PM-80

January, 2000

MF-9011 INSTRUCTION MANUAL

Solvent Delivery System

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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.

Table of Contents

Section 1. PREFACE

This manual explains the installation and operation of the PM-80 Pump, as well as procedures for routine maintenance and troubleshooting. Read the entire manual prior to installation and start-up.

The PM-80 is a reciprocating, dual-piston unit. It is designed for precise and reliable solvent delivery for isocratic and optional gradient elution at flow rates between 0.01 and 5.0 mL/min. Advanced features of the PM-80 pump include:

1. Type 316 stainless steel tubing throughout.

2. A microprocessor-controlled, computer-designed, dual-piston pump. Each head is removable as a single, precision-engineered assembly, which may be interchanged in seconds. The construction of the pump is solid (cast aluminum and machined 316 stainless steel); no sheet metal is included. The end result is a greater durability, mechanical reliability, and serviceability.

3. Solid-state pressure transducer, to monitor system backpressure in real time.

4. Pulse damper, installed as a standard feature for use at high sensitivity.

5. Purge valve, for bypassing the column and injector while flushing the solvent delivery system.

6. High- and low-pressure limit controls, for safety.

7. Analog output for pressure monitoring.

8. Provision for remote-control operation.

9. Optional ternary gradient capability. Call BAS for information on upgrading your isocratic PM-80 to a gradient system.

The PM-80 has 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-80 pump is unconditionally warranted for 90 days 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 (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-80 Pump
2. PM-80 Accessories (includes: power cord, 1/8" PTFE inlet lines with fittings, 50 mL syringe).
3. PM-80 Manual
4. Optional Gradient Controller

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 and back views of the PM-80 pump. The parts identified by number are described in Table 3.1.

Figure 3.1. Front panel of PM-80

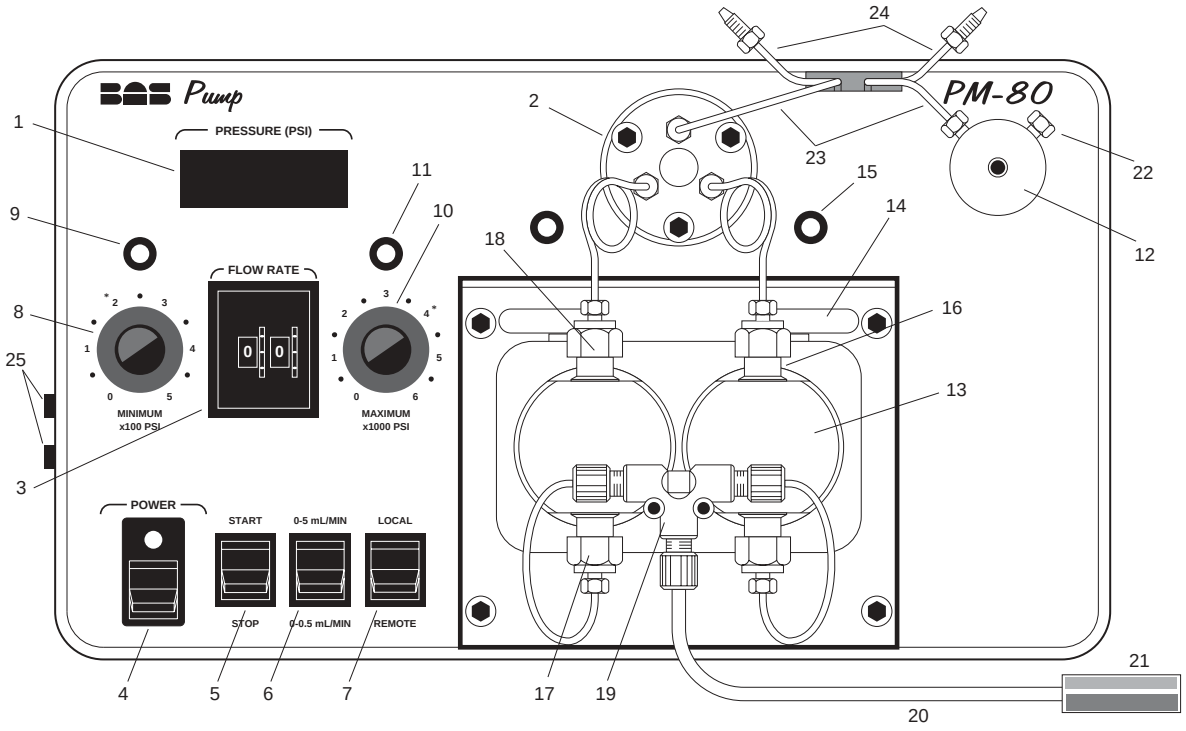


Figure 3.2. Rear panel of PM-80.

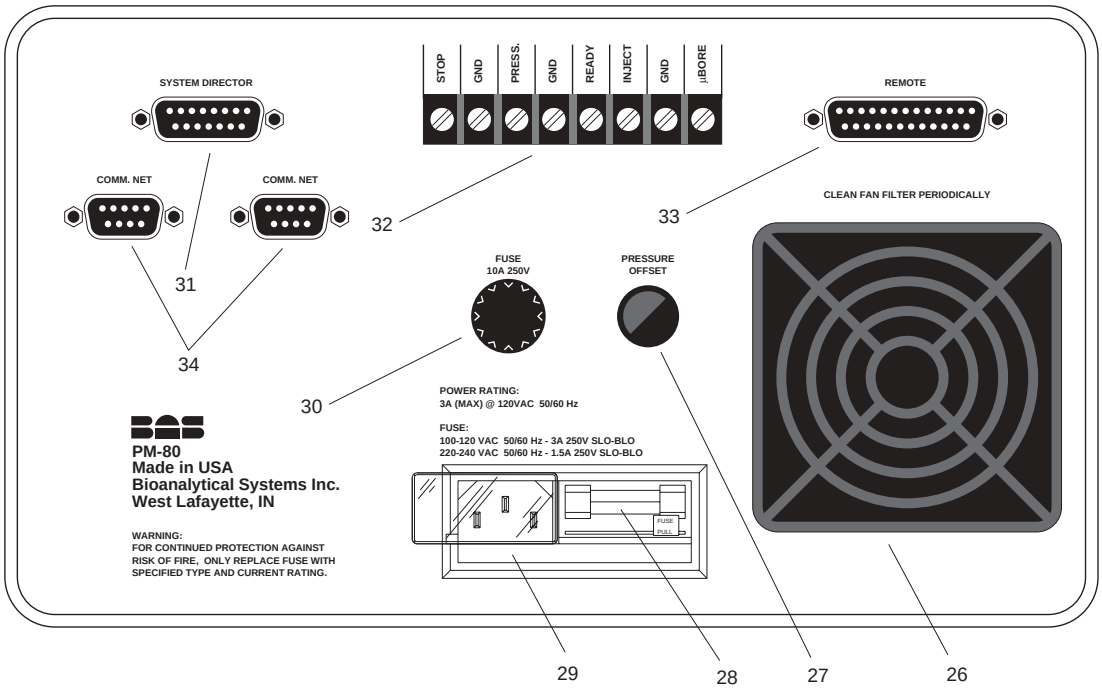


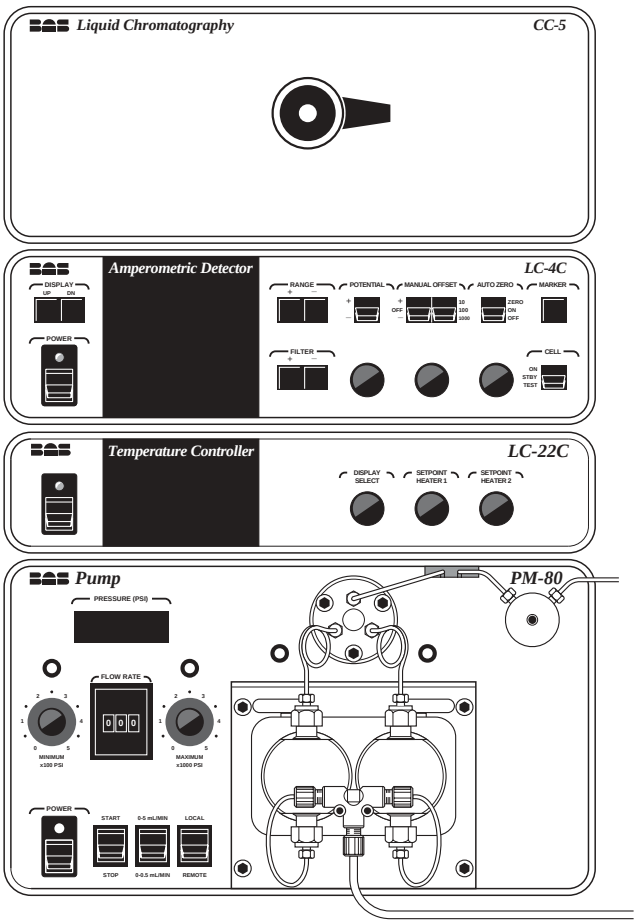
Table 3.1. Parts of the PM-80 pump.

