thrust) / (2 x rated volume)   where thrust is in lbf and volume is in mL.

A typical thrust curve in presented in Section 5.3.4. The thrust available at low speeds is about 78 lbf. Only the thrust demanded by the application will actually be applied to the pump piston, subject to the maximum available. The maximum available decreases from the 78 lbf limit as
speed is increased to the maximum of 5000 ½-steps per second. The actual decrease I available thrust with speed increases depends upon the motor driver design. The maximum low-speed thrust will be 30% lower, or about 56 lbf, for microstepping drives and for ½-stepping drives that do not provide torque ripple compensation.

The drop in thrust with speed should not be used to limit system pressures, as the motor must accelerate from lower speeds to reach the higher, more limited pressure speeds. Good system design should allow for these considerations.

NOTE: System design must consider the maximum pressure that can be delivered by the pump at the lowest programmed speed.

3.2 POSITION REFERENCE OPTO

The Opto Sensor leads on pins 4, 5 and 9 provide bias and sensing for the syringe travel optical detector as shown in Figure 3-1.

3.2.1 Opto Function

The Position Reference Opto is an optical detector that senses the presence of a flag attached to the syringe drive. The signal from this detector provides a single, fixed, mechanically known position at the dispense end of the syringe stroke from which all other syringe positions can be determined as steps from the flag detection point. This detection point is 2.00 ± 0.15mm from the far end of the available syringe travel in the dispense direction, as the signal transitions from low to high.

3.2.2 Opto Bias

The opto emitter should be biased by placing a resistor between pin 9 and the positive supply voltage. The value of this resistor should be chosen to provide about 20 mA. The resistance value for a 5Vdc supply would be 180 ohms at ¼ watt, 100 ohms at ¼ watt from a 3.3Vdc supply or 1.1K at 1 watt for a 24 Vdc supply.

The opto detector output is an open collector transistor that sinks up to 1.0 mA for an emitter bias of 20 mA. A pull-up resistor is typically placed from the output at pin 5 to the positive voltage supply. The output voltage signal is then taken from pin 5. The recommended resistance for a 5Vdc supply is 4.7K, 3.3K for a 3.3Vdc supply, or 27K for a 24 Vdc supply. All these pull-up values can be ¼ watt.

3.2.3 Opto Signal

Under the bias conditions given in Section 3.2.2, the output voltage of the opto will be logic high (supply voltage) when the reference flag is seen. The logic low level (<0.4V) occurs when the flag is not seen. The transition between the two logic states is gradual, with the full transition occurring over a distance of several steps. Conditioning the signal with a Schmidt trigger can produce abrupt threshold transitions if required. Most modern microprocessor inputs have sufficient gain to preclude the need for this signal conditioning unless the pump is operating in an electrically noisy environment. It should be noted the flag is narrow and a low output voltage level can be seen for piston positions on either side of the flag engagement.

3.3 VALVE OPERATION

Some versions of the Inline pump are equipped with attached 3-way solenoid valves. The product matrix in Section 4 specifies which models are so equipped.

The 3-way solenoid valve provides one common port connected to the syringe and two ports, one of which is connected to the common port, depending on the state of the valve solenoid, which is either On of Off. This provides remote selection of one of two fluid paths to the syringe.

3.3.1 Driving

The two solenoid leads are located on pins 3 and 8 of the connector. They are non-polar and can be connected interchangeably. The solenoid is designed for actuation from a 24Vdc power source, although a 12Vdc version can be made available by custom order.

Actuation and release times are not more than 500 msec. Faster valves are available as custom orders. When de-energized, the solenoid valve connects the syringe to the pump port labeled “NO”, which stands for “Normally Open”. When actuated, the syringe is connected to the pump port labeled “NC”, or “Normally Closed”. Do not drive the syringe axis during the time the valve is actuating or releasing.

With a 24Vdc excitation, the solenoid will draw a nominal 167 mA and dissipate four Watts. This power level will cause overheating of the solenoid valve if sustained too long. The technique of idle power reduction, explained in Section 3.3.2, precludes this problem.

