187 E. 670 S., Kamas, UT 84036
435.783.6040 888.796.2476
https://wkfluidhandling.com

PEM050 Owner's Manual

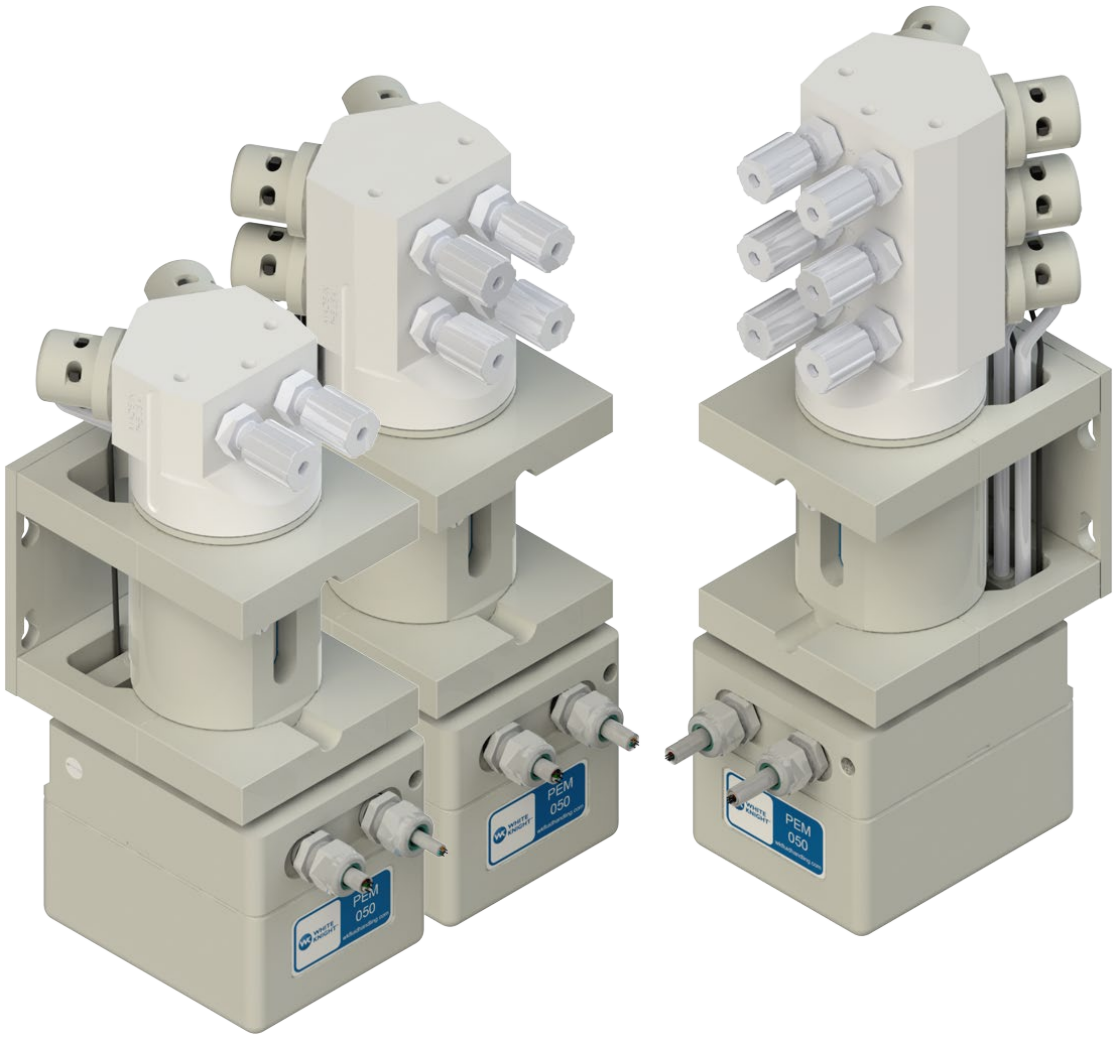


Table of Contents

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

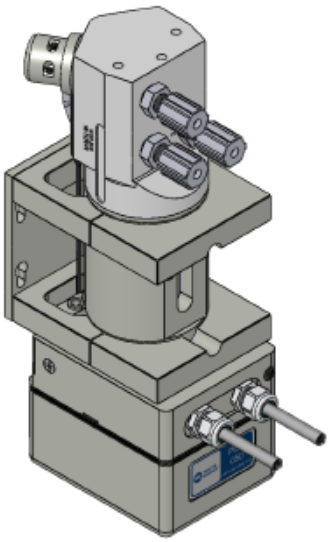
PEM050 Pump Specifications							
Dispense Range per Stroke[1]	Max Discharge Pressure[2]	Repeatability (Full Scale)[3]	Max Cycles Per Minute[4]	Air Consumption SCFM[5]	Fluid Path Materials	Fluid Temperature range	Suction Lift[6]
50 ml Max 1 ml Min	55 psi	+/- 0.1%	Up To 6	1-3 SCFM	PTFE	0-100°C 32-212°F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

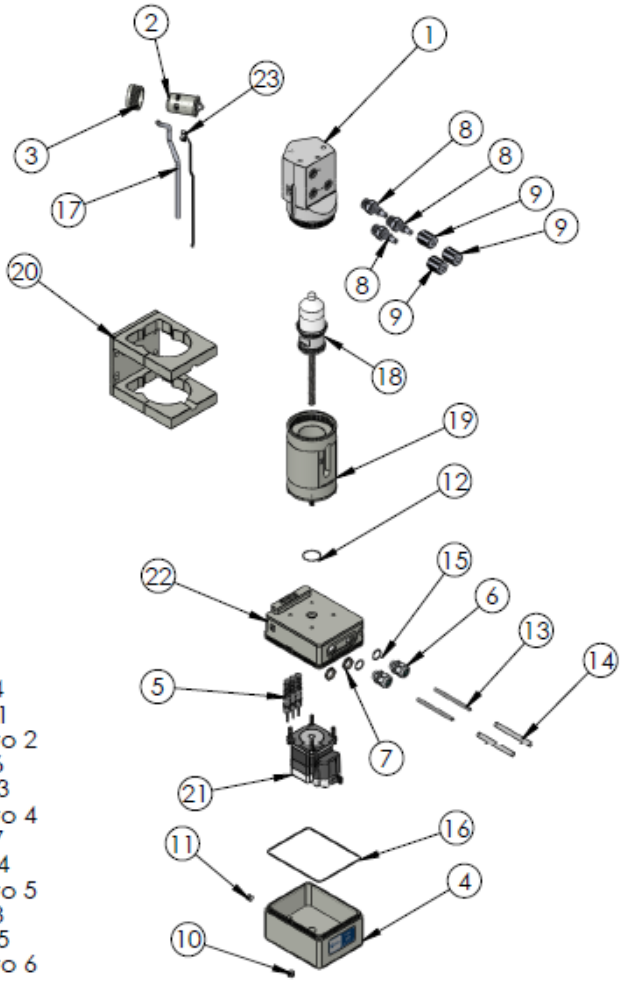
Supply Air Pressure	**Fluid Valves**	**Valve Manifold**	**Communication Protocol**	**Pump Mechanism**
60-80 psi	Pneumatic Pilot valves	2-6 Valves	ASCII commands over: * RS422 * RS485 (Configurable) * Ethernet	Stepper Motor connected to a rolling Diaphragm piston.

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



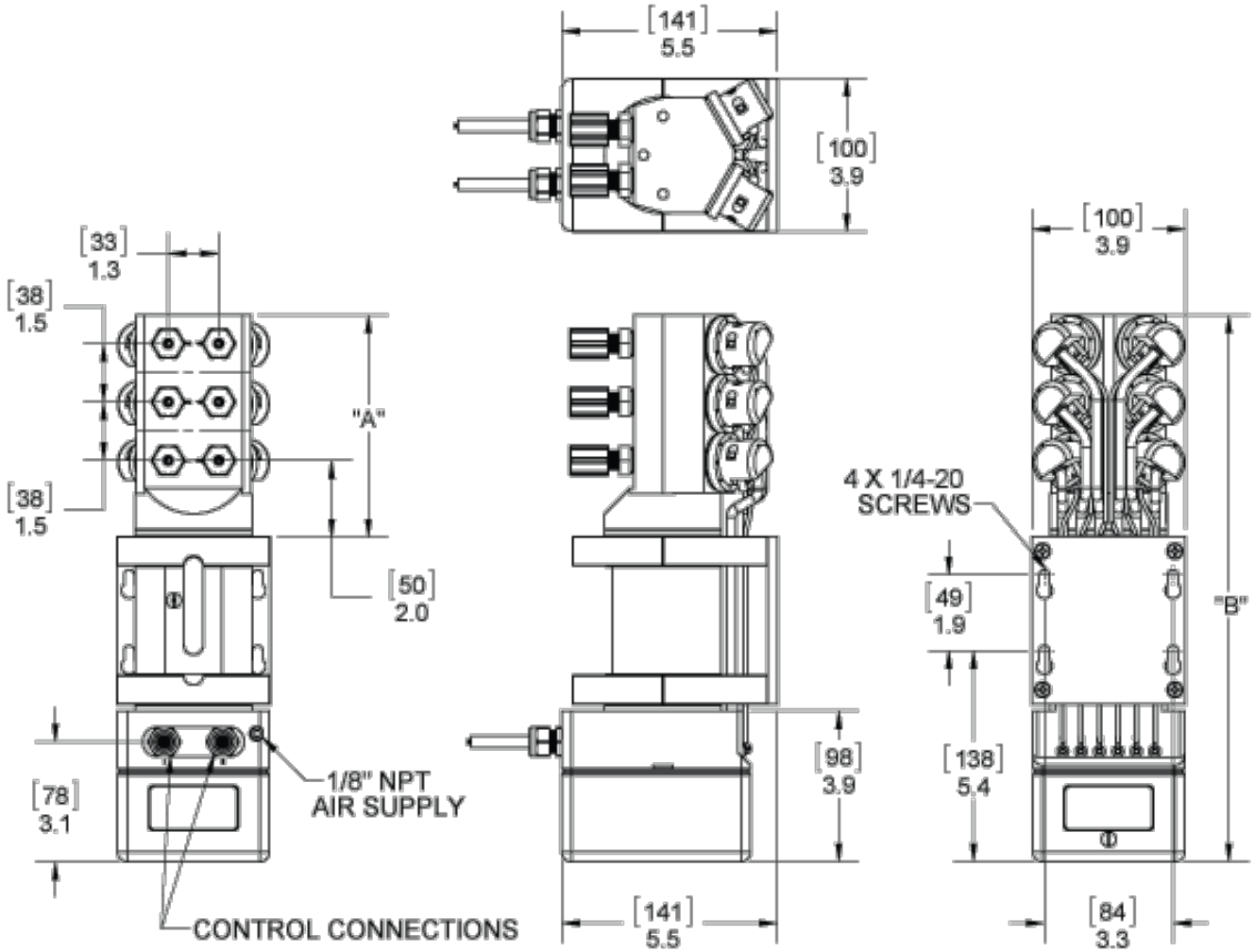


For PEM050-02: Change item number 1to 2127-TE-0064
Change item number 22 to 14400-XX-0001
Change QTY of item 2, 3, 5, 8, 9, 17, and 23 to 2
For PEM050-04: Change item number 1to 2127-TE-0066
Change item number 22 to 14400-XX-0003
Change QTY of item 2, 3, 5, 8, 9, 17, and 23 to 4
For PEM050-05: Change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

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

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

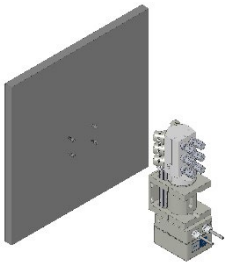
Clean Supply Air (CDA)
White Knight high purity pumps require the use of Class 2 air for particles and moisture per ISO 8573-1. (Use 10 micron filter, maintain -40° C dew point)
Abrasive Slurries
Pumping of abrasive slurries will shorten the life of any pump. White Knight high purity pumps are still 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.

