



PM-92€/PM-91€

August, 2000

MF-9097

INSTRUCTION MANUAL

Solvent Delivery System

Bioanalytical
Systems, Inc
2701 Kent Avenue
West Lafayette
Indiana 47906

MANUFACTURER'S NOTE

This instrument, either wholly or in part, is manufactured for research purposes only. Use for medical diagnosis is not intended, implied or recommended by the manufacturer. Use for this purpose and accountability for the same rests entirely with the user.

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Section 1. PREFACE

This manual explains the installation and operation of the PM-92€ dual head and PM-91€ single head Pump, as well as procedures for routine maintenance and troubleshooting. Read the entire manual prior to installation and start-up.

The PM-92€ is a reciprocating, dual-piston unit. It is designed for precise and reliable solvent delivery for isocratic elution at flow rates between 1.0 and 2000 $\mu\text{L}/\text{min}$. Advanced features of the PM-92€ pump include:

1. Dual independently controlled reciprocating pistons each driven by a microstepping motor through a high efficiency ballscrew.
2. Solid-state pressure transducers monitor each piston head pressure along with system pressure to provide smooth crossover from one piston delivery to the next.
3. Minimal flow-through volume. No pulse damper required for all but the most demanding applications.
4. Optimized for microbore flow rates.
5. Piston velocity profile and stroke length is software controlled.
6. Pump performance is independent of system backpressure.
7. Each head is removable as a single, precision-engineered assembly which may be interchanged in seconds.
8. High and low pressure limit controls, for safety.
9. Analog output for pressure monitoring.
10. Provision for remote-control operation.
11. Wetted materials: 316 stainless steel, sapphire, UHMW polyethylene, Teflon, PEEK

The PM-91€ is a reciprocating, single-piston unit. It is designed as an economical alternative to the PM-92€ for isocratic elution at flow rates between 1.0 and 2000 $\mu\text{L}/\text{min}$. Advanced features of the PM-91€ pump include:

1. Reciprocating piston driven by a microstepping motor through a high efficiency ballscrew.
2. Solid-state pressure transducer monitors head pressure and system pressure independently.
3. Microprocessor control takes a 'snapshot' of system pressure just prior to refilling and drives the plunger to quickly refill and pressurize the mobile phase to the 'snapshot' pressure before resuming the desired delivery flow rate.
4. Fast refill and pressurize in combination with a pulse damper provides minimal flow and pressure fluctuation.
5. Optimized for microbore flow rates.
6. Pump performance is independent of system backpressure.
7. The pump head is removable as a single, precision-engineered assembly which may be interchanged in seconds.
8. High and low pressure limit controls, for safety.
9. Analog output for pressure monitoring.
10. Provision for remote-control operation.
11. Wetted materials: 316 stainless steel, sapphire, UHMW polyethylene, Teflon, PEEK

The PM-90 series pumps have been engineered for durability, and with proper maintenance should provide years of reliable service.

Section 2. SUPPORT POLICY

2.1 USER UPDATES

To activate your warranty, and receive product update news and valuable information, fill out and return the Warranty Enrollment Card which was shipped with the instrument. We would like to know who you are and what more you want to know about BAS chromatographic and electrochemical products.

2.2 DAMAGED SHIPMENTS

Breakage of any part of this instrument during shipping should be reported immediately to BAS Customer Service. You must retain the original packing box and contents for inspection by the freight handler. BAS will replace any new instrument damaged in shipping with an identical product as soon as possible after the claim filing date. Claims not filed within 30 days after the shipping date will be invalid.

Do not return damaged goods to Bioanalytical Systems without first contacting Customer Service for a Return Authorization Number (RA#). When a defective part is returned to BAS, the RA# immediately identifies you as the sender, and describes the item being returned. Bioanalytical Systems refuses all unauthorized return shipments.

2.3 PRODUCT WARRANTY

Bioanalytical Systems, Inc. products are fully warranted against defects in material and workmanship. The PM-92€/PM-91€ pump unconditionally warranted for one year from date of shipment, except when failure is due to obvious abuse or neglect, unauthorized tampering, procedures not described in manuals, or improper connection of components. Electrochemical cells are warranted for 60 days from date of shipment under the same exclusions. Chromatographic columns and injection valves are warranted for 30 days. The following items are not covered under any warranty: carbon paste, activated aluminum oxide, lamps, panel lights, fuses, pump seals, valve seals and reference electrodes.

For any product expressly covered under this warranty, Bioanalytical Systems is liable only to the extent of replacement of defective items. Bioanalytical Systems, Inc. shall not be liable for any personal injury, property damage, or consequential damages of any kind whatsoever. The foregoing warranty is in lieu of all other warranties of merchantability and fitness for a particular purpose.

2.4 SERVICE

Bioanalytical Systems provides a skilled service staff available for consultation if an equipment-oriented problem should arise. For further details, call customer service personnel at (765) 463-4527. Following discussion of your specific difficulties, an appropriate course of action will be described and the problem resolved accordingly. Do not return any products for service until a Return Authorization Number (RA#) has been obtained. The RA# identifies you as the sender and describes to us the problem you are having in full detail. Turnaround time on service can be quoted to you at the time your RA# is issued, although we cannot determine the actual amount of service required until we have received your unit and diagnosed the problem. All correspondence and shipments should be sent to:

RA#____, Service Department
Bioanalytical Systems, Inc.
2701 Kent Avenue
West Lafayette IN 47906

Section 3. INSTALLATION

3.1 UNPACKING

Please retain the shipping box and packing material until the unit has been fully tested. The shipping materials will be needed if you discover damage incurred during shipping.

The shipping box should contain the following items:

1. PM-92€ or PM-91€ Pump
2. PM-92€/PM-91€ Accessories (includes: power cord, 1/8" PTFE inlet lines with fittings, 60 mL syringe, luer adapter).
3. PM-92€/PM-91€ Manual
4. Pulse Damper (PM-91€ ONLY)

If any discrepancies exist, retain the packing slip and contact BAS Customer Service for assistance.

3.2 IDENTIFICATION OF PARTS

Figures 3.1 and 3.2 show front views of the PM-92€ and PM-91€ pumps. Figure 3.3 shows the back view of the PM-92€ and PM-91€ pumps. The parts identified by number are described in Table 3.1.