1. Pressure display
2. Pressure transducer
3. FLOWRATE control
4. POWER switch
5. START/STOP switch
6. FLOWRANGE switch
7. LOCAL/REMOTE switch
8. MINIMUM pressure (low limit)
9. Minimum pressure warning LED
10. MAXIMUM pressure (high limit)
11. Maximum pressure warning LED
12. Prime/purge valve
13. Pump head
14. Pump-head release lever
15. Pump-head indicating LED
16. Plunger-irrigation port (hidden)
17. Inlet check-valve assembly
18. Outlet check-valve assembly
19. Inlet tee
20. Solvent-uptake line (Isocratic version)
21. Solvent-uptake frit (Isocratic version)
22. Outlet port to injection valve
23. Connections to pulse damper
24. Optional connections to mixer
25. Solvent intakes (gradient version)
26. Air filter
27. Offset adjustment for pressure output
28. Voltage selector
29. Power input
30. Fuse
31. LCD Controller connector
32. Terminal strip
33. REMOTE connector
34. BAS Instrument Control connectors

3.3 SITING THE PUMP

The PM-80 pump is designed to serve as the base for a stack of BAS chromatography instruments. A typical setup is illustrated by the BAS-480 chromatograph (Figure 3.3). The components of this system are (from the bottom up) the PM-80 pump, LC-22C temperature controller, LC-4C electrochemical detector, and CC-5 flowcell compartment.

Figure 3.3. The BAS-480 Liquid Cromatograph.



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-80 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, but the correct voltage must be selected before use at the cord connector (Figure 3.4, Table 3.2).

Should the power option need to be changed, unplug the line cord and slide the plastic window to the left. The orientation of the small circuit board now exposed in this socket determines the voltage option. If the voltage labeled on the outer edge of this board is not that required, pull out the board and turn it such that the desired voltage is readable. Reinsert the board and push the fuse holder back into the cavity. Also check to see that the fuse is the proper rating (Table 3.2).

Figure 3.4. Voltage selection

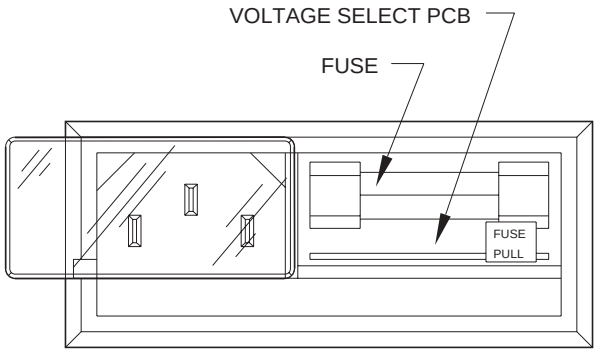


Table 3.2. Correct Fuse Selection

Voltage	Fuse
100-120V	3 A/SB
220-240V	1.5 A/SB

3.5 FLUID CONNECTIONS

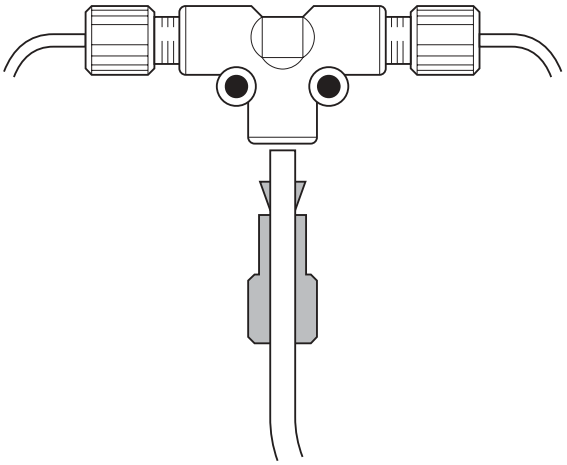
The PM-80 is factory plumbed, and ready as received for final connection of the inlet and outlet solvent lines. Unwrap the teflon tubing carefully and remove the protective cover from the solvent-uptake frit. The uptake tubing connects to the tee at the pump head with a flangeless fitting. Be sure to install this with the flat face of the ferrule entering the tee (Figure 3.5).

Connect a solvent-outlet line between the prime/purge valve and the pump input of your injection valve. A nut and ferrule are provided for connection to the prime/purge valve. 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.

Installation is now complete. Refer to section 4.2 (STARTUP) to begin purging the pump.

NOTE: See section 5 for connections for optional gradient system.

Figure 3.5 Orientation of flangeless fitting.



Section 4. OPERATION

4.1 CONTROLS

Power

An on/off toggle switch that applies power to the pump. When the power switch is turned on, the microprocessor performs a self test. During the self test the pressure display will alternately flash BAS and the software version number.

Start/Stop

A toggle switch that starts or stops the pump. This control is used to start or stop solvent flow without turning off the main power.

Local/Remote

A toggle switch that selects between flow control by the front-panel switches or by a remote computer or optional gradient controller.

Minimum

A potentiometer that sets the low-pressure limit (in PSI) for pump operation. It is EXTREMELY IMPORTANT that this limit be set to some reasonable non-zero value (e.g., 200 PSI, as indicated by the asterisk on the instrument) during normal operation. 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.

If the low-pressure limit is reached, the pump will stop and the red LED above the potentiometer will light. After correcting the problem, reset the protective circuitry by cycling the START/STOP toggle switch through STOP and START.

The low-pressure limit is enabled only after pressure exceeds its set value. Thus, you can run the pump with the prime/purge valve open (pressure will be 0 PSI) even though the low-pressure limit is set to 200 PSI. Only after the prime/purge valve is closed, and pressures get above 200 PSI, will a drop in pressure trigger the protective circuitry.

Maximum

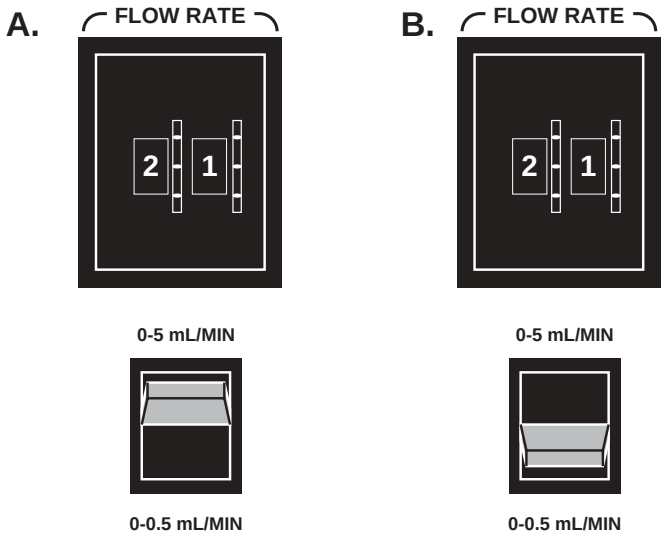
A potentiometer that sets the high-pressure limit (in PSI) for pump operation. It is EXTREMELY IMPORTANT that this limit be set to some reasonable value; if a clog develops anywhere in the flow stream between the pump and the detector, the high-pressure cutoff will stop the pump as pressure increases. We suggest setting the cutoff 1000 PSI above your typical operating pressure. A general-purpose setting is 4000 PSI, as indicated by the asterisk on the face of the instrument.

If the high-pressure limit is reached, the pump will stop and the red LED above the potentiometer will light. After correcting the problem, reset the protective circuitry by cycling the START/STOP toggle switch through STOP and START.

Flowrange

A toggle switch that chooses between standard- and micro-flow rates. In the 0-5 mL/min position, the FLOWRATE controls have an imaginary decimal point between the two digits (Figure 4.1). In the 0-0.5 mL/min position, the flowrate controls have an imaginary decimal point to the left of the digits.

Figure 4.1. Flowrate Selection. Flow is 2.1 mL/MIN in A, 0.21 mL/MIN in B.