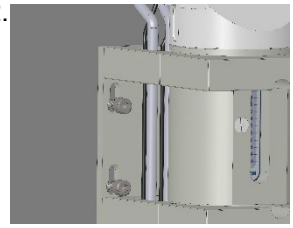
4.4 Installation Instructions

1



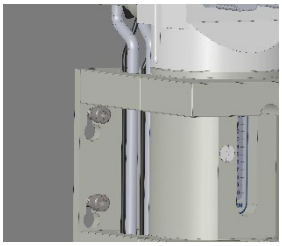
Drill and tap (4) holes to accept 4, ¼-20 set screws. Location of holes is critical, please see dimensional on page 4 of this manual.

2.



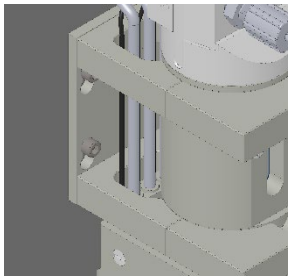
Thread screws partially into wall, leaving approximately ¼" of threads exposed. Align bracket holes with set screws and press against the wall.

3.



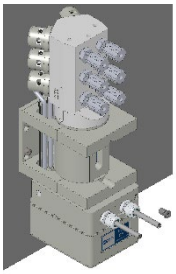
Ensure that the pump sits on all four (4) screws and is flush against the wall.

4.



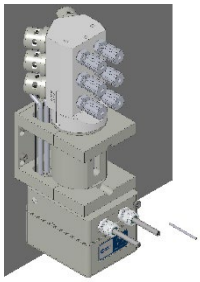
Tighten screws until slight pressure is applied to the mounting plate. CAUTION: OVER TORQUEING CAN CAUSE DAMAGE TO THE BRACKET AND/OR THE WALL THE PUMP IS MOUNTED TO!!

5.



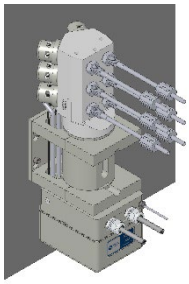
Attach the Quick connect fitting to the motor housing

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.



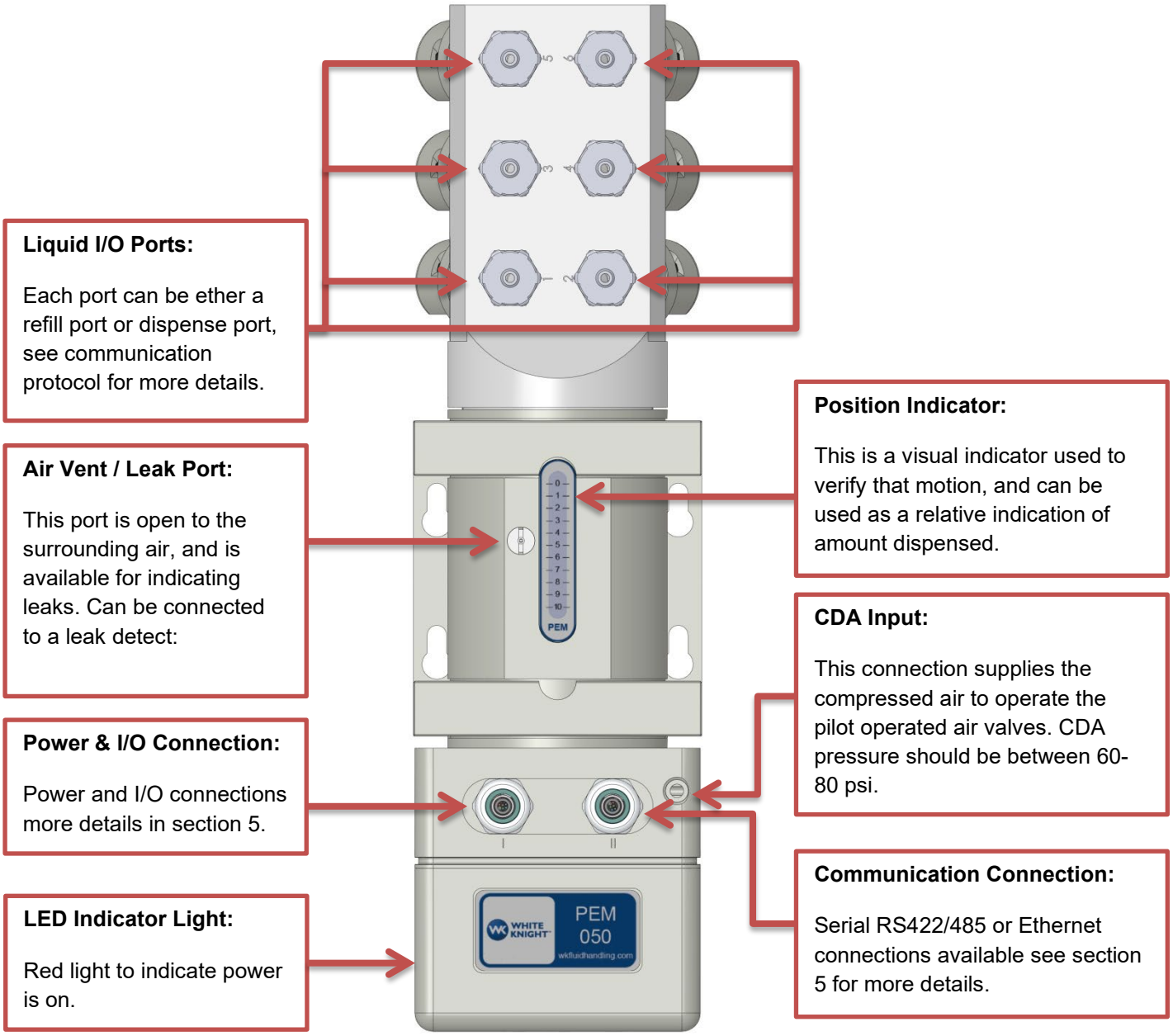
Attach Liquid Fittings per manufacturers' instructions.

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.

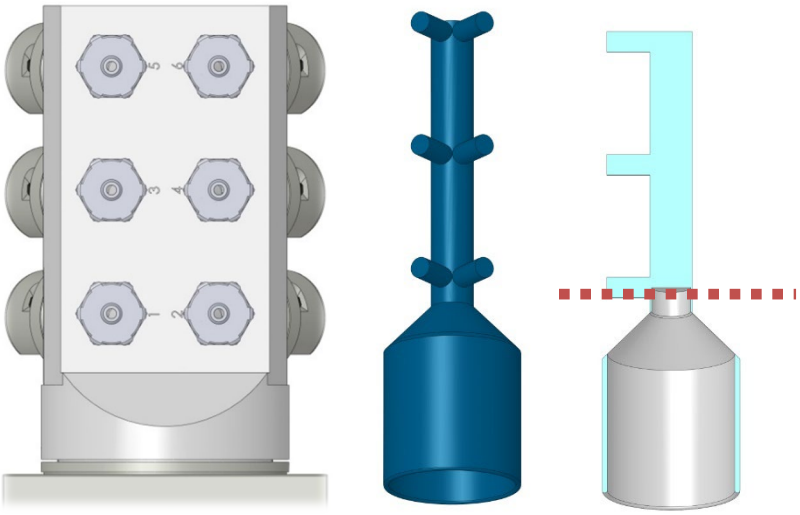
4.5 Connections

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

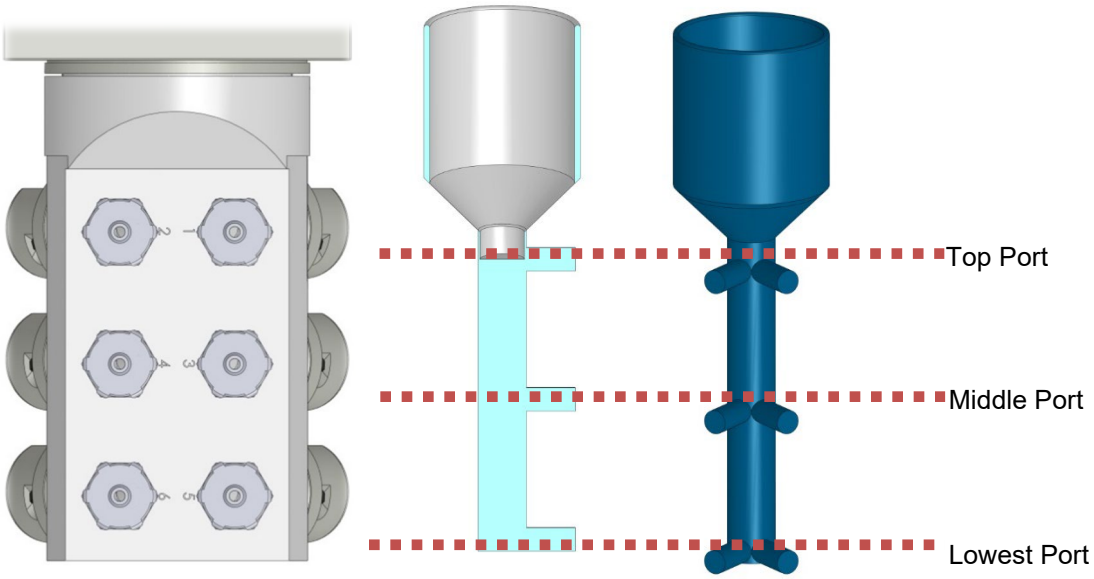
5.1 Motor on Bottom Orientation:



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:

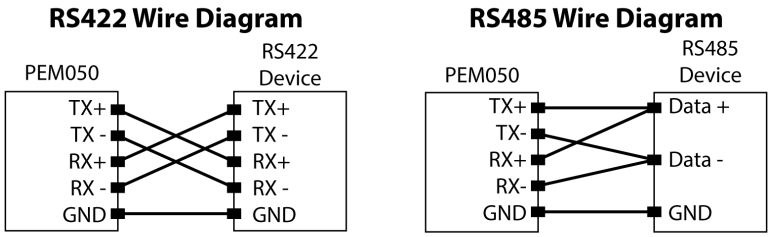
- Default - Serial RS422 (4 wire full duplex) with option to Configure in RS485 (two wire half duplex) communication.
- H1, H2 - Ethernet TCIP
- H3 - Serial RS232 communication.