Figure 3.1 Front panel of PM-92€

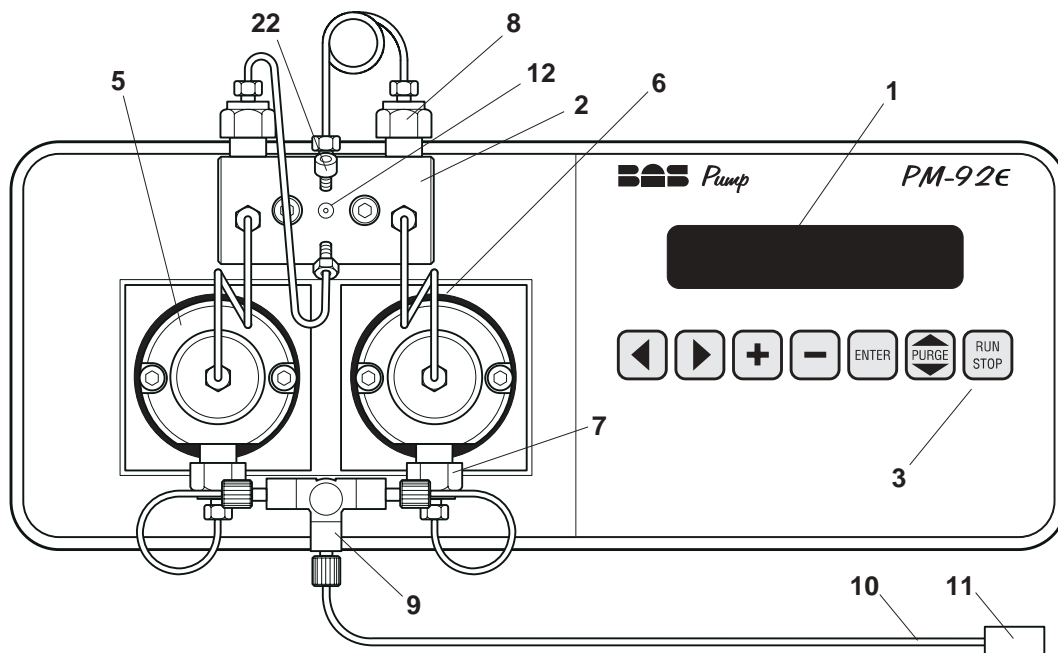


Figure 3.2

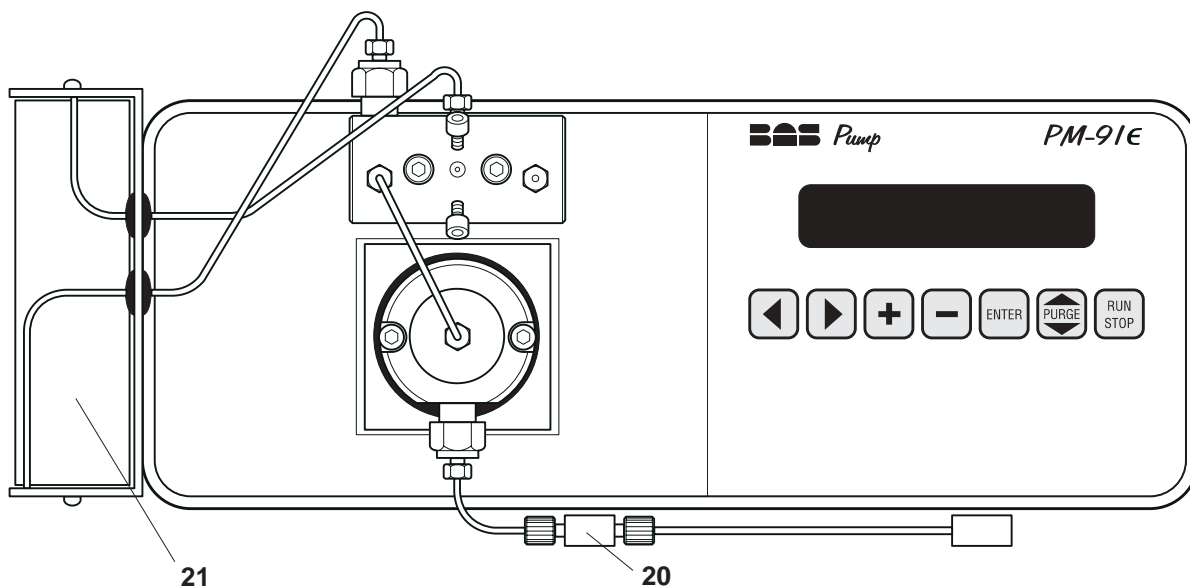


Figure 3.3 Rear panel of PM-92e/PM-91e

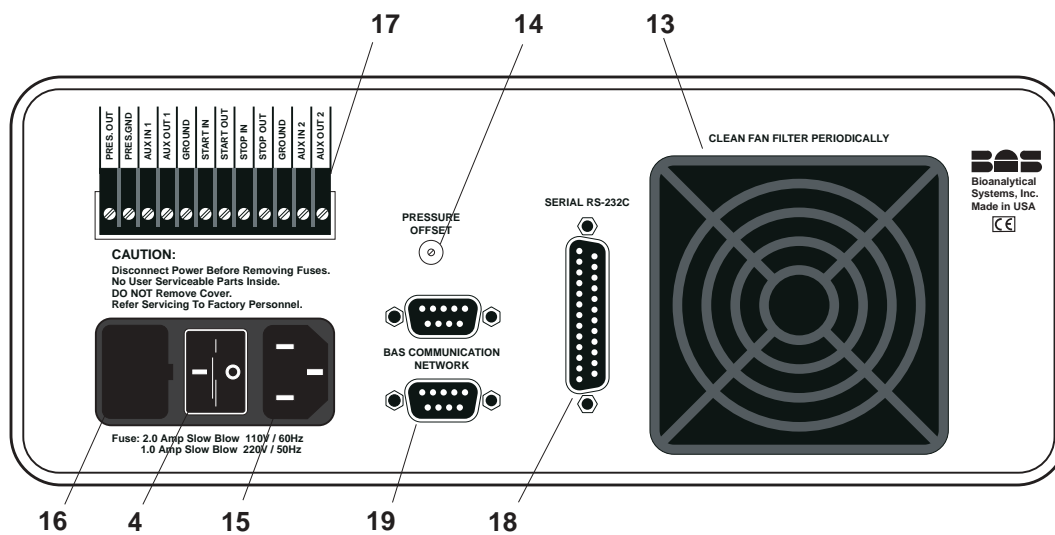


Table 3.1 Parts of the PM-92e/PM-91e pump

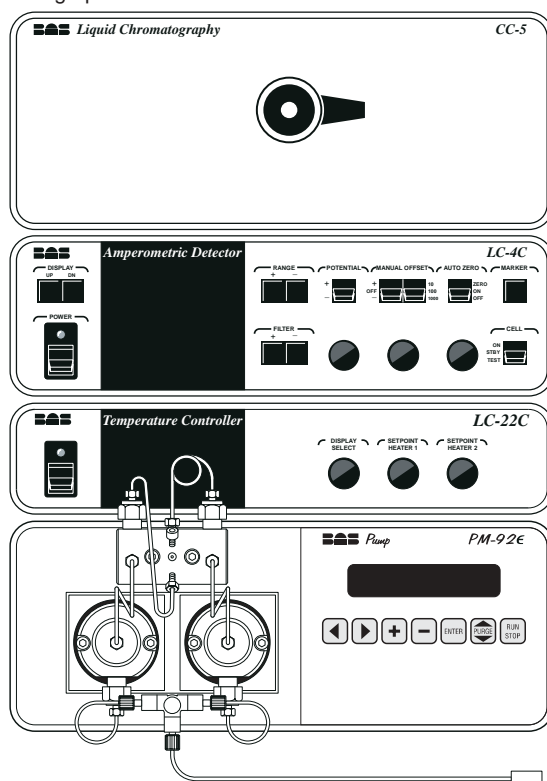
1. LCD display
2. Pressure manifold
3. Keyboard
4. POWER switch
5. Pump head
6. Plunger-irrigation port (hidden)
7. Inlet check-valve assembly
8. Outlet check-valve assembly

9. Inlet tee (PM-92€)
10. Solvent-uptake line
11. Solvent-uptake frit
12. Outlet port to injection valve
13. Air filter
14. Offset adjustment for pressure output
15. Power input
16. Fuse
17. Terminal strip
18. REMOTE connector
19. BAS Instrument Control connectors
20. Inlet fitting (PM-91€)
21. Pulse Damper (PM-91€)
22. Prime/Purge Plug

3.3 SITING THE PUMP

The PM-92€/PM-91€ pump is designed to serve as the base for a stack of BAS chromatography instruments. A typical setup is illustrated by the BAS-490 chromatograph (Figure 3.4). The components of this system are (from the bottom up) the PM-92€ pump, LC-22C temperature controller, LC-4C electrochemical detector, and CC-5 flowcell compartment.

Figure 3.4 The BAS-490 Liquid Chromatograph.



Siting considerations for the pump must, of necessity, include the requirements for all the component instruments in the stack. Use the following guidelines:

1. Provide a surge-free power source which can be dedicated to the chromatograph. Other laboratory instruments such as ovens, vortex mixers, centrifuges, and large motors may cause spikes in the power supply.
2. Ensure that all components of the chromatograph share the same ground circuit. This can best be accomplished by plugging all components into a multi-outlet power strip. Plugging the components into independent outlets can produce ground loops (current that flows between ground circuits at slightly different potentials) which can produce baseline noise.
3. Locate the chromatograph on a stable bench. Vibrations can hamper the performance of any sensitive instrument.
4. Select a room where temperature remains stable throughout the day. Avoid installing the chromatograph near windows, air ducts, ovens, or refrigerators.
5. Place the chromatograph away from busy, congested areas. Remote, isolated areas are best for high-sensitivity work.
6. Avoid very dry areas and areas that are carpeted. Static electricity can affect instrument performance. Anti-static floormats and benchmats are useful if spiking caused by static charge is a problem.
7. Avoid areas where radio-frequency interference is likely. Beeper-type paging devices can be a problem in some installations.

3.4 POWER REQUIREMENTS

The power cord attaches to the PM-92€/PM-91€ via the receptacle on the rear of the instrument. The pump can be operated with either 100, 120, 220, or 240 VAC and 50 or 60 Hz power. The instrument uses a fused self-sensing power supply. There is no need to make power related adjustments.

Check to see that the fuse is the proper rating (Table 3.2).