3.3.2 Idle Power Reduction

After the solenoid has been energized by the 24Vdc power, the voltage on the solenoid can be reduced to the **Holding Voltage** value. This is value that reduces power dissipation to a thermally acceptable long-term value while maintaining the solenoid in the energized state. The recommended holding value is 16 to 17 Vdc. This is most easily accomplished by driving the solenoid with a pulse-width-modulated (PWM) waveform having a duty cycle of 100% for 100 milliseconds, followed by reducing the duty cycle to 66% to 71% for the sustaining drive. The drive circuitry should include a clamp diode across the solenoid to absorb the transient voltage induced by turning off a solenoid.

4.0 OPTIONS

There are two basic versions of the InLine pumps, the 1000 Series and the 2000 Series. Each series can be available in both 10,000 ½-steps full-stroke and 20,000 ½-steps full-stroke resolutions. In addition, each series is available with or without an attached solenoid valve. Version designed without solenoid valves are used with external valves and can withstand higher pressures than units with integral solenoid valves.

The 1000 Series uses a borosilicate glass syringe barrel installed in a PVDF manifold. The glass syringe barrels are not replaceable at the field level. Pumps must be returned to Kloehn under RMA numbers for replacement. The solenoid valve versions use FFKM (Perfluoroelastomer) diaphragms. The wetted materials for the 1000 Series are listed in Section 5.4.1.

The 2000 Series is a positive displacement pump using a piston in an acrylic manifold. The solenoid valve versions use EPDM (ethylene propylene diene M-class rubber) diaphragms. The wetted materials for the 2000 Series are listed in Section 5.4.2.

The 1000 Series pumps are intended for applications with more aggressive chemical resistance requirements than an acrylic material would support. It is also a good choice in applications in which sharp-edged particulates may exist or may precipitate out.

It should be emphasized that frequent cleaning will prolong the life of any pump when a pump is used with aggressive or particulate-laden solutions. Such solutions should not be allowed to lay unmoved for long periods of time in the internal pump volume or in the valve if the maximum pump operating life is desired.

Both the 1000 Series and the 2000 Series are available in a variety of rated pump fluid volumes ranging from 50uL to 5mL depending on the model series and the selected full-stroke resolution. The standards pump fluid displacement volumes are 50uL, 100uL, 250uL, 500uL, 1.0mL, 2.5mL and 5.0mL. Consult the Kloehn Product Data Sheet for details about the standard models that are currently available. If a pump displacement volume is required that is not listed on a product data sheet, that volume and resolution could be available via a request for a custom version. Custom versions will be assigned unique part numbers to facilitate consistent unit ordering and to ensure proper replacement parts and service.

Solenoid valves are replaceable at the field level by the customer, using proper procedures. See Section 2.3 for the correct procedure. Pumps having custom valves will also be assigned unique part numbers as stated in the preceding paragraph.

5.0 SPECIFICATIONS

The design and operating specifications for the InLine Pump assembly are given in this section. Environmental specifications refer to the operating ambient conditions seen by the pump in the user's application.

5.1 ENVIRONMENTAL

Temperatures:	Operating	0 to 50 °C
	Storage	-25 to 85 °C
Humidity		5% to 95% RH, non-condensing at 50 °C

5.2 MECHANICAL

Accuracy & Precision				
1000 Series			0.5% to 1% CV, max	
2000 Series			0.5% CV, max	
Dimensions				
Height (incl connector)			2.61 in	66.3 mm
Width			1.63 in	41.4 mm
Length				
	2000 Series			
		No valve	5.75 in	146 mm
		With valve	8.25 in	206 mm
	1000 Series			
		No valve	6.54 in	166.1 mm
		With valve	8.92 in	223.8 mm
Weight				
	2000 Series			
		No valve	460g	
		With valve	495g	
	1000 Series			
		No valve	492g	
		With valve	528g	
Orientation			Any; vertical, motor down preferred	
Pressures				
With solenoid valve			50 psi, max	
No solenoid valve			100 psi, max	
Mounting screw torque			3 in-lbf, max	

5.3 ELECTRICAL

5.3.1 Motor

Configuration	Hybrid stepper, 4-lead bipolar
Current	0.70 A rms per phase
Inductance	19 mH per phase

Resistance	9.6 ohms per phase
Steps full-stroke	10,000 or 20,000 ½-steps (see Section 4)

5.3.2 Opto

Emitter bias	20 mA, nom (at forward voltage = 1.25 V, typ)
Detector Output	Open-collector,
Output current	1 mA sink, min
Output voltage	30 Vdc, max