Flowrate

These two control switches change the flowrate in conjunction with the FLOWRANGE toggle switch. With the toggle switch in the 0-5 mL/min position, the digits of the control are to be read with an imaginary decimal point between them (Figure 4.1). With the toggle switch in the 0-0.5 mL/min position, the digits are to be read with the decimal point to the left of both digits.

Prime/Purge

This valve provides a tap into the solvent flow line between the pulse damper and the injection valve. Suction can be applied here with a syringe to prime the pump, or new mobile phase can be rapidly brought through the pump and pulse damper.

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

Terminal strip (rear panel)

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

Pressure

Provides a 1 V per 1000 PSI output to monitor pressure. The output indicates absolute pressure when the offset adjustment is fully counter-clockwise. See section 4.3.4 for monitoring pressure fluctuations.

Stop

A switch closure or low-level TTL across the STOP and GND terminals will stop the pump when it's in the LOCAL mode.

Ready

A switch closure or TTL-low across the READY and GND terminals will trigger the start of a timed run. Used to accept a "ready-to-inject" signal from an autosampler (gradient versions).

Inject

Sends a six second TTL-low signal at the start of a timed run. Used to trigger an autosampler to inject (gradient versions).

µBore

A switch closure or TTL-low across th µBORE and GND terminals will switch the pump from normal flow ranges (0-5 mL/min) to µbore ranges (0-0.5 mL/min). Used to slow down the flowrate after a series of runs, to conserve mobile phase. For example, a switch closure signal from an autosampler after the last sample has been injected will change a 1 mL/min flowrate to 100 µL/min. WARNING: running at low pressure might decrease plunger-seal life.

Remote (rear panel)

The 25-pin "D" connector is not currently used.

System director (rear panel)

A 15-pin "D" connector provided for the LCD gradient controller or the DA-5/ChromGraph computer system.

Pressure offset (rear panel)

A potentiometer used to adjust pen position when recording pump pressure (section 4.3.4, page 15).

4.2 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

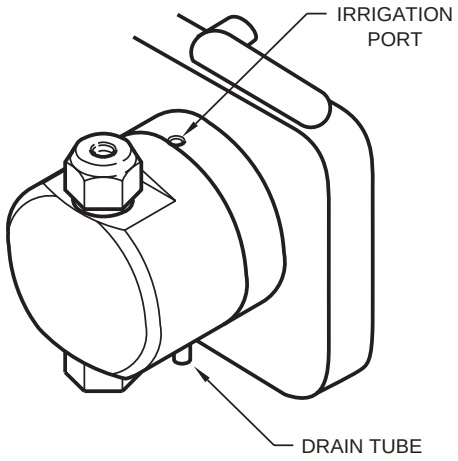
NEVER LEAVE STAGNANT MOBILE PHASE IN THE PUMP

Correct startup procedure is as follows:

1. Put the START/STOP toggle switch in the STOP position and turn the POWER on.

2. Squirt a few drops of water into the plunger-irrigation ports (Figure 4.2). Use only enough water to moisten the plungers.

Figure 4.2. 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-80 PUMP SHOULD BE FILTERED THROUGH 0.2 μm MEMBRANE FILTERS. USE ONLY LC-GRADE SOLVENTS AND TYPE I REAGENT-GRADE WATER.

4. Attach a 50-mL disposable syringe to the prime/purge valve and open the valve one turn (don't forget that system pressure must be below 30 PSI before opening the valve). Aspirate until solvent comes through the pump. Leave the syringe attached with the prime/purge valve open.

5. Set the FLOWRATE control to 5 mL/min. Then turn the START/STOP switch to START and pump for 5 minutes. During this purge you may alternately draw back and release the syringe plunger to help dislodge air bubbles from the system.

6. Stop the pump. Set the FLOWRATE control to 1 mL/min. Close the prime/purge valve.

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 again 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 1 mL/min or other appropriate setting.

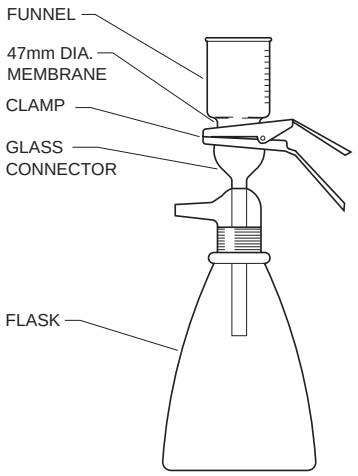
4.3 ROUTINE OPERATION

4.3.1 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/cm^2. 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 (Figure 5.1). This highly effective instrument reliably and consistently delivers bubble-free mobile phase to the PM-80 pump.

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

4.3.2 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 START/STOP toggle switch to the STOP position and turn the POWER switch on.

3. Flush the plunger-irrigation ports with water (Figure 4.2). A plastic squeeze bottle is ideal for this.

4. Attach a 50-mL disposable syringe to the prime/purge valve and open the valve one turn (remember that system pressure must be less than 30 PSI before opening this valve). Aspirate until mobile phase comes through the pump. Leave the syringe attached with the prime/purge valve open.

5. Set the FLOWRATE control to 5 mL/min. Then turn the START/STOP switch to START and pump for 5 minutes. This purge step ensures that all old mobile phase has been flushed from the pump and pulse damper, so fresh mobile phase is ready to flow to the column.

6. Stop the pump. Reset the FLOWRATE control to 1 mL/min. Close the prime/purge valve.

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 control to 1 mL/min or other appropriate setting.

9. Switch the START/STOP toggle switch to the START position to begin pumping. Observe the pressure readout until it stabilizes, and check all connections for leaks.

4.3.3 Routine Maintenance

A regular maintenance schedule is part of normal operation. See section 6.8 (page 40) for recommended procedures.

4.3.4 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. and GND connectors on the terminal strip of the PM-80 to the input of the chart recorder. Use an electronic alignment tool to adjust the PRESSURE OFFSET potentiometer on the rear panel of the PM-80, 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)

4.4 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. Switch the START/STOP toggle switch to STOP and 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-80 PUMP SHOULD BE FILTERED THROUGH 0.2 μm MEMBRANE FILTERS. USE ONLY LC-GRADE SOLVENTS AND TYPE I WATER.

3. Place a 50-mL syringe on the prime/purge valve. Check to make sure that system pressure is below 30 PSI, then open the valve one turn. Set the FLOWRATE to 5 mL/min.

4. Switch the START/STOP toggle switch to the START position and pump for 5 minutes at 5 mL/min. This will bring fresh solvent through the pump and pulse damper.

   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 1 mL/min or other appropriate range. Close the prime/purge valve. Pump 100 mL 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 2 mL/min. Pump 100 mL solvent through the pump, pulse damper, and injector (in INJECT position to flush the loop). Then shut the system off.

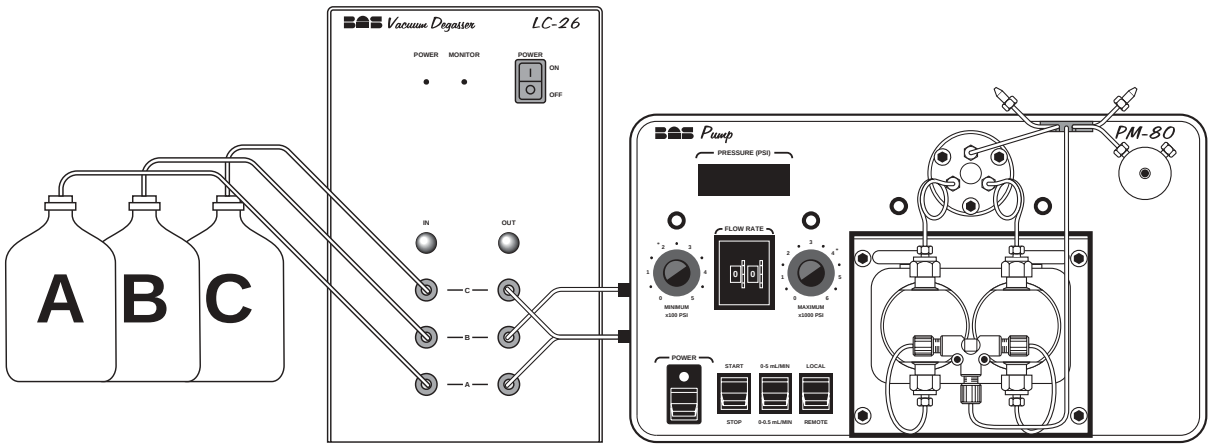
Section 5. GRADIENT CONTROL

NOTE: REFER TO SECTION 4 FOR GENERAL OPERATION, PROPER USAGE, AND DESCRIPTION OF ALL CONTROLS. THIS SECTION WILL DISCUSS ONLY THE MECHANICS OF GRADIENT OPERATION.