Table 3.2 Correct Fuse Selection

<u>Voltage</u>	<u>Fuse</u>
100-120V	2.0 Amp Slow Blow
220-240V	1.0 Amp Slow Blow

3.5 FLUID CONNECTIONS**PM-92€**

The PM-92€ is factory plumbed, and ready as received for final connection of the inlet and outlet solvent lines. Unwrap the teflon tubing carefully and remove the protective cover from the solvent-uptake frit. The uptake tubing connects to the tee at the PM-92€ pump head with a flangeless fitting. Be sure to install this with the flat face of the ferrule entering the tee (Figure 3.5).

Connect a solvent-outlet line between the pump manifold outlet and the pump input of your injection valve. A nut and ferrule are provided for connection to the pump outlet. We recommend 1/16" OD, 0.015" ID, #316 stainless steel for this line. An in-line filter assembly (MR-4135) is recommended between this tubing and the injection valve.

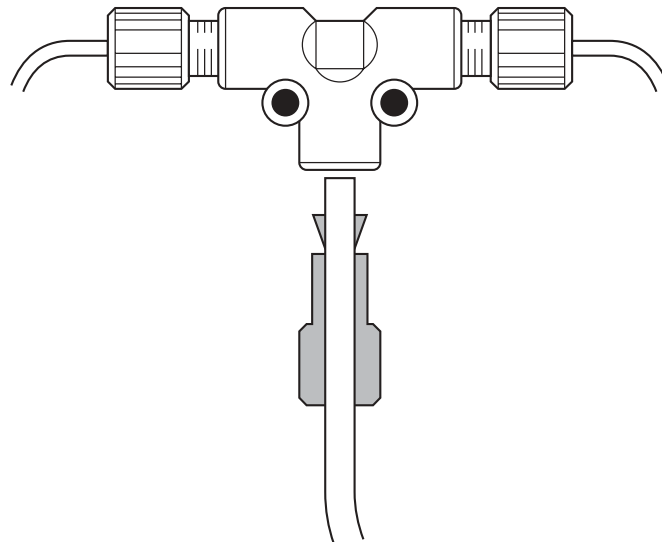
PM-91€

Mount the pulse damper to the left side of the pump cover using the two 6-32 flat head screws supplied. The short tubing line from the pulse damper should be located on top. (Figure 3.2)

Connect the bottom line of the pulse damper to the outlet check valve assembly. Connect the top line of the pulse damper to the top central port on the pressure manifold. Unwrap the teflon tubing carefully and remove the protective cover from the solvent-uptake frit. The uptake tubing connects to the inline fitting at the PM-91€ pump head with a flangeless fitting. Be sure to install this with the flat face of the ferrule entering the inline fitting.









Installation is now complete. Refer to section 4.3 (STARTUP) to begin purging the pump.

Figure 3.5 Orientation of flangeless fitting.



Section 4. OPERATION

4.1 KEY FUNCTIONS

-  and  move the cursor left and right within a line
-  and  increase or decrease a numerical value within a line
-  advances to the next input line — use this key to quickly navigate and review the two screens
-  sets the pump to operate at a flow rate of approximately 5 ML/min to aid in priming the pump or purging the system of trapped air
-  starts or stops purging— when purging is stopped, both plungers are moved to the full forward position for head removal or installation.
-  starts or stops the pump — this control is used to start or stop solvent flow without turning off the main power

4.2 CONTROLS

There are three parameters involved in setting up the pump for operation:

1. Flow Rate
2. Low Pressure Limit
3. High Pressure Limit

Flow Rate

A flow rate ranging from 1-1999 $\mu\text{L}/\text{min}$ can be selected using the + and – keys to increment or decrement the value. After selecting the desired flow rate, press the ENTER key to advance to the next screen. If the pump is currently running, the flow rate will change as new values are entered.

Low Pressure Limit

Use the + and – keys to select the Low Pressure Limit (PSI). The Low Pressure limit can be adjusted to a value between 0 and 999 PSI. Press the ENTER key to advance to the next field.

If a fitting develops a leak, or if the mobile-phase reservoir runs dry during unattended operation, the low-pressure cutoff will stop the pump as pressure drops. Proper setting of this control will avoid pump damage. When the Low Pressure Limit is set to 0 PSI this function is disabled.

If the low-pressure limit is reached, the pump will stop and the LCD will display a Low Pressure message. After correcting the problem, reset the protective circuitry by pressing the ENTER key. The pump can then be restarted by pressing the RUN key.

The low-pressure limit is enabled only after pressure exceeds its set value. Thus, you can run the pump with the prime/purge connection open (pressure will be 0 PSI) even though the low-pressure limit is set to a value such as 300 PSI. Only after the prime/purge connection is closed, and pressure rises above 300 PSI, will a drop in pressure trigger the protective circuitry.

High Pressure Limit

Use the + and – keys to select the High Pressure Limit (PSI). High Pressure limit can be adjusted to a value between 1000 and 4999 PSI. Press the ENTER key to return to the Flow Rate Screen.

It is EXTREMELY IMPORTANT that this limit be set to some reasonable value; if a clog develops anywhere in the flow stream between the pump and the detector, the high-pressure cutoff will stop the pump as pressure increases. We suggest setting the cutoff 1000 PSI above your typical operating pressure.

If the high-pressure limit is reached, the pump will stop and the LCD will display a High Pressure message. After correcting the problem, reset the protective circuitry by pressing the ENTER key. The pump can then be restarted by pressing the RUN key.

Purge

The PURGE key causes the pump to operate at a flow rate of approximately 5 ML/min to aid in priming the pump or to purge the system of trapped air. The purge plug on the manifold should be removed prior to purging the pump if a column is connected. The plug can be replaced by a luer adapter which allows a syringe to be connected to apply suction to aid in priming the pump.

To avoid inadvertant purging, the RUN/STOP key must be pressed after the PURGE key to begin purging.

Pressing the STOP key will stop purging and move both pistons to their full forward position. This is done to allow easy removal or installation of pump heads. It may take 1-2 seconds for the pump to come to a complete stop after the STOP key is pressed while purging. After the STOP key is pressed the pump will be reset to the flow rate prior to the start of purge.

NOTE: Always allow the system pressure to fall below 30 PSI before opening the prime/purge plug on the manifold. This will prevent pressure shocks from damaging the column or pulse damper.

Power

An on/off toggle switch is located on the rear panel next to the power cord. It applies power to the pump. When the power switch is turned on, the microprocessor performs a self test. During the self test the LCD display will show the software version number.

Terminal strip (rear panel)

Has connections for externally monitoring pump pressure and for communication with peripheral equipment.

Pressure Out

Provides 1 volt per 1000 psi output to monitor pressure. The output indicates absolute pressure when the pressure offset adjustment is fully counter clockwise.

Pressure Ground

Reference. An analog ground reference level.

Aux In 1

Input. Reserved

Aux Out 1

Output. Reserved

Ground

Reference. A digital ground reference level. There are two digital ground terminals.

Start In

Input pulse. A switch closure or TTL-low across the START and GROUND terminals will start the pump. Same as pressing RUN key from the front

Start Out

Output pulse. Sends a 1 second TTL-low signal when the pump is started.

Stop In

Input pulse. A switch closure or TTL-low signal across STOP and GND terminals will stop the pump. Same as pressing STOP key from the front panel.

Stop Out

Output pulse. Sends a 1 second TTL-low signal when the pump is stopped.

Aux In 2

Input. Reserved

Aux Out 2

Output. Reserved

Remote (rear panel)

A 25-pin "D" connector is provided for remote control of the PM-92€/PM-91€ pump.

Pressure offset (rear panel)

A potentiometer used to adjust pen position when recording pump pressure (section 4.4.4).

4.3 STARTUP

Proper startup and shutdown procedure is vital for long and dependable pump life. The two most important considerations are:

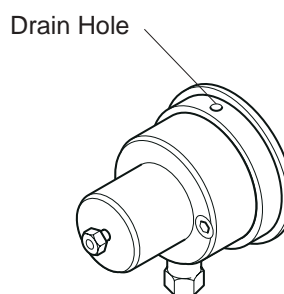
NEVER START THE PUMP WITH DRY PLUNGERS

NEVER LEAVE STAGNANT MOBILE PHASE IN THE PUMP

Correct startup procedure is as follows:

1. Turn the POWER on.
2. Squirt a few drops of water into the plunger-irrigation ports (Figure 4.1). Use only enough water to moisten the plungers.

Figure 4.1 Flushing the plunger-irrigation ports.



