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https://wkfluidhandling.com

PEM050 Owner's Manual

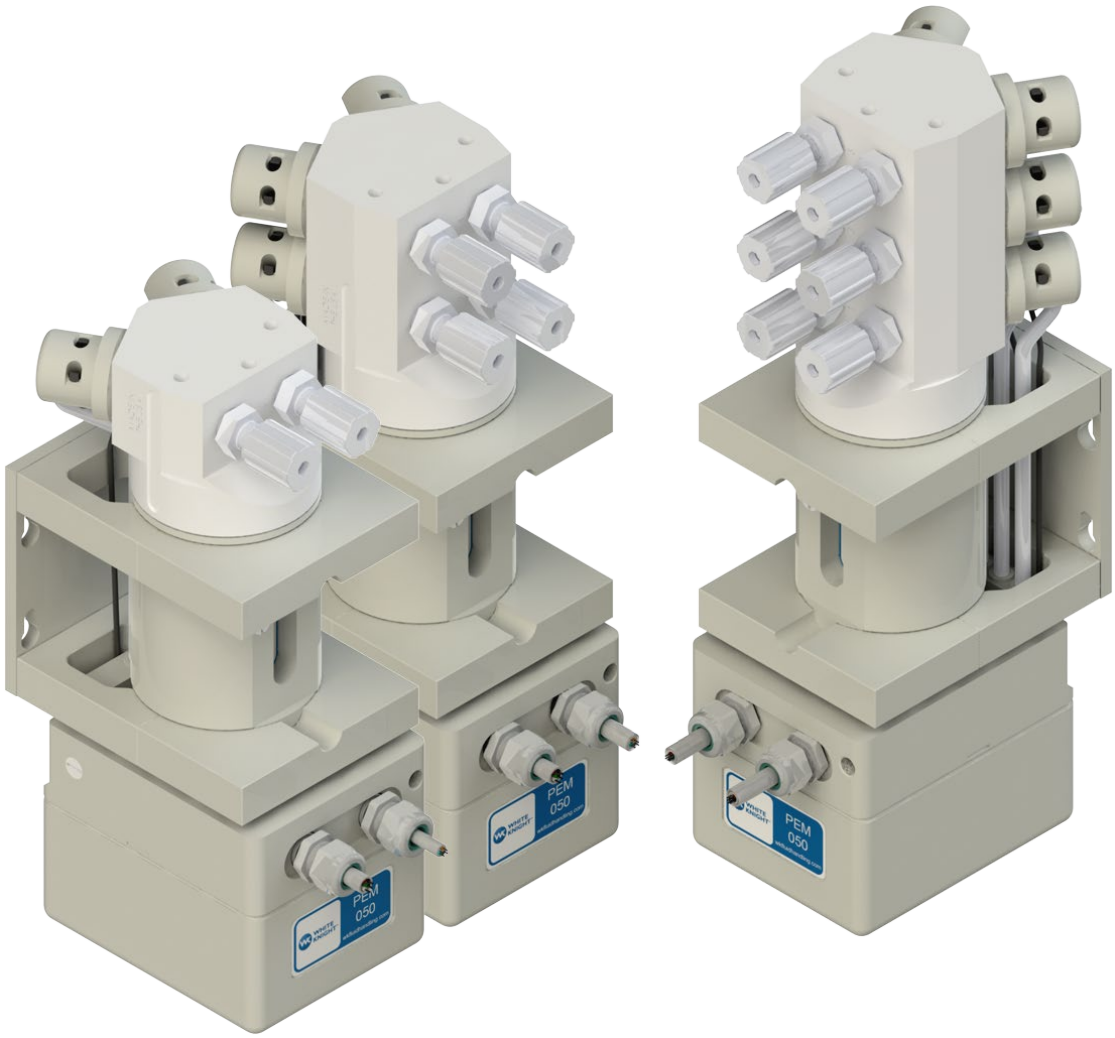


Table of Contents

1 Introduction

Thank You for Purchasing White Knight Products

You have purchased a White Knight product that has been designed to our exacting specifications and built by a team of technicians with the highest commitment to quality!

White Knight is the world leader in zero-metal, ultra high-purity pumps and continues to drive the industry with new technology and products. Since the inception of White Knight in 1995, we have been awarded over 14 US patents for our designs and have multiple other patents pending! White Knight currently produces over 30 sizes/models of pumps in varying materials to meet our customers' stringent requirements in numerous applications including ultra-high temperature re-circulation; slurry and high-pressure chemical delivery systems.

White Knight has been the recipient of multiple prestigious industry awards for its designs and continues to lead the industry in quality because White Knight manufactures products from raw material to finished goods in our own facility located in Kamas, UT. This allows us to rigorously manage our quality assurance process to ensure that our strict cleanliness procedures are always followed and that components are built using consistent methods and conditions to make our products reliable and consistent.

Our strict process controls include assembling and testing our products in a class 100, temperature and humidity-controlled cleanroom. White Knight products also pass functional tests and are then dried with CDA and double bagged in the cleanroom to ensure cleanliness and operational integrity.

Before installing your White Knight product, please carefully review the product manual. There are many helpful hints and ways to optimize the set up and use of your White Knight product as well as instructions and requirements for installation. In addition, there are many accessories in this manual that will enhance the functionality of your White Knight product.

Our team has gone to great lengths to provide you with the highest quality products at the best value and we back them up with excellent warranties and world class support! We hope you agree our products will serve your exacting needs and meet your stringent requirements every time you use a White Knight Product.

Sincerely,

Brian Callahan
CEO
White Knight Fluid Handling

P: 435.783.6040 | info@wkfluidhandling.com | https://wkfluidhandling.com/pem050/

2 Specifications & Performance

2.1 Pump Specifications

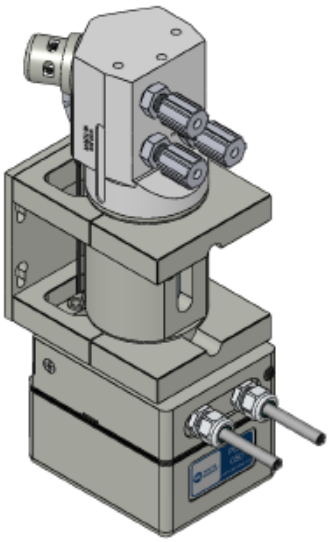
PEM050 Pump Specifications							
Dispense Range per Stroke[1]	Max Discharge Pressure[2]	Repeatability (Full Scale)[3]	Max Cycles Per Minute[4]	Air Consumption SCFM[5]	Fluid Path Materials	Fluid Temperature range	Suction Lift[6]
50 ml Max 1 ml Min	55 psi	+/- 0.1%	Up To 6	1-3 SCFM	PTFE	0-100°C 32-212°F	4.6 meters 15 feet

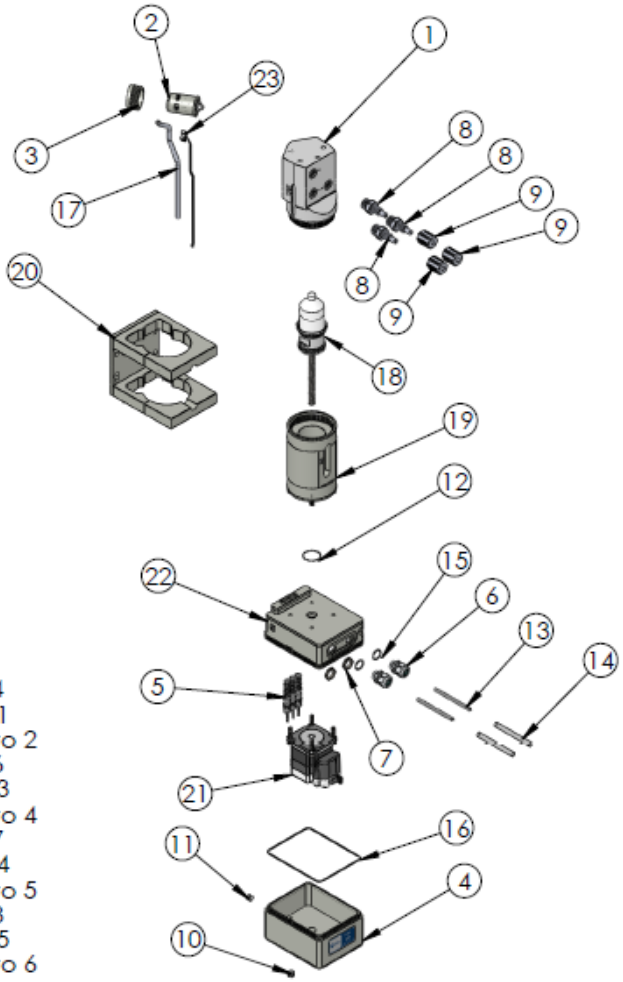
Supply Air Pressure	**Fluid Valves**	**Valve Manifold**	**Communication Protocol**	**Pump Mechanism**
60-80 psi	Pneumatic Pilot valves	2-6 Valves	ASCII commands over: * RS422 * RS485 (Configurable) * Ethernet	Stepper Motor connected to a rolling Diaphragm piston.