5.1 CONNECTIONS

The gradient version of the PM-80 pump differs from the isocratic version in the number and location of solvent uptake lines, and in the presence of an internal high-pressure mixer (Figure 5.1).

Figure 5.1



5.1.1 Solvent Uptake

Connect the three solvent-uptake lines to the ports marked “A”, “B”, and “C” on the left side of the pump. Be sure to observe the correct orientation for the flangeless ferrules (Figure 3.5, page 8). The solvent-uptake frits should be placed into three bottles of freshly filtered mobile phase. (For initial startup, cleaning, etc., you may put all three uptake lines into the same bottle of 40:60 acetonitrile:water or other appropriate solution.) For best results, elevate the mobile-phase bottles to provide hydrostatic pressure to the pump.

WE STRONGLY RECOMMEND THE USE OF THE LC-26 DEGASSER (Figure 5.1). Use of an on-line degasser is required for dependable and continuous performance during gradient operation.

5.1.2 Mixer

The high-pressure mixer is located inside the cabinet, at the front, upper-right side. Four steel tubes emerge from the cabinet at this point: the two labeled “M” come from the mixer, while the two unlabeled tubes come from the pulse damper. The two uses are mutually

exclusive. Isocratic operation will benefit from a pulse damper, and does not require a mixer. Gradient operation does require a mixer, and will be impaired by the large dead volume of a pulse damper.

To convert from isocratic to gradient operation, remove the tubes from the pulse damper at the pressure transducer and the purge valve, and replace them with those from the mixer.

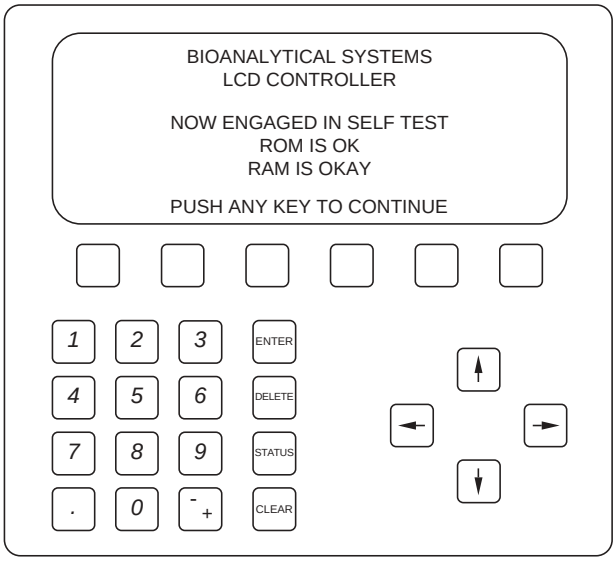
BE SURE TO FLUSH OUT THE PUMP WITH 40:60 ACETONITRILE:WATER BEFORE CHANGING BETWEEN THE MIXER AND THE PULSE DAMPER, so stagnant mobile phase doesn't corrode the unused component.

The mixer motor is software controlled: it turns on whenever a method calls for more than one bottle of mobile phase.

5.2 LCD CONTROLLER

The LCD controller connects to the SYSTEM DIRECTOR port on the back panel. It takes over all functions from the front panel when the LOCAL/REMOTE switch is in the REMOTE position. The controller can edit and store up to seven methods. Programming the controller is best learned by the hands-on approach. The following guidelines will make this process smoother. Refer to Figure 5.2.

Figure 5.2 Startup Screen.



The row of blank buttons directly under the display become active when function labels appear in the display just above them.

Use the ENTER key to scroll horizontally across lines of information.

Use CLEAR to remove an erroneous entry.

The cursor cannot back up. If you enter an erroneous entry, complete the line and come back to it with the UP arrow key.

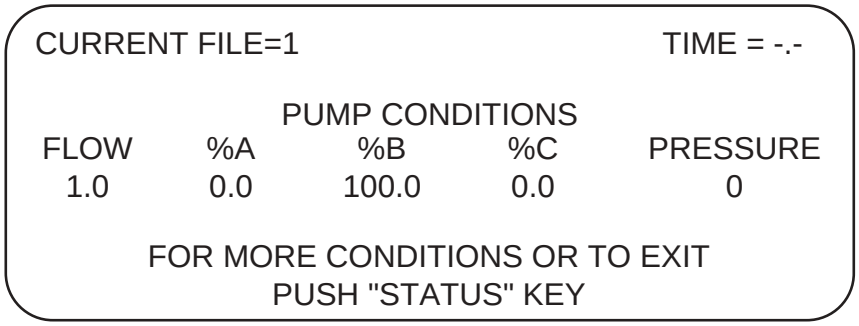
Use DELETE to remove an entire line of information. The cursor must be on the left side of the line for DELETE to be active.

Use UP and DOWN arrows to scroll vertically among lines. The cursor must be on the left side of the line for these keys to be active.

To SAVE a modified method, you must press two save functions. The first saves the method to RAM, the second saves it to permanent storage under a file number from 1-7.

STATUS will toggle to a status screen that shows pump conditions and run time (Figure 5.3). Press STATUS again to return to the previous screen. STATUS is active at all times.

Figure 5.3 Pump Status Screen.

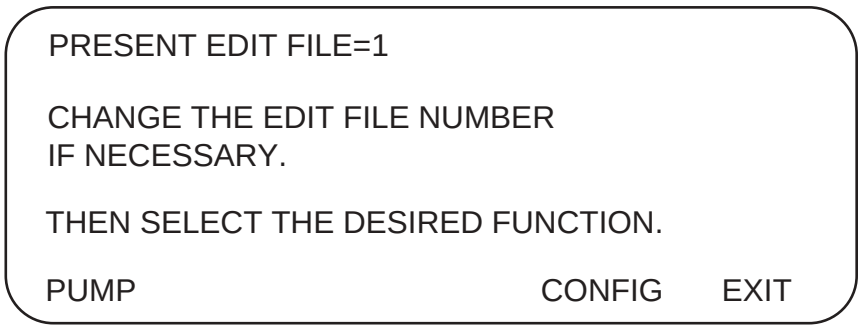


5.3 MANUAL PUMP OPERATION

Gradient operation generally requires a timed program in which the proportion of mobile phase from the bottles varies with time. However, many routine operations, such as cleaning columns and setting up initial conditions, require only that the pump be started at a specified flowrate and mobile-phase mix. These manual operations can be set into effect with a few keystrokes. For example, to set up the initial conditions of 80% A, 20% B, 1 mL per minute, do the following:

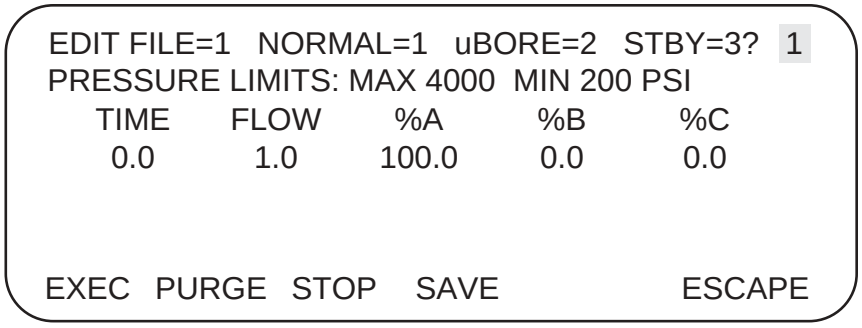
1. Turn on the main power and set the pump for REMOTE operation. The LCD will come on, do some self checks and ask you to press any key. The screen will then look like Figure 5.4 (Edit File Screen).

Figure 5.4 Edit File Screen



2. Press the key below the word PUMP, and the screen in Figure 5.5 will appear. This is the main programming screen for the pump.

Figure 5.5 Main Programming Screen



3. The cursor will appear at the top right of the screen, with a default of 1. The two valid choices here are:

   1 = normal flow rates, 0-5 mL per minute in 0.1 mL increments.

   2 = microbore flow rates, 0-0.5 mL per minute in 0.01 mL increments.

Choose normal flow rates by pressing ENTER. (To choose microbore, key in a "2", then press ENTER.