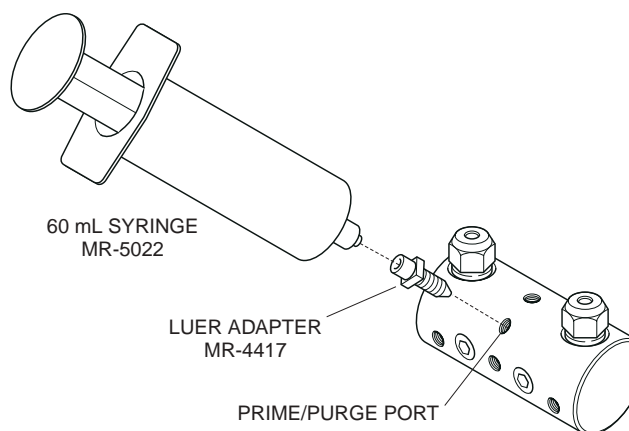
3. Place the solvent-uptake frit into a glass reagent bottle containing 40:60 (v:v) acetonitrile:water. Elevating the reservoir to provide hydrostatic pressure will be helpful.

NOTE: ALL SOLVENTS AND MOBILE PHASES USED IN THE PM-92€/PM-91€ PUMP SHOULD BE FILTERED THROUGH 0.2 μm MEMBRANE FILTERS. USE ONLY LC-GRADE SOLVENTS AND TYPE I REAGENT-GRADE WATER.

4. Attach the luer adapter (supplied) to a 60 mL disposable syringe. Remove the purge plug from the manifold (don't forget that system pressure must be below 30 PSI before opening the plug) and replace with the luer adapter. Aspirate until solvent comes through the pump. Leave the syringe attached. (Figure 4.2)
5. Press the PURGE Key, then press the RUN/STOP key to start the pump for five minutes. During this purge you may alternately draw back and release the syringe plunger to help dislodge air bubbles from the system.
6. Press the RUN/STOP key to stop the pump. Note: The pump may take 1-2 seconds to come to a complete stop following purge. Set the FLOWRATE control to 1000 $\mu\text{l}/\text{min}$. Replace the luer adapter with the plug.

7. If there is no column attached, you may wish to pump solvent through the injection valve to displace any air and old solvent. Simply start the pump by pressing the RUN/STOP key and collect the waste solvent at the outlet of the injection valve.
8. To change solvents, repeat steps 3-7 as appropriate.
9. If necessary, reset the FLOWRATE control to 100 $\mu\text{l}/\text{min}$ or other appropriate setting.

Figure 4.2 Using a syringe to purge the pump.



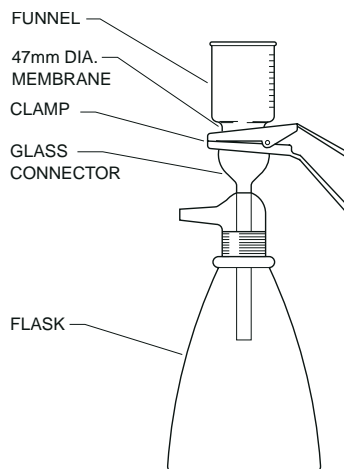
4.4 ROUTINE OPERATION

4.4.1 Mobile Phase Preparation

Use only high-purity solvents and buffer salts for preparing mobile phases. Water should be type I reagent grade, with a resistivity of > 15 megohms/cm². Don't forget to thoroughly wash all glassware used to prepare and hold the mobile phase.

Filter all mobile phases through a 0.2 μm membrane filter. Figure 4.3 illustrates the filtering device recommended by BAS for doing this. It is borosilicate glass throughout, and uses ground glass joints to avoid contamination from stoppers. The filtration step will reduce problems with column degradation significantly. **CLEAN, PARTICLE-FREE MOBILE PHASES ARE CRITICAL TO ANY LC METHOD!**

Figure 4.3 Mobile phase filtration apparatus, part number MF-6126



Mobile phases should be degassed prior to use. Vacuum filtering may be sufficient to degas the mobile phase. But if bubbles are a problem in your system, a more-thorough degassing is required. Allowing the solution to sit under the vacuum generated by an aspirator for 5-15 minutes should be sufficient. The MF-6126 kit also can be used for degassing, by replacing the filtration apparatus on the top of the unit with a stopper. Small amounts of volatile organic modifiers may be lost, but not enough to cause any difficulty.

The easiest and most effective method of degassing is the LC-26 on-line degasser (MF-8501B). This highly effective instrument reliably and consistently delivers bubble-free mobile phase to the PM-92€/PM-91€ pump.

Whichever way you make your mobile phase, be consistent; consistency in mobile phase preparation is critical for reproducible chromatography.

4.4.2 Starting the Pump

1. Place a fresh bottle of mobile phase next to the pump and insert the solvent-uptake frit into it. Elevating the reservoir to provide hydrostatic pressure will be helpful.
2. Turn the POWER switch on.
3. Flush the plunger-irrigation ports with water (Figure 4.1). A plastic squeeze bottle is ideal for this.
4. Replace the prime/purge plug on the manifold with the luer adapter and attach a 60-mL disposable syringe to the luer adapter (remember that system pressure must be less than 30 PSI before removing the prime/purge plug). Aspirate until mobile phase comes through the pump. Leave the syringe attached. (Figure 4.2)
5. Press the PURGE key and then press the RUN/STOP key to begin purging the pump. Purge the pump for 5 minutes. This purge step ensures that all old mobile phase has been flushed from the pump, so fresh mobile phase is ready to flow to the column.
6. Press the RUN/STOP key to stop the pump. Note: The pump may take 1-2 seconds to come to a complete stop following purge. Set the FLOWRATE to 1000 $\mu\text{L}/\text{min}$. Replace the luer adapter with the plug.
7. If there is no column attached, you may wish to pump mobile phase through the injection valve to displace any air or old mobile phase. After doing this, connect the column.
8. If necessary, reset the FLOWRATE to 100 $\mu\text{L}/\text{min}$ or other appropriate setting.
9. Press the RUN/STOP key to begin pumping. Observe the pressure readout until it stabilizes, and check all connections for leaks.

4.4.3 Routine Maintenance

A regular maintenance schedule is part of normal operation. See section 5.7 and 5.8 for recommended procedures.

4.4.4 Monitoring Pump Performance

The simplest method of monitoring pump performance is to develop a regular habit of observing the pressure display. Learn what is normal pressure and normal pressure fluctuation under your conditions, so you can recognize abnormal behavior.

Pump performance also can be monitored with a strip-chart recorder, using the analog pump-pressure output on the rear panel. First set your chart recorder for an input of 10 V. Connect two wires from the PRESS OUT and PRESS GND connectors on the terminal strip of the PM-92E/PM-91E to the input of the chart recorder. Use an electronic alignment tool or small flathead screwdriver to adjust the PRESSURE OFFSET potentiometer on the rear panel of the PM-92E/PM-91E, until the chart-recorder pen is about mid-scale. Now reduce the input voltage of the chart recorder in steps, adjusting the PRESSURE OFFSET control as necessary. Reduce the input voltage of the chart recorder until the pressure fluctuations can be measured on the chart (a 0.1 V input range should be about right). The analog pressure output produces 1 volt per 1000 PSI. The chart can be calibrated with the following formula:

$$P = \frac{1000 \times D \times V}{W}$$

where:

P = pressure fluctuation in PSI

W = width of chart paper (mm)

D = magnitude of pen deflection (mm)

V = input range of chart recorder (Volts)

4.5 SHUTDOWN

The most important principle to remember when turning off your pump for storage is to remove all mobile-phase salts. Salts in the system will lead to corrosion of the stainless steel lines (yes, they corrode, but at a slow rate), and the presence of abrasive crystals in the pump heads. Abrasives will scratch the seals and plungers during subsequent startup.

The shutdown procedure is as follows:

1. Turn the POWER on.
2. Place the solvent-pickup frit in a reagent bottle containing 40:60 (v:v) acetonitrile:water. Elevating the reservoir to provide hydrostatic pressure will be helpful.

NOTE: ALL SOLVENTS AND MOBILE PHASES USED IN THE PM-92€/PM-91€ PUMP SHOULD BE FILTERED THROUGH 0.2 μm MEMBRANE FILTERS. USE ONLY LC-GRADE SOLVENTS AND TYPE I WATER.

3. Check to make sure that system pressure is below 30 PSI. Replace the prime/purge plug on the manifold with the luer adapter and connect a 60-mL syringe to the luer adapter. (Figure 4.2)
4. Press the PURGE key then press the RUN/STOP key to begin purging the pump. Purge for five minutes. This will bring fresh solvent through the pump.

If the column is to be cleaned with this solvent, proceed to step 5. If the column has been removed, go to step 6.

