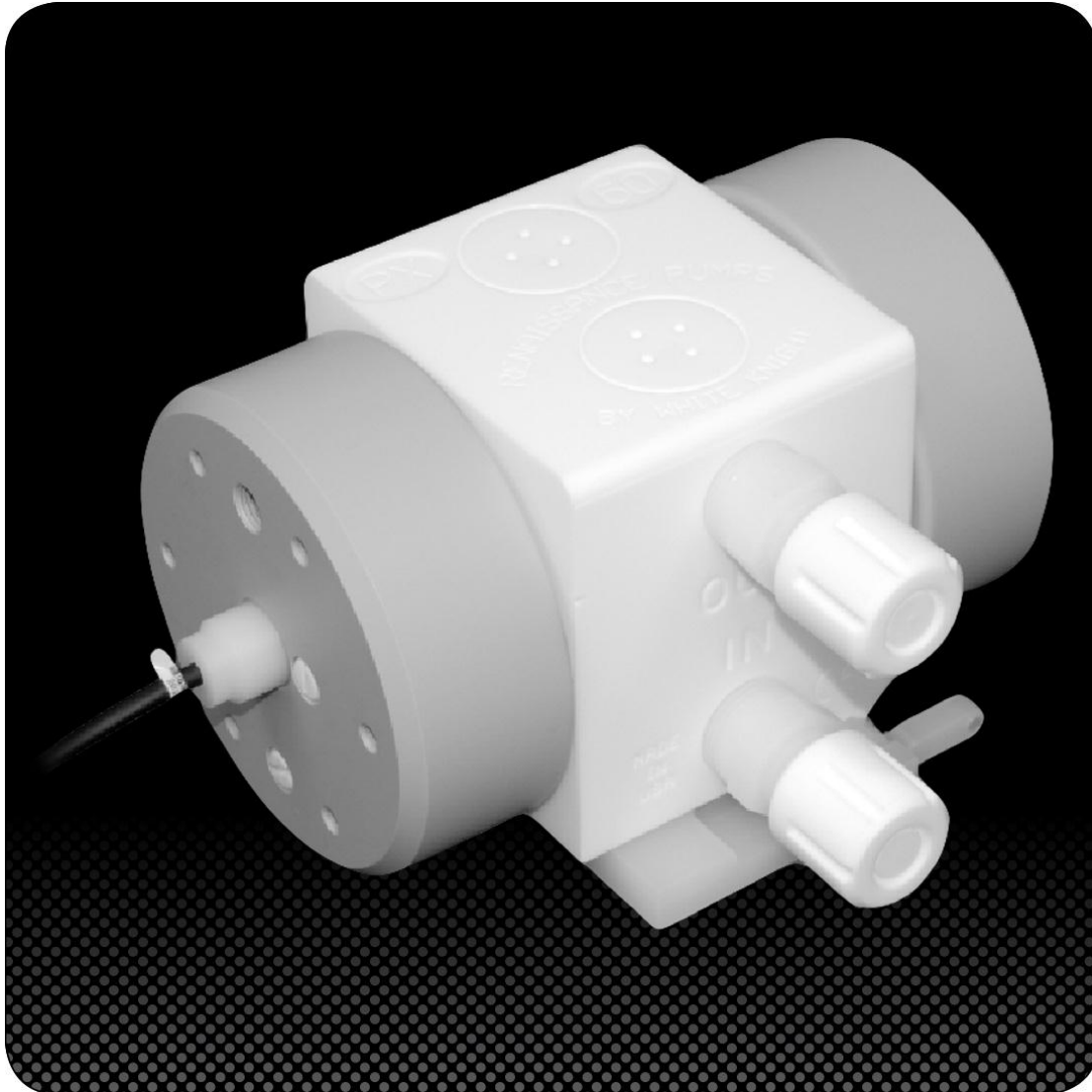


WHITE KNIGHT

PLF60 Owner's Manual



**WHITE
KNIGHT™**

White Knight Fluid Handling Inc.

187 E 670 S Kamas, Utah 84036 USA

Phone 435.783.6040 • Fax 435.783.6128 • Toll Free 888.796.2476

wkfluidhandling.com

TABLE OF CONTENTS

Recommended Mode of Installation	4
When Replacing a Competitor's Pump	8
Cautions on Installation	10
Exploded View	11
Installation Instructions	12
Leak and Stroke Detect Port Locations	13
Fiber Optic Calibration Procedure	14-16
Footprint	17
Flow Curves	17
Air Consumption	18
Air Supply Pressure to Temperature Limits	18
Rebuild Information and Options	19
Trouble Shooting	19
Decontamination Instructions	20
Ordering Instructions for PLF60 series pumps	21-23
Rebuild Service or Kit Ordering Instructions	24
Warranty	25
Pulsation Dampening	26-29
Other Accessories	30
Electronic Accessories	31
Decontamination Certificate	32

Pricing and other information contained within this owner's manual is subject to change without notice.

Congratulations!

You are about to install a pump that has become legendary in the high purity chemical pumping industry. White Knight is a leader in no metal high purity pumps and continues to drive the industry with new technology. Since the inception of White Knight in 1995, we have been awarded an impressive 10 US patents for our designs, with multiple other foreign and domestic patents pending! Currently, White Knight produces over 20 size/model combinations of zero metal high purity pumps, far more than any other producer of high purity pumps anywhere. That equates to an average of over three new pumps per year! White Knight has also been the recipient of multiple prestigious industry awards for its designs.

Other than PLFA tubing and a few ceramic and electronic assemblies and components, all parts of White Knight pumps are manufactured right here at our plant in Kamas, Utah. This allows us to be rigorous in our quality assurance process where almost all processes are performed right here at White Knight. White Knight molds its own PTFE and machines all of its own PTFE, PLFA, and plastic components. This ensures that strict cleanliness procedures are always followed and that components are built under consistent methods and conditions to make our products as reliable and consistent as possible.

Your new pump was assembled and tested in a class 100, temperature and humidity controlled cleanroom. It successfully underwent a battery of tests and was then dried out and double bagged in the cleanroom to ensure cleanliness and its operational integrity.

Before installing your White Knight pump please carefully review this owner's manual. There are many helpful hints and ways to optimize the installation of your White Knight pump as well as instructions and requirements for installation and use.

White Knight also provides many accessories that will enhance the abilities of your White Knight pump. Many of these are briefly described in this manual.

We have gone to great lengths to provide you with what we believe to be not only the best value for the money in high purity pumps, but the best high purity pump period. We hope that you agree.

John Simmons
President, White Knight Fluid Handling, Inc.

Recommended Mode of Installation New System Design

The following is an attempt to go over some basic physics of White Knight pumps so that care may be taken in the design phase of equipment or applications wherein White Knight pumps are used. Following the principles described in this document will ensure the most practical and reliable installation of White Knight pumps, though it is understood that the ideal mode may not always be possible.

Several principles should be understood before proceeding.

- **SUCTION LIFT:** Any air driven pump pushes better than it lifts. This means that if you have to move liquid up ten feet, that the pump will move more liquid faster (and in most cases the pump will be more reliable) if the pump is installed at liquid level and is allowed to push the liquid up the ten feet. Rather than being installed at the ten foot level to lift liquid up to the delivery level. The same should be said for long runs. The best installation is with the pump as near the source as possible.
- **RESTRICTION OF LIQUID INLET LINE:** Restricting the liquid supply of the pump causes the pump to work harder and should be avoided when possible, particularly in the event of pumping more viscous liquids.
- **UNDER SUPPLY OF OPERATIONAL AIR:** Under supplying of air to an air driven pump can cause a pump to run erratically. Air driven pumps vary throughout the cycle as to how much air they require. Though the rate of air usage is averaged for air usage charts, if the bare minimum air supply (as shown on the charts) is provided, there are fractions of seconds during a cycle where a pump would be “starved” for air. This could cause a pump to run erratically or to stall. In many instances, it could effect the ability of the pump to self-prime. White Knight publishes the size of air line orifice for all of its pumps to avoid this situation. These sizes are listed on the “Warning” sheet shipped out with every pump and included in this manual.
- **DRY RUNNING:** While the consequences vary from model or brand of air driven pump, it is always best to limit the amount of dry running that the pump is required to perform. The worst case is in the instance of pumps with wetted shafts such as the White Knight AT, AP, APLFM, and Renaissance series as well as some other brands of air driven pumps. Pumps with wetted shafts use the liquid that they are pumping to lubricate the shaft and seals. When these pumps are run dry, they are not receiving sufficient lubrication to keep abnormal wear from the shaft and/or seal. When this occurs, the pump gradually loses its ability to self-prime. It is White Knight’s recommendation that all air driven pumps with wetted shafts be installed in a flooded style (with gravity feeding liquid to the pump). This does not mean that the pump *must* be installed in a flooded style, remember that we are talking about “ideal” conditions. It should also be understood that when any air driven pump is running dry, it is cycling faster than it would be if it were pumping liquid. This means that in the same amount of time, a pump running dry will achieve a higher number of cycles

against its life expectancy than a pump that is pumping liquid, thereby shortening (in time) the life of the pump.