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

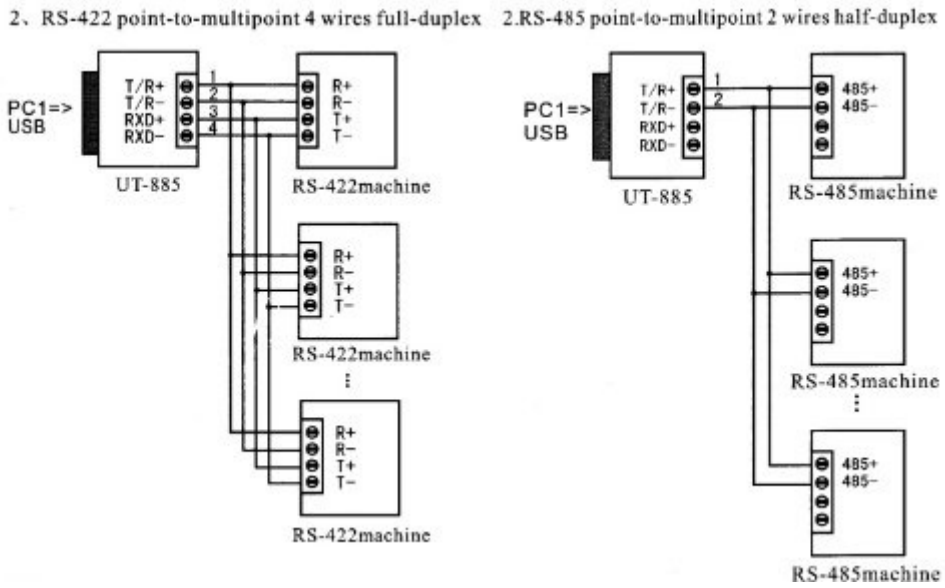
* RS485 communication must first be configured using RS422 communication. Required settings included enabling party mode and setting echo mode 1. See communication protocol for more information.



Ground connection is optional and not required for communication

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

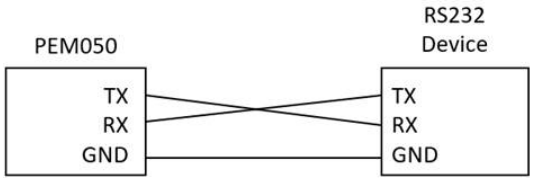
In some cases, an application might require using one serial port to communicate to multiple devices. A PEM050 can be put into party mode, which allows the serial communication line to be split to talk to multiple devices over a single serial port. To connect multiple devices each device is connected 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.

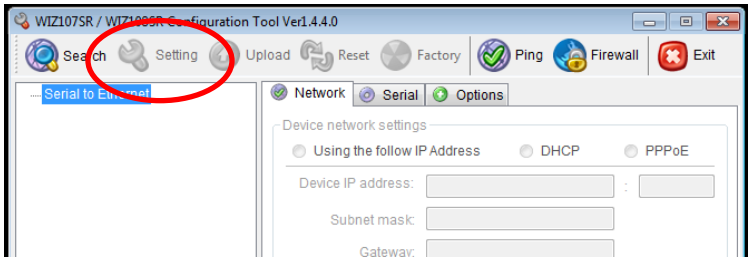
PEM050 Connection	Turck Connector Pin # - Cable Color	Cable Wire Color (Before January 2020)	Cable Wire Color (After January 2020)	Ethernet Connector Pin Position
TX+	1 - Brown	White with Blue line	Brown	1
TX-	2 - White	Blue with White line	White	2
RX+	3 - Blue	White with orange line	Blue	3
RX-	4 - Black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

6.1.5.1 Configuring Ethernet Converter:

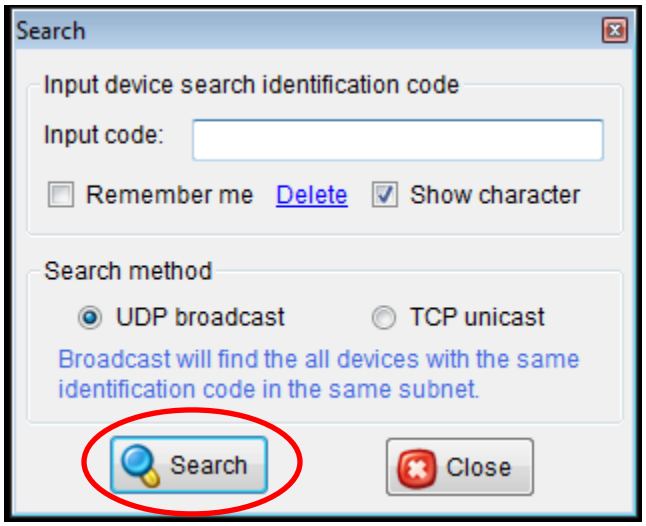
To configure the Ethernet converter, it is recommended to connect the PEM050 on the same network switch as the computer. The Ethernet converter setup software is found in the Ethernet Setup tab on the PEM050 Interface or as a standalone Ethernet Configuration Tool; both software packages can be obtained 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.

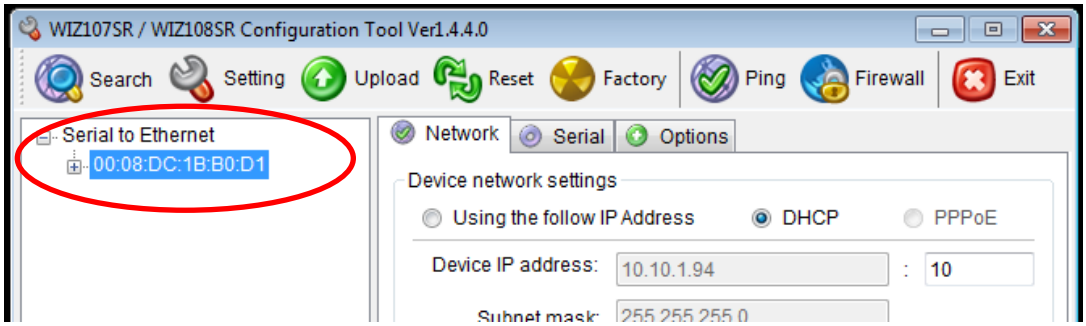
STEP 1) Open Configuration tool in either PEM050 interface or in standalone Ethernet configuration tool.
STEP 2) Verify that your computer and the PEM050 are both connected into the same Ethernet switch. Then click on the search button at the top of the window.



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.

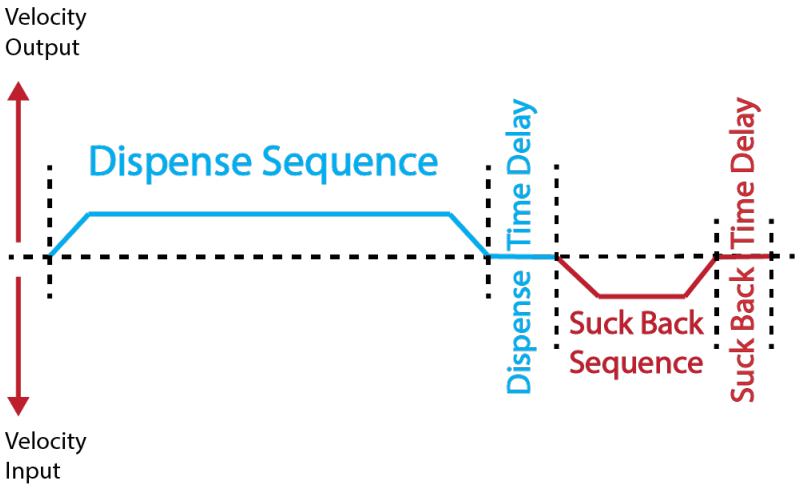


Figure 1: Graphical representation of the dispense action. The refill action consists of two parts:

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.

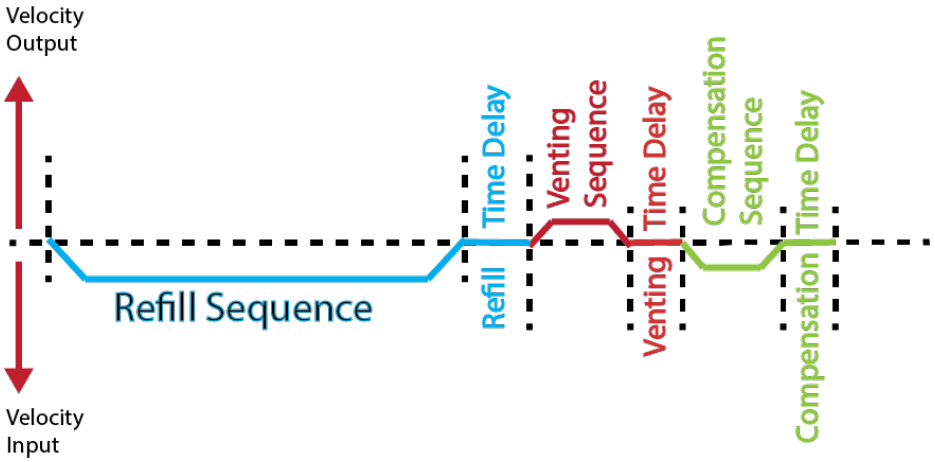


Figure 2: Graphical representation of the refill action. The refill action consists of three parts:

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.

8.4.3.3 Air Vent Commands and settings

	Description	Example	Notes
VT	Vent Amount: 0 = No vent volume defined >0 = Vent volume defined	Set: *VT=2* Request: *PR VT*	Default Value = 813 The vent volume should be a small value. Assuming that little to no air gets drawn in when refilling the pump. Then no fluid would need to be vented.
VP	Vent Port: Value must be greater than zero and less than or equal to the number of liquid ports on the pump	Set: *VP=2* Request: *PR VP*	Default Value = 1 A valid port needs to be defined before the venting will take place.
VD	Vent Time Delay: Time delay after the vent is in milliseconds, and must be zero or a positive integer.	Set: *VD=2* Request: *PR VD*	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.
VV	Vent 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 sec.	Set: *VV=2* Request: *PR VV*	Default Value = 9756 Motor will accelerate up to the max speed, and will continue at the max speed until the motor needs to decelerate.

8.4.3.4 Pressure Compensation Factor

	Description	Example	Notes
CI	Compensation Factor: 0 = No compensation factor defined CI is valid for any integer value that is greater than -200 and less than 200	Set: *CI=20* Request: *PR CI*	Default Value = 0
CD	Compensation Time Delay: Time delay after the compensation is in milliseconds, and must be zero or a positive integer.	Set: *CD=200* Request: *PR CD*	Default Value = 0 The time delay is helpful if working with viscous fluid that may need some time to settle in order to get accurate repeatability.

8.4.4 Zero Pump Action:

Zero pump action sets the encoder position. The pump will zero at start-up. There is no need to perform this action during process unless it is suspected that the encoder position did not get set properly the first time. Regularly performing the zero action during process is discouraged; it will waste time and chemical and add cycles to the pump thus reducing the pumping life of the pump.