Electrical Specifications			
	Absolute Minimum	**Nominal**	**Absolute Maximum or Peak**
Voltage Requirements	17 VDC	24 VDC	24 VDC
Current Draw	1 amp	1.3 amps	2 amps

1. Power supply should be regulated. Unregulated power supplies may damage electrical components.
2. Pressure operation >55 psi back pressure diminishes over time.
3. Optimized parameters can improve repeatability (up to ± 0.01%). Contact White Knight for details. Dispense measured at full stroke with maximum and minimum supply pressures at 80 psi and 60 psi.
4. White Knight only warrants the PEM050 to 500,000 cycles, test ran at full stroke.
5. “Max” represents 80 psi supply pressure; “Min” represents 60 psi supply pressure.
6. To maximize repeatability, it is best to minimize suction lift scenarios.
   Note: all tests ran with water at ambient temperature.

2.2 Exploded View and Bill of Materials





For PEM050-02: Change item number 1to 2127-TE-0064
Change item number 22 to 14400-XX-0001
Change QTY of item 2, 3, 5, 8, 9, 17, and 23 to 2
For PEM050-04: Change item number 1to 2127-TE-0066
Change item number 22 to 14400-XX-0003
Change QTY of item 2, 3, 5, 8, 9, 17, and 23 to 4
For PEM050-05: Change item number 1to 2127-TE-0067
Change item number 22 to 14400-XX-0004
Change QTY of item 2, 3, 5, 8, 9, 17, and 23 to 5
For PEM050-06: Change item number 1to 2127-TE-0068
Change item number 22 to 14400-XX-0005
Change QTY of item 2, 3, 5, 8, 9, 17, and 23 to 6

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	2127-TE-0065	HEAD, PUMP, PEM050-03	1
2	14470-XX-0002	VALVE, 1/4", WK	1
3	10010-NP-0010	NUT, VALVE, 1/4" WK	1
4	10100-NP-0002	COVER, BOTTOM MOUNT, PEM050	1
5	8600-XX-0028	VALVE, SOLENOID, BULLET, BV310A	3
6	8600-KY-0001	CABLE GRIPPER, .160 to .312	2
7	8600-XX-0029	NUT, CABLE GRIPPER	2
8	7200-PF-0012	1/4" Flaretek X 04 WK LIQUID FITTING	3
9	7210-PF-0001	NUT, FLARETEK, 1/4"	3
10	10040-TE-0015	PLUG, VENT, NPT, 1/8"	1
11	10040-TE-0002	PLUG, NPT, 1/8"	2
12	10080-VI-022-75	O-RING, 022 X .070	1
13	8600-XX-0030	Cable, 6 Wire, Shielded, 24 AWG	2
14	10070-PF-0005	Tubing, PFA, .250 I.D. x .312 O.D.	2
15	10080-VI-015-75	O-RING, 016 x .070	2
16	10080-VI-048-75	O-RING, 048 X .070	1
17	10070-PF-0001	TUBING, 1/4", THICK WALL	1
18	14320-XX-0001	SHAFT ASSEMBLY	1
19	14861-XX-0005	BODY ASSEMBLY	1
20	14200-XX-0001	BASE PLATE ASSEMBLY	1
21	148600-XX-0003	AIR MOTOR ASSEMBLY	1
22	14400-XX-0002	SHUTTLE ASSEMBLY	1
23	8600-XX-0027	SENSOR, LIGHT BREAK	1

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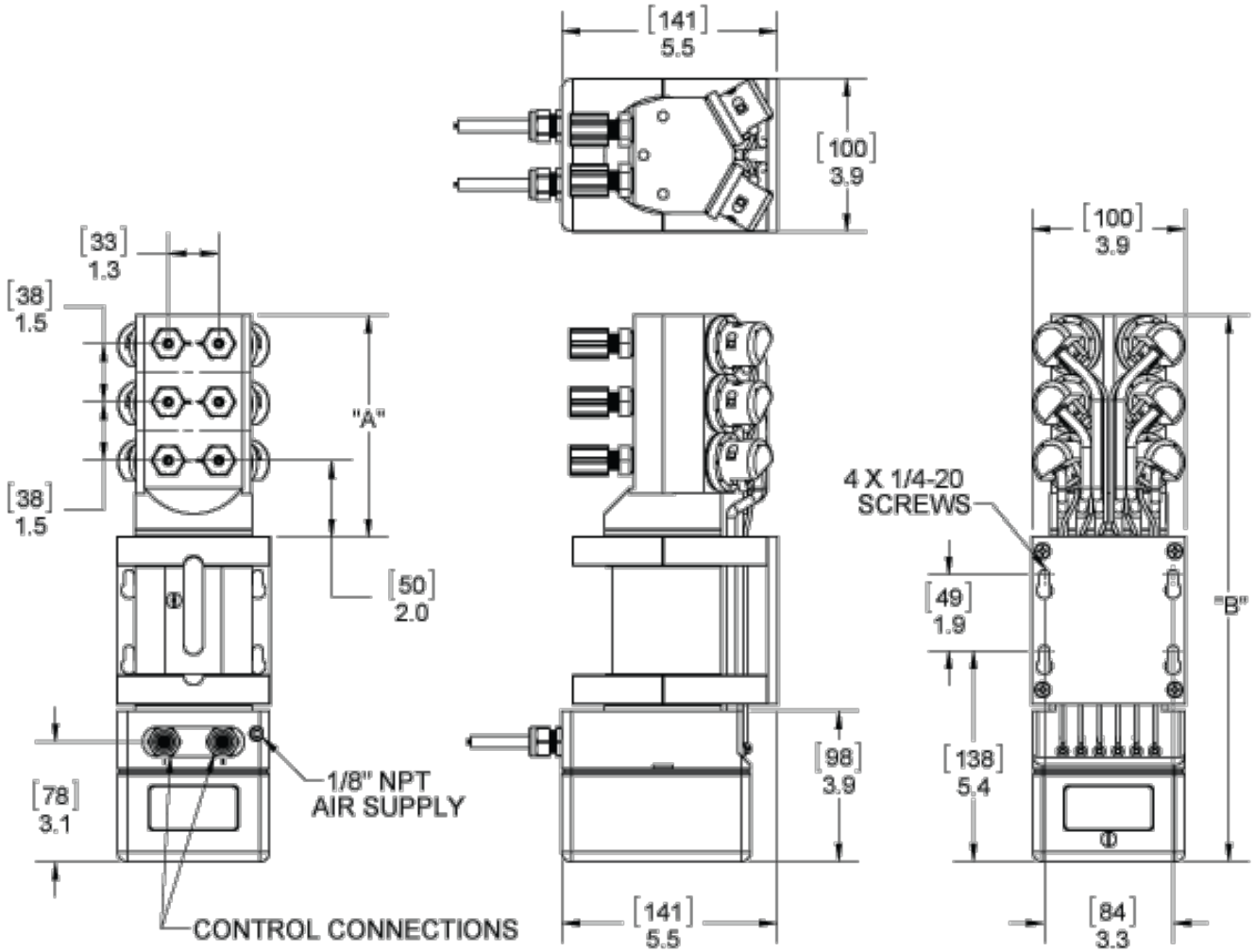
2.3 Dimensions



Pump Config.	"A"	"B"
PEM050-02	2.7 (69)	11.0 (279)
PEM050-03	4.2 (107)	12.5 (318)
PEM050-04	4.2 (107)	12.5 (318)
PEM050-05	5.7 (145)	14.0 (356)
PEM050-06	5.7 (145)	14.0 (356)

3 Pump Warranty

White Knight Fluid Handling follows strict procedures in all phases of manufacturing, assembly, and testing to ensure reliability of its products. Each pump is individually tested to assure its functional operation integrity.

White Knight Fluid Handling warrants the PEM050 metering pump, subassemblies and components to be free from defects in materials and workmanship to one year from date of start-up, 18 months from the date of shipment or upon completion of 500,000 cycles, whichever occurs first. Failures due to misuse, abuse or any unauthorized disassembly of a White Knight® pump will nullify this warranty.

The PEM050 metering pump is warranted for up to 80 psi air supply pressures, and 55 psi discharge pressures. Wearable parts are not covered if used to pump abrasive slurries.

Due to the broad and ever-evolving applications for usage of White Knight® pumps we cannot guarantee the suitability of any pump component or subassembly for any particular or specific application. White Knight Fluid Handling shall not be liable for any consequential damage or expense arising from the use or misuse of its products in any application. Responsibility is limited solely to the replacement or repair of defective White Knight® pumps, components or subassemblies. All options to rebuild or replace aforementioned items shall remain under the judgment of White Knight Fluid Handling. Decisions as to the cause of failure shall be solely determined by White Knight Fluid Handling.

Prior written, faxed or emailed approval must be obtained from White Knight Fluid Handling before returning any pump component or subassembly for warranty consideration.

THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED INCLUDING ANY WARRANTIES OF SUITABILITY FOR ANY PARTICULAR PURPOSE. NO VARIATIONS OF THIS WARRANTY BY ANYONE OTHER THAN THE PRESIDENT OF WHITE KNIGHT FLUID HANDLING IN A SELF-SIGNED AGREEMENT SHALL BE HONORED OR CONSIDERED LEGALLY BINDING.