- **HEAD PRESSURE:** While some air driven pumps common to the high purity chemical industry limit the percentage of head pressure (amount of liquid line pressure that the pump is pumping against) to air supply pressure, no White Knight pumps are restricted in any such way. White Knight pumps can be installed in any head pressure situation up to dead head (liquid line pressure equaling air supply pressure, which equates to no flow). White Knight pumps come standard to work in high back pressure situations. For applications where high head pressures are needed the Renaissance series of pumps are recommended as they are capable of running at air pressures of up to 100 PSI.
- **DEAD HEAD:** Though some air driven pumps in the industry do not allow it, White Knight pumps can actually be controlled by opening and closing the outlet line of the pump.
- **CLOSED OR PLUGGED LIQUID INLET LINE:** Air driven pumps should not be controlled by closing the liquid inlet line to the pump. This causes undue stress on bellows or diaphragms, and in many cases can cause a pump to “race” thereby subtracting cycles from its life expectancy at an alarming rate.
- **ORIENTATION:** While it is possible to install air driven pumps in other than up right positions in flooded suction circumstances, it is not recommended. Check valves within White Knight pumps are actuated by gravity and/or flow. Therefore, a pump installed in the upright position would run more efficiently than a pump that was installed in another way. A White Knight (and most other air driven pumps in the high purity chemical industry) will not prime themselves if installed in any way other than upright (within a few degrees).
- **THERMAL CYCLING:** Some pumps in the industry have limits on or special maintenance requirements for pumps in conditions that thermal cycle. No White Knight pumps have special requirements for thermal cycling applications, but pumps must be operated within their respective temperature to pressure limitations.
- **SUPPLY PRESSURE RECOMMENDATIONS:** While all manufactures of air driven pumps set a limit (red line) on how much air pressure can be used for pump operation, it is always best to operate a pump at lower than red line supply pressures. Life expectancy goes up as supply pressure goes down. The life of many air driven pumps goes up significantly if the pump is operated at between 60%-70% of red line pressures, particularly in open loop systems where there is very little head pressure to slow pump cycling.
- **PASSING SOLIDS:** In any instance where pumps are installed in an application where solids could be introduced into the liquid, a pre pump filter such as the White Knight **Catcher™** should be installed in the inlet line going to the pump. These pre pump filters are designed to catch solids before they get to the pump where they

could damage bellows, diaphragms, or other parts of the pump. Of particular concern are shards from broken wafers in semiconductor manufacturing. Care should be taken in selecting the pre pump filter. Some pre pump filters have a very fine screen that screens out anything that could damage a pump, but screens this fine come with other problems. Some chemistries including but not limited to sulfuric acid and phosphoric acid can begin to produce crystals similar in size and shape to table salt crystals. Such crystals can plug up the screen and cause undue stress to the pump, particularly to bellows or diaphragms. White Knight does not cover such damage under warranty. While there is no perfect size of screen that keeps out the bad without plugging up, the best scenario is to use White Knight **Catcher™** pre pump filters. With the **Catcher™** the screen is large enough to keep from becoming plugged in normal industry conditions. And, when a **Catcher™** is used in conjunction with a White Knight pump, if a solid passes through the **Catcher™** and damages the pumps (very unlikely) White Knight will repair the pump under warranty.

- **OVERSIZED INLET LINE:** White Knight (as well as many other air driven pumps) are best installed with liquid inlet lines larger than the liquid outlet lines, particularly in open loop systems where there is very little head pressure. This reduces strain on bellows and diaphragms and also in many cases reduces surge in the outlet line from the pump.
- **PULSATION:** White Knight pumps are famous for the low surge created in outlet lines down stream from the pump. However, there are things that can be done to reduce surge even further. White Knight offers **Flatliner™** Pulsation dampeners in various sizes to minimize surge created by air driven pumps. In open loop systems where there is very little head pressure, most White Knight customers find it unnecessary to use additional pulsation dampening devices, however, as head pressure increases, the requirement for pulsation dampening increases. A less expensive way to lessen pulsation in the outlet line is by the usage of a “stand tube”. This is accomplished by installing a Tee in the outlet line from the pump. The Tee is pointed upward and a piece of tubing (typically 3-4 feet long) is stood up and capped. As the pump runs, the liquid pressure in the line compresses the air in the stand tube during the pressure part of the pump stroke and the compressed air in the stand tube pushes liquid back into the line during the shift part of the pump cycle. These stand tubes are pretty effective, however, they must be monitored and from time to time the cap may need to be removed to allow the tube to release liquid and refill with air.
- **LEAKY LINES:** All liquid tubing connectors upstream and downstream from the pump should be tight and leak proof. But on the inlet side of the pump, a leak may not be noticed, as if the leak is sufficiently large, the pump will simply not prime. Select a quality type of liquid connection throughout your system and make sure that they are installed properly.
- **BOILING LIQUID:** In the event of pumping chemistries at or near their boiling point, it must be remembered that the boiling temperature of any liquid reduces under

vacuum conditions. As a pump sucks liquid into it, the liquid in the supply line to the pump is under a vacuum condition. Depending on the amount of vacuum and the temperature of the liquid, liquid could boil in the outlet line of the pump when it is not boiling in the tank (or other supply reservoir). Placing the pump as close as possible to the tank and with as little vertical lift as possible (the pump being flooded by gravity is ideal) minimizes boiling in the inlet line. Boiling of the liquid in the inlet line causes a pump to “race” thereby shortening its life, and in extreme circumstances will cause the pump not to prime.

- **FLAMMABLE SOLVENTS:** High purity pumps are frequently used to pump flammable solvents. Any system used to pump flammable solvents should be properly grounded to avoid ignition by static charge. Where high purity pumps are constructed from insulative materials (PTFE and PLFA) grounding the pump is not sufficient. A test from River’s Edge on using insulative pumps to pump flammable liquids indicated that the liquid itself must be grounded and that other procedures should be followed. A copy of the test is available from our web site or may be acquired by calling or emailing us at White Knight. Designs planning the use of any insulative type pump for use with flammable solvents should only be done by those having proper training and understanding of the effects of static electricity buildup in such systems.
- **CLEAN SUPPLY AIR:** White Knight (as well as many other high purity air driven pumps) require the use of CDA (Clean Dry Air) (Solids: No more than 1PPM with size no more than 1.0um Moisture: No more than 1PPM Oils: No more than 1PPM) or nitrogen. Use of supply air that does not meet these specifications could result in close tolerance parts of the pump shifting mechanisms to seize.
- **ABRASIVE SLURRIES:** Pumping of abrasive slurries will shorten the life of any pump. Pumps are still warranted when used in abrasive applications, however components that wear with use, will wear faster. Normal wear is not a condition covered by warranty.
- **CROSS CONTAMINATION:** When replacing pumps in existing systems, care should be taken to avoid cross contamination. PTFE (and for that matter all plastics as well) are porous. As a high purity pump is run in a chemistry, that chemistry is retained in the pores of the material. This situation is increased if the pump is used in a thermal cycling application. This being the case, care should be taken to keep a record of which pumps (White Knight and most other high purity pump suppliers serial number each pump) have been in which chemistries and then should be used only in the same chemistry to avoid cross contamination.
- **PUMP MONITORING:** Pump monitoring can be performed by several methods such as Fiber Optic stroke detection (special pump heads required) or Solid State Pressure Switch monitoring which can be installed on any White Knight pump. These options are described on our web site in the options section and are available through our authorized distributors.

- **LEAK DETECTION:** Several types of leak detection are also available from White Knight including **Bubble In – Bubble Out™** and fiber optic air side leak detection. These products are also described on our web site and are available through our distributors.
- **PROGRAMABLE CONTROLLING:** White Knight has developed the *Merlin™* pump controller that can be used to program a White Knight pump. Run time and volume “recipes” can be programmed into the *Merlin™* to control any White Knight pump.

Things to Watch For When Replacing Our Competitor’s Pumps

- **AIR UNDERSUPPLY:** Some other air driven pumps used in pumping high purity chemistry are not as sensitive to air under supply as the White Knight pumps are. Make sure that if you are replacing a competitor’s pump with a White Knight pump that the proper sized air line is used. This information is contained on a page called “warning” which is sent out with every White Knight pump, is included in this manual and is also available from our web site.
- **INLET/OUTLET CONFIGURATION:** Most other air driven pumps used in high purity applications are very particular in their connections to liquid inlet and outlet for the pump. Many configurations are available on all White Knight pumps and in most cases we can attach to liquid lines in a very similar orientation and connection type as the pump that you have been using. A list of options is available in the ordering section of this manual and on our web site under ordering instructions for each of our respective pumps, or contact a White Knight representative for assistance.
- **PUMP MONITORING AND TRANSLATION:** Many tools monitor a pump while it is running and have alarms set for when pumps cycle too fast or too slow, which could indicate a problem. White Knight pumps can use several types of monitoring that provide a signal back to the tool that allows monitoring of the White Knight pump. The problem is that no two brands or models of pumps have the same displacement per stroke. This means that if upper or lower limits are set in a monitoring system and a different brand or model of pump is installed, that alarms could be immediately thrown. There are two ways to overcome this problem. First of all, the alarms set in the tool or its monitoring system can be reprogrammed. The biggest problem with this option is that many times if a tool is upgraded with manufacturer’s software later on the alarms are re-set. This can also cause problems with the same tools in one area running different pumps, especially in the event of a gradual change out. Different tools with different needs for programs can become hectic. Because of this, White Knight developed *Merlin™* pump translators. *Merlin™* pump translators are programmable at the White Knight factory or by the user with the purchase of an additional kit. The *Merlin™* pump translators are capable of converting output to a fractional derivative of actual operation based on displacement in order to provide

monitoring information back to tool similar to what signals would have been with other pump of different displacement at similar flow. This eliminates the need for reprogramming alarms in most instances.