5. (To clean both the column and the pump.) Set the flowrate to 100 $\mu\text{L}/\text{min}$ or other appropriate range. Replace the luer adapter with the plug. Pump an appropriate amount of solvent through the column. Shut the system off, remove and cap the column for storage, and you're done.
6. (To clean only the pump.) Remove the column. Set the FLOWRATE to 1999 $\mu\text{L}/\text{min}$. Pump at least 25 mL solvent through the pump, pulse damper, and injector (in INJECT position to flush the loop). Then shut the system off.

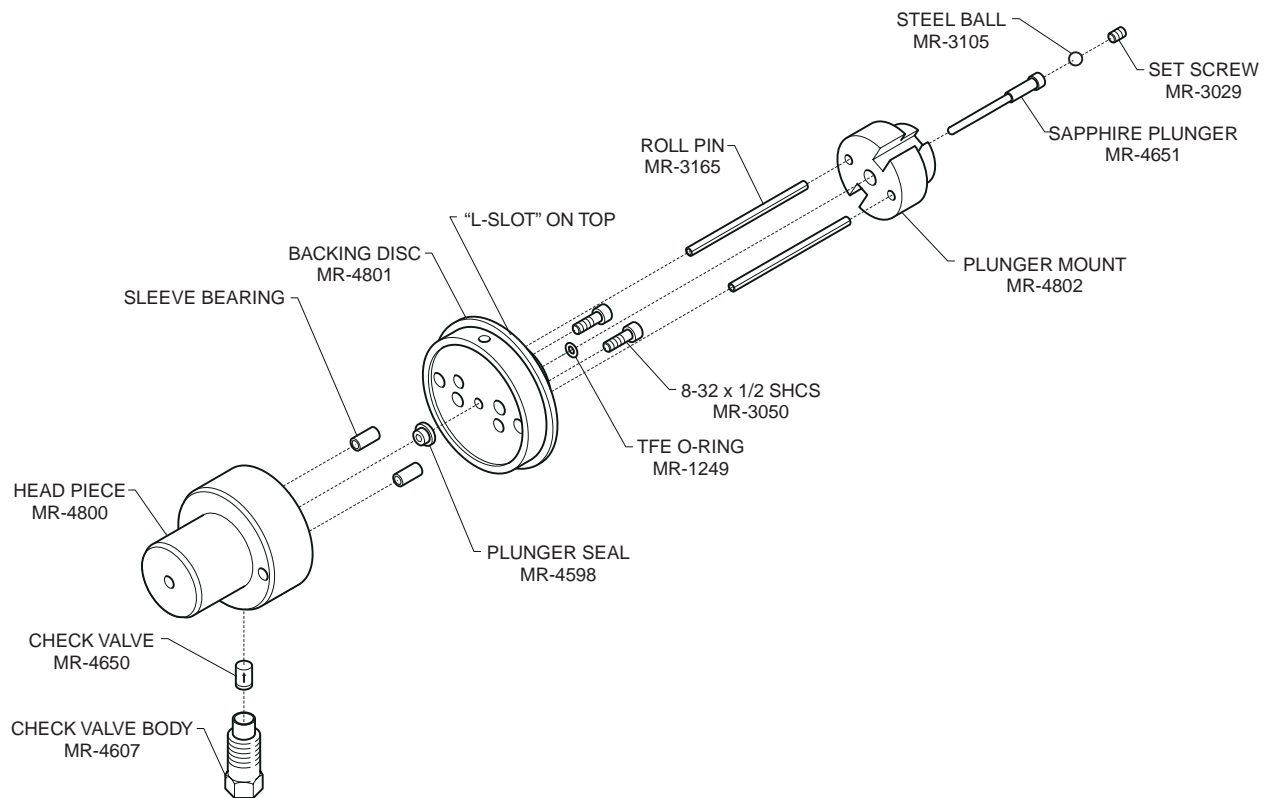
Section 5. MAINTENANCE

5.1 PUMP HEAD SERVICING The procedures detailed below encompass all user services that require removal of the pump heads. They include :

- Pump head replacement
- Plunger seal replacement
- Plunger free-play adjustment
- Plunger replacement

This section will detail the entire procedure, from head removal to re-insertion. The text will indicate which sections can be skipped when performing simple maintenance.

Figure 5.1 Exploded view of pump head.



5.1.1 Pump Head Removal

An entire pump head may be rapidly removed by the following procedure:

1. Open the purge plug. Press the PURGE key and purge the pump for 5 seconds. Then press the STOP key to stop the pump. This step moves the plungers to the full forward position for removal of the pump heads.
2. Observe the pressure display to make sure there is no residual pressure in the lines. Then turn the POWER off.
3. Remove the outlet line from the head using a 1/4" wrench.
4. Hold the inlet check-valve assembly stationary with a 1/2" wrench and remove the inlet line with a second 1/4" wrench.
5. Using a 9/64" hex head driver, unscrew two 8-32 socket head cap screws from the pump head.
6. Rotate the head 30° counterclockwise until it stops, then gently pull the head straight out of the housing. (Figure 5.2)
7. To install a new pump head, proceed to section 6.1.6.

5.1.2 Pump Head Disassembly

Servicing or inspection of the plunger seal and plunger require disassembly of the pump head. Proceed as follows:

1. Gently pull the plunger assembly straight back from the Head pulling the plunger out of the Head. (Figure 5.3)
2. Locate the two 8-32 socket head cap screws on the back of the Head and remove using a 9/64" hex head driver. Pull the Backing Disk away from the head to expose the plunger seal. (Figure 5.4)

Figure 5.2 Removal of head from pump.

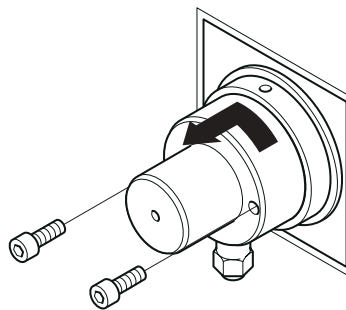


Figure 5.3 Removal of plunger assembly from head.

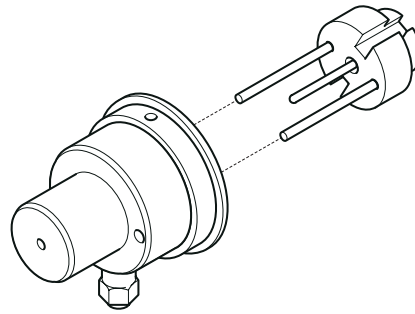
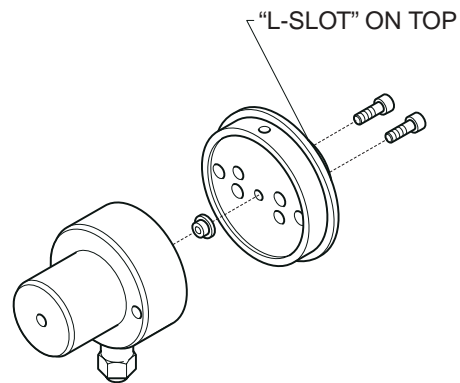


Figure 5.4 Exposing the plunger seal.



5.1.3 Plunger Inspection and Servicing

1. Examine the plunger carefully. Wash the sapphire rod with water and methanol. Salts may be removed by gently scrubbing with a green Scotchbrite® scouring pad moistened with water. Replace the plunger if it is chipped, scored or scratched (if replaced, proceed to item 4).
2. Test the plunger free-play. Hold the plunger assembly in one hand with the sapphire rod pointing up. Wiggle the sapphire rod from side to side with the other hand. It should move freely. Rotate it radially; it should move freely through 360°, much as you would roll your head on your shoulders to stretch your neck muscles. Now try to move it up and down; there should be no movement in the longitudinal direction.
3. If the rod passes the free-play test, proceed to section 5.1.4 (seal replacement) or section 5.1.5 (reassembly). If the sapphire rod is either too loose or too tight, perform the adjustment procedure beginning in item 6.
4. To replace the sapphire plunger, grasp the Plunger Mount firmly and unscrew the set screw from the back of the Plunger Mount. Remove the plunger by sliding it out of the back of the Plunger Mount and replace with a new one. A small ball bearing sits at the base of the plunger and is held in place with a dab of grease. Do not lose the ball during assembly.