Brian Callahan, CEO

White Knight Fluid Handling

4 Installation and Precautions

4.1 Precautions

Use of Electronically Controlled Metering Pumps
Electrically controlled metering pumps do not qualify for use in explosion proof environments.
Handling
DO NOT LIFT PUMP BY LIQUID FITTINGS OR AIR TUBING!
Air Supply
The operation of the PEM050 requires a minimum of 60 psi air supply pressure, ran through a minimum ⅛" ID airline. Supplying less than 60 psi air supply pressure to the pump will not allow the positively controlled inlet/outlet valves to fully actuate. Max air supply pressure is 80 psi.
Dry Priming/Air Purging
Initial priming of the PEM050 is critical to the pump's performance. For optimal air purging, the pump should be mounted with the liquid ports up (motor bottom configuration). The pump should be fully cycled until no air is found in the liquid dispense line.
Pumping Slurries and Abrasives
For pumping slurries, White Knight recommends mounting the PEM050 with the liquid inlet/outlet ports at the bottom of the pump (motor top configuration).
Restriction of Liquid Inlet Line
Restricting the liquid supply of the pump forces the pump to work harder than normal and should be avoided when possible. Pumping against a closed liquid inlet will cause serious damage to your pump and will void the pump warranty.
Cross Contamination
PTFE and many other plastics are very porous and may retain chemicals in the pores of the material. Record chemistries used in a pump to avoid cross contamination.
NEMA 5 Applications
The PEM050 is capable of NEMA 5 classification. However, this requires that the end user route the constant air-cool bleed to a safe location. The port is located on the back of the motor housing and is assembled and shipped with a muffler to allow for immediate use upon arrival. The exhaust must remain clear of obstruction, or the motor housing cover will disengage. The exhaust port is ⅛" NPT, recessed in the motor housing.
WARNING: Liquids and Gasses Under Pressure
 While in a live system, pumps contain pressurized liquids and gasses. All pressure, liquid and air must be eliminated via shut off valves before the pump may be removed or detached from the system.
WARNING: Handling of Chemicals
 In the event that hazardous chemicals are used in or around the pump, ensure that appropriate personal protective equipment is used before handling. Reference the chemistry's Material Safety Data Sheet (MSDS) for handling instructions or other information specific to that chemical.
WARNING: Do Not "Hot Plug" Pump
Hot plugging is making or breaking electrical connections while the pump is powered on. Doing this will void the pump warranty and will likely damage the pump.

4.2 System and Pump Environment Recommendations/Requirements

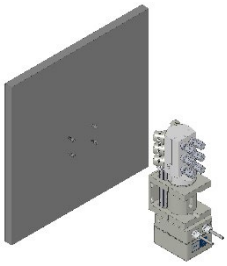
Clean Supply Air (CDA)
White Knight high purity pumps require the use of Class 2 air for particles and moisture per ISO 8573-1. (Use 10 micron filter, maintain -40° C dew point)
Abrasive Slurries
Pumping of abrasive slurries will shorten the life of any pump. White Knight high purity pumps are still warrantied when used in abrasive applications however; wear of components will be accelerated. Normal wear is not a condition covered by warranty.
Environmental Temperature
This pump is rated to withstand environmental temperatures up to 80°C.

4.3 Installation Advantages

High Discharge Pressure
The PEM050 is capable of discharging at pressures up to 55 psi, allowing the PEM050 to pump directly into pressurized vessels or lines.
Mounting Orientation
The PEM050 can be mounted in any orientation. For optimal air purge, resulting in highest accuracy, the pump should be mounted with liquid ports up (motor bottom configuration). When pumping slurries/abrasives the pump should be mounted with liquid ports on bottom (motor top configuration) to help increase the life of the diaphragm.

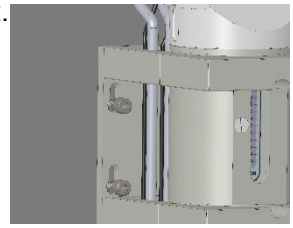
4.4 Installation Instructions

1



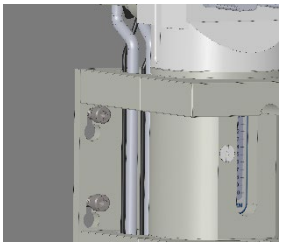
Drill and tap (4) holes to accept 4, ¼-20 set screws. Location of holes is critical, please see dimensional on page 4 of this manual.

2.



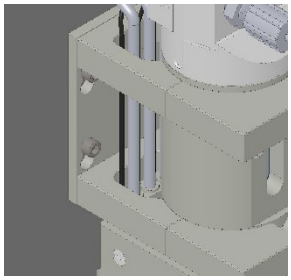
Thread screws partially into wall, leaving approximately ¼" of threads exposed. Align bracket holes with set screws and press against the wall.

3.



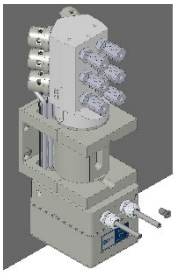
Ensure that the pump sits on all four (4) screws and is flush against the wall.

4.



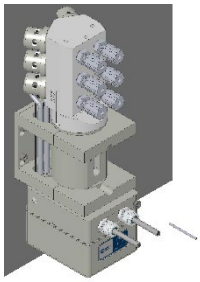
Tighten screws until slight pressure is applied to the mounting plate. CAUTION: OVER TORQUEING CAN CAUSE DAMAGE TO THE BRACKET AND/OR THE WALL THE PUMP IS MOUNTED TO!!

5.



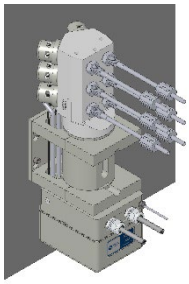
Attach the Quick connect fitting to the motor housing

6.



Attach airline to the quick connect. Air supply line must be ⅛" minimum orifice, unrestricted to source. Air supply must be at least 60 PSI, and not more than 80 PSI at point of use.

7.



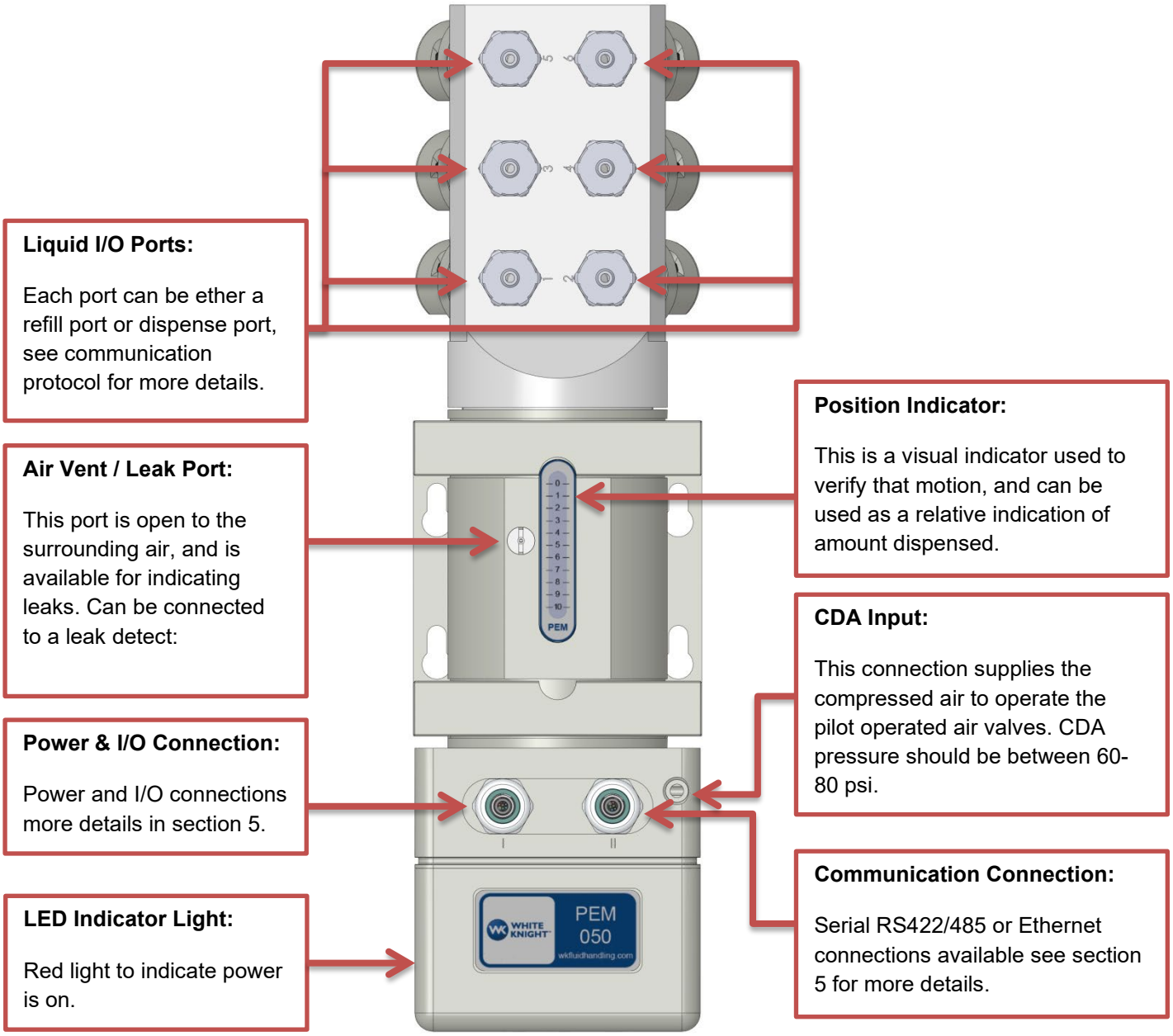
Attach Liquid Fittings per manufacturers' instructions.