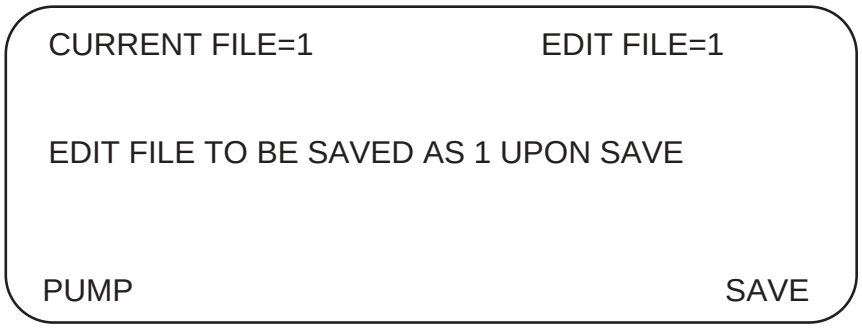
4. The cursor then moves down to the high- and low-pressure cutoffs, which should be set for most uses at 4000 and 200 PSI. Press ENTER to accept these defaults.

5. The cursor is now at the 0.0 time line. Press ENTER to move to the FLOW column, and change it, if necessary. Then press ENTER to move to the % A column. Press ENTER if it is correct (80.0% in this example), or key in the correct percentage, then press ENTER. The % B column is done similarly. The % C column is calculated automatically as the difference between A+B and 100%.

6. The cursor should now be at the start of line 2 (even if it is a blank line). Press EXEC to start the pump with the conditions set in the 0.0 time line. The STOP button will stop the pump, and the SAVE button is the first of the two-step process to make the file permanent. Pressing SAVE will bring up the Save File Screen (Figure 5.6). File numbers 1-7 are valid entries for up to 7 stored methods. Change the file number if necessary, then press SAVE again to complete the process.

7. If you do not want the current pump conditions to become part of a permanent method (e.g., you are flushing the column with an organic solvent), do not SAVE the instructions. When you wish to recall the original program, use the ESCAPE button. The LCD screen of Figure 5.6 will appear. Press PUMP, and Figure 5.5 appears, with the temporary instructions lost and the original instructions in place. The pump will still be carrying out the temporary instructions, but pressing EXEC will reinstate the original instructions.

Figure 5.6 Save File Screen

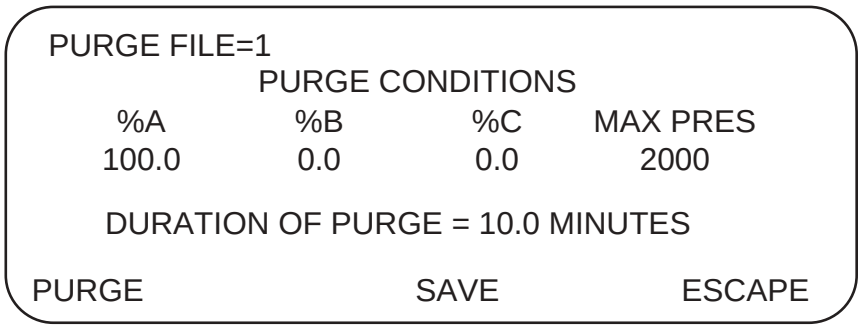


5.4 PURGE

Purge instructs the pump to automatically modify flowrate to maintain a given pressure. If the preset pressure is not reached, the pump will gently increase flowrate to its maximum of 5 mL per minute. A purge is useful to wash a column, or to bring fresh mobile phase from the solvent reservoirs up to the prime/purge valve. To begin a purge:

1. Start from the main programming screen (Figure 5.5). Press the key under the PURGE label. The purge control screen will appear (Figure 5.7). Enter the percentages to be metered from each solvent reservoir, and the pressure that the pump should attempt to hold. A valid pressure range is between 0 and 5000 PSI.

Figure 5.7 Purge Screen



2. Enter the length of the purge (0.1 - 99.9 minutes).

3. The purging information can be saved, if desired, by pressing SAVE in this screen, SAVE in the main programming screen, and SAVE in the Save File screen.

4. ESCAPE will return to the main programming screen.

5. Before beginning the purge:

   A. If the purge is to bring fresh mobile phase up to the prime/purge valve, put a 50-mL disposable syringe on the valve, and open the valve one turn.

B. If the purge is to wash a column, make sure the maximum pressure setting does not exceed the working pressure of the column, and that the prime/purge valve is closed.

6. Press PURGE to start the purge cycle. The pump will slowly increase flowrate until it hovers around the preset pressure. If the preset pressure is not reached, the pump will increase its flowrate to 5 mL per minute.

7. At any time during the purge, ESCAPE will end the purge, and STATUS will bring up the status screen.

5.5 PROGRAMMED AND GRADIENT OPERATION

A program (a series of timed events) must be used whenever a gradient is needed, and whenever the pump must be synchronized with peripheral equipment (such as an autosampler).

Before beginning a gradient, check that pump synchronization is turned on (Section 5.6, page 24). Synchronization ensures precise, repeatable gradients by delaying the start of each run until a specific piston position is reached.

Program a gradient as follows:

1. Start at the main programming screen (Figure 5.5). Assuming the FLOWRANGE, MAX and MIN settings are correct, press ENTER three times to put the cursor at the left of the 0.0 time line.

2. Enter the FLOW and bottle percentages as appropriate for the 0.0 time line (initial conditions).

3. The cursor will automatically begin the second time line. Enter the time (minutes) and bottle percentages for this line (there is no FLOW programming, so this column will be blank).

4. A program must have at least two time lines: a start (0.0) line and an end line. Up to ten lines are permitted.

5. Only three time lines will fit on the screen simultaneously. The lines will scroll up during entry of subsequent lines. For review of hidden lines, move the cursor to the left side of a line and use the UP and DOWN arrows.

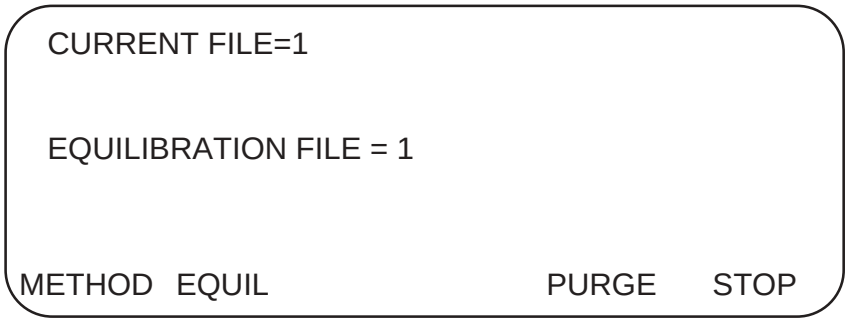
6. Use DELETE to remove an entire line, use CLEAR to change an erroneous entry.

7. Lines can be entered in any order and will sort themselves out on the screen.

8. After the last entry, press SAVE in the programming screen (Figure 5.5) and SAVE in the Save File screen (Figure 5.6).

9. To start the pump under the conditions in the 0.0 time line, press EXEC in the main programming screen (Figure 5.5) or EQUIL in the equilibration screen (Figure 5.8).

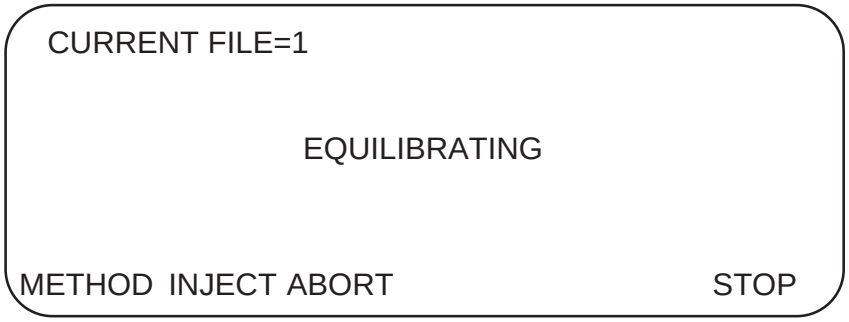
Figure 5.8 EquilibratION Screen



Begin gradient operation as follows:

1. From the equilibration screen (Figure 5.8) press EQUIL. The pump will start, and Figure 5.9 (Equilibrating Screen) will appear. This indicates that the program is ready to begin. Note that there is a difference between the Equilibration screen (i.e., ready to equilibrate) and the equilibrating screen (i.e., already equilibrating, ready to run).