5. A nylon patch locks the reusable set screw in position once the position is set.
6. To adjust the new or old sapphire plunger, tighten or loosen the set screw while testing free play.
7. Wiggle the sapphire plunger from side to side; it should move freely. Rotate it radially; it should move freely through 360°, such as you would roll your head on your shoulders to stretch your neck muscles. Now try to move it up and down; there should be no movement in the longitudinal direction.
8. Proceed to section 5.1.4 (plunger seal replacement) or section 5.1.5 (reassembly)

5.1.4 Plunger Seal Replacement

1. Place the front portion of the pump head on a flat surface with the seal facing up.
2. Remove the seal by inserting a 6-32 threaded screw into the seal material several turns, then pulling out the seal. Be careful not to scratch the metal of the pump head with the screw.
3. Wash the pump head with water. Use a squeeze bottle to flush liquid through the check valves and all exposed ports.
4. Irrigate the pump head and new seal (part number MR- 4598) with methanol, and push the seal fully into its seat with your thumb. Do not scratch the seal with a fingernail.
5. Irrigate the Backing Disk if salt deposits have collected inside the irrigation ports.
6. Proceed with pump head reassembly (section 5.1.5). Be sure to follow the break-in procedure for new plunger seals (section 5.2) after the pump is reassembled.

5.1.5 Pump Head Assembly

1. Wash all parts with water.
2. Place the front part of the pump head face down on a flat surface. Irrigate the plunger seal with methanol.
3. The backing disk has an "L" shaped slot in its side for locking the head assembly to the pump housing. Orient the backing disk so the "L" shaped slot is opposite the check valve assembly on the head. Insert the backing disk on the back of the head and screw down with two 8-32 socket head cap screws in the counterbored holes. (Figure 5.4)
4. Irrigate the sapphire plunger with methanol.

IT IS IMPORTANT THAT THE SEAL BE MOIST BEFORE INSTALLING THE PLUNGER ASSEMBLY!

5. Align the guide rods on the plunger assembly with the two thru holes in the backing disk and insert the plunger assembly with the sapphire plunger entering the plunger seal. (Figure 5.2) Insert the plunger assembly until it is about ¼" away from the Backing Disk. Do not press the plunger assembly all the way down against the backing disk or the head cannot be reinstalled into the pump drive.

5.1.6 Pump Head Installation

To properly engage the plunger to the plunger drive mechanism, the plunger drive mechanism must be fully forward. This procedure assures that the drive mechanism is properly positioned for head installation or removal.

1. Turn Power on the pump.
2. Press the PURGE key.
3. Press the RUN key. Purge for 5 seconds.
4. Press the STOP key. By stopping the pump following purging, the plunger drive mechanism(s) will automatically be moved to the full forward position for installation of the pump head.

NOTE: THE PLUNGER DRIVE MUST BE FULLY FORWARD FOR THE PLUNGER TO ENGAGE THE DRIVE MECHANISM.

5. With the pump head inlet check valve facing down, align the slot in the plunger assembly with the pin in the housing and slide the head assembly straight into the housing. As the head plunger mount contacts the plunger drive in the pump, the resistance to insertion will increase as the plunger slides within the seal. Continue to slide the head forward until the head backing disk rests firmly against the face of the housing.
6. Rotate the head clockwise 30° until the check valve is vertically down and the head mounting holes align with the threaded holes in the housing. This engages the plunger mount to the plunger drive.

Note: If the plunger assembly is closer than ¼" to the Backing Disk, the head will be locked out from rotating into place. Remove the head and pull the plunger assembly away from the Backing Disk about ¼" and repeat steps 5 and 6.

7. Tighten the head to the housing with two 8-32 socket head cap screws.
8. Insert the second head (PM-92€) as in steps 5, 6, and 7.

9. Hold the inlet check valve assembly stationary with a ½" wrench and attach the inlet line with a second ¼" wrench.
10. Attach the fitting on the pressure manifold line to the front of the head(s).
11. Follow the start-up procedure in section 4.3. It is very important to:
 - 1) ensure that the plunger seals are moist at start up, and
 - 2) purge all air from the system.
12. If new plunger seals were installed, follow the break-in procedure in section 5.2.

5.2 PLUNGER SEAL BREAK-IN

Plunger seals must seat properly for longest life. A salt-free solvent is recommended for break-in. Proceed as follows after installing new seals:

1. Wet the irrigation ports in the pump heads with a few drops of water.
2. Purge the system with filtered 40:60 (v:v) acetonitrile:water.
3. Attach a column to the system. It need not be a good column, as its only purpose is to provide backpressure.
4. Run the pump for two hours at a pressure of 3000-3500 PSI. Adjust the FLOWRATE as necessary to achieve this pressure.
5. After two hours you may switch to mobile phase and begin chromatography.

5.3 SERVICING CHECK VALVES

The PM-92€/PM-91€ pumps use cartridge-type check valves (part number MR-4650) that do not contain removable parts. The same valve is used for both the inlet and outlet check valves on the pump. Each check-valve cartridge contains two precision-engineered balls and seats in series, for a reliable seal. You can determine the direction of flow through the cartridge by attempting to squeeze water or methanol through it in each direction. An arrow on the side of the cartridge also indicates flow direction. When installing, remember that flow is always "up" through the pump.

In most cases, faulty check-valve performance (as indicated by large pressure fluctuations) is due to microscopic debris, salt precipitation, or trapped gas pockets. Gas can be removed by purging (section 4.3) with freshly degassed mobile phase or solvent. The check valves may be cleaned by sonication (section 5.3.2), or (if necessary) replaced. When cleaning or replacing these cartridges, remember that any lint from towels, paper wipes, etc. may reintroduce the problem. The best approach is to flush the check valves with methanol and to reassemble them wet.

An understanding of flow through the pump and check valves is helpful in diagnosing check-valve problems. Figure 5.5 diagrams flow during a full cycle of two pump strokes for the PM-92E pump. When the left pump head is compressing. The inlet check valve below it closes, preventing any backflow. The outlet check valve above it opens, allowing mobile phase to proceed towards the system pressure transducer in the center of the pressure manifold then out of the pump.

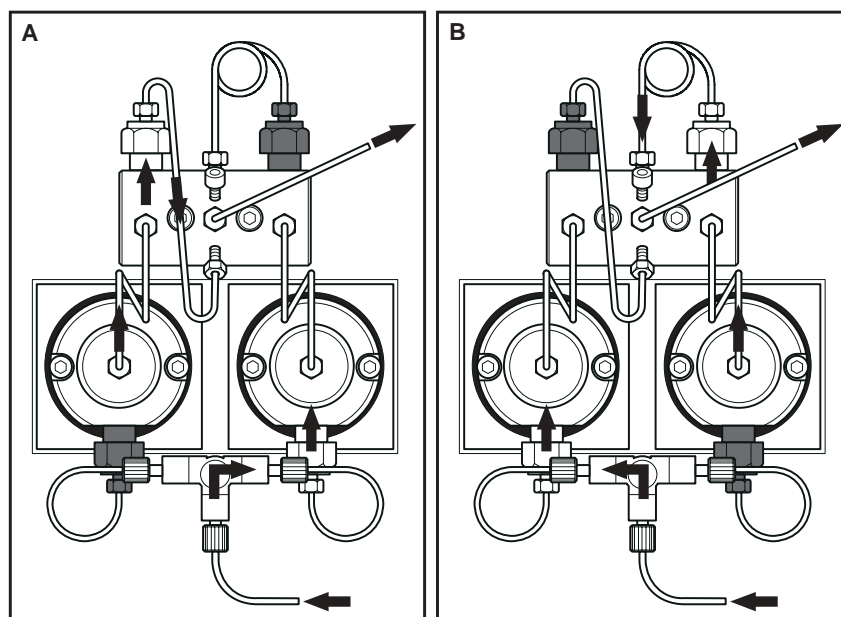
While this is occurring, the right pump head is aspirating. Its inlet check valve is open, allowing mobile phase to enter from the solvent reservoir. The outlet check valve is closed, which prevents any backflow into the right pump head from the left head and manifold. The PM-92E LCD displays an "L" during this part of the pump cycle.

After the left pump head finishes its stroke, the roles of the two pump heads reverse. The right pump head begins compressing. The inlet check valve closes, and the outlet check valve opens. The left pump head begins aspirating; its inlet check valve opens and its outlet check valve closes. The PM-92E LCD displays a "R" during this part of the pump cycle.

Pump-related malfunctions that produce pressure fluctuations can be localized by observing the pump stroke and pressure readout. When the display shows "L" while pumping, the left head is compressing. Its inlet check valve must shut, and its outlet check valve must open. In addition, because the pressure manifold chamber is open to both pump heads, the outlet check valve of the right pump head must close. If it didn't, fluid would flow from the left pump head into the manifold, then down into the right pump head. The opposite argument applies to the right pump head.