- **PULSATION DAMPENING:** When replacing one of our competitors' pumps for reasons of potential metal contamination take care to eliminate any other source of potential metal contamination that you can. In many instances when replacing a competitive pump with a White Knight, pulsation dampeners that have been required before are no longer needed due the low pulsation created by White Knight pumps. If this is the case, remove any pulsation dampeners that have metal parts in them and discard them. If pulsation dampening is still required, replace the pulsation dampener with a zero metal pulsation dampener such as the White Knight **Flatliner**[™] pulsation dampener.
- **PASSING SOLIDS:** Make sure that if there is a potential for solids (such as wafer shards) to be introduced into the liquid that the pump will be pumping that a suitable pre pump filter such as the White Knight **Catcher**[™] is installed. White Knight warrants all White Knight pumps against passing solids when used in conjunction with a **Catcher**[™].
- **AIR VALVE AND REGULATOR NEEDS:** Double check to make sure that all air regulators and solenoid valves are sufficiently sized to run the White Knight pump that you are installing.

WARNING

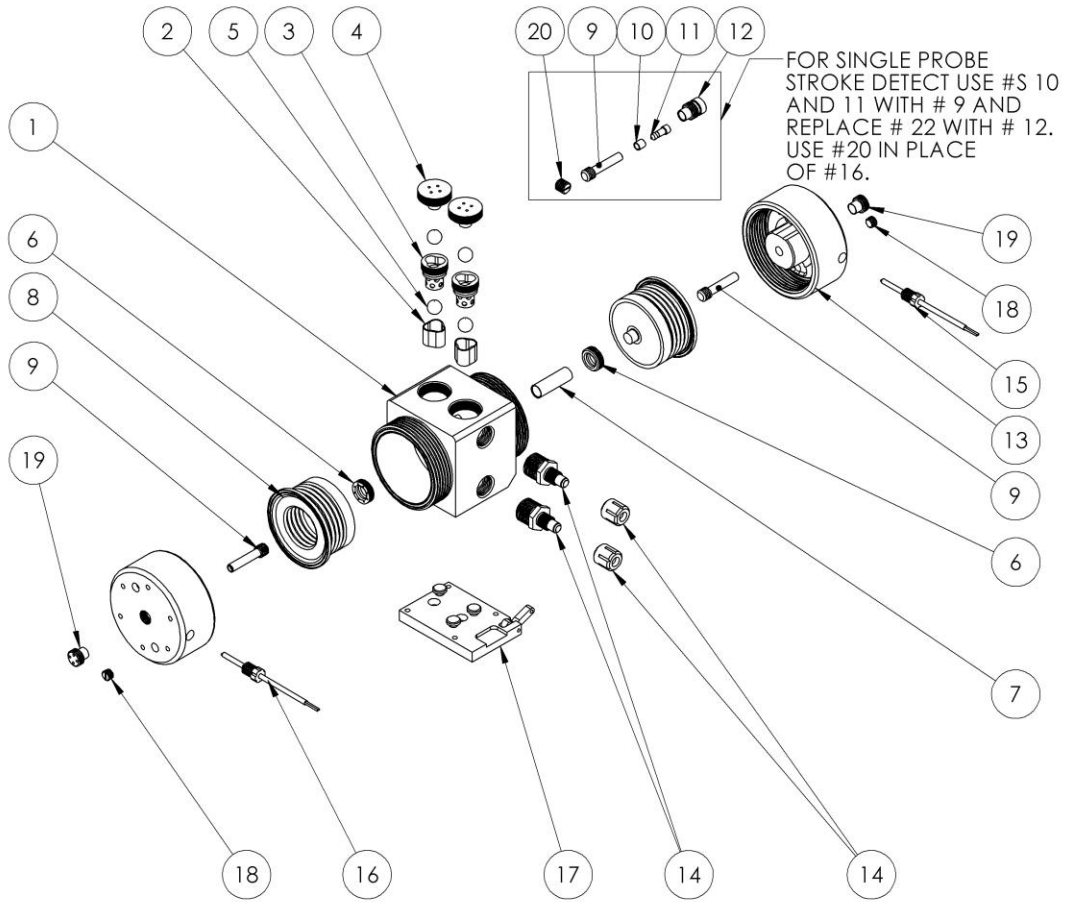
- ◆ **DO NOT LIFT PUMP BY SHUTTLE VALVE ASSEMBLY!**
Damage may occur to mounting system.
- ◆ Required air flow for the AT/AP50/PLF/PL/PX30 pneumatic shuttle is 3/16" minimum orifice unrestricted.
Required air flow for the AT/AP100 pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the PLF/PL/PX60 pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AP200 pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AT/AP300 pneumatic shuttle is 3/8" minimum orifice unrestricted.
Required air flow for the PLF/PL/PX120 pneumatic shuttle is 3/8" minimum orifice unrestricted.
- ◆ Required air flow for the AP50FM pneumatic shuttle is 3/16" minimum orifice unrestricted.
Required air flow for the AP100FM pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AP200FM pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AP300FM pneumatic shuttle is 3/8" minimum orifice unrestricted.
- ◆ Required air flow for the AT/AP25EXT2 pneumatic shuttle is 3/16" minimum orifice unrestricted.
Required air flow for the AT/AP50EXT2 pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AP100EXT2 pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AT/AP100EXT3 pneumatic shuttle is 3/8" minimum orifice unrestricted.
- ◆ Required air flow for the AP25FMEXT2 pneumatic shuttle is 3/16" minimum orifice unrestricted.
Required air flow for the AP50FMEXT2 pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AP100FMEXT2 pneumatic shuttle is 1/4" minimum orifice unrestricted.
Required air flow for the AP100FMEXT3 pneumatic shuttle is 3/8" minimum orifice unrestricted.
- ◆ Do not operate any White Knight® pumps above the "air supply/fluid temperature limitations" (see chart for specifications) or 60psi static in ambient applications on all versions of AP and AT series pumps.
- ◆ Minimum operating pressure is 20psi.
- ◆ Tubing connectors supplied by White Knight must be used on the inlet and outlet ports of the pump. **THESE PORTS ARE NOT NPT OR ANY OTHER STANDARD.** Attempting to use connectors other than ones supplied by White Knight will damage the pump. Such damage is not covered under warranty. Many styles of connection are available. If your pump does not have the style of connector that you desire, please contact White Knight for other options.
- ◆ **BE FAMILIAR WITH WHITE KNIGHT® PUMP INSTALLATION INSTRUCTIONS.**
White Knight® pump installation requirements may vary from requirements of other pneumatic pumps.

If you are in need of any of the above mentioned literature please contact us by one of the following:

Toll free : 888.796.2476 Phone : 435.783.6040 Fax : 435.783.6128

E-mail : customer.support@wkfluidhandling.com Web site : wkfluidhandling.com

PLF Series Pump Exploded View



PLF60 Bill Of Materials							
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.	ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	1125-TE-0014	Pump Body	1	11	8150-TE-0002	Fiber Optic Stem Extension	1
2	4135-TE-0002	Bottom Check Seat	2	12	8100-PF-0002	Extended Fiber Optic Stroke Cap (Single Probe Dual Detect Mode)	2
3	4142-TE-0003	Top Check Cage	2	13	2127-EP-0011	Pump Head	2
4	4140-TE-0002	Top Check Plug	2	14	14510-TE-0005	Flaretek® Compatible Assembly	2
5	4100-TE-0002	Check Ball	4	15	14700-XX-0005	Fiber Optic Stroke Detect Assembly(Single Probe Stroke Detect Mode)	1
6	5143-TE-0003	Shaft Seal	2	16	14700-XX-0005	Fiber Optic Stroke Detect Assembly (Dual Probe Stroke Detect mode) Replace with a 5/8" NPT Plug When Not In Use.	1
7	5144-PF-0002	Shaft	1	17	14200-NP-0002	Base Plate Assembly	1
8	3130-MP-0022	Bellows	2	18	10040-TE-0003	NPT Plug-1/4"	2
9	8140-TE-0002	Fiber Optic Stem	2	19	8100-PF-0004	Stroke Detect End Cap	2
10	8160-BP-0002	Fiber Optic Target	1	20	10040-TE-0007	5/8" NPT Plug	1

PLF60 Installation Instructions

- ◆ The PLF60 base plate is designed to be mounted with two 3/8" or two 10mm socket head cap screws spaced 2.000" apart.
- ◆ Remove the base plate (18) from the pump by lifting the lever lock base plate lever and sliding the pump (1) forward then lifting it off of the base mount knobs on the base plate (18).
- ◆ Install base plate (18) into work station by tightening it down with two 3/8" or two 10mm socket head cap screws, screwed into previously drilled and tapped mating holes at a 2" hole distance.
- ◆ Place the pump assembly (1) onto the mating base mount knobs of the base plate (18) the lever lifts up automatically. Slide the pump assembly (1) back and the lever drops to hold the pump in place.
- ◆ Affix PLFA thick wall tubing to fluid connectors without wrenches, hand tighten only. Installation of lines is: intake on bottom; discharge on top. If pump is equipped with Synchro flare fittings, use standard flaring procedures.
- ◆ Hook up 2 each 1/4" NPT fittings to the top 1/4" FNPT ports on the left and right pump heads (10,11) attaching a minimum of 3/8" tubing . Air supply must be 1/4" minimum orifice (1/4" unrestricted air flow) back to supply source.
- ◆ If Leak or Stroke detect options have been selected for pump see below picture for hook up instructions.
- ◆ Minimum operating pressure of 20psi. Maximum operating pressure of 100psi. Check temperature to air supply charts for exact maximum allowable air supply pressure.

CAUTION: AIR SUPPLY MUST BE 1/4" MINIMUM ORIFICE (1/4" UNRESTRICTED AIR FLOW) FROM SUPPLY SOURCE TO PUMP.