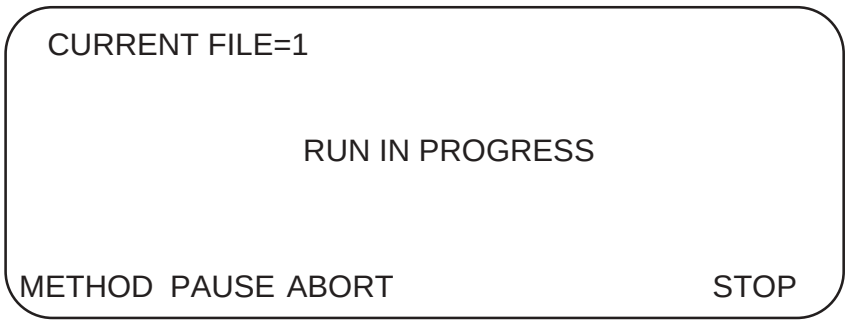
Figure 5.9 EquilibratING Screen



2. Press INJECT to start the run. Depending on the options you have selected in the configuration file (Section 5.6), the run may start immediately, or after a delay for synchronization. If AUTO RUNS was selected, you will be asked to enter the number of runs desired. When the run starts, Figure 5.10 (Run in Progress) appears.

3. STATUS may be pressed at any time during a run. However, the RUN IN PROGRESS screen (Figure 5.10) must be visible for the run to end properly and for subsequent runs to begin (i.e., do not leave in status mode).

Figure 5.10 Run in Progress Screen.



4. ABORT terminates the gradient run and returns to the 0.0 time conditions.

5. STOP terminates the gradient run and stops the pump.

6. PAUSE will halt the clock and maintain the current mobile phase composition indefinitely. The PAUSE button will change to CONTinue, to resume the run.

7. You can make changes to the pump program and save it at any time. However, the old program will still be in effect. To put the new program into effect, press ABORT then EQUIL.

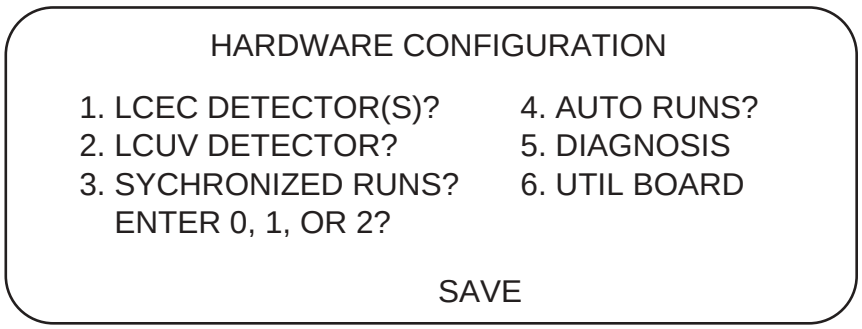
8. The run will end when the last time line of the program is reached. The Equilibrating screen (Figure 5.9) will appear, and the zero-time conditions will be maintained. If AUTO RUNS was selected, the next run will start. If not, the pump will await a signal from the operator or autosampler.

5.6 HARDWARE CONFIGURATION

Certain options are available to control the behavior of the pump in gradient and non-gradient operations, and for communication with an autosampler. To reach the hardware configuration screen, do the following:

1. From initial startup, follow the “PUSH ANY KEY TO CONTINUE” instruction. A screen with software versions will appear. Press any key to continue. The next screen says “PRESENT EDIT FILE=1" at the top left (Figure 5.4). Press the CONFIG key. The Configuration Screen (Figure 5.11) appears.

Figure 5.11 Configuration Screen.



2. To get to the configuration screen from the main programming screen (Figure 5.5), press SAVE, then SAVE in the next screen, then METHOD in the equilibration screen, then the CONFIG button (Figure 5.4).

3. Options 1 and 2 (detector options) are invalid in this application. Set them to “0".

4. Option 3: PUMP SYNCHRONIZATION. Turn synchronization on with a “1", off with a ”0". Pump synchronization ensures that each gradient run starts with the pistons in the same relative positions, for precise control of retention times. ALWAYS TURN SYNCHRONIZATION ON FOR GRADIENT OPERATION. Synchronization may be left on for isocratic operation as well. There will be a slight delay (up to 12 seconds at 1 mL/min) before each run starts.

5. Option 4: AUTO RUNS. With certain kinds of autosamplers, we want the PM-80 pump to be in control and signal the autosampler to inject. (See section 5.7 on autosamplers.) In this situation, turn AUTO RUNS on (“1") so the pump will initiate subsequent runs automatically. When AUTO RUNS is on, you will be asked ”HOW MANY RUNS" when you press INJECT to start the runs. You will also be asked for the “NEXT FILE NUMBER”, which allows the chaining of several methods.

6. Option 5 provides onscreen diagnostics for use by our engineers. May be left on or off.

7. Option 6 is invalid in this application. Set it to “0". Press ENTER to continue.

8. Press SAVE to exit and institute whatever changes were made.

5.7 AUTOSAMPLERS

The PM-80 gradient pump can communicate with autosamplers for automatic operation. The specific procedure to be used depends upon the type of autosampler that is available.

5.7.1 CMA-200 Autosampler

The CMA-200 autosampler is capable of two-way communication with the PM-80 pump. Two-way communication ensures that no injections will occur if either unit malfunctions. Thus, samples are safeguarded. Use cable number ER-9500, and connect the 37-pin end to the REMOTE connector on the CMA-200 power supply. Connect the START lead and its GND to the READY and GND terminals on the pump. Connect the INJECT lead and its GND to the INJECT and GND terminals on the pump.

When programming the two units, make sure that the autosampler’s run length is a minute or two longer than that of the pump. This ensures that the pump is in the EQUILIBRATING screen (Figure 5.9) when the autosampler sends its READY signal. AUTO RUNS should be off. To start the sequence of runs, program the pump (Figure 5.5). Then press SAVE, SAVE, and EQUIL. You’re now in the EQUILIBRATING screen (Figure 5.9). Start the autosampler. When it has loaded the sample it will send a READY signal, which triggers the

PM-80 to begin the run. The PM-80 sends the INJECT signal to the autosampler when the run begins.

Special Microbore Instructions

When using microbore flow rates (< 500 µL/min) pump synchronization can take several minutes. Turning synchronization off will not help, because the autosampler must wait for an inject trigger that is based on the pump's internal synchronization.

If these delays are objectionable, they can be bypassed in two ways:

1. Switch the pump to local mode and control it with the front-panel controls (Section 4.1, page 9). Two-way communication with the autosampler is still automatic, so samples will be safeguarded.
2. Continue to use the LCD Controller, but use a 1-line file as in Figure 5.5, page 20. Turn pump synchronization on (yes, on) in the configuration screen (Figure 5.11, page 25). Again, samples will be safeguarded by two-way communication with the autosampler.

5.7.2 Other Autosamplers: PM-80 In Charge

If an autosampler is not capable of two-way communication, but will accept an INJECT signal, the system can be automated with the PM-80 pump in charge. Program the autosampler so it will end its run and load the next sample before the PM-80 has completed its run. The autosampler must then wait for a trigger from the PM-80. Connect leads from the INJECT and GND terminals on the PM-80 to the SAMPLE ENABLE terminals on the autosampler. Turn AUTO RUNS on (Section 5.6), which will allow the PM-80 to do a sequence of runs without waiting for a trigger.

To start the sequence, first start the autosampler. When it has loaded the sample and is waiting, bring the PM-80 to the EQUILIBRATING screen (Figure 5.9; to get here from the main programming screen press SAVE, SAVE, EQUIL). Now press INJECT. Enter the number of runs in the sequence, and the next file number (typically the same as the current file). Press ENTER to accept the file number, and the sequence of runs will begin.

5.7.3 Other Autosamplers: Autosampler In Charge

If the autosampler will not accept an INJECT signal, then the autosampler must be in charge of the run. Pump synchronization must be off, since there is no way to communicate the variable start times to the autosampler. For isocratic runs, simply turn on the pump in the local mode, and let it run while the autosampler injects.

For gradients, attach leads to the autosampler terminals that signal when an injection has occurred. Connect these to the READY terminals on the PM-80. Put the PM-80 in the EQUILIBRATING screen (Figure 5.9), then start the autosampler.