Because of this relationship, there are three likely places to check when pressure drops as one pump head compresses: the pump head itself (plunger seal, plunger), the inlet check valve for that pump head, and the outlet check valve for the opposite head.

Figure 5.5 Solvent flow during compression of the left (A) and right (B) pump heads. Shaded check valves are closed.



5.3.1 Check Valve Removal

1. Stop the pump and allow pressure to dissipate. Then turn off the POWER.
2. Hold the check-valve assembly stationary with a ½" wrench and remove the inlet or outlet line with a ¼" wrench.
3. Remove the check-valve assembly, which contains the check-valve cartridge.

5.3.2 Check Valve Cleaning

1. Place the entire check-valve assembly in a solution of laboratory detergent warmed to 50°C. We recommend a 50% solution of RBS-35[®] (Pierce Chemical Company). Soak for 1-2 hours. (Do not warm the solution above 60°C, because plastic parts in the check valves may become distorted.)
2. Sonicate the check-valve assembly for 15 minutes in the detergent solution.
3. Flush with deionized water, then methanol.
4. Reinstall the check-valve assembly following instructions in section 5.3.4. If check-valve problems continue, install a new cartridge (section 5.3.3).

5.3.3 Check-valve Cartridge Replacement

1. Remove check-valve assembly from the pump head or pressure manifold.
2. If the cartridge does not shake out of the assembly, push it out with a paper clip. This may require some force. Alternatively, you may be able to insert a small screw into the cartridge and pull it out of the assembly. Discard the old cartridge, as it is now damaged.
3. Clean the new cartridge (section 5.3.2).
4. Insert the new cartridge. Be certain to install the cartridge so it allows flow in the proper direction (Figure 5.5). Flow is always "up" through the pump; inlet check valves permit flow from the inlet line to the pump head, outlet check valves permit flow from the manifold to the outlet line.

5.3.4 Check Valve Installation

1. Squirt some methanol through the check valve. This will both wet it and allow you to observe whether the direction of flow is correct.
2. Install the check-valve assembly onto the pump head or manifold with a wrench.
3. Hold the check-valve assembly stationary with the wrench and connect the inlet or outlet tubing with a second wrench.
4. Follow the startup procedure in section 4.3 to prime the pump and remove all air from the check valves and lines.

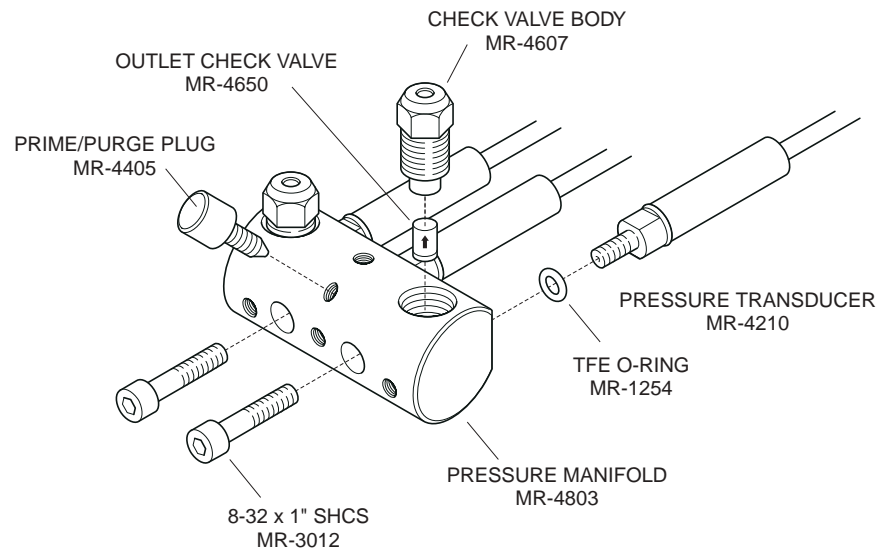
5.4 PRESSURE TRANSDUCERS

There are three pressure transducers located in the pressure manifold of the PM-92€ pump. Two pressure transducers are located in the manifold of the PM-91€ pump. They should rarely need attention. If a leak ever develops, there is a PTFE o-ring on the pressure transducer that needs to be replaced (Part Number MR-1254). Refer to Figure 5.6. Follow these steps:

1. Stop the pump and allow system pressure to fall to 30 PSI or less. Turn the POWER off.
2. Using a ½" wrench to hold the outlet check valve, remove the fitting attached to the outlet check valve using a ¼" wrench. Remove the fittings from the other outlet check valve.
3. Using a ¼" wrench, remove all the fittings from the pressure manifold.
4. Remove the two 8-32 socket head cap screws which mount the pressure manifold to the front panel.
5. Pull the pressure manifold straight back. Three pressure transducers are mounted to the back of the pressure manifold. (PM-92€)
6. Use a ⅜" wrench on the flat of the leaking pressure transducer to unscrew the transducer from the pressure manifold. Pull the transducer straight back from the manifold.
7. Remove the o-ring from the transducer and replace with a new o-ring (Part Number MR-1254).
8. Before screwing the pressure transducer back into the pressure manifold, twist the pressure transducer four turns counter-clockwise so that when the transducer is screwed into the manifold, the transducer cable is unwound and is left untwisted when the transducer is mounted tightly to the pressure manifold.

9. Screw the pressure transducer into the manifold finger tight, so the o-ring is squeezed against the back of the pressure manifold. Using a $\frac{3}{8}$ " wrench, tighten the transducer another $\frac{3}{4}$ turn.
10. Mount the pressure manifold to the front panel with two 8-32 socket head cap screws.
11. Reconnect all fittings to the same ports they were connected to previously. (See figure 3.1)
12. Purge the pump (see section 5.5).

Figure 5.6 Exploded view of Pressure Manifold.



5.5 FITTINGS

Check all fittings for leaks every day. Large leaks will be obvious. Small leaks will be apparent only by the accumulation of salt deposits around the fitting. It is not normal for fittings to have even small leaks, and these should be tended to.

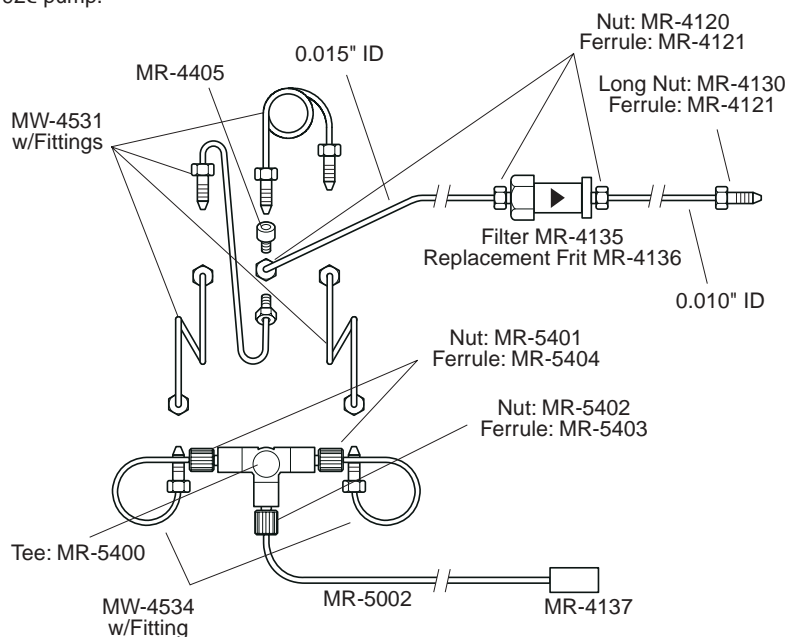
The first approach to treating a small leak is to clean up the salts with water and tighten the nut slightly. About $\frac{1}{8}$ turn should do it, unless the nut is loose. If this doesn't stop the leak, it's best to replace the fitting and line entirely. Why?

It's certainly tempting to use a lot of force to stop a small leak. But several bad things can happen when you overtighten a fitting:

1. The nut may break off with its threads still in the hole. A machinist will have to get it out for you, and if you're very lucky the part won't be damaged.
2. The nut may fuse in place, and break off the next time you try to open it.
3. The tubing end may become crimped, restricting flow and causing performance problems.

It makes more sense to replace a fitting or line before any of these events occur. Figure 5.7 gives part numbers and ferrule types for all tubing used in the PM-92e pump.

Figure 5.7 Tubing and fittings used in the PM-92e pump.