Electrical Connections

Use of electronics does not qualify for pumps used in potentially explosive atmospheres. For instruction on the installation of the electrical connections and setup of this pump, please see section 5 of this manual.

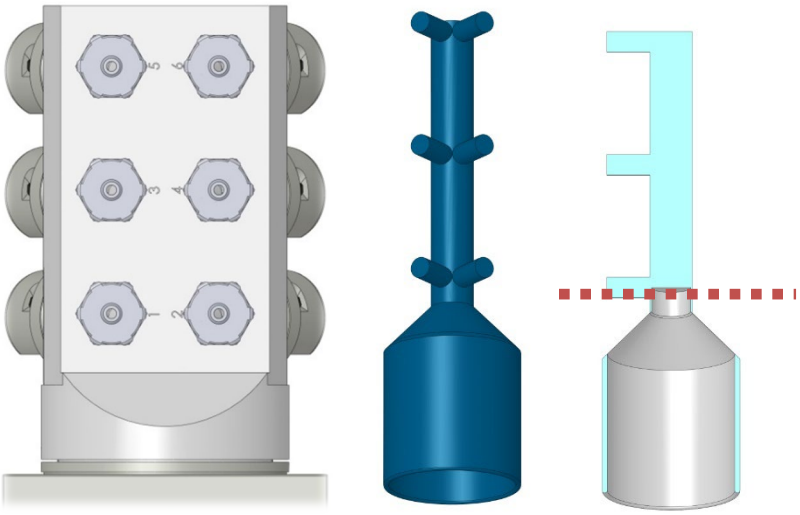
4.5 Connections

All connections to the PEM050 can be accessed from the front of the pump. The diagram below shows all of the connections for reference throughout the manual.



5 Hold Up Volume

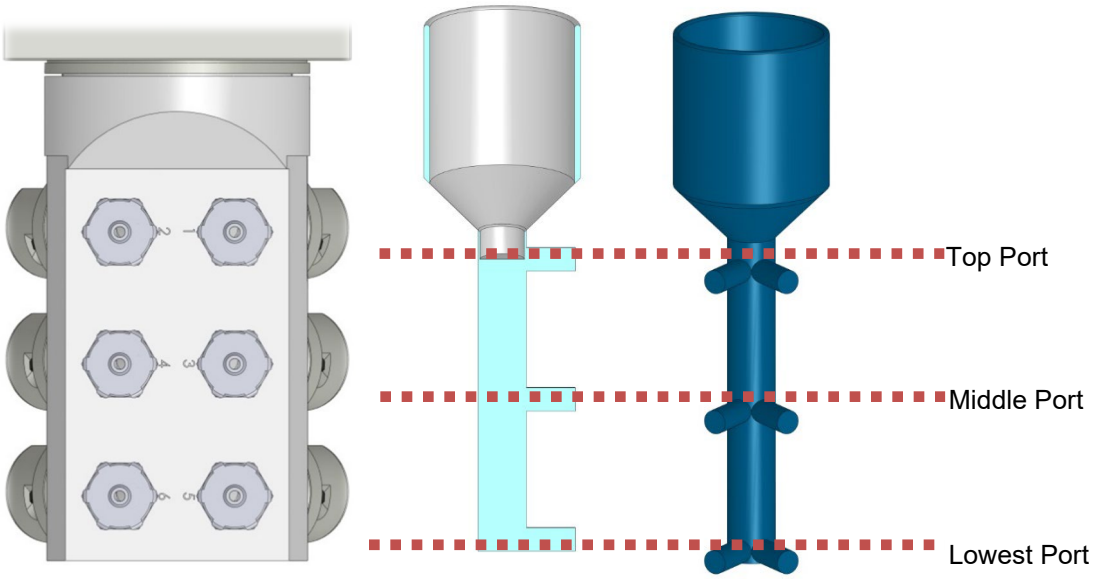
5.1 Motor on Bottom Orientation:



The above image shows: Left) PEM050 6 port head, Middle) a 3D rendering of the minimum internal pump volume, Right) a section view of the minimal internal pump volume (shown in blue). The minimal hold-up volume consists of the volume that is undrainable out of the lowest port of the pump, shown in blue below the dotted line.

Port Configuration	Minimum Pump Internal Volume [mL]	Minimal Hold-Up Volume [mL]
Port 2	9.42	8.60
Port 3	14.66	8.60
Port 4	15.07	8.60
Port 5	20.32	8.60
Port 6	20.73	8.60

5.2 Motor on Top Orientation:



The above image shows: Left) PEM050 6 port head, Right) a 3D rendering of the minimum internal pump volume, Middle) a section view of the minimal internal pump volume. In the table volume below the dotted line for each port level is noted assuming all fluid above the bottom of the fluid line will drain out.

Port Configuration	Minimum Pump Internal Volume below port level [mL]
Top Ports	11.31
Middle Ports	5.66
Bottom Ports	0

6 Electrical

6.1 Wire Connectors/Wire Leads

The PEM050 has two electrical outputs labeled with roman numerals I and II. These outputs are available in several configurations:

E1: Cable output with PVC Jacket to flying leads (before January 2020);
Cable output with ETFE Jacket to flying leads (after January 2020)
E2: Cable output encapsulated in PFA Tubing to flying leads
E3: Turck EuroFast* 5 pin receptacles mounted on the device without mating cables.
E4: Turck EuroFast* 5 pin receptacles mounted on the device with mating cables to flying leads

- Note: Turck EuroFast connectors are an M12 circular connector that are sealed to prevent liquid from entering into the motor enclosure, and are O-ring sealed to the motor enclosure.

6.1.1 Connector I: Power Connection Table

Connection Type	Cable Wire Color (Before January 2020)	Cable Wire Color (After January 2020)	Turck Connector Pin # - Cable Wire Color	Description
24 VDC	RED	Brown	1 - BROWN	The PEM050 requires a regulated DC power supply in the range of 18-24 VDC. This will power both the digital

Connection Type	Cable Wire Color (Before January 2020)	Cable Wire Color (After January 2020)	Turck Connector Pin # - Cable Wire Color	Description
				I/O used for the valves, and the stepper motor. Note: digital input signals should not exceed power supplied to pump.
Analog		White	2 - WHITE	Analog input; this analog input is not used with the standard protocol, but is available for use in custom programs.
Ground	BLACK	Blue	3 - BLUE	Connect to the common ground for both motor operation and digital I/O operation.
Digital I/O 1	GREEN	Gray	5 – GRAY	Digital input 1 can be configured to be an alarm or software reset signal using the standard protocol or can be used in custom programs. Digital 1 is available on all models.
Digital I/O 2	WHITE	Black	4 - BLACK	Digital input 2 can be configured to be an alarm or software reset signal using the standard protocol or can be used in custom programs. Digital 2 is available on 2 port – 5 port models. On 6 port model this port is connected to valve 6 and will not operate correctly if modified.

Note: Pin 2 was previously allocated as a high voltage in. This function has been removed as of Feb 28 2014. All pumps sold after this date will utilize the new pin function listed above.

6.1.2 Connector II: Communication Connection

Communications are performed using ASCII character commands. The communication protocol is available in the following configurations:

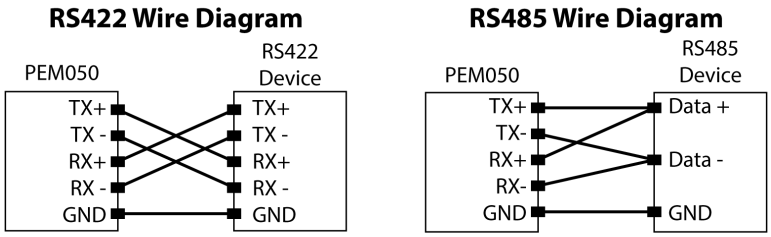
- Default - Serial RS422 (4 wire full duplex) with option to Configure in RS485 (two wire half duplex) communication.
- H1, H2 - Ethernet TCIP
- H3 - Serial RS232 communication.