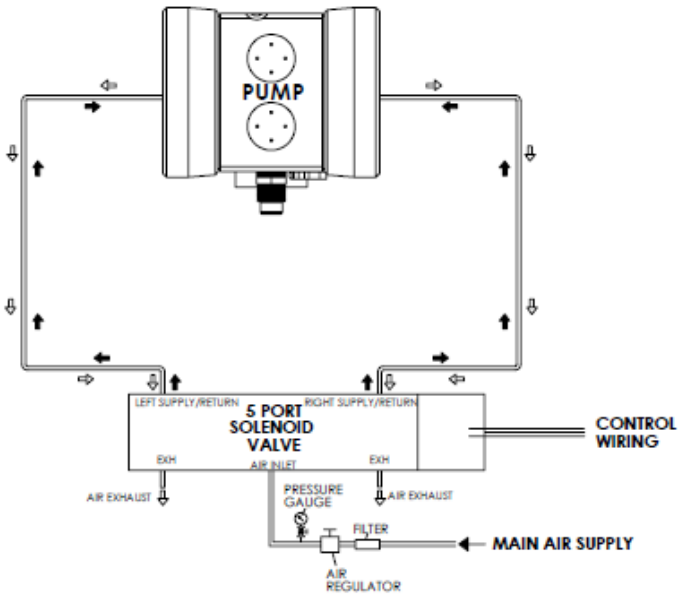
Problems or Questions, call toll free:

888.796.2476

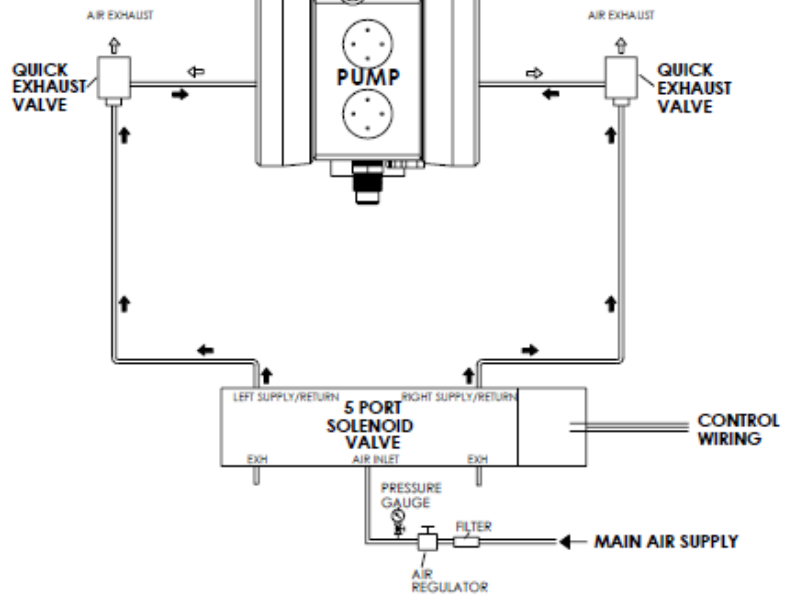
Or 435.783.6040

PLF60 Air Connection Instructions

No Quick Exhaust

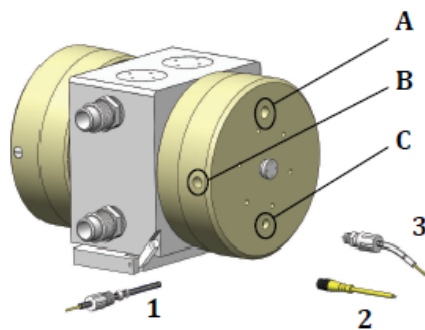


With Quick Exhaust



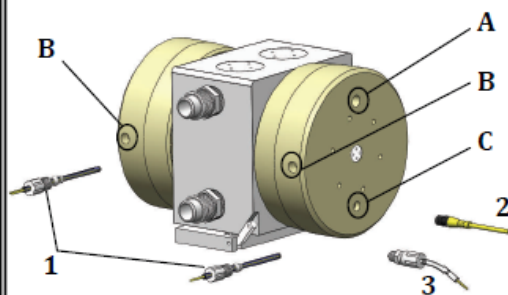
PLF60 Optional Connections

Single Probe, Dual Detect



Pump Head

Dual Probe, Single Detect



Options

A: Air Supply Port—connect to air source (1/4" NPT for PF30 and PF60, 3/8" NPT for PF120)

B: Fiber Optic Stroke Detection Port (See #1)

C: Optional Leak Detection Port—Can be used with either Fiber Optic or Conductivity sensors—This port will be plugged with 1/4" NPT plug when not in use

1: Fiber Optic Stroke Detection Assembly

2: Conductivity Leak Detection Cable

3: Fiber Optic Leak Detection Assembly

PLF Fiber Optic Calibration Procedures

The PLF Series of pumps are external solenoid valve oscillated with fiber optic sensors used as end of stroke detection. There are two types of fiber optic end stroke detection available. The first is, Standard End Stroke Detection. The second is, Single Probe Dual Detect.

Standard End Stroke Detection

Standard End Stroke Detection consists of two fiber optic probe/cable assemblies which are manufactured and supplied by White Knight and 2 fiber optic sensor/amplifiers which can either be supplied by White Knight or by the integrator.

White Knight recommends a sensor/amplifier which has an adjustable threshold such as the Banner D10 Series.

For Standard End Stroke Detection each of the two bellows is monitored by a single fiber optic probe assembly. The fiber optic probes are attached in a manner which allows them to watch a PTFE piston/target which is firmly attached to the pump bellows. As the bellows is inflated with CDA the bellows is extended up to the point where the piston/target chops the fiber optic beam. As this fiber optic beam is chopped additional light is sent back to the fiber optic sensor/amplifier indicating that the pump has reached the end of its stroke. The PLC or host pump controller should then immediately send a signal to the solenoid valve to stop sending air to this side of the pump and now send air to the other side of the pump. As the air pressure is switched to the opposite bellows the bellows will now travel the opposite direction up to the point where the second fiber optic probe assembly is able to detect the second piston/target and subsequent signal sent. The pump then continues on in this manner oscillating back and forth.

Single Probe Dual Detection

Single Probe Dual Detection consists of one fiber optic probe/cable assembly which is manufactured and supplied by White Knight and 1 fiber optic sensor/amplifier which can either be supplied by White Knight or by the integrator.

White Knight recommends a sensor/amplifier which has an adjustable threshold such as the Banner D10 Series.

For Single Probe Dual Detection one of the two bellows has a special piston/target firmly affixed to it. This special piston/target has an additional black portion followed by an additional PTFE portion added to the end of the piston. The black portion is positioned so that when the pump is centered or in resting position the fiber optic probes sees it. This black portion being much less reflective than the PTFE reflects little light back causing the sensor/amplifier to send no signal.

As either of the bellows is inflated with CDA the bellows is extended up to the point where the black portion of the piston/target passes by the fiber optic eye leaving the highly reflective PTFE portion of the piston/target to send additional light back to the fiber optic sensor/amplifier indicating that the pump has reached the end of its stroke. The PLC or host pump controller should then immediately send a signal to the solenoid valve to stop sending air to this side of the pump and now send air to the other side of the pump. As the air pressure is switched to the opposite bellows the bellows will now travel the opposite direction once again returning the black portion of the piston/target which sends no signal (no light reflection) up to the point where the black portion of the piston/target disappears leaving the highly reflective PTFE portion of the piston/target to send additional light back to the fiber optic sensor/amplifier indicating that the pump has reached the end of its stroke. The pump then continues on in this manner oscillating back and forth.

Fiber Optic Sensor/Amplifier Calibration Procedure

Once the pump has been installed into the system per pump installation instructions noted in Owner's Manual please follow the following steps for calibration of the fiber optic sensor/amplifier.

Step 1: Ensure that the fiber optic probe(s) is/are inserted in the fiber optic probe port(s) of the pump until they are firmly seated on the fiber optic cap(s) and then tighten gripper nut securing probe assembly. Ensure that the other end of the fiber optic cable is mounted flush into the fiber optic sensor/amplifier.

Step 2: Ensure that the air supply pressure for the pump is set to 10-20 PSI. Calibrating of the fiber optic sensor/amplifiers at higher air supply pressures can damage the pump bellows.

Step 3: Ensure that there is no back pressure on the pump outlet and that the pump can pump freely into atmosphere.

Step 4: For Banner D10, hold down the "+" button for two seconds. Now oscillate the pump at 10 Cycles/Minute (3 Seconds/Stroke) while still holding down the "+" button. This will allow the sensor/amplifier to see the lightest conditions, and the darkest conditions present allowing the sensor/amplifier to learn these conditions. After 5 seconds of learning release the "+" button and stop the pump from oscillating. This entire process should take less than 30 seconds. If liquid is not present in the pump this process should not exceed 30 seconds. Running the pump dry for longer than 30 seconds at a time is detrimental to the pump.

If a fiber optic sensor/amplifier other than the Banner D10 is desired to be run with the PLF pumps please contact White Knight.

Step 5: Fiber optic sensor/amplifier is now calibrated and ready to run.

Cautions: When calibrating fiber optic sensors ensure that the pump is operating at very low air supply pressures (between 10 and 20 PSI) to ensure that bellows are not damaged. We recommend calibrating the fiber optic

sensor/amplifier after all cabling has been firmly mounted/affixed. If cabling is to be modified/moved the fiber optic sensor/amplifier should then be re-calibrated.

A 5 port, center position closed, exhaust at center, type solenoid valve should be used. Use of another type of solenoid valve can cause damage to the pump depending on other parameters. A center position closed, exhaust at center type solenoid valve keeps residual air pressure from being built up in pump when the pump is not operating.