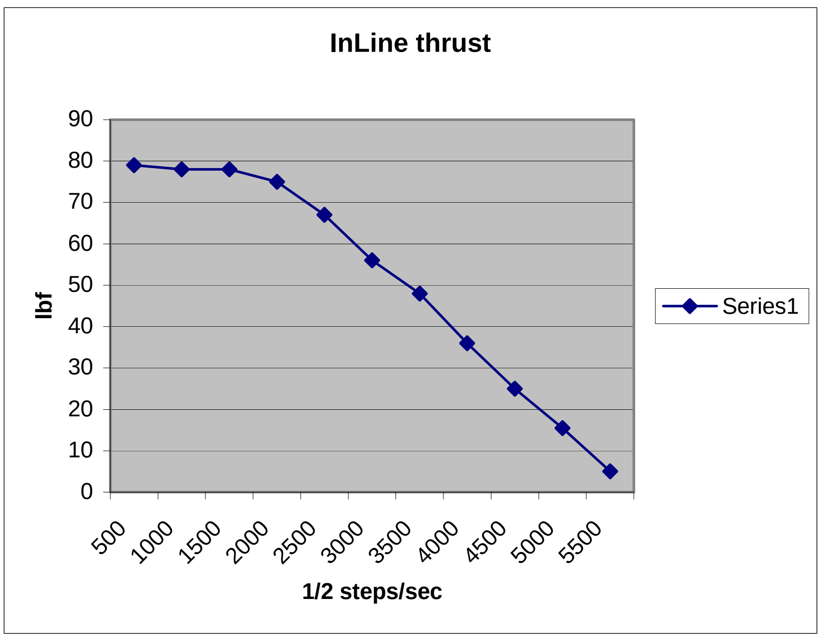
5.3.3 Valve

(Solenoid valves only)

Voltage	
Activating	24 Vdc, nominal, 1 sec max or 71% duty factor max
Sustaining	17 Vdc, max 15 Vdc, min
Resistance	144 ohms

5.3.4 Pump

Stroke for rated volume	30 mm
Backlash	< 0.05 mm typ, < 0.10 mm max
Flag detection to limit of travel	2.00 ± 0.15 mm



5.4 MATERIAL COMPATIBILITY

Material compatibility with various chemicals can be checked at the Cole-Parmer website at:

http://www.coleparmer.com/techinfo/ChemComp.asp

5.4.1 1000 Series Pump Wetted Materials

Pump only materials (no valve):	Teflon, borosilicate glass and PVDF
Valve materials:	FFKM, PEEK

5.4.2 2000 Series Pump Wetted Materials

Pump only materials (no valve):	Acrylic, UHMW-PE and 316L Stainless Steel
Valve materials:	EPDM, PEEK

6.0 Warranty

Warranty

Kloehn Ltd. guarantees our products to be free of defects in materials and workmanship with a one (1) year limited warranty.

We will repair or replace, at our discretion, standard product that fails due to material defect or workmanship at no cost to the customer.

The customer is required to return the product with a pre-approved Return Material Authorization number (RMA#), and if applicable, a Material Safety Data Sheet (MSDS).

It is the customer's responsibility to establish suitability of the application and material compatibility of the product.

7.0 Returned Material Authorization

When Pumps are to be returned for service or replacement, an RMA (Returned Material Authorization form must accompany the item(s) to be returned. This form is included with or used as the packing slip on the package in which the item(s) are returned. The RMA form is presented on the flowing two pages.

RMA Req. Date	*RMA Number*	DEBITED (check)		Order Number	
		YES	NO	Order Value	
Any contaminants? (If yes, what is the contaminant and ask for an MSDS) – (explain all must be free of contaminants to be received into Kloehn or rejected)					

Customer Service RMA Request Form

Attached any and all support documents for Customer Service Files

Customer Name		Customer No	
Telephone No		Fax	
Contact Name		Email Address	
Original PO Number		PO Date Issued	

Customer Comments:

Kloehn Response :

Thank you,

Kloehn Customer Support

Signature: _____ Date: ____

P/N	Qty	Description and Serial Number	Pricing	Rcvd	Ship

Kloehn Inc.
Attn:
10000 Banburry Cross Drive
Las Vegas, NV 89144

Please include this document inside the box being returned to Kloehn – Thank you.