6.1.3 RS422/RS485

RS422 Communication	Wire Cable Color (Before January 2020)	Wire Cable Color (After January 2020)	Turk Connector Pin #	RS485 Communication*
RX+	White with blue line	White	2 - WHITE	Data + (Connect RX+ and TX+ together)
TX+	White with orange line	Blue	3 - BLUE	
RX-	Blue with white line	Brown	1 - BROWN	

RS422 Communication	Wire Cable Color (Before January 2020)	Wire Cable Color (After January 2020)	Turk Connector Pin #	RS485 Communication*
TX-	Orange with white line	Black	4 - BLACK	Data - (Connect RX- and TX- together)
Ground		Gray	5 - GRAY	Ground

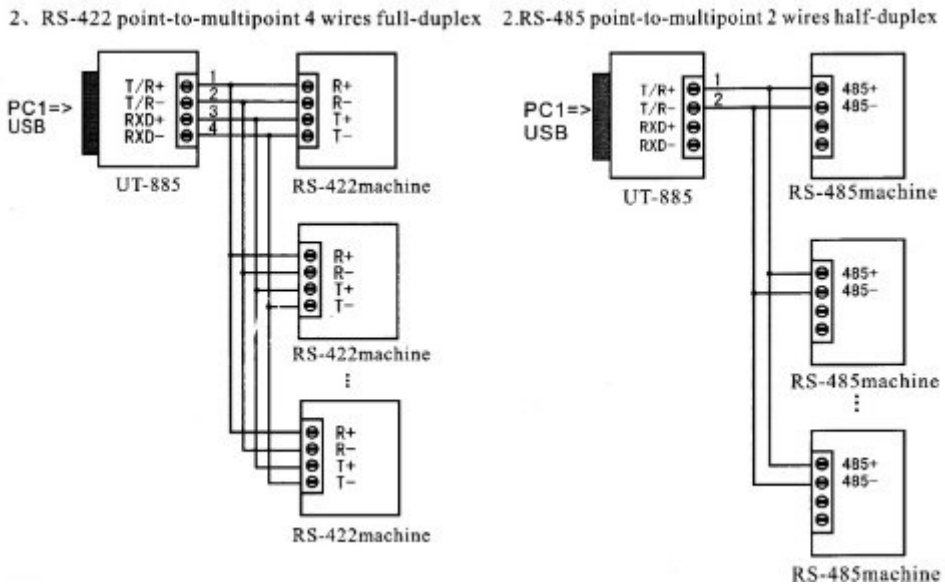
* RS485 communication must first be configured using RS422 communication. Required settings included enabling party mode and setting echo mode 1. See communication protocol for more information.



Ground connection is optional and not required for communication

6.1.3.1 Connecting to Multiple Devices Using Party Mode and RS422/RS485

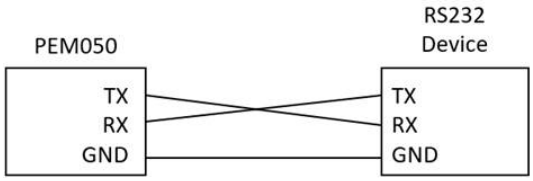
In some cases, an application might require using one serial port to communicate to multiple devices. A PEM050 can be put into party mode, which allows the serial communication line to be split to talk to multiple devices over a single serial port. To connect multiple devices each device is connected as if it was a single device where transmit +/- on the computer/PLC is connected to the receive +/- on the PEM050 and the receive +/- on the computer/PLC connects to the transmit +/- on the PEM050. (make sure to match + to + and – to -)



6.1.4 RS232

Pin	RS232 Out	Description	Wire Color
1	TX	RS232 Transmit Signal	Brown
2	RX	RS232 Receive Signal	White
3			Blue
4			Black
5	Ground	RS232 Ground Signal	Gray

RS232 Wiring Diagram



6.1.5 Ethernet over TCIP

The PEM050 is a device that communicates using a serial communication protocol. The Ethernet communication is achieved by adding a serial to Ethernet converter inside the PEM050. As a result, Ethernet functionality is limited to connecting to only one device at a time. The Ethernet connection is available in both Turck connection and cable out with twisted pairs. The connection table below shows connection information for both connection options.

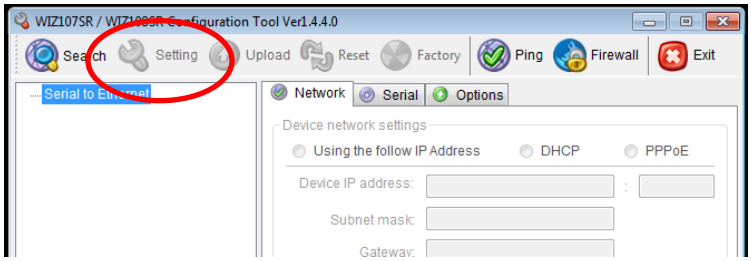
PEM050 Connection	Turck Connector Pin # - Cable Color	Cable Wire Color (Before January 2020)	Cable Wire Color (After January 2020)	Ethernet Connector Pin Position
TX+	1 - Brown	White with Blue line	Brown	1
TX-	2 - White	Blue with White line	White	2
RX+	3 - Blue	White with orange line	Blue	3
RX-	4 - Black	Orange with white line	Black	6

6.1.5.1 Configuring Ethernet Converter:

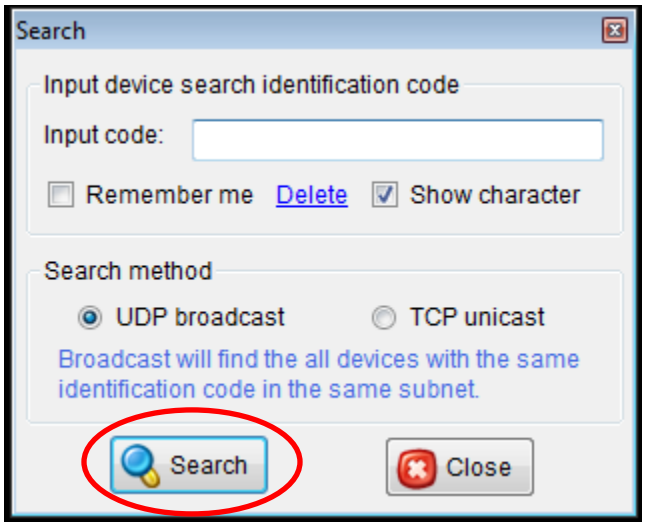
To configure the Ethernet converter, it is recommended to connect the PEM050 on the same network switch as the computer. The Ethernet converter setup software is found in the Ethernet Setup tab on the PEM050 Interface or as a standalone Ethernet Configuration Tool; both software packages can be obtained by contacting White Knight customer service by email: customer.support@wkfluidhandling.com.

Below is shown the steps for configuring the Ethernet Converter using the configuration tool.

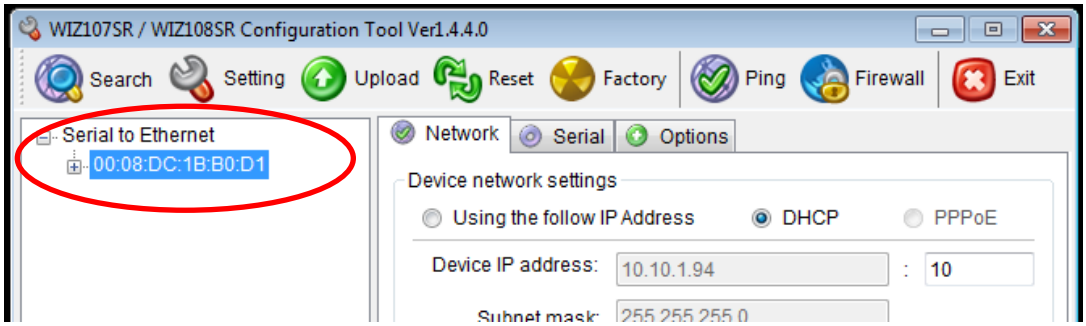
STEP 1) Open Configuration tool in either PEM050 interface or in standalone Ethernet configuration tool.
STEP 2) Verify that your computer and the PEM050 are both connected into the same Ethernet switch. Then click on the search button at the top of the window.



STEP 3) The search window will open up as shown below. Click on the search button at bottom of search window.



STEP 4) The search window will close and when the search is completed a list of available devices will be listed on the main window on the left. Each PEM050 will have a unique MAC address, The MAC address has been attached to the PEM050 with a tag.



STEP 5) Select the MAC address for the device to be configured and use the Network tab to configure the Ethernet converter as desired.

STEP 6) Use the Serial tab to modify the serial communication settings if necessary. The serial communication should be setup as follows:

A) Enable Debug Message: Unchecked.
B) Baud Rate: 9600
C) Parity: None
D) Stop Bits: 1
E) Flow Control: None

STEP 7) Press Save Settings button to set the settings on the Ethernet Converter.

STEP 8) Ethernet configuration is complete; now test communications to verify functionality.

7 Software Interface

White Knight offers a user interface to enable an easy startup with the PEM050 pump. This software should have arrived with the pump. If a new copy of the software is required, contact White Knight Customer Support for a new copy of the current software version. customer.support@wkfluidhandling.com.

8 Standard Communication Protocol

The PEM050 is a stepper motor driven metering pump that is able to dispense volumes from 1 milliliter up to 50 milliliters. The PEM050 uses a standard RS-422 full duplex serial communication, which can be configured as a RS-485 half duplex serial communication port or can be ordered with an Ethernet converter to adapt into Ethernet networks.