Timer/Oscillating with External Solenoid Valve

The PLF Pumps are capable of being run in Timer/Oscillating mode which simply put means; the pump is oscillated via an external solenoid valve at a given cycle rate. The solenoid valve can be provided by customer, White Knight does not manufacture its own solenoid valves

Cautions: Ensure that the pump is always oscillating at a speed fast enough to ensure that the bellows are not crashing into the pump body. The formula for setting this speed is as follows:

First determine the maximum flow rate which the pump will be pumping. If the PLF60 will be run between 2 and 10 GPM we would calculate the stroke (cycle) rate as follows: maximum flow rate 10 **divided by** displacement. 025GPM per stroke (.05GPM per cycle) **equals** 400 stokes (200 cycles). We then multiply this number by 1.25 to give us a 25% safety margin: 400 strokes (200 cycles) **multiplied by** 1.25 **equals** 500 strokes (250 cycles) per minute. To show this as a factor of time we need to take the number of seconds in a minute, 60, and divide it by the stroke (cycle) rate. 60 seconds **divided by** 500 strokes (250 cycles) **equals** .12 seconds per stroke (.24 seconds per cycle). This means that if the maximum flow rate that the PLF60 will see is 10 GPM that the timer setting for this pump should be .12 seconds per bellows.

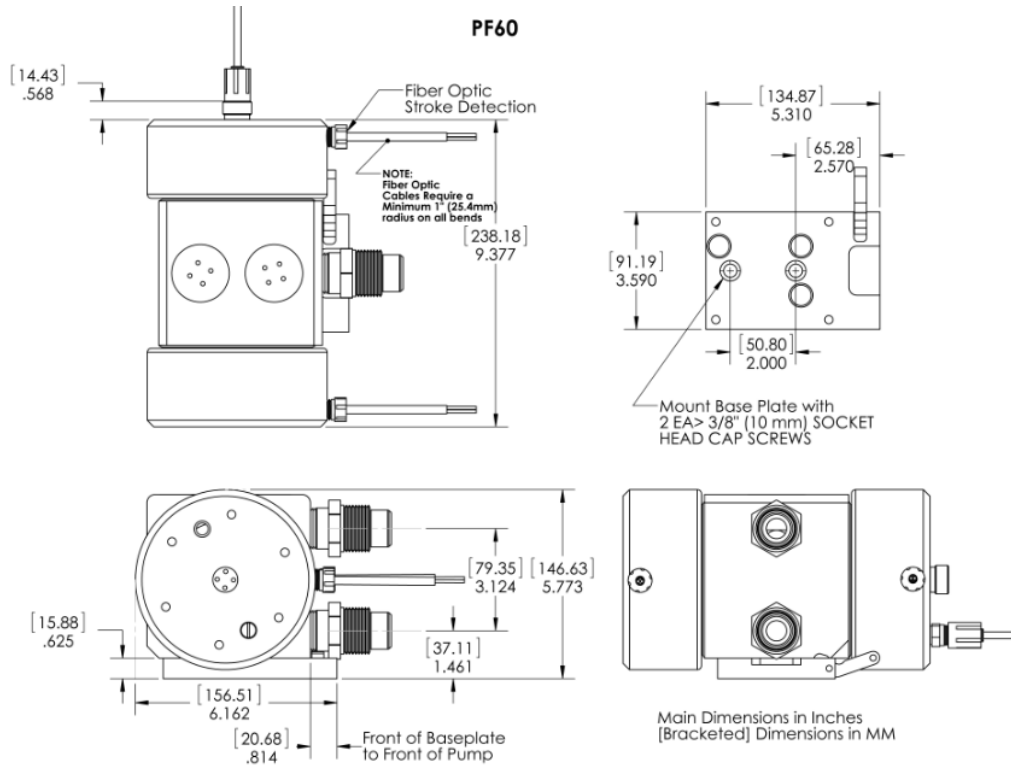
On a side note, the 25% safety margin is there in case you are just guessing the flow rate. If you know for sure what the flow rate is (you have a flow meter in line) then you do not need to add the 25% safety margin. In addition you can always just set the pump at its maximum flow rate and not include a safety margin. For flow rates of 13GPM-17.5GPM this maximum flow rate number can be used. There is no need for a 25% safety margin for these flow rates because the pump is not capable of running more than 17.5 GPM.

Max flow rate Timer Settings:

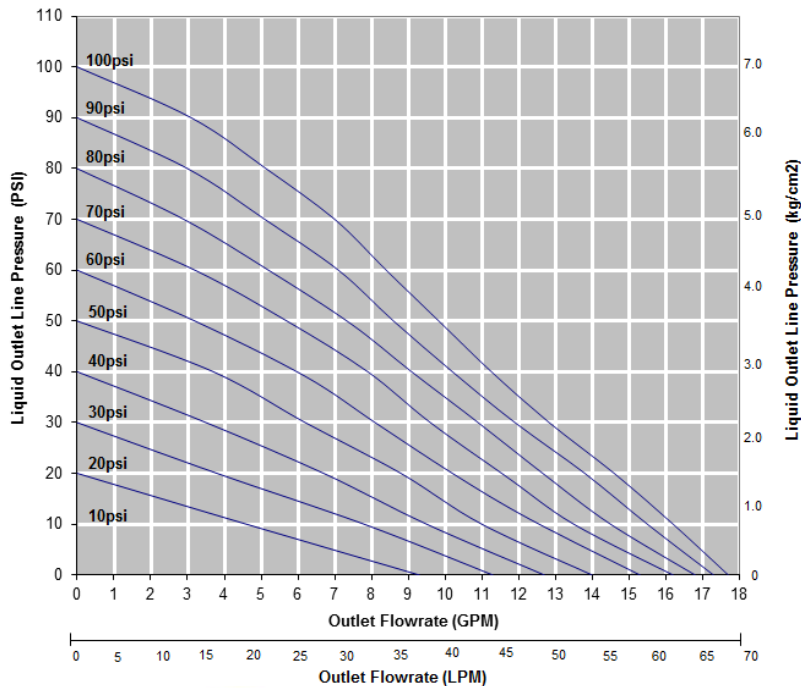
Maximum flow rate 17.5 **divided by** displacement. 025GPM per stroke (.05GPM per cycle) **equals** 700 stokes (350 cycles). To show this as a factor of time we need to take the number of seconds in a minute, 60, and divide it by the stroke (cycle rate). 60 seconds **divided by** 700 strokes (350 cycles) **equals** .086 seconds per stroke (.172 seconds per cycle). This means that the maximum cycle rate for the PLF60 pump should be .086 seconds per bellows. This means that the PLF60 is never at a risk of crashing its bellows into the pump body with a stroke speed of .086 seconds per bellows. In addition there is no need to cycle the pump faster than this stroke speed.