	Description	Example	Notes
ZI	Zero Pump Initiation: 0 = No calibration action to be preformed 1 = Calibration action to complete when ready	*Set:* *ZI=1* *Request:* *PR ZI*	Default Value = 0
ZP	Zero Pump Port: Value must be greater than zero and less than or equal to the number of liquid ports on the pump	*Set:* *ZP=1* *Request:* *PR ZP*	Default Value = 1 A valid port needs to be defined before the calibration will take place.
ZD	Zero Pump Time Delay: Time delay after the calibration is in milliseconds, and must be zero or a positive integer.	*Set:* *ZD=200* *Request:* *PR ZD*	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.
ZV	Zero Pump 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:* *ZV=200* *Request:* *PR ZV*	Default Value = 4065 Motor will accelerate up to the max speed, and will continue at the max speed until the motor needs to decelerate.
ZA	Zero to Filled Position This defines the direction of the zero action. If set to 1 then the pump will zero by pulling fluid in from the specified port. If set to 0 then the pump will dispense out the specified port.	*Set:* *ZA=1* *Request:* *PR ZA*	Default Value = 0 This variable can be used to minimize chemical sent to drain during the zero routine. This is a new feature in version 1.6
ZT	Zero Stop at Hard Stop This defines the direction of the zero action. If set to 1 then the pump will zero by pulling fluid in from the specified port. If set to 0 then the pump will dispense out the specified port.	*Set:* *ZT=1* *Request:* *PR ZT*	Default Value = 0 This is a new feature in version 1.6

8.4.5 Clear Errors:

	Description	Example	Notes
XI	Clear Errors Initiation: 0 = No clear error action to be preformed 1 = Clear error action to be completed when ready	Set: *XI=1* Request: *PR XI*	Default Value = 0 The clear errors command will reset all flags, commands, and errors

8.4.6 Quit Current action:

	Description	Example	Notes
QT	Quit Initiation: 0= Quit not active 1= Quit active	Set: *QT=1* Request: *PR QT*	Default Value = 0 When the quit is active then the pump will exit all currently activities and go back to the wait for new commands. The QT will

	Description	Example	Notes
			automatically return to once the current action has been fully exited.

8.4.7 Constant Run Mode:

	Description	Example	Notes
CO	Constant Run Mode: This is a special command starts/stops the pump in constant run mode. 0= Constant run mode off 1= Constant run mode on	Set: *CO=0* *Request* *PR CO*	Once constant run mode is enabled then the pump will dispense amount available in the pump using dispense settings then refill to refill amount without end. Note: Power cycling the pump will turn off constant run mode. *This is a new feature in version 1.6*

8.4.8 Stop Pump:

	Description	Example	Notes
SL	Stop Pump: This is a special command to stop the motor mid process.	Set: *SL 0*	To effectively use this command, it should be preceded by the quit current action command. Thus, stopping the pump from starting another process as well as stopping the motor mid process.

8.4.9 Save Configurations:

	Description	Example	Notes
SI	Save Initiation: 0= Save command not active 1= Save command active	Set: *SI=1* Request: *PR SI*	Default Value = 0 The save command will save when no other actions are stopped.

8.4.10 Open Valve:

	Description	Example	Notes
PO	Open Port: 0= Close all ports 1= Open port one 2= Open port two 3= Open port three 4= Open port four 5= Open port five 6= Open port six	Set: *PO=1* Request: *PR PO*	Default Value = 0 This command is only available while the PEM050 is not performing any other operations. This can be used for verifying valve functionality. When performing any pumping action (i.e., dispense or refill) the pump will open the specified port for each action. Example: When dispensing the valve, the number assigned to DP will open at the correct time.

8.4.11 Empty Pump:

	Description	Example	Notes
EI	Empty Pump: 0= Empty pump action not pending 1= Empty pump action pending	Set: *EI=1* Request: *PR EI*	Default Value = 0 This action tells the pump to move to the hard stop position to minimize the amount of chemical in the pump.
EP	Empty Pump Port:	Set: *EP=1* Request:	Default Value = 1

	Description	Example	Notes
		PR EP	This action tells the pump which port should be opened during the venting action
EV	Empty Pump Velocity:	Set: *EV=1000* Request: PR EV	Default Value = 4065 This parameter the motor travel speed during the empty action.

8.4.12 Suck Back Only:

	Description	Example	Notes
SO	Suck Back Only: 0= Suck back action not pending 1= Suck back action pending	Set: *SO=1* Request: *PR SO*	Default Value = 0 This action tells the pump to perform a suck back action with no dispense.

8.5 Motor Current Settings:

The default value for motor currents was initially set high to make sure customers had full power available from day one. However, it has come to our attention that most customers don't require full power and when set in a constant run application the motor can get damaged due to excessive heat generation. White Knight is recommending that all customers analyze their implementation of the metering pump and to reduce the motor current to an appropriate value for their application. This section will review how motor currents can be adjusted and recommended values based upon operation parameters.

8.5.1 Motor Currents

The metering pump has an internal current limit to minimize heat generated by the motor. There are two motor current setting that both have an input range from 0-100 representing 0-100% (only whole numbers are allowed).
Note: As of Feb 14 2017 the default values for hold and run currents have been lowered.

	Name: *(Variable Name)* Description	**Example:**	**Notes:**

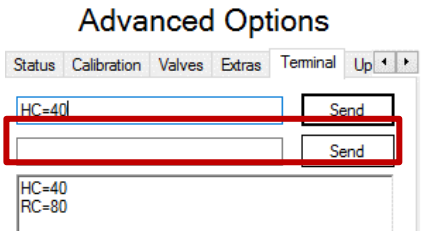
HC	**Hold Current:**
	The amount of current sent to the motor while in the idle or non-moving state.
		Get Hold Current:
		`PR HC`
		Set Hold Current:
		`HC = 20`
			Default Value = 20
			Recommended Range: 10 to 20
			Some amount of hold current is beneficial to help the motor hold position if a port is connected to a pressurized line.

RC	**Run Current:**
	The amount of current sent to the motor while the motor is moving.
		Get Run Current:
		`PR RC`
		Set Run Current:
		`RC = 50`
			Default Value = 80
			Recommended Range: 30 to 80
			The run current should be set to the minimum value that is able to perform the application and not stall. The higher the run current, the more torque the motor can apply; however, this also increases heat generation on the motor which can cause overheating issues.

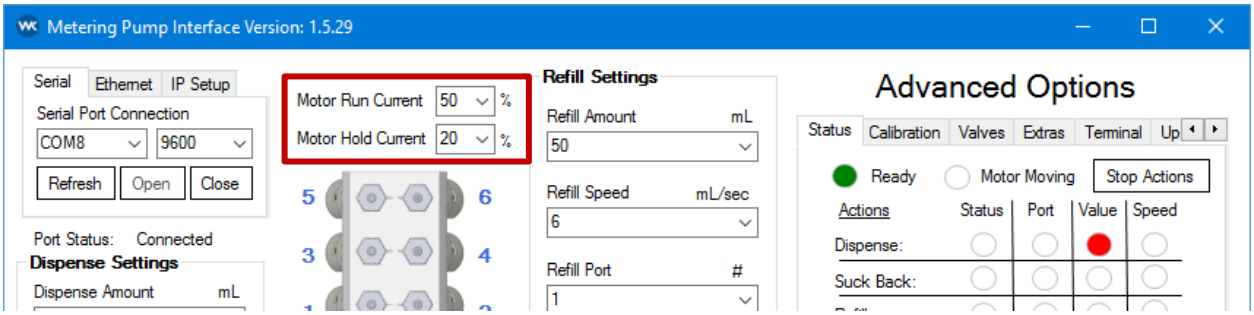
Setting the Motor Currents Using the Terminal

The motor current values can be set using any serial terminal using the variable name (RC or HC) set equal to the desired value. For example, changing the value to HC=40 adjusts the motor hold current to 40%.
The pump interface has a terminal section for entering such commands.

For versions 1.5.27 or earlier, enter motor current variables in Terminal section of pump interface.



8.5.2 Setting the motor currents using the updated interface



In the updated interface motor run/hold currents have been added to enable easy setting changes.
Once the pump is connected, these two dropdown menus can be utilized to update the motor current settings.

8.5.3 Optimize Motor Current Setting

To optimize motor current settings a balance between motor power and heat reduction should be achieved. This should be done for both motor hold current and motor run current.

8.5.3.1 Hold Current Optimization:

Hold current is to prevent the motor from moving while in the idle state; for example, if connecting a pressurized line to one of the inlets. Use the following table for setting an appropriate hold current.

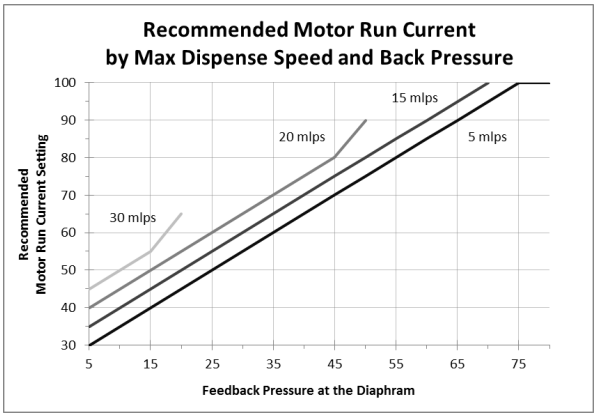
Pump is connected to a pressurized line:	**Set hold current to:**
30 psi or Less	HC = 0
60 psi or Less	HC = 10
80 psi or Less	HC = 20
Other - Note the valves on the motor may not close when line pressure is above 80 psi.	HC = 30

8.5.3.2 Run Current Optimization:

Run current is used to move the motor and overcome back pressure and fluidic resistance generated in the pumping process. Each system is different it is recommended to test to determine the optimal run current.

$$Recommended\ Motor\ Run\ Current = (Fluid\ Back\ Pressure\ [psi]) + 30$$

To test the run current start with the recommended motor run current from the equation above, or from the graph on the right. Then run the process with the motor run current set.



- If the motor does not stall during process then the recommended motor current settings are sufficient for the process. To see if the motor can run at a lower current to minimize heat generation, reduce the current in increments of 5 – running the process until the motor stalls during process. The lowest current setting that did not stall plus 10 is the optimal motor run current.
- If the motor stalls during the process, then increase the motor current in increments of 5 till the motor no longer stalls out during process. Then increase the motor current by 10; this would be the optimal motor current for the process.

8.5.4 Constant Operation

Pumps should not run constantly when high motor run currents are set (high is assumed to be 75 or above). In these applications, the pump should have some time to cool down between operations so that the motor does not get damaged due to heat generated by the motor.