8.1 Communication Syntax & Communication Modes:

The PEM050 can be programed using any standard ANSI terminal emulator. The PEM050 understands communication as ASCII strings, with control characters. Below is a table of control characters used by the PEM050. Appendix 1 contains a full table of ASCII characters with their integer and hex values.

ASCII Character	Integer Value	Hex Value	Abbreviation	Terminal Entry Command
Acknowledgment	6	06	ACK	
Line Feed	10	0A	Lf	Ctrl + J
Carriage Return	13	0D	Cr	Ctrl + M
Negative Acknowledgement	21	15	NAK	
End of Text	3	03	EOT	Ctrl + C

Command Termination: To end a command a termination character needs to be sent to the PEM050. The command termination character is dependent on the party and checksum modes. See table below. By default, nether checksum or party modes are enabled, for more information see the party mode and checksum mode sections of this manual.

Termination Character / Hex Value

		Check Sum Mode	
		CK=0	***CK=1***
Party Mode	***PY=0***	Carriage Return / 0D (Default)	Line Feed / 0A
	PY=1	Line Feed / 0A	Line Feed / 0A

Changing the Value of a Variable: Enter the variable followed by an equal sign with the new value for that variable. Example “DP=1” ending with the termination character.

Requesting Variable Value: Enter “PR” followed by a space with the variable. Then the PEM050 will respond with the value of the variable. Example “PR DP” followed by the termination character.

The protocol works by changing variable values, and the program will react according to the new value assigned to the variable. All variables consist of one or two alphanumeric characters. **Variables can only be assigned integer values, do not send any decimal or floating-point values; the onboard processor does not understand decimals.**

Baud Rate: The device baud rate can be changed using the BD variable. After the baud rate is changed then the device will start responding to the new baud rate, and the parameters should be saved.

Mode Setting	Baud Rate	Notes
BD=48	4800	
BD=96	9600	(default)
BD=19	19200	
BD=38	38400	
BD=11	115200	Not recommended for party mode

- Note: when configuring the serial settings use the following settings along with the configured baud rate: Data bits: 8, Parity: None, Stop Bits: 1, Flow Control: None.

8.1.1 Communication Modes:

By default, the PEM050 will echo back each character as each character is received. This is helpful when using a terminal to interact with a single PEM050. However, when connecting to a PLC or if connecting multiple devices in series then it may be desired to enable one or all of the following communication modes:

Echo Mode: Echo mode controls how the PEM050 responds when communications are received. The echo mode is set using the EM variable.

Mode Setting	Mode Description
EM=0	All information is echoed back as it is received; both a carriage return & a line feed are returned when a command accepted. (Full Duplex) (Default) Note: In this operation mode the communication will also send a command prompt “>” after any response when there are no errors, and when there is an error the device will respond with a question mark “?”.
EM=1	Print command (PR) returns the requested information; both a carriage return & a line feed are returned when a command accepted. (Half Duplex) (Required for RS485 communication)
EM=2	Print (PR) only; device will only respond to print commands. Both a carriage return & a line feed are returned at the end of a print response. Otherwise no command acceptance characters are transmitted.
EM=3	PEM050 stores commands as they are received, then echoes the command back when the command has been accepted.

Party Mode: Party mode enables the multiple PEM050’s to be connected together. The party mode is enabled using the PY variable. Each PEM050 can be assigned a unique device name (DN). By default, the device name is configured to an exclamation point (!). The device name can be set by assigning the DN variable the new device name in parenthesis. Example: setting the device name to the letter A. Command: DN=”A” then end with the command termination character. Note: the value for DN can be changed any time, and can only be set to a single alpha numeric character.

Mode Settings	Mode Description
PY=0	Single unit mode. Use this command to take the device out of party mode. Note: if the device is currently in party mode, then the command will need to start with the device address. (Default)
PY=1	Turn on party mode. After telling the device to turn on party mode, then a line feed character needs to be sent to enable party mode. Once party mode is enabled then each device will only respond to commands that start with the correct device name.

Example 1: Use PR command to tell the PEM050 to print a message “Hello” out to the serial line.

- Command: APR “Hello”
- Response: Hello
- Description: The starting letter A is the device name, PR represents the print command, and to request a string to be sent out the letters of the message need to be enclosed by quotation marks. The whole message should be end with a line feed (hex value 0A). The response sends only the text enclosed in the quotation marks, followed by both a carriage return & line feed.

Example 2: Use PR command to request the value of dispense port DP.

- Command: APR DP
- Response: 1
- Description: the starting letter of the command is the device name A, the PR letters represent the print command, followed by the variable that is being requested DP. The command is terminated using a carriage return or line feed. The response is the value assigned to the variable DP sent as an ASCII character. The response is terminated by both a carriage return & line feed.

Note: If a command is to be sent to all devices the asterisk “*” is a special device address that all PEM050 will respond to independent of their unique device name. When the asterisk is used none of the PEM050s in the network will echo the command to prevent communication issues.

Check Sum Mode: Check sum mode is used to validate that communication is sent correctly across the serial line. When check sum mode is enabled all communications require an additional character at the end of the command that represents the checksum value of the command string. If the PEM050 has been placed in party mode, the command string includes the device name character at the start.

Mode Settings	Mode Description
CK=0	Disable check sum mode. This command is used to get out of checksum mode. If the device is currently in checksum mode, then the command would need to be followed by the check sum character. (Default)
CK=1	Enable check sum mode. All commands must end with a checksum character before the line feed. PEM050 will respond with an acknowledge character (ASCII hex value 06) for received commands where the checksum matches; for commands that the check sum does not match a not acknowledge character (ASCII hex value 15) will be returned and the command ignored. All printed responses from the PEM050 will contain a checksum character at the end of the response.

The checksum character is calculated in binary as follows:

- Add up the decimal value for each ASCII character in the command to be sent to the PEM050. See ASCII table in appendix 1.
- Convert to an 8-bit binary number, discarding all bits larger than the 8 bits.
- Take the one’s complement by inverting the binary
- Take the two’s complement by adding 1.
- Set the 8th bit as true,
- Result: the ASCII character that has the same numeric result as the calculation above is the check sum character. This character can be typed by holding the alt key and type the number using the keypad.

Example Check Sum Character Calculation:

- Example Command “DI=1”
- Get ASCII Values “D” = 68, ”I” = 73 ,”=” = 61 , “1” = 49
- Sum ASCII Values 68+73+61+49 = 251
- Convert Sum value to binary 251 -> 11111011
- Take one’s complement by inverting binary 11111011 -> 00000100
- Take two’s complement by adding 1: 00000100 + 00000001 = 00000101
- Set the 8th bit as true: 00000101 -> 10000101
- Convert back into decimal value 10000101 -> 0133
- Type ASCII character for the value 0133 -> …
    - Note: Fonts may represent ASCII characters differently. To type a ASCII character using the numeric value, hold the Alt key and type the four number numeric value (as shown above with a 0 in front) using the number pad, then let go of the Alt key. The ASCII character should then appear on your screen.
- The command with the checksum character included “DI=1…”

Working with Multiple Communication Modes Enabled: Since there is some interaction between the different modes, this section is intended to help clarify how commands will be sent and received between all communication modes. In the table below all 16 combinations of transmission and responses to one simple command PR “Hello” are shown. The items shown in brackets represent the following ASCII characters: [Cr] = carriage return, [Lf] = line feed, [ACK] = Acknowledge, [NAK] = Not Acknowledge, and [CK:#] = Checksum with the # representing the Hex value for the checksum character. The device name is assumed to be “A”.

		Echo Mode			
Party Mode	**Check -Sum Mode**	**EM=0**	**EM=1**	**EM=2**	**EM=3**
Off	**Off**	**Transmission:** PR "Hello"[Cr] **Response:** PR "Hello"[Cr][Lf] Hello[Cr][Lf]	**Transmission:** PR "Hello"[Cr] **Response:** [Cr][Lf] Hello[Cr][Lf]	**Transmission:** PR "Hello"[Cr] **Response:** Hello[Cr][Lf]	**Transmission:** PR "Hello"[Cr] **Response:** PR "Hello"[Cr][Lf] Hello[Cr][Lf]
On	**Off**	**Transmission:** APR "Hello"[Lf] **Response:** APR "Hello"[Cr][Lf] Hello[Cr][Lf]	**Transmission:** APR "Hello"[Lf] **Response:** [Cr][Lf] Hello[Cr][Lf]	**Transmission:** APR "Hello"[Lf] **Response:** Hello[Cr][Lf]	**Transmission:** APR "Hello"[Lf] **Response:** APR "Hello"[Cr][Lf] Hello[Cr][Lf]
Off	**On**	**Transmission:** PR "Hello"[CK:86][Lf] **Response:** PR "Hello"[CK:86][ACK] Hello[CK:8C][Cr][Lf]	**Transmission:** PR "Hello"[CK:86][Lf] **Response:** [ACK] Hello[CK:8C][Cr][Lf]	**Transmission:** PR "Hello"[CK:86][Lf] **Response:** Hello[CK:8C][Cr][Lf]	**Transmission:** PR "Hello"[CK:86][Lf] **Response:** PR "Hello"[CK:86][ACK] Hello[CK:8C][Cr][Lf]
On	**On**	**Transmission:** APR "Hello"[CK:C5][Lf] **Response:** APR "Hello"[CK:C5][ACK] Hello[CK:8C][Cr][Lf]	**Transmission:** APR "Hello"[CK:C5][Lf] **Response:** [ACK] Hello[CK:8C][Cr][Lf]	**Transmission:** APR "Hello"[CK:C5][Lf] **Response:** Hello[CK:8C][Cr][Lf]	**Transmission:** APR "Hello"[CK:C5][Lf] **Response:** APR "Hello"[CK:C5][ACK] Hello[CK:8C][Cr][Lf]

8.1.2 Saving Communication Settings:

When any of the communication settings are changed the settings need to be saved, otherwise all changes will return to the previously saved settings during a power cycle. To save the settings, send the "SI=1" command to the pump when no actions are occurring.