PLF60

PF60



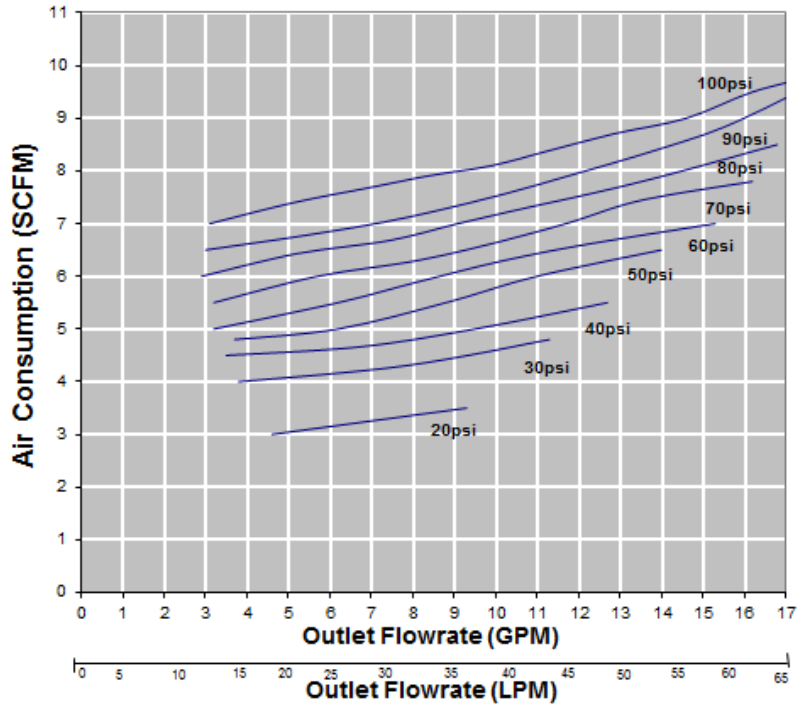
PF60 Head Pressure Line Chart



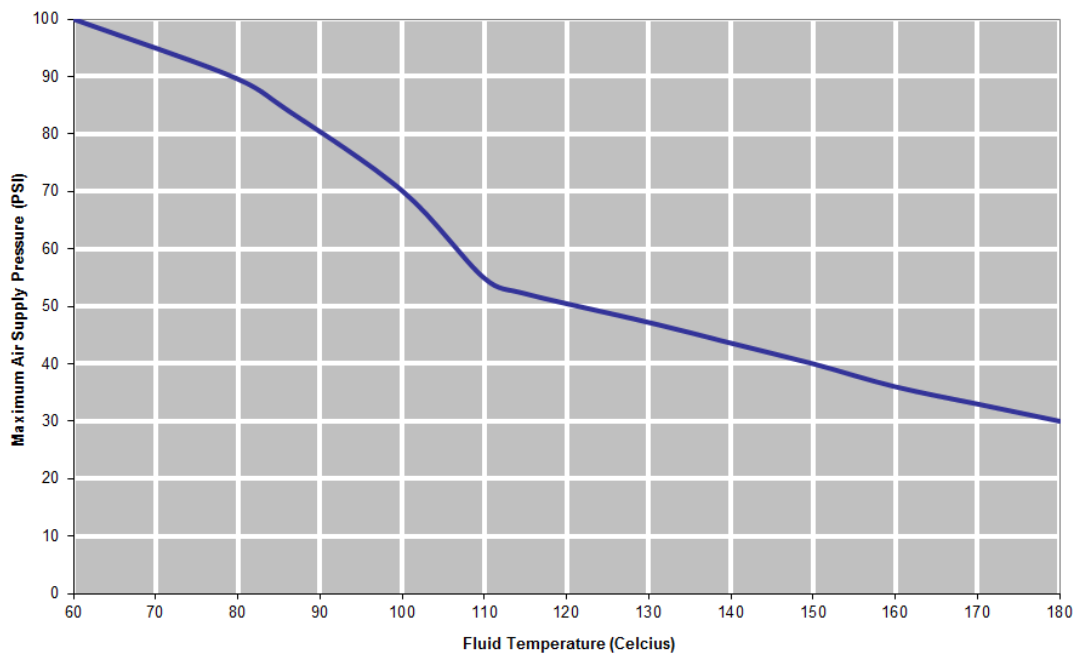
**WHITE
KNIGHT™**

PLF60

PF60 Air Consumption Line Chart



PF60 Air Supply/Fluid Temperature Limitations



Rebuild Information

While an exploded view of this pump is contained within this owner's manual, we felt that including rebuild instructions herein would be insufficient with the other instruments that we have made available. White Knight has provided Virtual Rebuild instructions on our web site where written technical instructions are accompanied by a virtual pump. After reading each technical instruction the reader can click on the instruction and watch the operation performed with a virtual tool on the virtual pump. Please visit our web site at wkfluidhandling.com for a free download of Virtual Rebuild.

Failed or problematic pumps under warranty must be returned to White Knight for warranty coverage. With pumps that are out of warranty White Knight offers four options.

1. Our best recommendation is to return the pump to us at White Knight where the pump will be fully evaluated and you will receive a written quote on rebuilding the pump through our local distributor. If the quotation is accepted and a purchase order granted, the pump will be fully rebuilt and will receive a new warranty (parts and labor) equal to what the pump had when it was new. At White Knight our technicians have more experience rebuilding our pumps than anywhere else in the world. Their vast experience and expertise ensure that the pump will be running at its best when it is reinstalled into the system.
2. Another option that White Knight offers is to train technicians of companies who own White Knight pumps at no charge to maintain and rebuild White Knight pumps. While there is no charge for the two days of training, companies participating in this program are responsible for their own travel and expenses. Persons successfully completing the training course will be given a certificate that certifies them on whichever pumps they are trained to rebuild for two years. White Knight will warranty parts in pumps rebuilt by White Knight certified technicians for the same amount of time that White Knight would have warranted the pump were it rebuilt at White Knight.
3. The third option is made available to companies who are concerned about shipping of pumps back and forth. White Knight has trained a number of third party companies to rebuild pumps. If you are concerned about shipping pumps back and forth to White Knight for rebuilding, please contact us at White Knight to see if there is a certified third party rebuilder in your area.
4. The last option is for you to purchase rebuild kits through your local White Knight distributor (a list of local distributors can be found on our web site at wkfluidhandling.com) and rebuild the pumps on your own without training, though we discourage this practice. But, if this is what you decide to do, please at least download a copy of Virtual Rebuild instructions from our web site.

Trouble Shooting

From time to time we learn of new things to assist in troubleshooting pumps and the systems they run in. Because of this our troubleshooting guide changes from time to time. For an updated version of our troubleshooting guide, please visit our web site at wkfluidhandling.com

White Knight Pump Decontamination Instructions

Attention:

White Knight pumps are designed to pump caustic and otherwise dangerous liquids. Therefore, every pump must be handled as if it contains dangerous chemicals whether or not it actually does. White Knight specifies that if a pump runs under its own power that the pump should circulate DI water for twenty minutes before disassembly or double bagging for shipment. If the pump does not run under its own power, then DI water should be forced from the inlet, through the outlet for 40 minutes before disassembly or double bagging for shipment. Only those who have been adequately trained in safety with and the handling of acids and other dangerous chemicals should attempt to handle a White Knight pump that has been used. Adequate safety gear appropriate for the chemical that has been in the pump must be used/worn and no attempt should be made to handle the pump until Material Safety Data Sheets (here after MSDS) for the chemical that the pump has been used in have been reviewed. Ph Papers, Showers, antidotes, clean-up equipment, neutralizers, and any other safety devices that could be used for detecting, neutralizing or minimizing effects from the chemical described in the appropriate MSDS must be present as well as emergency numbers for use in the event of an accident. Take great care in the handling of liquids and/or residues contained in these pumps or any other chemical handling equipment. Remember, **Safety First**.

Note:

Any pumps returned to White Knight for warranty evaluation or repair must be complete with all parts and components including but not limited to base plates, mount screws, tubing connectors, tubing connector caps, flare noses, shuttle valves, mufflers, and tubing. Any missing parts will be added to the pump and charged to the customer in the event of repair or replacement, warranty or otherwise.

Removal of Pump From Station:

1. Disconnect liquid tubing connectors from the front (opposite the externally mounted shuttle valve) of the pump.
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 using thumb and forefinger but do not completely remove the screw from the base plate.
5. If another White Knight pump of the same model number is to go into the same application the base plates are interchangeable and the base plate in the station would not need to be removed. Otherwise, the base plate should be removed using the proper tool for the fastening devices (not provided by White Knight) used. (usually allen wrenches or flat head screw driver).
6. Return all removed parts to the pump.

Return of Pump to White Knight:

1. After removing the pump from the station the pump must be flushed as described in the attention section of this document.
2. Remaining DI water in the pump should be drained from the inlet and outlet liquid tubing connectors to the greatest extent possible.
3. The pump liquid outlets must then be plugged as described in the removal of pump from station section of this document on line two.
4. Dry off the pump.
5. Double bag the pump **sealing it** in thick polyethylene bags.
6. Return the pump to its original packaging.
7. Include MSDS for the chemical that the pump was handling in the box with the pump.
8. Complete Decontamination Certificate and fax or email to White Knight to begin RMA process.
9. Obtain RMA number from White Knight and write it on the outside of the box.
10. Ship to White Knight following all rules, regulations and laws regarding the shipping 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.

Before Returning a Pump to White Knight an RMA From White Knight is Required. At the end of this manual is a Decontamination Certificate which will need to be filled out and sent back to White Knight. Once this form is received an RMA # will then be issued along with pump return instructions. Requests for RMA#'s may be sent to customer.support@wkfluidhandling.com or faxed to 435.783.6128.

The Following Decontamination and Shipping Instructions Must be Followed.



Ordering Instructions PLF60

White Knight Pumps have many options and configurations to make them as versatile as possible for our customers. With this versatility comes the trouble of a part numbering system that makes it reasonably easy to order pumps, retrieve part numbers and recognize the numbers as pumps are in the field. For this reason, we have devised the following part numbering system.

All White Knight pump part numbers will begin with the model number (in this case PLF60). The prefix will then be followed by a series of letters and or numbers. Each letter or number will designate the configuration of a certain part of the pump.

The following is a list of those areas, their options, and the letter or number specifying the specific option. Choose an option for each of the 8 spaces and add the appropriate value to the Pump List Price. The standard dash letters are in large bold type.

PLF60-____-____-____-____-____-____-____-____

Area:	Option:	Letter:
Check Valve Configuration (First number of suffix optional)	Ball, PTFE	2
	High-Flow Ball, Co-Polymer	3
Liquid Inlet Configuration (First letter of suffix)	Front, Straight	A
	Front, Ell	B
	Front Straight Catcher II Prefilter	C
Liquid Outlet Configuration (Second letter)	Front, Straight	A
	Front, Ell	B
	Top, Straight	C
	Top, Ell	D
Liquid Inlet Connection Style (Third letter)	3/4" Synchro-Flare	A
	1/2" Synchro-Flare	B
	1" Synchro-Flare	C
	1/2" fnpt	D
	3/4" fnpt	E
	1" fnpt	F
	1/2" Kurabo Finalock®*	J
	3/4" Kurabo Finalock®*	K
1" Kurabo Finalock®*	L	

1/4" Tubing Out	M
1/2" Tubing Out	N
3/4" Tubing Out	O
Blank	P

(This is not an NPT or any other standard, a fitting provided by White Knight Fluid Handling, INC is required in order to make any connection to the pump)

1/2" Flaretek® Compatible	Q
3/4" Flaretek® Compatible	R
1" Flaretek® Compatible	S
1/2" PureBond®	T
3/4" PureBond®	U
1" PureBond®	V
1/2" Pillar Super 300®	W
3/4" Pillar Super 300®	X
1" Pillar Super 300®	Y
1" Tubing Out	Z
1 1/4" Tubing Out	1A
1 1/4" Flaretek® Compatible	1B
1 1/4" Pillar Super 300®	1C
3/4" SMC LQ3®	1D
1" SMC LQ3®	1E

*These options require the appropriate nut and ferrule and are NOT supplied by White Knight Fluid Handling, INC

Liquid Outlet Connection

Style

(Fourth letter)

3/4" Synchro-Flare®	A
1/2" Synchro-Flare®	B
1" Synchro-Flare®	C
1/2" fnpt	D
3/4" fnpt	E
1" fnpt	F
1/2" Kurabo Finalock® *	J
3/4" Kurabo Finalock® *	K
1" Kurabo Finalock® *	L
1/4" Tubing Out	M
1/2" Tubing Out	N
3/4" Tubing Out	O
Blank	P

(This is not an NPT or any other standard, a fitting provided by White Knight Fluid Handling, INC is required in order to make any connection to the pump)