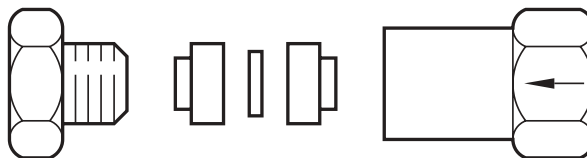
5.6 IN-LINE SOLVENT FILTER

The in-line filter (Figures 5.7 and 5.8) should be suspected whenever system pressure rises above normal. (See Section 6.6 on troubleshooting high pressure.) The filter becomes clogged by doing its job: preventing particles from the mobile phase or pump seals from lodging in the injector or on the column. To replace the filter frit do the following:

1. Stop the pump and allow pressure to fall below 30 PSI.
2. Remove the inlet and outlet tubing to the filter assembly. Be sure to note the flow direction (Figure 5.8).
3. Loosen the two halves of the filter assembly with two wrenches, but do not separate them yet.
4. Hold the assembly vertically, with the smaller section on the bottom. Now unscrew the larger section and remove.
5. The two frit supports and the frit can now be removed from the smaller section. Keep the supports separate so they can be reassembled in the same order: they seal best when installed in the section from which they came.
6. Flush water through each support to ensure that its passageway is not clogged.

7. Place the appropriate support on the smaller section, then put a new filter frit (MR-4136) on top of it. Put on the remaining support, then screw on the larger section. Tighten with two wrenches.
8. Attach the inlet outlet from the pump to the inlet of the assembly, observing proper flow direction. Pump some mobile phase through the unit to remove air, then attach the outlet tubing.

Figure 5.8 Exploded view of in-line solvent filter.



5.7 FAN FILTER

The fan filter should be removed for cleaning at least once per year (more often if it's visibly dirty.) Proceed as follows:

1. Gently pry off the retaining grid with a screwdriver (Figure 5.9).
2. Carefully pull out the filter. You may either vacuum it clean, or wash it gently in warm sudsy water. Be careful not to tear the filter.
3. If you've washed the filter, blot it well between sheets of paper towels, then allow it to dry.
4. Reinstall the filter by holding it in place over the fan opening, then snapping the retaining grid in place. Position the grid with its ridges facing in towards the filter.

Figure 5.9 Removing the fan filter.



**5.8 ROUTINE
MAINTENANCE**

A regular maintenance schedule will keep your pump's performance up to specifications. We recommend the following:

Every Day

Inspect all fittings in the flow path for leaks. (Figure 5.7)

Every Three Months

Replace plunger seals and inspect interior of pump head (Section 5.1).

Every Year

Clean the fan filter (Section 5.7).

Section 6. TROUBLESHOOTING

6.1 POWER WON'T TURN ON

1. Check power connection.
2. Check fuse and fuse type.

6.2 AUDIBLE NOISE

Continuous Buzzing Sound

1. Grasp each pump head with your hands. Is the audible noise significantly reduced? If so, the noise is due to motor generated vibration. At certain flow rates, the stepper motor excites the pump module to greater vibrations. This can cause the pump module to contact the adjacent pump module or the sheet metal front panel.. This is more likely to happen when there is no load (no high pressure) and at higher flow rates.
2. Open the purge plug, reduce the flow rate to 50 ul/min. and observe the L and R indicator on the LCD screen. Does the pump make a continuous knocking sound the entire time while either L or R is displayed? If so, Call BAS.

Intermittent Buzzing Sound

1. Open the purge plug , reduce the flow rate to 50 uL/min. and observe the L or R indicator on the LCD screen to correlate the noise with Left or Right head. Does the buzzing resolve into a continuous knocking sound which only occurs with one head? Does the knocking sound occur only towards the end of stroke of one head? If so, the pump head is not engaged to the drive mechanism. Remove the head and reinstall it. See section 5.1.6 for instructions.

6.3 NO SOLVENT FLOW

1. Check flow rate setting. Is it set for a valid, non-zero range (1 - 1999 ul/min)?
2. Has Run/Stop key been pressed to start the pump. The LCD will display pumPing or iniTing while the pump is operating.
3. Is the high or low pressure limit displayed on the LCD? If so, see section 4.2.
4. Is there an error message on the LCD? If so, call BAS
5. Check for loose connections on the inlet side of the pump. Purge with freshly degassed mobile phase.
6. Mobile phase reservoir is empty. Purge with fresh mobile phase.
7. Solvent uptake frit is clogged. Clean or replace.

**6.4 NO SOLVENT FLOW
FROM ONE HEAD ONLY**

1. Check for loose inlet connection to that head. Purge with freshly degassed mobile phase.
2. Head not engaged to drive mechanism. Remove head and reinstall. See section 5.1.1 and 5.1.6 for instructions.
3. Inlet check valve failure. Switch inlet check valves between the two heads. If the problem follows the check valve then clean or replace inlet check valve cartridge.
4. Check irrigation port outlet behind and under the head. If wet or buffer salt deposits have accumulated, a seal may be leaking. See section 5.1 for seal replacement.

**6.5 PUMP STOPS:
LOW PRESSURE LIMIT**

1. Mobile phase reservoir is empty. Make fresh mobile phase and purge.
2. There is a leak in the system. Check all connections.
3. Inlet check valve failure. Switch inlet check valves between the two heads. If the problem follows the check valve then clean or replace inlet check valve cartridge.
4. Check irrigation port outlet behind and under the head. If wet or buffer salt deposits have accumulated, a seal may be leaking. See section 5.1 for seal replacement.
5. The low pressure limit is set too high. Reset to a reasonable value for your conditions.

**6.6 PUMP STOPS:
HIGH PRESSURE LIMIT**

1. The high pressure limit is set too low. Reset to 4000 psi or a reasonable value (1000 psi above your typical operating pressure) for your conditions.
2. The injection valve is not fully in the inject or load position. Rotate it to one side.
3. The injection valve is not rotated fast enough when switching from load to inject or inject to load. When making an injection the valve must be rotated quickly or pressure will quickly exceed the high pressure limit.
4. There is a clog in the flow path. It could be anywhere between the pump outlet and the detector. It may be the in-line solvent filter. Start opening fittings at the detector and work towards the pump. At some point the pressure will drop, pinpointing the location of the clog. (NOTE: There will be a normal drop in pressure when the column is removed)
5. Have you changed to a more viscous mobile phase (e.g., one with more methanol)?

6.7 PRESSURE FLUCTUATIONS

1. The most common cause of pressure fluctuations at microbore flow rates is the failure of check valves to seal. This can be caused by air bubbles or contaminants in the check valve. Purge the pump with freshly degassed mobile phase. If performance improves, air bubbles were in the check valves. If the problem returns, degas the mobile phase more frequently and check the connections to the inlet side of the pump where air can be sucked in. Note which head is compressing on the LCD display "L" or "R" when the pressure drops.
2. Switch the outlet check valves between the two heads. If the pressure drop now occurs on the opposite pump head, it is associated with the outlet check valve on the head that does not show a pressure drop. Clean or replace as in section 6.3.
3. Switch the inlet check valves between the two sides of the pressure manifold. If the pressure drop now occurs on the opposite pump head, it is associated with the inlet check valve on the head showing the problem. Clean or replace as in section 5.3.
4. One or both pump heads may need an overhaul. See section 5.1.
5. One of the outlet lines from the pump to the pressure transducer may be clogged. Remove and examine. Replace as necessary.
6. Check irrigation port outlet behind and under the heads. If wet or buffer salt deposits have accumulated, a seal may be leaking. See section 5.1 for seal replacement.

6.8 FLUID LEAKS

1. Fluid leaks from (or salt accumulates around) fittings. Leaks indicate that fittings need to be tightened or replaced (section 5.5)
2. Fluid leaks (or salt accumulates) around pump heads or from irrigation waste ports. This indicates that the plunger seals are worn and leaking. They must be replaced (section 5.1) to prevent internal corrosion of the pump head.
3. Fluid leaks (or salt accumulates) around the junction of the front and back halves of the pressure transducer. Replace the pressure-transducer o-rings (section 5.4).

6.9 OVERHEATING

If the pump heads or cabinet feel warm, clean the fan filter (section 5.7) and check that the fan is operating.

Section 7. SPECIFICATIONS

HEIGHT:	4.6 inches
LENGTH:	9 inches
WIDTH:	11 inches
WEIGHT:	15 pounds
FLOW RATE:	1-1999 μ l/min
FLOW PRECISION:	better than 0.3% RSD
FLOW REPEATABILITY:	0.3%
PRESSURE RANGE:	0-4999 PSI (0-34 bar) with selectable limits
INPUT VOLTAGE:	100/120/220/240 vac 50/60 Hz
POWER:	2A (max) @ 120 VAC 50/60 Hz

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