8.1.3 *Software Reset:*

In some cases, a user may want to perform software reset on the PEM050. A software reset will respond the same as a power cycle; however, frequently a software reset is easier to perform than a power cycle, and reduces the chance of damaging the PEM050 due to power surges from a power cycle. There are 3 methods available to perform a software reset: 1) Send the command "EX 1" and end with the command termination character. 2) Send the ASCII character for "End of Text" (hex value 03). 3) Setup and use a digital input (see configure digital I/O section). After the software reset the PEM050 will perform a calibration before it is ready for use.

8.1.4 Configure Digital Signals:

The PEM050 has two digital I/O ports available for 2 – 5 port versions, and one digital I/O port available for the 6-port version. The available digital ports can be configured to operate as:

- **Reset Input:** When the correct input signal is sent to a digital port configured as a reset, then this will tell the PEM050 to restart similar to a power cycle.
- **General Output**: This is the default configuration, and will not be used in normal operation.
- **Motor in Motion Output Flag:** When the digital port is configured as a motor in motion flag, then this port will turn active whenever the motor starts moving, and will deactivate when the motor stops moving.
- **Error Flag Output:** When the digital port is configured as an error output flag, then this port will turn active whenever the ER variable turns to a non-zero value, see appendix 2 for a full list of all potential errors. The signal will deactivate when the ER variable is set to zero, the errors are cleared using the XI command, or when the ER variable is read "PR ER" (Note: reading the ER variable does not zero out the ER variable but will only stop the alarm.)
- **Motor Stall Output:** When the digital port is configured as a motor stall output, then the output will turn active whenever the motor stalls. The flag would deactivate when the motor stall flag is cleared. To clear this flag, send the clear all errors command XI, or set the ST variable to zero.

To set the digital port in the desired mode you will need to send the configuration command, and save the configuration change. To send the configuration command use the table below by sending a single command starting with the value from Input 1 column followed by an equal sign, then enter input 2 through 4 separated by commas. See examples following the table to see the syntax. **Note: S11 should not be changed on the 6 port model because S11 is being used to operate the 6th valve.**

Input 1: **Digital Port**	**Input 2:** **Signal Type**	**Input 3:** **Active State**	**Input 4:** **Connection type**
S12: Digital Port 1 * Wire Leads: Green wire * Turck Connector: Pin 5 (Gray Wire)	11: Software Reset Input 16: General Output * Default	0: Active Low	0: Sinking
S11: Digital Port 2 * Wire Leads: White wire * Turck Connector: Pin 4 (black wire) * Do not change in 6 port	17: Motor Moving Output 18: Error Output 19: Motor Stall Output	1: Active High	1: Sourcing

Examples of digital port configurations (Text after apostrophe are comments and not part of code):

```
S12=11,0,0 'Digital port 1 configured as reset input/ active low/ sink
S12=11,1,0 'Digital port 1 configured as reset input/ active high/ sink
S11=11,0,1 'Digital port 2 configured as reset input/ active low/ Source
S11=16,0,0 'Digital port 2 configured as general input/ active low/ sink
```

8.2 Setting Up RS485 Communication

Where needed, RS485 two wire communication is able to be configured. To set up the new communication protocol it is required that the device be connected using RS422. Use any serial terminal program such as Hyper Terminal; the WK PEM interface is not currently setup for RS485 communication.

Steps for setting up RS485 communication:

1) Connect PEM050 using RS422 to a terminal interface.
2) Send a test command to verify communication. For example:
   (note: <CR> is a carriage return, and <LF> are line feed characters)
   PR “Hello”<CR>
   It should respond with:
   PR “Hello”<CR><LF>
   Hello<CR><LF>
   >
3) Now set echo mode equal to 1
   EM=1<CR>
   From this point, it will stop echoing back the text you sent it and stop sending the carrot or question mark.
4) Set the device name you would like to use. For this example, I set it to an exclamation point.
   (note: the default device name is an exclamation point.)
   DN=”!”<CR>
5) Send the party mode equal to 1 command
   PY=1<CR>
6) Now for party mode to get enabled you will need to send a line feed character in a separate command.
   <LF>
7) Now party mode should be enabled. Check that party mode is functioning. Send command
   PR “Hello”<LF>
   The device should not respond to this command or any variation of it that doesn’t start with an exclamation point. Or any commands terminating with a carriage return.
8) Now try to get a command that will work. Send command
   !PR “Hello”<LF>
   This should respond with
   Hello<CR><LF>
   If it didn’t respond, try again, and if it still doesn’t work, check that the correct device name is being used. If you are unsure what device name is being used, you can use an asterisk “*” the wildcard device name and ask what device name is currently in use. To do that send “*PR DN”
9) Now that party and echo modes are correctly set, save the settings. Send the force save command
   !S<LF>
10) Now the setup is complete; connect via RS485 connection. (Unfortunately, it is impossible to setup the device to communicate in RS485 mode while connected with an RS485 system)
11) Now test your RS485 connection
12) Send a test command
    !PR “Hello”<LF>
    The device should respond
    Hello<CR><LF>
13) Configuration is complete; contact support@wkfluidhandling.com if you encounter further issues.

8.3 Operating the PEM050

The PEM050 is configured to execute predefined actions; the actions will act according to the parameters currently set on the PEM050. Each action can be called using the action initiation command. Below is a brief overview of each action, for more details about each action, go to the action section:

8.3.1 Pumping Actions:

1. **Hard Stop Calibration -** The calibration action is a hard stop calibration that enables the pump to detect its position relative to the bottomed-out position. The pump will automatically preform a calibration when powered on. At the end of the calibration routine, the pump will pull back to the suck back position. The calibration should not be called while another action is in progress. Use the "ZI=1" command to start the calibration action.
2. **Dispense-** The dispense action will dispense the number of steps sent to the DT variable. When the dispense is completed the motor will perform a fluid suck back the number of steps specified by the SB variable. Use the "DI=1" command to start the dispense. Note: at the end of a dispense the DT variable will return to a value of zero, and must be specified before the next dispense can take place.
3. **Refill-** The refill action will fill the pump with the number of steps specified by the RA variable. As part of the refill action the pump will over fill the by the vent amount VT plus the pressure compensation amount CI. Then the pump will vent and compensate for pressure; when the action is complete the remaining number of steps will be as specified by RA. Use the "RI=1" command to start the refill action.
4. **Suck Back Only –** In normal usage sending a suck back only command is unnecessary because the dispense action includes the suck back. However, some scenarios require the ability to perform a suck back only action. Use "SO=1" command to start a suck back only action.
5. **Empty Pump -** The empty pump action forces the pump to go to the hard stop position, then stops and does not return to the suck back position. This is useful for purging the pump. Use "EI=1" command to start the empty pump action.
6. **Open Valve –** When no action is being performed then any valve can be opened by setting the PO variable to the valve number to be opened. If PO is set to zero, then all valves will close.
7. **Clear Errors** – This action will reset all flags, errors, and indicators back to a zero state. Use "EI=1" to start the clear errors action.
8. **Save** – This action saves the current values for all variables in the pump. The pump will also save its variable every 50 refills. Use the SI=1 command to start the save action.
9. **Quit Current Action** – The quit action will cause any program that is currently in action to stop and back out, if the motor is moving then the program will exit the action once the motor stops. Use the "QT=1" command to issue the quit command.

8.3.2 Steps to Volume Conversion:

When interacting with the PEM050 the values for: amounts are in steps, velocities are in steps per second, and accelerations are in steps per second squared. Thus, it becomes relevant to know how to convert from steps to volume. The conversion ratio is 40500 steps = 50 mL, which is approximately 1.23 microliters per step.
Reminder; all values sent to the PEM050 need to be truncated, and cannot have decimal places.

8.3.3 High Repeatability vs. Long Diaphragm Life:

When operating the PEM050 there are two main methods of operating the pump. One method will help get a better life out of the diaphragm before any maintenance is needed, the other will achieve more repeatable results. In this section, both methods will be discussed.