1/2" Flaretek® Compatible	Q
3/4" Flaretek® Compatible	R
1" Flaretek® Compatible	S
1/2" PureBond®	T
3/4" PureBond®	U
1" PureBond®	V
1/2" Pillar Super 300®	W
3/4" Pillar Super 300®	X
1" Pillar Super 300®	Y
1" Tubing Out	Z
1 1/4" Tubing Out	1A
1 1/4" Flaretek® Compatible	1B

1 1/4" Pillar Super 300®	1C
3/4" SMC LQ3®	1D
1" SMC LQ3®	1E

*These options require the appropriate nut and ferrule and are NOT supplied by White Knight Fluid Handling, INC

Stroke Detection

(Fifth letter)

Dual Fiber Optic (No probe/sensors) A

Dual Fiber Optic (PNP) Sourcing	B
Dual Fiber Optic (NPN) Sinking	C
Dual Fiber Optic (No sensors)	D
Single Probe Dual Detect (No probe/sensors)	E
Single Probe Dual Detect (PNP) Sourcing	F
Single Probe Dual Detect (NPN) Sinking	G
Single Probe Dual Detect (No sensors)	H

¹(Should not be used for explosion proof environment)

Leak Detection

(Sixth letter)

No Leak Detection A

Fiber Optic (PNP) Sourcing	B
Fiber Optic (NPN) Sinking	C
Fiber Optic (No sensors)	D
Conductivity ¹	E

¹(Should not be used for explosion proof environment)

Pulse Dampener

(Seventh letter)

No Pulse Dampener A

EQ100 (Air-run) Pump mount	B
EQ100 (Air-run) In-line ¹	C
SL100 (Passive) In-line ¹	D
AL60 (Air-run) In-line ¹	E

¹ (Fittings same as pump outlet)

Old rev level

(Eighth letter optional)

Specify rev level A

(This option is added for customers requiring Copy Exact due to their ISO specifications. Pumps ordered without the eleventh letter will be shipped the latest revision)

Order Notes

For example, a PLF60 with Straight Front inlet, Top Straight outlet, 3/4"fnpt inlet, 3/4"fnpt outlet, No Stroke Detection, No Leak detection would be ordered as follows: PLF60-ACEEAAA.

Standard for a White Knight PLF60 is inlet straight front, outlet straight front, inlet 3/4"fnpt, outlet 3/4"fnpt, no Stroke Detection, no Leak Detection, and no Pulsation Dampener.

We have added an optional numerical option to the beginning of the part number which signifies the type of check valve desired with the pump. If no numeral is placed at the beginning of the part number then the pump will be shipped with the default or standard check valve which is the PTFE Ball check valve or option "2". A standard pump with High Flow check valves would be ordered with the following part number PLF60-3-AAEEAAA.



**WHITE
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Rebuild Parts For PLF60 Series Pumps

	Part Name	Part Number	Quantity
**** ** *	Bellows Shift Assembly	3130-MP-0022	2
	** 3/4" Check Ball	4100-TE-0002	4
***	3/4" Check Ball – Co-Polymer	4100-MP-0001	4
	** Check Cage Bottom	4135-TE-0002	2
***	Check Cage Bottom – Co-Polymer	4135-MP-0001	2
	** Check Cage Top	4142-TE-0003	2
***	Check Cage Top – Co-Polymer	4142-MP-0001	2
**** ** *	Shaft	5144-PF-0002	1
**** ** *	Shaft Seal	5143-TE-0003	2
	Labor	PLRB60-50	1

Rebuild Kits For PLF60 Series Pumps

Kit Name	Part Number
** Rebuild Kit w/ Ball Checks	RBPLF60-1-B
*** Rebuild Kit w/ High Flow Checks	RBPLF60-1-M
**** Rebuild Kit W/O Checks	RBPLF60-3
PLF60 Tool Kit	PLF60-170

** Items in RBPLF60-1-B

*** Items in RBPLF60-1-M

**** Items in RBPLF60-3

A PLF60 Tool Kit is required to perform rebuilds on PLF60 pumps.

Renaissance Pumps rebuilt by White Knight Fluid Handling, Inc. receive a full 2-year warranty.

White Knight

FLUID HANDLING, INC.

PUMP WARRANTY

White Knight Fluid Handling, Inc. 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, Inc. warrants pumps, subassemblies and components to be free from defects in materials and workmanship for the period of one year from the date of start-up or 18 months from the date of shipment, whichever applies. Failures due to misuse, abuse or any unauthorized disassembly of a **White Knight® pump** could nullify this warranty.

Some pumps carry additional warranty coverage, for instance, Renaissance Series pumps carry two year warranties and EXT Series pumps carry two or three year warranties depending on the version of pump.

The Renaissance™ Series pumps are warranted for up to 100psi air supply pressure, are not covered under dry run conditions, and are not covered in the event of running abrasive slurries.

All variations of AP, AT, and APLFM as well as EXT models are only covered up to 60psi of air supply pressure, are not covered under dry run conditions, and are not covered in the event of running 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, Inc.** 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, Inc.** Decisions as to the cause of failure shall be solely determined by **White Knight Fluid Handling, Inc.**

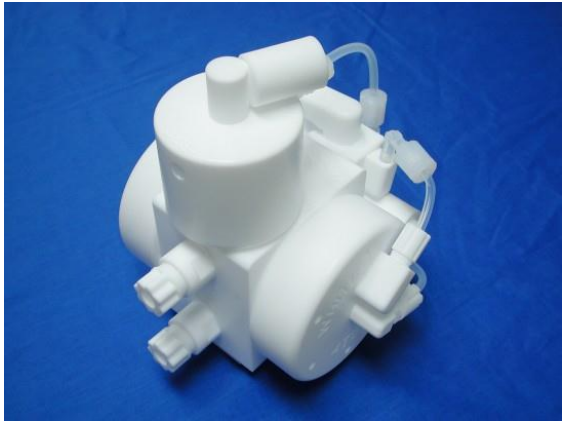
Prior written, faxed, or emailed approval must be obtained from **White Knight Fluid Handling, Inc.** before returning any pump, component, or subassembly for warranty consideration.

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 Inc.** in a self signed agreement shall be honored or considered legal binding.

John Simmons, President
White Knight Fluid Handling, Inc.

Flatliner™ Pulsation Dampeners

By White Knight



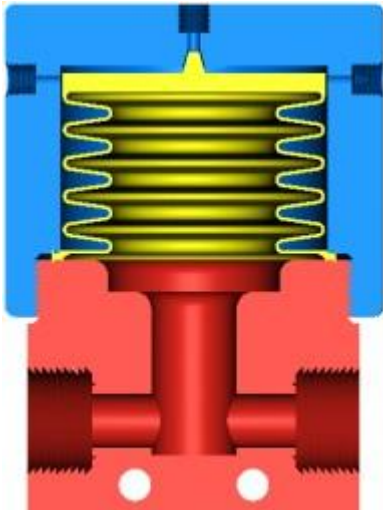
Did You Say That You Wanted A Pulsation Dampener With Only One Moving Part?

- Mount in line with any pump.
- Top of pump mounting available on AT Series Pumps.
- Reduces line pulsation to as low as plus or minus ½ PSI*
- 100% PTFE Construction.
- Temperatures to 200° Celsius.
- Only One Moving Part.**

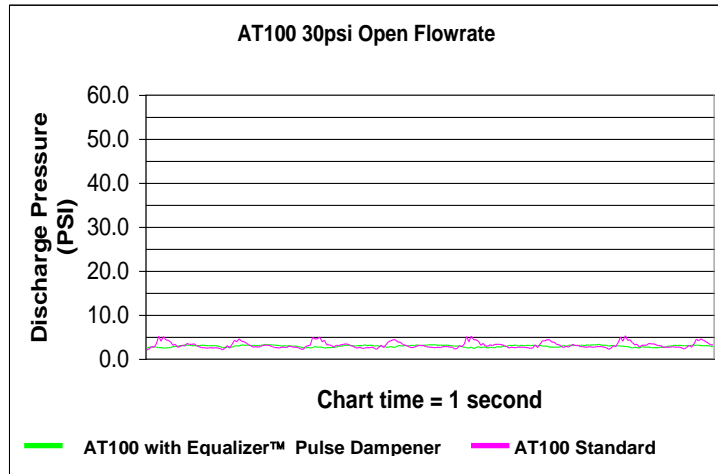
*Line pressure delta varies in relation to head pressure in line.

Flatliner™ Pulsation Dampeners

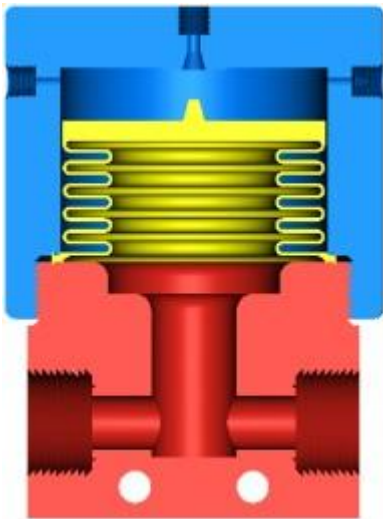
By White Knight



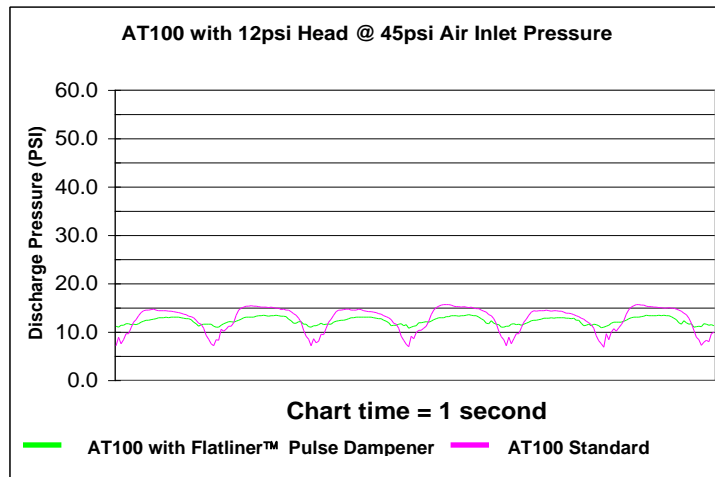
During stroke of the pump liquid pressure overrides air pressure and fills bellows with liquid.