Section 6. MAINTENANCE

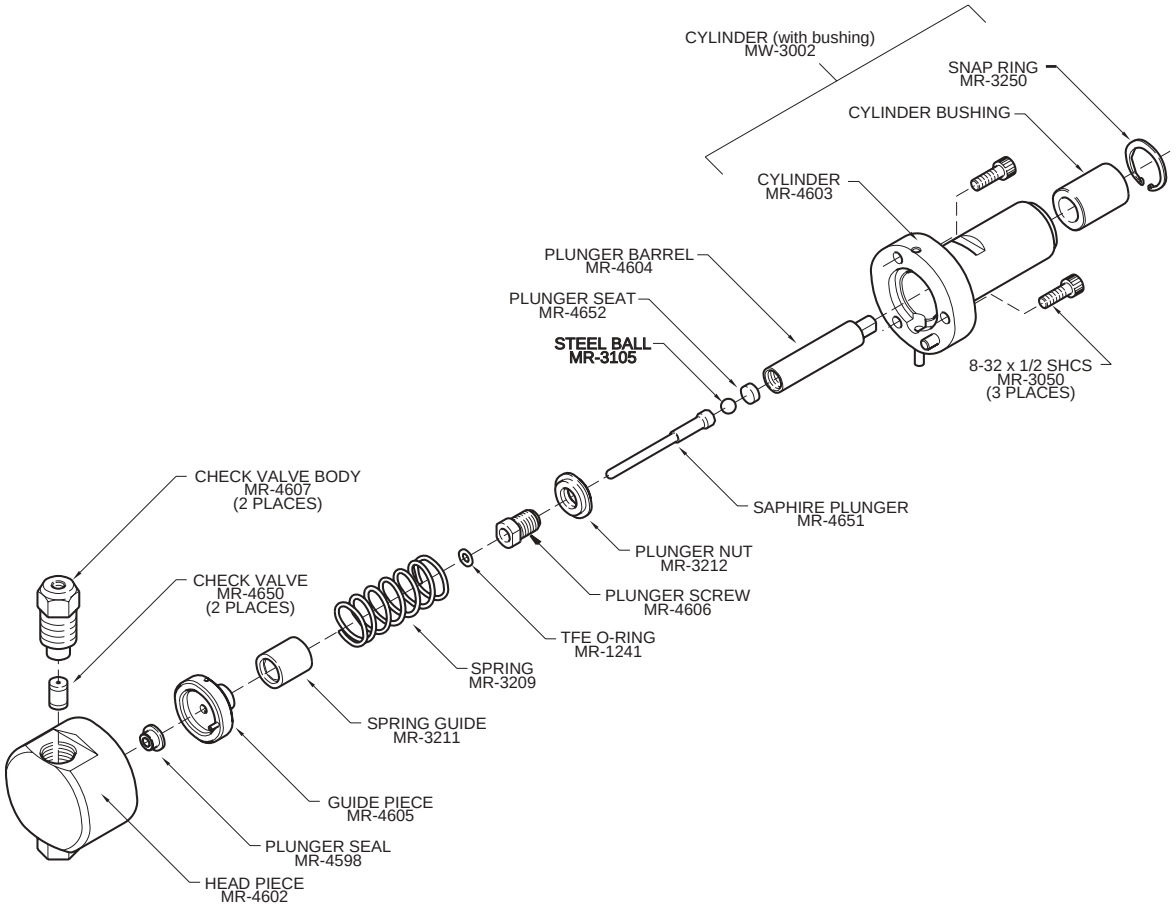
6.1 PUMP HEAD SERVICING

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

Pump head replacement
Plunger seal replacement
Plunger spring 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 6.1. Exploded view of pump head.



6.1.1 Pump Head Removal

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

1. Observe the pressure display to make sure there is no residual pressure in the lines. Then turn the POWER off.

2. Hold one check-valve assembly stationary with a wrench and remove the inlet or outlet line with a second wrench. Repeat for the other check-valve assembly.

3. Hold the pump head against the body of the pump with the palm of one hand, and flip the locking lever towards the remaining pump head.

   CAUTION: THE PUMP HEAD WILL BE EJECTED WITH SOME FORCE!

4. To install a new pump head, proceed to section 6.1.6.

6.1.2 Pump Head Disassembly

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

1. Place the pump head face down on a clean surface, and locate the three hex-head screws on the back of the pump head. Loosen all three slightly with a hex wrench.

2. It is important to remove the three hex-head screws evenly; this will prevent spring pressure from cocking the rear part of the head and snapping the plunger. Remove these screws by alternately undoing each a few turns at a time.

3. Carefully lift off the rear part of the pump head. Pull the plunger assembly straight up to remove it (Figure 6.2).

4. Remove the plunger spring and examine it for corrosion, breaks or nicks. Replace the spring if damaged.

5. Lift the guide piece from the rear face of the pump head to expose the plunger seal (Figure 6.3).

Figure 6.2. Removal of pump-head rear section.

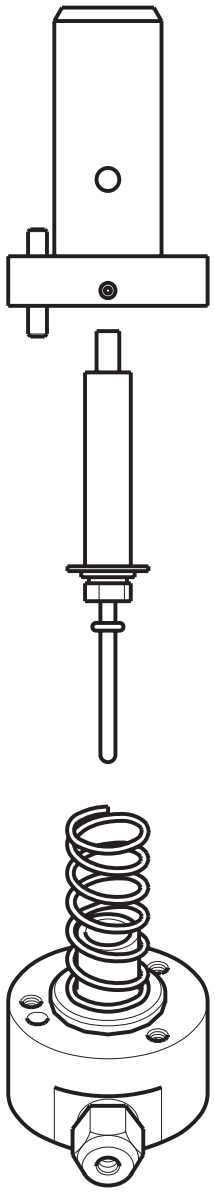
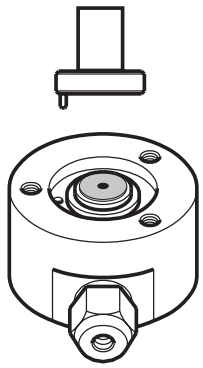


Figure 6.3. Exposing the plunger seal.



6.1.3 Plunger Inspection and Servicing

1. Examine the plunger carefully. Remove the white o-ring and wash the saphire 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 saphire rod pointing up. Wiggle the saphire 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.

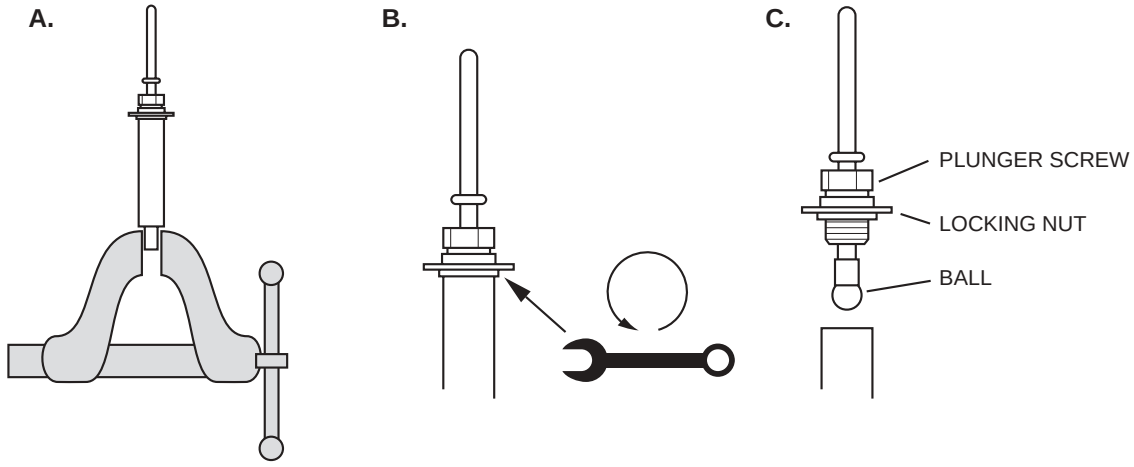
3. If the rod passes the free-play test, proceed to section 6.1.4 (seal replacement) or section 6.1.5 (reassembly). If the saphire rod is either too loose or too tight, perform the adjustment procedure beginning in item 4.

4. To replace or adjust the saphire rod, place the end of the plunger assembly that is farthest away from the rod in a vise, with the rod facing up (Figure 6.4). The tip of the piston assembly has two flat surfaces that the vise can grip. Do not overtighten and damage the assembly.

5. Loosen the plunger nut by turning counterclockwise (with reference to the vise) with a wrench. Loosen this nut only enough to unlock the plunger screw above it.