Optimizing for Higher Repeatability: Follow the recommendations below to obtain the most repeatable results: (Note: operating in this manner may reduce the life of the rolling diaphragm.)

- Set the refill amount and the dispense amount to the same value if dispense amount is less than or equal to maximum capacity of the PEM050. If greater than full capacity then set the dispense to full capacity, and let the PEM050 dispense full shots.
- Refill the pump immediately before dispensing.
- Use the vent option by setting a vent amount greater than 20 steps (max 1000 steps) and vent to waste. This will help remove any air bubbles that form.
- Have the PEM050 dispense the same amount every time.
- Discard the first dispense if PEM050 has sat idle for a long time, or when changing dispense amounts. Discarded dispenses can be discarded out the vent port. Exercising the diaphragm in this manner help obtain better repeatability.

Optimizing for Long Diaphragm Life: Follow the recommendations below:

- Set the refill amount to the full scale.
- Refill the PEM050 only when needed, or let the PEM050 auto refill when it is needed.

8.4 Actions:

Each action will have several parameters or settings associated with it for example speed, amount, and port number. Each action will also have an initiation command which is used to start the action. All of the actions are described in the following sections.

8.4.1 Dispense Action:

The dispense action has two parts the fluid dispense and the suck back. The fluid dispense will push a desired amount of fluid out of the designated port, at the end of the dispense the metering pump is set to suck back a specified amount of fluid back to prevent uncontrolled drips out of the point of use.

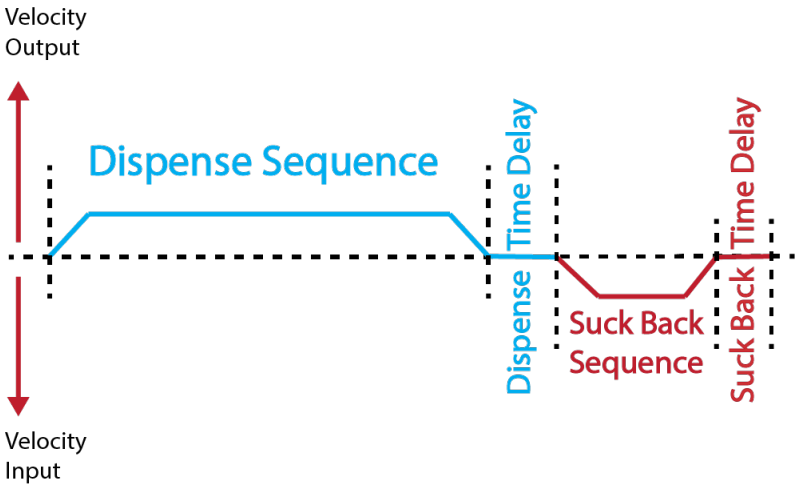


Figure 1: Graphical representation of the dispense action. The refill action consists of two parts:

Dispense Sequence [Blue]:
1) Open the dispense port (if not already open),
2) Dispense specified amount
3) Pause for fluid to settle.

Suck back sequence [Red]:
1) Suck back set amount of fluid,
2) Pause for fluid to settle.
* The dispense port stays open

8.4.1.2 Fluid Dispense Commands:

To start a dispense, both “Dispense Amount” and “Dispense Initiation” commands must be sent to the pump.

	Description	Example	Notes
DI	Dispense Initiation: 0 = No dispense action to be performed 1 = Dispense action to be completed when ready	Set: *DI=1* Request: *PR DI*	Default Value = 0 A dispense amount needs to be defined before each dispense.
DT	Dispense Amount: 0 = No dispense volume defined >0 = Dispense volume defined 48000= Max single dispense volume	Set: *DT=1000* Request: *PR DT*	Default Value = 0 The dispense amount will return to zero at the completion of each dispense.
DP	Dispense Port: Value must be greater than zero and less than or equal to the number of liquid ports on the metering pump	Set: *DP=2* Request: *PR DP*	Default Value = 2 A valid port needs to be defined before the dispense will take place.
DD	Dispense Time Delay: Time delay after the dispense is in milliseconds, and must be zero or a positive integer.	Set: *DD=100* Request: *PR DD*	Default Value = 200 The time delay is helpful if working with viscous fluid that may need some time to settle in order to get accurate repeatability.
DV	Dispense Velocity: This defines the max speed that the motor will dispense the fluid. Defined as steps per second. Value must be positive integer. The max recommended velocity is 15000 steps per second.	Set: *DV=10000* Request: *PR DV*	Default Value = 4879 Motor will accelerate up to the max speed, and will continue at the max speed until the motor needs to decelerate.

8.4.1.3 Suck Back Parameters:

The suck back operation will automatically occur at the end of the dispense action. If this action is not desired, then the "Suck Back Amount” should be set to zero.

	Description	Example	Notes
SB	Suck Back Amount: 0 = No suck back volume defined >0 = Suck back volume defined	Set: *SB=500* Request: *PR SB*	Default Value = 813 Suck back amount should be kept small (less than 1000 steps) to allow for maximum pumping action.
SD	Suck Back Time Delay: Time delay after the suck back routine value is in milliseconds, and must be zero or a positive integer.	Set: *SD=100* Request: *PR SD*	Default Value = 200 The time delay is helpful if working with viscous fluid that may need some time to settle in order to get accurate repeatability.
SV	Suck Back Velocity: This defines the max speed that the motor will suck back on the fluid. Defined as steps per second. Value must be positive integer. The max recommended velocity is 15000 steps per second.	Set: *SV=10000* Request: *PR SV*	Default Value = 813 Motor will accelerate up to the max speed, and will continue at the max speed until the motor needs to decelerate.

8.4.3 Refill Action:

The refill action has three parts; fluid refill, air vent, and pressure compensation. The fluid refill will bring in the desired amount of fluid in to the pump. At the end of the fluid refill the metering pump is set to do an air vent purge. After the air vent then the pump is able to be programmed to move a few steps to increase or decrease internal pressure to match the discharge pressure requirements.

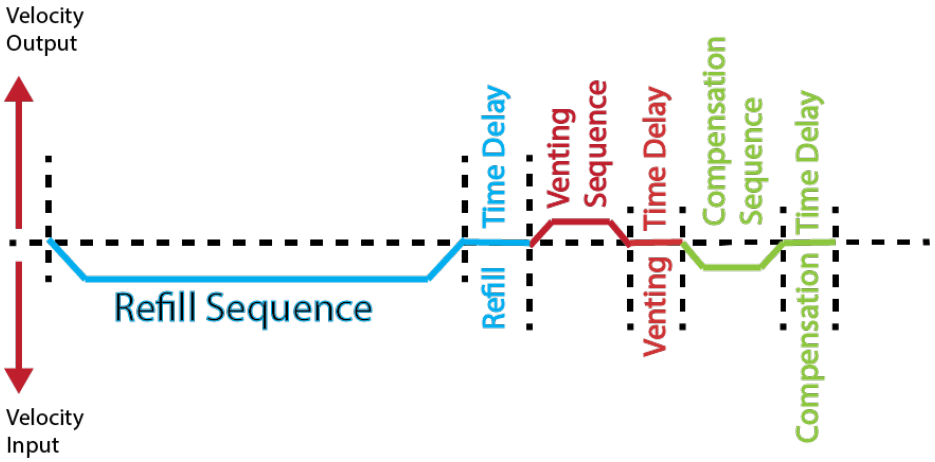


Figure 2: Graphical representation of the refill action. The refill action consists of three parts:

Refill Sequence [Blue]:
1) Open the input valve,
2) Refilling the pump will fluid,
3) Pause for fluid to settle,
4) Close input Valve.

Venting Sequence [Red]:
1) Open vent port,
2) Vent small amount of fluid.
3) Pause for fluid to settle,
4) Close Vent port.

Compensation Sequence [Green]:
1) Step the motor a few steps to release or increase pressure.
2) Pause for fluid to settle.

8.4.3.1 Fluid Refill Commands and settings

	Description	Example	Notes
RI	Refill Initiation: 0 = No Refill action to be preformed 1 = Refill action to be completed when ready	Set: *RI=1* Request: *PR RI*	Default Value = 0
RA	Refill Amount: 0 = No refill volume defined >0 = refill volume defined 48000= Max refill volume	Set: *RA=41000* Request: *PR RA*	Default Value = 40650 The refill volume is the volume of fluid that will remain in the pump after venting and compensation.
RP	Refill Port: Value must be greater than1 and less than or equal to the number of liquid ports on the metering pump.	Set: *RP=1* Request: *PR RP*	Default Value = 1 A valid port needs to be defined before the refill will take place.
RD	Refill Time Delay: Time delay after the refill is in milliseconds, and must be zero or a positive integer.	Set: *RD=1* Request: *PR RD*	Default Value = 200 The time delay is helpful if working with viscous fluid that may need some time to settle in order to get accurate repeatability.
RV	Refill Velocity: This defines the max speed that the motor will refill the fluid. Defined as steps per second. Value must be positive integer. The max recommended velocity is 15000 steps per second.	Set: *RV=1* Request: *PR RV*	Default Value = 4878 Motor will accelerate up to the max speed, and will continue at the max speed until the motor needs to decelerate.