AT100 with 30PSI supply, unrestricted flow



During shift of the pump air pressure overrides liquid pressure and moves liquid from bellows to outlet line to reduce line pressure delta.



AT100 with 12PSI of head pressure



Auto Level™

Pulsation Dampeners

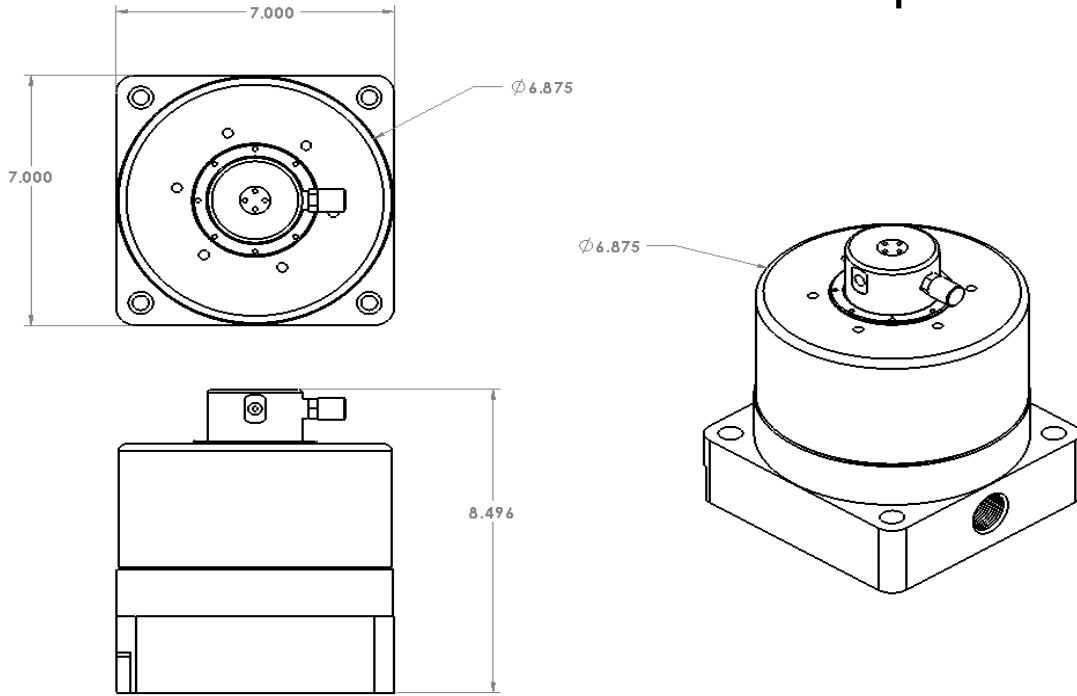
By White Knight



Finally! A Pulsation Dampener That Will Adjust to Your Application!

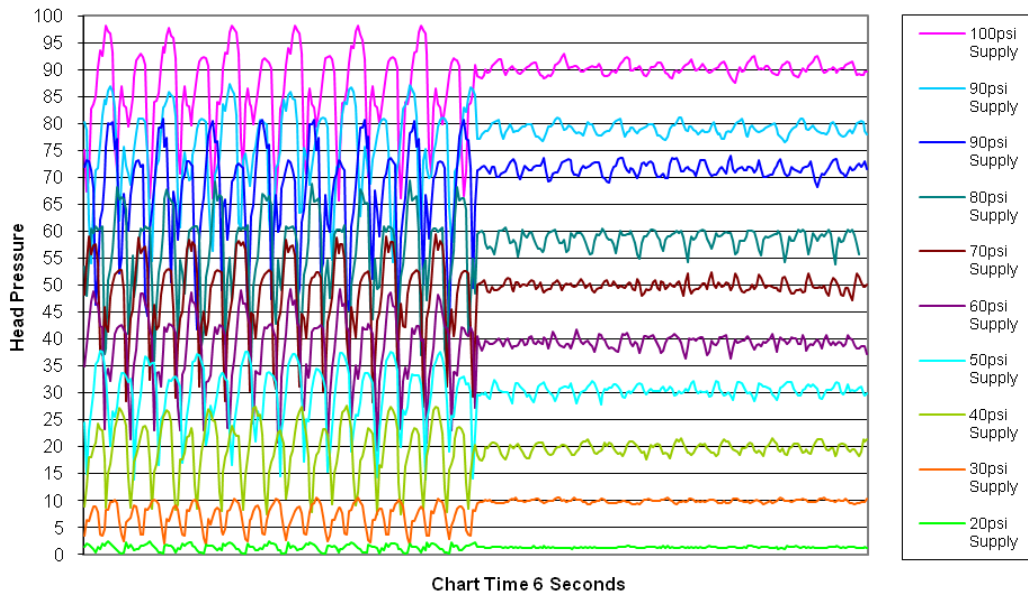
- Mount In-Line with Any Pump.
- Reduces Line Pulsation on Average by Nearly 82%!*
- 100% PTFE Wetted Construction.
- Two Year Warranty.
- NO Adjustment Required!

AL60 Footprint



PL60 without Pulse Dampener

PL60 with AL60 Pulse Dampener



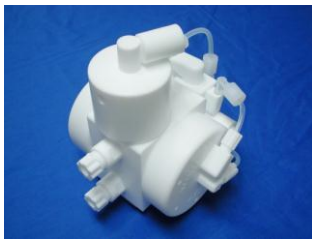
*Actual Pulsation Resulted in Reductions of 70% to Over 86%. Testing Performed Using CDA and DI Water.

Pump Accessories By White Knight

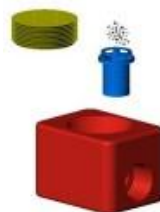
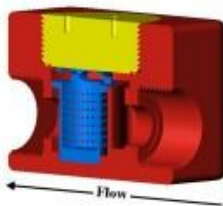


Merlin™ pump translator. Converts input from stroke detection to output of different fractional rate to allow for drop in replacement of other monitored pumps of different displacements.

Merlin™ pump controller. Provides programming of pump for times on and off as well as multiple programmable flow rates based on displacement and air pressure.



Pulse Dampeners. Pulse dampeners come preset from White Knight for the best all around pulse dampening, but additional bleed orifices are included so that a pulse dampener can be fine tuned for maximum performance to a specific pump supply pressure to back pressure setting.



Catcher™ Pump inlet screen. To protect pump from harmful solids such as wafer shards. Larger through holes than many pre pump filters to avoid loading of filter by fine crystals often found in chemistries while still filtering out the majority of solids that could damage the pump. Screen can be removed and cleaned without disconnection of liquid inlet and outlet lines. If a White Knight pump is damaged from passing a solid while using the Catcher™, White Knight will repair the pump at no charge to the customer.



Whisper™ Porous PTFE muffler inserts. Provide all the chemical compatibility of PTFE baffles while providing the noise reduction typical of material type mufflers.





Bubble In – Bubble Out™ Fiber optic leak detection. Monitors inlet line for bubbles and outlet line for bubbles. If both have bubbles (as in priming or if chemistry is boiling) the monitor does not react. If there are no bubbles in the inlet line, but bubbles are present in the outlet line, a leak is assumed and alarm is sent.

Fiber Optic air side leak detection. Watches for liquid in the air side of the pump and sends alarm when sighted.



Fiber optic stroke detection. Watches for reciprocating portion of pumps to come in proximity of fiber optic and sends signal. Communicates to Merlin™ products, PLC, etc.

Solid State pressure switch stroke detection. Translates puff of air sent to pump muffler on exhaust into electronic signal for monitoring of pump. Communicates to Merlin™ products, PLC, etc.



Hardware and software for programming Merlin™ pump translator from laptop or PC.





RMA#: _____

Decontamination Certification

I, the undersigned, employee of _____ certify that all decontamination and safety procedures outlined in the White Knight document labeled "White Knight Pump Decontamination Instructions" have been followed for the pump listed below.

Pump Serial Number: _____ Shuttle Serial Number: _____
(If Known)

Please check one of the following:

- 1. The pump has **not** been used in metal processes (I.E. Copper and Bumping Processes).
- 2. The pump has been used in Metal Processes.

2a. The Metal Process that it was used in is _____
(Insert type of process I.E. Copper, Gold, Lead Bumping, Tin Bumping, Aluminum Etch, Other (please describe))

Failure Mode: _____

Specific Failure Details: _____

Application Parameters: Air Supply: _____ Flow Rate: _____

Process Chemistry: _____ Process Temperature: _____

Duty Cycle: _____ Installation Date (if known): _____

Contact Information to send RMA# and Evaluation Report to: Name: _____

Phone: _____ Email: _____

Customer Reference # (if needed): _____

Pumps that have been exposed to metal processes must be returned to White Knight in packaging or containers which are clearly and conspicuously marked on the outside that the enclosed pump has been exposed to metal processes and to which metal they may have been exposed!

Pumps exposed to Metal Processes must be returned to White Knight via the following address:

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

Pumps **not** exposed to Metal Process must be returned to White Knight via the following address:

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

Name: _____

Notes