8.6 Advanced Configurations:

	Description	Example	Notes
SR	Signal when Ready This defines if the pump will send an unsolicited character "+" upon the completion of any action. This is to assist customers in their customer application. If set to 1 then the option is enabled by if set to 0 then the option is disabled.	Set: SR=1 Request: PR SR	Default Value = 0 This is a new feature in version 1.6
DL	Dispense Loop: This value sets the maximum number of attempts the pump will try to get to the desired dispense value.	Set: *DL=1* Request: *PR DL*	Default Value = 4 This is only takes effect if the desire value is not reached. The most likely cause for the pump to not get to its desired value is because the motor stalled mid dispense.
DA	Dispense allowable error: This value sets how many steps the final dispense can be off before a dispense retry is necessary.	Set: *DA=1* Request: *PR DA*	Default Value = 20
A	Acceleration: This values sets how fast the pump will accelerate to the specified maximum velocity. The maximum recommended acceleration is 80000 steps per second squared	Set: *A=5000* Request: *PR A*	Default value =100000 This variable can be modified to speed up the dispense, or help reduce splashing when dispensing into an open container.
D	Deceleration: This value sets how fast the pump will decelerate from the specified velocity back to its rest position. The maximum deceleration allowable is 61035160.	Set: *D=5000* Request: *PR D*	Default Value = 100000 This variable can be modified to speed up the dispense, or help reduce splashing when dispensing into an open container.
BL	Back Lash Compensation: This value sets the number of steps that is moved at the end of any suck back or refill action. This is to reduce any motor backlash that may occur when changing motor directions.	Set: *BL=20* Request: *PR BL*	Default Value = 20

8.7 Checking PEM050 Status:

8.7.1 Process Flags:

	Description	Example	Notes
YV	Waiting for valve to open: 0= No Valve change in progress 1= Valve change in progress	Request: *PR YV*	This flag will turn true at the start of a valve change process and will turn false at the end of a valve change process. If this flag stays active for a long time, then the air pressure should be checked to make sure there is sufficient air pressure to operate the valves.
MV	Motor in motion: 0= Motor not in motion 1= Motor in motion	Request: *PR MV*	This flag will turn true at the start of any motor motion and will turn false at the end of the motor motion.
YZ	Zero Metering Pump Action in Progress: 0= Zeroing not in progress 1= Zeroing in progress	Request: *PR YZ*	This flag will turn true at the start of the zeroing action and will turn false at the end of the zeroing.
YD	Dispense Action in Progress: 0= Dispense action not in progress 1= Dispense action in progress	Request: *PR YD*	This flag will turn true at the start of the dispense action and will turn false at the end of dispense.
YR	Refill Action in progress: 0= Refill action not in progress 1= Refill action in progress	Request: *PR YR*	This flag will turn true at the start of the refill action and will turn false at the end of the refill.
YA	Metering pump is ready for action: 0= Metering pump is not ready for action 1= Metering pump is ready for action	Request: *PR YA*	This flag will turn true when all other actions have completed and is ready for the next action. This flag will turn false once an action is started.
YE	Emptying Action in Progress: 0= Metering pump is not emptying 1= Metering pump is currently emptying	Request: *PR YE*	This flag will turn true when the metering pump is emptying, and will turn false when compete.
YS	Suck Back Only action in Progress: 0= Metering pump is not performing a suck back 1= Metering pump is performing a suck back	Request: *PR YE*	This flag will turn true when the metering pump is performing the suck back only action, and will turn false when compete.
YW	Waiting for Valve to Close: 0= Not waiting for a valve to close 1= Waiting for a valve to close	Request: *PR YW*	This flag will turn true when waiting for a valve to close, and will turn false when the valve closes. If this flag persists then it is possible that a valve is stuck open. Before any new valve can open the previous one must be closed.
I1	Valve Open Status 0= All valves are closed 1= A valve is open.	Request: *PR I1*	This flag shows the status of the valve sensors. If any of the valves are open then the status will be 1, if all valves are closed then the value will be 0.

8.7.2 Input Errors:

	Description	Example	Notes
ST	Motor stalled in last action: 0= No error detected 1= Error detected	Request: *PR ST*	This value will turn true when the motor gets stalled in any action. This error could occur for several reasons: • The action velocity may have been set too high. (viscous fluid may require slower velocity) • The air supply could have turned off after the motor was in motion.
WP	Position Error: 0= No error detected 1= Pump is over/under filled relative to the last desired location	Request: *PR WP*	If the pump over shoots or undershoots the desired location, then this error will occur with a value of one or two. This will most likely occur when the motor stalls out due to over pressurization. If this occurs in the dispense cycle, the dispense loop will attempt to recover from the error the set number of times.
WM	Mid Dispense Refill Required: 0= No error detected 1= Error detected	Request: *PR WM*	This error will occur if the specified dispense amount is not able to be achieved in a single dispense. It is up to the user to decide if the use of multiple dispenses is acceptable for their application.
WB	Invalid Suck Back Value: 0= No error detected 1= Error detected	Request: *PR WB*	The suck back error will occur if the amount in the pump is less than the amount required by the suck back. If this error occurs, then a refill is recommended. If the error persists, check that the suck back amount is small relative to the refill amount.
WC	Invalid Compensation Factor value: 0= No error detected 1= Error detected	Request: *PR WC*	The compensation factor should be less than 200 steps and larger than -200 steps. If the value is outside of this range, then this error will occur.
WR	Invalid Refill Value: 0= No error detected 1= Error detected	Request: *PR WR*	The maximum refill value is set to 50000 steps. If the RA value is greater than 50000 then this error will occur.
WD	Invalid Dispense Velocity: 0= No error detected 1= Error detected	Request: *PR WD*	The maximum allowable velocity in the system is limited to 30000 steps per min. If a velocity larger than 30000 steps per min is specified, then this error will occur

	Description	Example	Notes
WF	Invalid Refill Velocity: 0= No error detected 1= Error detected	Request: *PR WF*	The maximum allowable velocity in the system is limited to 24000 steps per min. If a velocity larger than 24000 steps per min is specified, then this error will occur
WS	Invalid Suck Back Velocity: 0= No error detected 1= Error detected	Request: *PR WS*	The maximum allowable velocity in the system is limited to 24000 steps per min. If a velocity larger than 24000 steps per min is specified, then this error will occur
W1	Invalid Dispense Port: 0= No error detected 1= Error detected	Request: *PR W1*	This error will occur if a non-valid dispense port was specified. Example, if this is a 2-port metering pump, and DP was set to 3, this would cause the port error.
W2	Invalid Refill Port: 0= No error detected 1= Error detected	Request: *PR W2*	This error will occur if a non-valid Refill port was specified. Example, if this is a 2-port metering pump, and RP was set to 3, this would cause the port error.
W3	Invalid Vent Port: 0= No error detected 1= Error detected	Request: *PR W3*	This error will occur if a non-valid vent port was specified. Example, if this is a 2 port metering pump, and VP was set to 3, this would cause the port error.
W4	Invalid Zero Port: 0= No error detected 1= Error detected	Request: *PR W4*	This error will occur if a non-valid calibration port was specified. Example, if this is a 2 port metering pump, and ZP was set to 3, this would cause the port error.
W5	Invalid Empty Port: 0=No error detected 1= Error detected	Request: *PR W5*	This error will occur if a non-valid calibration port was specified. Example, if this is a 2 port metering pump, and EP was set to 3, this would cause the port error.

8.7.3 Using Status Codes:

As part of the PEM050 program there are process indicator flags, errors, and troubleshooting indicators that can be called at any time to understand the PEM050's status. Most flags and errors are only a Boolean data type (1 or 0). Using the Boolean flags and errors the WA variable has been created as a 30-bit binary status code. Each bit of the status code represents the status of a unique error, flag, or action initiation variable. Each variable can be called independently; however, by using the status code it is the same as requesting all the flags and errors with only one call. The following table lists binary power position along with the variable name and a brief description for what each variable represents. For more information regarding each individual flag, error, or troubleshooting indicator please see the troubleshooting section of the manual.

2^x Power	Variable	Description
0	YA	Flag: Pump is ready for new action
1	WP	Error: Pump stopped outside of the desired limits
2	DI	Actions: Dispense action received and waiting to be preformed
3	ZI	Actions: Zero action received and waiting to be preformed
4	RI	Actions: Refill action received and waiting to be performed
5	XI	Actions: Clear variables action received and waiting to be performed
6	QT	Actions: QT action in progress
7	SI	Actions: Save action received and waiting to be performed
8	EI	Actions: Empty pump action received and waiting to be performed
9	SO	Actions: Suck back only action received and waiting to be performed.
10	YV	Flag: Opening valve
11	MV	Flag: Motor in motion
12	YZ	Flag: Zeroing action in progress
13	YD	Flag: Dispense action in progress
14	YR	Flag: Refill action in progress
15	YE	Flag: Empty pump action in progress
16	YS	Flag: Suck back only action in progress
17	YW	Flag: Closing valve
18	ST	Error: Motor stalled during last operation
19	WM	Error: Refill Required in order to complete the dispense
20	WB	Error: Suck back value error. This would result in a negative dispense
21	WC	Error: Compensation factor is outside of allowable limits
22	WR	Error: Invalid Refill amount
23	WD	Error: Invalid dispense velocity
24	WF	Error: Invalid Refill velocity
25	WS	Error: Invalid suck back velocity
26	W1	Error: Invalid Dispense Port
27	W2	Error: Invalid Refill Port
28	W3	Error: Invalid Vent Port
29	W4	Error: Invalid Zero Port
30	W5	Error: Invalid Empty Port

8.7.4 Troubleshooting Indicators:

	Description	Example	Notes
WA	Bitwise Errors and flags: This variable is a 30-bit integer that is coded to represent a bitwise representation of error and flags.	Request: *PR DR*	See “Using Status Codes” section
DR	Dispense Residual: This indicator shows the number of steps of a dispense that will not be dispensed in a single shot.	Request: *PR DR*	* Read only variable
RM	Refill Calculated Max: This indicator will show what the theoretical max refill for the pump based upon the vent and pressure compensation values	Request: *PR RM*	Since the refill action over fills the pump before so that it can vent, changing the vent amount may impact the amount refill amount. Thus, this variable calculates the max refill amount available based upon the VT, CI, and BL variables. * Read only variable
XA	Pending Actions Count: This indicator shows the number of action commands that have been received by the pump that, and are waiting to be processed.	Request: *PR XA*	* Read only variable
XF	Active flag Count: This indicator shows the number of flags that are currently active in the pump.	Request: *PR XF*	* Read only variable
XE	Active Errors Count: This indicator shows the number of errors that are currently active in the pump.	Request: *PR XE*	* Read only variable
XD	Amount last dispense was off: This indicator shows the number of steps that did not get completed by the last action. Might be caused by a motor stall error.	Request: *PR XD*	This variable is helpful for dispense verification. This variable represents the number of steps that did not complete at the end of each dispense. * Read only variable
AA	Amount Available for Dispense: This variable indicates the amount of fluid that is available for dispense. If the next dispense is to be completed in one shot, then checking this variable before dispensing will indicate if there is enough volume left to complete the dispense without needing to refill.	Request: *PR AA*	
ER	Errors: This variable indicates when errors occur and assigns an error code to each. This variable only returns one error. For a list of all possible errors See Appendix 2. If set to zero then it will clear the current error, but if the condition presenting the error is still present than error will persist.	Request *PR ER*	This value is cumulative meaning that if a dispense required multiple refills to complete, then this value will track total error for the complete dispense. * Read only variable
VJ	Version Major: Variable designated for recording firmware version installed on device.	Request PR VJ	The version tracking number represents both a major and a minor change commonly denoted with a

	Description	Example	Notes
			dot between the two. Version 1.5 would be VJ=1 and VB=5. This is a new feature in version 1.6
VB	Version Minor: Variable designated for recording firmware version installed on device.	Request PR VB	
WE	Dispense Error; As a dispense is occurring, if there is a stall that prevents a full dispense, then this value will hold the amount of steps not dispensed.	Request PR WE	This value is cumulative meaning that if a dispense required multiple refills to complete, then this value will track total error for the complete dispense.

8.8 Operation Examples:

This section will show several examples of how to use this protocol to operate the PEM050.

Example 1: Refill Pump.

There are three pumping actions that occur with the pump refill action: refill, vent, and pressure compensation. To configure set any parameters that are desired to be changed. All parameters associated with the refill, vent, or pressure compensation will stay from refill action to refill action, and only need to be changed to modify the refill action's behavior: (Note: text after apostrophes, are comments and do not need to be sent to the PEM050.)

```
RA=41000     'Refill Amount: 50 mL
RP=1         'Refill Port: set refill port to port 1
RD=200       'Refill Time Delay:  time in milliseconds
RV=5000      'Refill Velocity: recommended to stay less than 15000
VT=200       'Vent Amount: .25 mL
VP=2         'Vent Port: set vent port to port 2
VD=200       'Vent Time Delay: time in milliseconds
VV=10000     'Vent Velocity: recommended to stay less than 15000
CI=0         'Compensation Amount: recommended less than 200
CD=0         'Compensation Time Delay: Milliseconds
```

After the parameters are configured for the desired behavior, then issue the initiation command.

```
RI=1         'Start Refill.
```

*End each command with termination character.

Example 2: Dispensing fluid

There are two pumping actions that occur with the pump dispense action: Dispense, Suck back. If I were configuring this action for the first time then I would recommend setting all parameters, these are some typical settings that I use: (text after an apostrophe, are comments and not part of the code.)

```
DP=3         'Dispense Port: set to dispense out of port 3
DD=0         'Dispense Time Delay: time in milliseconds
DV=5000      'Dispense Velocity: recommended to stay less than 15000
SB=550       'Suck Back Amount: .67 mL
SD=200       'Suck Back Time Delay: time in milliseconds
SV=5000      'Suck Back Velocity: recommended to stay less than 15000
```

The parameters listed above will be maintained after each dispense is complete. Only the dispense amount should be specified before each dispense.

```
DT=4100      'Dispense Amount: 5mL
```

After the parameters are set, or if the current settings do not need to be changed, then issue the initiation command.

```
DI=1         'initiate Dispense.
```

*End each command with termination character.

8.9 ASCII Table Reference

Note: Each font may use different symbols to represent special characters or integer values 128 and larger.

Abbr	Int	Hex
NUL	0	0
SOH	1	1
STX	2	2
ETX	3	3
EOT	4	4
ENQ	5	5
ACK	6	6
BEL	7	7
BS	8	8
HT	9	9
LF	10	A
VT	11	B
FF	12	C
CR	13	D
SO	14	E
SI	15	F
DLE	16	10
DC1	17	11
DC2	18	12
DC3	19	13
DC4	20	14
NAK	21	15
SYN	22	16
ETB	23	17
CAN	24	18
EM	25	19
SUB	26	1A
ESC	27	1B
FS	28	1C
GS	29	1D
RS	30	1E
US	31	1F
space	32	20
!	33	21
"	34	22

Abbr	Int	Hex
#	35	23
$	36	24
%	37	25
&	38	26
'	39	27
(	40	28
)	41	29
*	42	2A
+	43	2B
,	44	2C
-	45	2D
.	46	2E
/	47	2F
0	48	30
1	49	31
2	50	32
3	51	33
4	52	34
5	53	35
6	54	36
7	55	37
8	56	38
9	57	39
:	58	3A
;	59	3B
<	60	3C
=	61	3D
>	62	3E
?	63	3F
@	64	40
A	65	41
B	66	42
C	67	43
D	68	44
E	69	45

Abbr	Int	Hex
F	70	46
G	71	47
H	72	48
I	73	49
J	74	4A
K	75	4B
L	76	4C
M	77	4D
N	78	4E
O	79	4F
P	80	50
Q	81	51
R	82	52
S	83	53
T	84	54
U	85	55
V	86	56
W	87	57
X	88	58
Y	89	59
Z	90	5A
[	91	5B
\	92	5C
]	93	5D
^	94	5E
_	95	5F
`	96	60
a	97	61
b	98	62
c	99	63
d	100	64
e	101	65
f	102	66
g	103	67
h	104	68

Abbr	Int	Hex
i	105	69
j	106	6A
k	107	6B
l	108	6C
m	109	6D
n	110	6E
o	111	6F
p	112	70
q	113	71
r	114	72
s	115	73
t	116	74
u	117	75
v	118	76
w	119	77
x	120	78
y	121	79
z	122	7A
{	123	7B
|	124	7C
}	125	7D
~	126	7E
DEL	127	7F
€	128	80
?	129	81
‚	130	82
ƒ	131	83
„	132	84
…	133	85
†	134	86
‡	135	87
ˆ	136	88
‰	137	89
Š	138	8A
‹	139	8B

Abbr	Int	Hex
Œ	140	8C
□	141	8D
Ž	142	8E
□	143	8F
□	144	90
‘	145	91
’	146	92
“	147	93
”	148	94
•	149	95
–	150	96
—	151	97
˜	152	98
™	153	99
š	154	9A
›	155	9B
œ	156	9C
□	157	9D
ž	158	9E
Ÿ	159	9F
	160	A0
¡	161	A1
¢	162	A2
£	163	A3
¤	164	A4
¥	165	A5
¦	166	A6
§	167	A7
¨	168	A8
©	169	A9

Abbr	Int	Hex
ª	170	AA
«	171	AB
¬	172	AC
	173	AD
®	174	AE
¯	175	AF
°	176	B0
±	177	B1
²	178	B2
³	179	B3
´	180	B4
µ	181	B5
¶	182	B6
·	183	B7
¸	184	B8
¹	185	B9
º	186	BA
»	187	BB
¼	188	BC
½	189	BD
¾	190	BE
¿	191	BF
À	192	C0
Á	193	C1
Â	194	C2
Ã	195	C3
Ä	196	C4
Å	197	C5
Æ	198	C6
Ç	199	C7

Abbr	Int	Hex
È	200	C8
É	201	C9
Ê	202	CA
Ë	203	CB
Ì	204	CC
Í	205	CD
Î	206	CE
Ï	207	CF
Ð	208	D0
Ñ	209	D1
Ò	210	D2
Ó	211	D3
Ô	212	D4
Õ	213	D5
Ö	214	D6
×	215	D7
Ø	216	D8
Ù	217	D9
Ú	218	DA
Û	219	DB
Ü	220	DC
Ý	221	DD
Þ	222	DE
ß	223	DF
à	224	E0
á	225	E1
â	226	E2
ã	227	E3
ä	228	E4
å	229	E5

Abbr	Int	Hex
æ	230	E6
ç	231	E7
è	232	E8
é	233	E9
ê	234	EA
ë	235	EB
ì	236	EC
í	237	ED
î	238	EE
ï	239	EF
ð	240	F0
ñ	241	F1
ò	242	F2
ó	243	F3
ô	244	F4
õ	245	F5
ö	246	F6
÷	247	F7
ø	248	F8
ù	249	F9
ú	250	FA
û	251	FB
ü	252	FC
ý	253	FD
þ	254	FE
nbsp	255	FF

8.10 Error Value Reference

This table contains all possible errors that the PEM050 could experience

ER	Description of error codes. ER
0	No Error
6	I/O configuration already set
8	I/O configuration not valid
9	I/O not available, or improperly set.
20	Tried to set unknown variable. Most likely a typo.
21	Invalid value sent variable. (some variables like BD only accept certain values)
24	Data has been entered that the device does not understand.
25	Variable or flag is read only and variables cannot be set.
28	Warning, variable error. Possibly typo.
29	Trying to redefine a built in command, variable or flag.
30	Unknown Variable. Possibly typo.
32	Variable error, possibly typo.
33	Trying to SET an Instruction.
34	Trying to Execute a Variable or Flag
35	Trying to Print Illegal Variable or Flag
37	Command, Variable or Flag Not Available. Possibly typo.
40	Program not running.
41	Communication errors, Stack overflow.
42	Illegal program address. Tried to Clear, List, Execute, etc. an incorrect Program address.
44	Program locked. The program cannot be listed or edited.
48	Program Execution stopped by I/O set as Stop.
61	Trying to set illegal BAUD rate. The only Baud Rates accepted are those listed on the Properties Page of IMS Terminal. (4,800, 9,600, 19,200, 38,400, 115,200)
63	Character over-run. Character was received. Processor did not have time to process it and it was over-written by the next character.
70	FLASH Check Sum Fault
71	Internal Temperature Warning, 10C to Shutdown
72	Internal Over TEMP Fault, Disabling Drive
73	Tried to SAVE while moving

ER	Description of error codes. ER
75	Linear Over Temperature Error (For units without Internal Over Temp)
86	Stall detected. The Stall Flag (ST) has been set to 1.
91	Motion stopped by I/O set as Stop.
200	WB-Suck back value error, either the suck back is set too high or a refill is needed. Please refill the pump, and clear errors. If error persists, try changing the suck back value.
201	WC- Compensation factor needs to be less than 200 and greater than -200.
202	WR- Refill amount is set too high. Please check that refill value is less than 42000
203	WD- Dispense velocity is higher than 24000 and may result in the motor stalling during dispense. User may proceed to run pump and see if pump does not stall mid dispense. If motor stalls, then the speed should be reduced. If the motor does not stall, then max velocity can be modified. Contact White Knight for details.
204	WF- refill velocity is higher than 24000 and may result in the motor stalling during the refill. User may proceed to run pump and see if pump does not stall mid refill. If motor stalls, then the speed should be reduced. If the motor does not stall, then max velocity can be modified. Contact White Knight for details.
205	WS- Suck back velocity is higher than 24000 and may result in the motor stalling during dispense. User may proceed to run pump and see if pump does not stall mid dispense. If motor stalls, then the speed should be reduced. If the motor does not stall, then max velocity can be modified. Contact White Knight for details.
206	W1- Dispense port error. Check that DP is set to a valid port 1 through max port number
207	W2- Refill port error. Check that RP is set to a valid port 1 through max port number
208	W3- Vent port error. Check that VP is set to a valid port 1 through max port number
209	W4- Empty port error. Check that DP is set to a valid port 1 through max port number
210	W5-Calibration port error. Check that ZP is set to a valid port 1 through max port number

9 Direct Motor Control Commands

Some users may choose to operate the pump using direct motor control instead of the standard pump protocol. The direct motor control gives added flexibility in operating the pump, however, when operating in this mode, the user should take extra precautions to ensure that the valves open and close correctly and to set the zero position.

Before using the direct motor control commands, you should first have decided if you want to permanently operate in direct control mode, or if this is just for temporary operation. If this is for temporary operation, then you will need to temporarily stop the program execution by “PS” command followed by a carriage return; to resume program execution then you would need to send the “RS” command. If you want to only use direct motor control then you would need to erase the standard program, to do this see erasing motor program section.

9.1 Motor Commands:

9.1.1 Valve Operation:

Description: To open/close a valve set the valve variable to an opened (1) or a closed (0) state, then send the termination character a carriage return. Note: These are write only variables.	
Command: Valve 1: O2 = <state> Valve 2: O3 = <state> Valve 3: O4 = <state> Valve 4: O9 = <state> Valve 5: O10 = <state> Valve 6: O11 = <state> • Where the <state> is either a 1 for open or a 0 for closed.	**Example 1:** Open Valve 1 O2=1<CR> **Example 2:** Close Valve 1 O2=0<CR>

9.1.2 Valve Sensors:

	Description	Example	Notes
I1	Read Valve Sensors: Every valve has a sensor attached to it for valve detection; however, due to limited Digital I/O available on the PEM all of the input sensors read as an OR signal. Meaning that if one or more valves are open then the sensor reads true, otherwise if all valves are closed then the sensor reads false.	Request: *PR I1*	Default Value = 0 Available Range = 0 to 1 Note: This is a read only variable

9.1.3 Motor Movement:

	Description	Example	Notes
MR	Motor Move Relative to Current Position: This is a motor function call. Sending this command to the motor will tell the motor a set amount relative to the motor’s current position.	Start: MR 1000	Available Range = -100000 to +100000 Note: the pump has a maximum travel of 60000 steps, so commanding the motor to go beyond the available space will hit a hard stop.
MA	Motor Move to Absolute Position: This is a motor function call. Sending this command to the motor will tell the motor to move to the absolute motor encoder position.	Start: MA 2000	Available Range = -100000 to +100000 Note: the pump has a maximum travel of 60000 steps, so commanding the motor to go beyond the available space will hit a hard stop.

	Description	Example	Notes

SL	Motor Run/Stop Command:
	This motor function call will tell the motor what speed and direction to run.
	• >0: Push fluid out
	• =0: Stops motor
	• <0: Pulls fluid in
		Push Fluid:
		`SL 1000`
		Pull Fluid:
		`SL -1000`
		Stop Motor:
		`SL 0`
			Available Range = VI+1 to 30000

MV	Motor Moving Flag: This variable will indicate if the motor is moving or not. Value will return a 1 if moving and a 0 if not moving.	Request: *`PR MV`*	Default Value = 0 Available Range = 0 to 1 This is a read only value

9.1.4 Motor Stall Detect:

	Description	Example	Notes
ST	Stall Flag: This variable indicates when a stall has been detected; returned value will be 1 if stalled and 0 if not stalled.	Clear Error: *`ST=0`* Request: *`PR ST`*	Default Value = 0 Available Range = 0 to 1

9.1.5 Position:

	Description	Example	Notes
P	Position: This variable indicates the current position relative to the zero point.	Set Zero: *`P=0`* Request: *`PR P`*	Default Value = 0 Available Range = -100000 to +100000 Note: The motor does not remember the encoder positions when powered down. At power up the motor count will be zero.

9.1.6 Errors:

	Description	Example	Notes
ER	Error Value: The error value will be set to a numeric indicator for any error that has occurred regarding the motor's operation	Clear Errors: *`ER=0`* Request: *`PR ER`*	Default Value = 0 Available Range = 0 to 300 Reference error code reference from previous section.

9.1.7 Motor Speed / Acceleration:

	Description	Example	Notes
A	Acceleration: This sets the rate that the motor will speed up in steps per second squared until it reaches velocity maximum.	Set: *A=91* Request: *PR A*	Default Value = 100000 Available Range = 91 to 200000 If this value is set too high it can cause motor stall out issues.
D	Deceleration: This sets the rate that the motor will slow down in steps per second squared until it reaches velocity zero.	Set: *D=91* Request: *PR D*	Default Value = 100000 Available Range = 91 to 200000 If this value is set too high it can cause motor stall out issues.
VM	Velocity Maximum: This sets the maximum velocity of the motor during motion.	Set: *VM=1000* Request: *PR VM*	Default Value = 5000 Available Range = VI+1 to 30000 If this value is set too high, it could cause the motor to stall prematurely. The upper limit of VM depends on system dynamics.
VI	Velocity Initial: This value sets the initial speed for the motor when starting up, then the acceleration factor will increase till velocity maximum is reached.	Set: *VI=1000* Request: *PR VI*	Default Value = 1 Available Range = 1 to VM-1 An error will occur if VI is set higher than VM-1.

9.2 Erase Pump Program

Erasing the pump program is a permanent change, and cannot be undone. Thus, only perform this action if you are sure that you want to only use the direct motor operations. If you are sure you want to erase the program, then send the “CP” command to the pump. Afterwards the pump will no longer respond to the pre-programed pumping protocol. This command keeps setting information needed for operating the valves.

9.3 Creating a Custom Program

White Knight will support custom program creation to modify the existing protocol or in creating a new protocol specific for customer requirements. Additionally, if a customer would like to program their own firmware then additional resources can be requested.

10 Firmware Version History

Version #	Version Change Notes

Version 0.8 (Released Aug. 2023)	• Recommended upgrade to Version 6.
	• Since Version 7 was never released to production this update applies to Version 6.
	• Firmware fixes issue associated with cycle counter save feature:
	  ○ A time delay occurs after every refill that is associated with the pumps cycle counter. The effect of this delay is approximately 8 seconds of delay for every 100K of cycles the pump has performed.
	  ○ If a user is not able to apply this firmware update to their pump but needs to fix the issue resolved for the short term, they can reset their cycle counter variable by sending the command RR=0.

Version 0.7 (Not released to production)	• Addressed customer complaint that dispense amount would return to zero after every dispense, resulting in the requirement to reissue dispense amount command after every dispense. • Other minor improvements were made. ○ Note: Beta testing of this version found that since the dispense amount would return to the last amount it could trigger the refill required indicator when a user was not expecting it. Because of this behavior change this version was not released to production but was available for customers who wanted the feature changed.

Version 0.6 (Released Feb. 2018)	• Reduced motor current defaults to minimize heat generation:
	  ○ Run Current From 100 to 60
	  ○ Hold Current From 40 to 20
	• Modified defaults settings so that they show as whole numbers in PEM interface.
	  ○ Dispense speed from 5000 to 4878
	  ○ Suck back amount from 550 to 813
	  ○ Suck back speed from 1000 to 813
	  ○ Refill amount from 41000 to 40650
	  ○ Refill speed from 5000 to 4878
	  ○ Vent amount from 200 to 813
	  ○ Vent speed from 10000 to 9756
	  ○ Empty pump speed from 5000 to 4065
	• Reduced zero pump speed to generate less back pressure when dispensing fluid.
	  ○ Zero speed from 10000 to 4065
	• Added a skip vent action when vent amount is set to zero
	• Modified startup valve actuation to include valve 6 and to only test valves that are available to the pump (for example: if pump is a 2-port pump only test the first two ports).
	• Added firmware version reference variables VB, VJ.
	• Added option to zero the pump to the full hard stop rather than zero to the empty hard stop (ZA).
	• Added zero stop at hard stop feature ZT. When the pump hard stops it does not immediately return to the working position
	• Added option to automatically send end action response with a “+” character (SR).

Field update instructions going from Version 6 to Version 8:

- Connect a single pump to a computer with the PEM050 Interface 2.8.x installed.
- Make sure the air pressure and power are turned on to the pump.
- Open connection to your pump.
- If there are any settings specific to your application (check sum mode, party mode, device name, or other) please make note of them so you can apply those setting after the update is made.
- Go to the “Update” tab.

- Verify that the current firmware version for your device is listed as “0.6”; if your version is anything but version 0.6 than stop the update and contact customer support to coordinate the update of application specific firmware.
    - Note: the 0 in the firmware calls out that it is a standard version. Any other number in this first position is a custom application firmware.
- Check the “Programming Mode” checkbox.
- Make sure the number of ports is correct for your device.
- Select program “Standard V8 (Current)”.
- Click “Program PEM050” button.
- The update will take about 3 minutes; follow all prompts until completed.
- The current firmware after the update should now show “0.8”.
- If you had application specific settings that need to be updated apply them now.
    - Click “Save Settings” button after applying application specific settings.
- The update is complete.

11 Pump Service & Rebuilds

11.1 Ordering Instructions

Configuration

Required — *Optional*

PEM050 - 02 B 1AF04 - E3 - H1 - LF0 - 2P6 - 3F4

0	1	2	3	4	5	6	7-11
Model	Ports	Motor	Fittings	Connection	Comm.	Leak Detect	Different Port Fitting Options

Instructions

Options 0-4 are required. Options 5-11 are not required.
To define fittings at different ports, see section 7-11
Contact support for revision or copy exact information.

Standard options are highlighted

0. Model	
50-ml electronic metering pump	PEM050

1. Ports	
Two ports	02
Three ports	03
Four ports	04
Five ports	05
Six ports	06

2. Motor Location	
Motor on bottom	B
Motor on top	T

3. Fittings * Selected fitting is for all ports unless different fittings are defined. (See 7-11).		
Flaretek Compatible 	1/4 in.	1AF04
	3/8 in.	1AF06
Pillar S-300 	1/8 in.	1AP02
	1/4 in.	1AP04
	3/8 in.	1AP06
FNPT	1/4 in.	1AN04
	3/8 in.	1AN06
Primelock	3/8 in.	1AL06

4. Connection & Cables	
Wire leads with 5-m (15-ft) ETFE-coated cable	E1
Wire leads with 5-m (15-ft) FEP-encapsulated cable	E2
Two 5-pin M12 Turck connectors, cable not included	E3
Two 5-pin M12 Turck connectors with 6-m (18-ft) cable	E4

* *Options E1/E2 connections are inside the pump casing. Options E3/E4 connectors are available outside of pump casing.*
* *Options with cables include power and communication cables.*
* *Turck connectors provide power and communication.*

5. Communication Protocol	
Serial over RS-422	Blank
Ethernet RJ45	H1
Ethernet RJ45, (communication cord cut to 2-m (6-ft))	H2
Serial over RS-232	H3

* *Cables match selected Connection & Cable options.*

6. Leak Detection	
No Leak detection	Blank
15 ft. fiber optic cable, no amplifier	LF0
15 ft. fiber optic cable, with D10 amplifier	LF1
25 ft. fiber optic cable, no amplifier	LF2
25 ft. fiber optic cable, with D10 amplifier	LF3
15 ft. conductivity cable	LC0
25 ft. conductivity cable	LC1

Example Configurations

PEM050-04B1AF04-E3	All four fittings are F04.
PEM050-04B1AF04-E3-2P6	Fitting 1 is F04. Fittings 2-4 are P6.
PEM050-04B1AF04-E3-2P6-3F4	Fittings 1, 3, and 4 are F04/F4. Fitting 2 is P6.
PEM050-06B1AF04-E3-3P6-5F6	Fittings 1-2 are F04/F4. Fitting 3-4 are P6. Fittings 5-6 are F6.

Fig. 1

Fig. 2

7-11. Different Fittings

Specify different port fittings with Port Location label (e.g. 2) and Fitting label (e.g. F4). Repeat both labels for fittings that differ from the previous specified option. Unspecified port fitting options use the last specified option.

Port Locations * Port location depends on motor location. See Fig. 1 and Fig. 2 for port numbers.		
Motor (B) *Fig. 1*	**Motor (T)** *Fig. 2*	**Port Label**
Top left	Bottom right	2
Center right	Center left	3
Center left	Center right	4
Bottom right	Top left	5
Bottom left	Top right	6

Fittings		Label
Flaretek Compatible	1/4 in.	F4
	3/8 in.	F6
Pillar S-300	1/8 in.	P2
	1/4 in.	P4
	3/8 in.	P6
FNPT	1/4 in.	N4
	3/8 in.	N6
Primelock	3/8 in.	L6

Wkfluidhandling.com/ordering-instructions

Please contact White Knight for orders requiring Copy Exact.

Rebuild Parts for PEM050 Series Pumps

Description	Quantity
Valve Assembly	1-6
Stepper Motor Assy	1
Rolling Diaphragm	1

Rebuild Kit Part Numbers

	Part Number	Description
Rebuild without Motor	RBPEM050-52	2 Port PEM050 Rebuild without motor, Performed at White Knight
	RBPEM050-53	3 Port PEM050 Rebuild without motor, Performed at White Knight
	RBPEM050-54	4 Port PEM050 Rebuild without motor, Performed at White Knight
	RBPEM050-55	5 Port PEM050 Rebuild without motor, Performed at White Knight
	RBPEM050-56	6 Port PEM050 Rebuild without motor, Performed at White Knight
Rebuild with Motor	RBPEM050-62	2 Port PEM050 Rebuild with motor, Performed at White Knight
	RBPEM050-63	3 Port PEM050 Rebuild with motor, Performed at White Knight
	RBPEM050-64	4 Port PEM050 Rebuild with motor, Performed at White Knight
	RBPEM050-65	5 Port PEM050 Rebuild with motor, Performed at White Knight
	RBPEM050-66	6 Port PEM050 Rebuild with motor, Performed at White Knight

Location of Rebuild Site
Due to the nature of the PEM metering pumps, rebuilds of the PEM must be performed at White Knights facility. White Knight reserves the right to refuse a rebuild request.

11.2 Rebuild Information

PEM050 pumps must be rebuilt at White Knight's facility to receive a new warranty.

Pumps that have the motor replaced will have a complete warranty offered for all components.

In pumps that do not have the motor replaced during rebuild, White Knight will renew the warranty for any failure mode not associated with a motor failure.

11.3 RMA Request Form

Return Material Authorization requests can be made online at https://wkfluidhandling.com/support/rma/

WHITE KNIGHT®

187 E. 670 S., Kamas, UT 84036
435.783.6040 888.796.2476
https://wkfluidhandling.com

RMA Request Form

COMPLETE AND RETURN THIS FORM TO WHITE KNIGHT FOR RMA QUOTE AND INSTRUCTIONS.
Mail completed form to: 187 E. 670 S., Kamas, UT 84036 or email to: customer.support@wkfluidhandling.com.
RMA requests can also be made online at https://wkfluidhandling.com/support/rma/.

I, the undersigned employee of _____, request a return merchandise authorization (RMA) for the product listed below.

Product used with:
- ☐ Copper
- ☐ Other Metal(s)
- ☐ No Metal(s)

Serial#: _____
(We cannot process returns without a product serial number.)

Reason for Return:
(Check all that apply.)

- ☐ **Standard Evaluation** *(See Purchase Order)*
- ☐ **Return of Demo Product**
- ☐ **Maintenance or Service Repairs**
- ☐ **Exchange Product**
- ☐ **Product has problem:**

(Check all that apply or write in other problems and/or details if necessary)

☐ Air Leak ☐ Fluid Leak ☐ Low/No Flow ☐ Non-Functional ☐ Erratic Operation ☐ Bellows Failure
☐ Check Failure ☐ Cycle Failure ☐ Shuttle Failure ☐ Shaft/Seal Failure ☐ Other: _____

Failure Details: _____

Purchase Order: _____
(For standard evaluation returns, please provide a Purchase Order for $200. If service is needed, this payment will be applied to the service.)

Air Supply Pressure: _____ (Max or range in PSI or Bar. *e.g.80 PSI, or 80-90 PSI*)
Flow Rate: _____ (Max or range in LPM or GPM)
Process Chemistry: _____ (e.g. HF, HCl, H2O2, etc.)
Process Metals: _____ (e.g. Cu, Au, Ba, Cd, Co, Ga, Ni, No, Pb, Pt, etc.)
Process Temperature: _____ (Max or range in °F or °C)
Duty Cycle: _____ (Max or range in PSI or Bar. *e.g.80 PSI, or 80-90 PSI*)
Product Installation Date: _____ (Date of product installation)

Additional Information: _____

Name: _____
Phone: _____
Email: _____

Signature: _____ **Date:** _____

11.4 Decontamination Instructions & Certificate of Decontamination

WHITE KNIGHT®

187 E. 670 S., Kamas, UT 84036
435.783.6040 888.796.2476
https://wkfluidhandling.com

Decontamination Instructions

PRINT COMPLETED DECONTAMINATION CERTIFICATION. IT MUST BE INCLUDED IN YOUR RMA SHIPMENT.

White Knight products are designed for use with caustic and otherwise dangerous liquids.
Handle every product as if it contains dangerous chemicals whether or not it actually does.

- Only those with adequate safety training should attempt to handle used pumps.
- Wear adequate safety gear appropriate for chemicals that have been in the pump.
- Review relevant Material Safety Data Sheets (MSDS) before handling the pump.
- Review emergency numbers for use in event of an accident.
- Prepare Ph papers, showers, antidotes, clean-up equipment, neutralizers, and other safety devices used to detect, neutralize or minimize effects of chemicals described in appropriate MSDS documents.

Rinse with DI Water

Circulate DI water through pump for twenty minutes before disassembly and/or double bagging for shipment. If pump is nonfunctional, force DI water from inlet through outlet for 40 minutes before shipment preparations.

Remove Pump from Station:

1. Disconnect liquid tubing connectors from front of pump (opposite externally-mounted shuttle valve).
2. Plug NPT fittings with PTFE plug, Flare fittings with flare nose cover and cap, or other plug or cap as recommended by connector supplier.
3. Disconnect air supply tubing from face of shuttle valve.
4. Loosen mount screw from base plate. (Note: do not remove screw from base plate).
5. Remove base plate using proper tool for the fastening devices (e.g. Allen wrench or screw driver). Note: Base plate may remain if needed for a White Knight pump used to replace the returned pump.
6. Return all removed parts to the pump.

Return Pump to White Knight:

1. Rinse pump with DI water as described above after removing it from its station.
2. Drain remaining DI water from the pump inlet and outlet liquid tubing connectors.
3. Plug liquid outlets as described in the *Remove Pump from Station* section of this document.
4. Dry the pump, double bag it, and seal it in thick polyethylene bags.
5. Return the pump to its original packaging.
6. Include MSDS for the chemical that the pump was handling in the box with the pump.
7. Obtain RMA number from White Knight and write it on the outside of the box.
8. Ship to White Knight following all rules, regulations and laws regarding shipment of dangerous materials. Ship freight pre-paid. No collect shipments will be accepted. Unauthorized use of White Knight shipping accounts will result in the adding of freight to the bill in addition to a service charge.

Include All Pump Components:

Pumps returned to White Knight for evaluation, service or repair must be complete with all components, including but not limited to base plate, mount screws, tubing connectors, tubing connector caps, flare noses, shuttle valves, mufflers, and tubing. Missing parts will be added to the pump and charged to the customer.

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

Decontamination Certification

COMPLETE AND PRINT THIS FORM. IT MUST BE INCLUDED IN YOUR RMA SHIPMENT.

I, the undersigned employee of _____, certify that all decontamination and safety procedures described in Decontamination Instructions section have been followed for return of product below.

RMA#: _____
(*We cannot process returns without **an** RMA number.*)

Serial#: _____
(*We cannot process returns without a product serial number.*)

Metal Exposure:
(*Check all that apply. Write in other metals if necessary.*)

- ☐ **Product was NOT used in a Metal Process.**
- ☐ **Product was used in a Copper Metal Process.**
- ☐ **Product was used in another Metal Process (Non-Copper).**
  - ☐ Aluminum ☐ Cobalt ☐ Gold ☐ Lead ☐ Nickel ☐ Platinum ☐ Silver ☐ Tin ☐ Titanium ☐ Tungsten ☐ Zinc
  - Other: _____

Chemical Exposure:
(*Check all that apply. Write in other chemicals if necessary.*)

- ☐ **Product was NOT used in chemicals (DI Water only).**
- ☐ **Product was used in chemicals.**
  - ☐ Ammonia ☐ Ammonium Hydroxide ☐ Hydrochloric Acid ☐ Hydrofluoric Acid ☐ Hydrogen Peroxide ☐ IPA
  - ☐ Nitric Acid ☐ Phosphoric Acid ☐ Sulfuric Acid Other: _____

Shipping Information:
Please indicate metal processes to which the product has been exposed by clearly and conspicuously labeling the outside of the return package with the metal.

Products exposed to Metal Processes must be sent to the following address:

White Knight Fluid Handling
187 East 670 South, **Suite B**
Kamas, UT 84036

Products NOT exposed to Metal Processes must be sent to the following address:

White Knight Fluid Handling
187 East 670 South, **Suite C**
Kamas, UT 84036

Print Name: _____

Signature: _____ **Date:** _____

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

Barclay-Phelps

CE MARKING SPECIALISTS
Hoi Yuen Road, Kwun Tong, Kowloon, Hong Kong

CERTIFICATE & DECLARATION OF CONFORMITY FOR CE MARKING

Company contact details:
White Knight Fluid Handling Inc.
187 E. 670 S., Kamas, Utah, 84036, USA
Tel: 435-783-6040 Fax: 435-783-6128 Email: Info@Whiteknightpumps.com

White Knight Fluid Handling Inc. declares that their:

Bellows Pump Line
PSA030, PSA060, PSA140, PSH030, PSH060, PSH140, PSU030, PSU060, PSU140, PSA025, PSA050, PFA030, PFA060, PFA140, PFH030, PFH060, PFH140, PFU030, PFU060, PFU140, PXA030, PXA060, PXA140, PXH030, PXH060, PXH140, PXU030, PXU060, PXU140

Diaphragm Pump Line (Non Conductive)
PSD04TE, PSD06TE, PSD08TE, PSD16TE, PSD24TE, PSD04UH, PSD06UH, PSD08UH, PSD16UH, PSD24UH

Diaphragm Pump Line (Conductive)
PSD04TC, PSD06TC, PSD08TC, PSD16TC, PSD24TC, PSD04UC, PSD06UC, PSD08UC, PSD16UC, PSD24UC

Legacy Pump Line
PLS30, PLS60, PLS120, PLX30, PLX60, PLX120, PX30, PX60, PX120, PLF30, PLF60, PLF120

Metering Pumps
PPM100, PEM100, PEM050

are classified within the following EU Directives as applicable:
Machinery Directive 2006/42/EC
Low Voltage Directive 2006/95/EC
Electromagnetic Compatibility Directive 2004/108/EC

and further conform with the following EU Harmonized Standards as applicable:
EN 809:1998+A1:2009 EN 60204-1:2006 + A1:2009
EN 61000-6-2:2005 EN 61000-6-4:2007+A1:2011

Dated: 05 September 2014
Position of signatory: Vice President
Name of Signatory: David Michael Simmons
Signed below: on behalf of White Knight Fluid Handling Inc.


WK
WHITE
KNIGHT®