6. To replace the saphire rod, fully unscrew (by hand) the plunger screw, remove the rod, and replace with a new one. A small ball bearing sits at the base of the rod, and is held in place with a dab of grease. Do not lose the ball during assembly. Make sure that the rod is fully seated inside the plunger nut. Reinstall the plunger screw into the barrel, but do not fully tighten it.

Figure 6.4. Replacing or adjusting the saphire rod.



7. To adjust the new or old saphire rod, tighten or loosen the plunger screw by hand, while testing free-play. Wiggle the saphire rod from side to side; 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. When the adjustment is correct, hold the plunger screw with a wrench and tighten the plunger nut (clockwise) to hold the adjustment.

8. Re-test the plunger free-play. There is a tendency for the rod to bind slightly when the plunger nut is tightened. You may have to loosen the plunger nut again, and back off the plunger screw a bit for a final adjustment.

9. Proceed to section 6.1.4 (plunger seal replacement) or section 6.1.5 (reassembly).

6.1.4 Plunger Seal Replacement

1. Place the front portion of the pump head on a flat surface with the seal facing up.

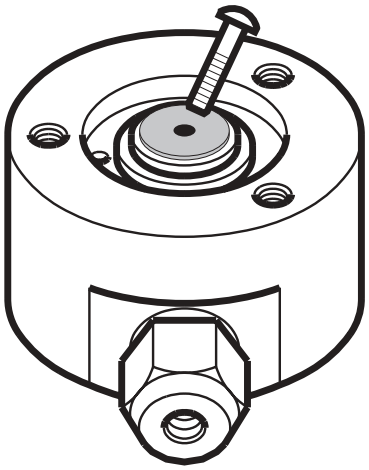
2. Remove the seal by inserting a 6-32 threaded screw into the seal material several turns, then pulling out the seal (Figure 6.5). Be careful not to scratch the metal of the pump head with the screw.

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 or the guide piece. Do not scratch the seal with a fingernail.

5. Proceed with pump head reassembly (section 6.1.5). Be sure to follow the break-in procedure for new plunger seals (section 6.2) after the pump is reassembled.

Figure 6.5. Removing the plunger seal.



6.1.5 Pump Head Assembly

1. Wash all parts with water.

2. Place the front part of the pump head face-down on a flat surface.

3. Insert the guide piece, with its registration pin seated into the matching hole on the inner face (hint: insertion will be easier if you dry the hole with a lab tissue).

4. Place the old or new spring over the PTFE spring guide on the back of the guide piece. (If the spring guide has been removed, be sure to put it back with the chamfered inner edge on the guide piece.)

5. Re-install the o-ring on the saphire rod.

6. Irrigate the plunger-seal area and the saphire rod with methanol.

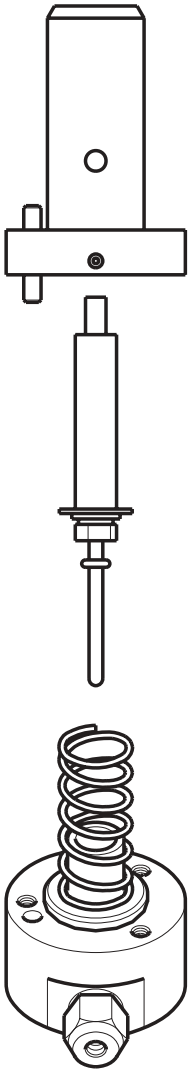
   IT IS IMPORTANT THAT THE SEAL BE MOIST BEFORE INSTALLING THE PLUNGER ASSEMBLY!

7. Insert the plunger assembly with the saphire rod entering the plunger seal (Figure 6.6).

8. Place the rear part of the pump head over the plunger assembly, and align the registration pin with the matching hole on the inner face of the front section.

9. Insert the three hex-head screws. Tighten these alternately, a few turns at a time, to avoid lateral stresses that could snap the saphire rod.

Figure 6.6. Reassembly of the pump head.



6.1.6 Pump Head Installation

1. Push the pump head into place in the PM-80 pump.

2. Flip the locking lever into the locked (outward) position.

3. Hold one check-valve assembly stationary with a wrench and attach the inlet or outlet line with a second wrench. Repeat for the other check-valve assembly.

4. Follow the startup procedure in section 4.2. It is very important to 1) ensure that the plunger seals are moist at startup, and 2) purge all air from the system.

5. If new plunger seals were installed, follow the break-in procedure in section 6.2.

6.2 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.

6.3 SERVICING CHECK VALVES

The PM-80 pump uses four 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. 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 4.2) with freshly degassed mobile phase or solvent. The check valves may be cleaned by sonication (section 6.3.2), 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 6.7 diagrams flow during a full cycle of two pump strokes. When the left pump head is compressing, the green LED above it lights. The inlet check valve below it closes, preventing any backflow. The outlet check valve above it opens, allowing mobile phase to proceed towards the pressure transducer.

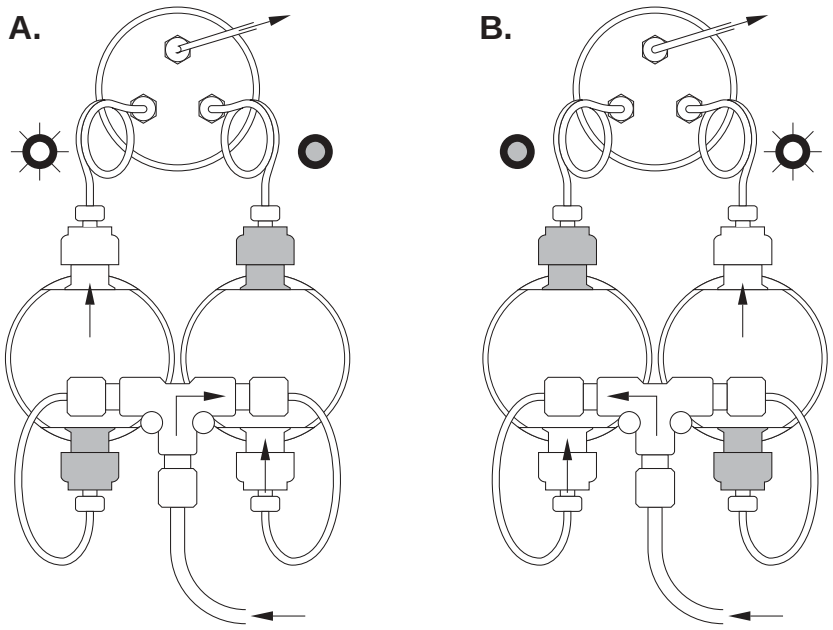
While this is occurring, the right pump head is aspirating. It’s inlet check valve is open, allowing mobile phase to enter from the solvent reservoir. The outlet check valve is closed, which prevents any backflow into the right pump head from the pressure transducer.

After the left pump head finishes its stroke, the roles of the two pump heads reverse. The green LED above the right pump head lights, and the 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.

Pump-related malfunctions that produce pressure fluctuations can be localized by observing the pump stroke and pressure readout. When the LED over the left pump head is on, the left head is compressing. It's inlet check valve must shut, and it's outlet check valve must open. In addition, because the pressure transducer 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 transducer, 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 spring, plunger), the inlet check valve for that pump head, and the outlet check valve for the opposite head.

Figure 6.7. Solvent flow during compression of the left (A) and right (B) pump heads. Shaded check valves are closed.



6.3.1 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 wrench and remove the inlet or outlet line with another wrench.

3. Remove the check-valve assembly, which contains the check-valve cartridge.

6.3.2 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 6.3.4. If check-valve problems continue, install a new cartridge (section 6.3.3).

6.3.3 Check-valve Cartridge Replacement

1. Remove check-valve assembly from the pump head.

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 6.3.2).

4. Insert the new cartridge. Be certain to install the cartridge so it allows flow in the proper direction (Figure 6.7). 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 pump head to the outlet line.

6.3.4 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 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 4.2 to prime the pump and remove all air from the check valves and lines.

6.4 PRESSURE TRANSDUCER

The pressure transducer will rarely need attention. If a leak ever develops, there are two PTFE o-rings inside that need to be replaced (part number MR-1240). Follow these steps:

1. Stop the pump and allow system pressure to fall to zero. Turn the POWER off.

2. Loosen and bend aside all 3 tubes entering the front face of the pressure transducer. Mark the front and back halves of the transducer with a grease pencil, so they can be reinstalled in the original orientation.

3. Loosen and remove the 3 hex screws. Remove the front face of the housing and the two teflon o-rings (Figure 6.8). Discard the o-rinqs. Save the steel spacers which are underneath the o-rings. Clean all parts that are to be reinstalled.

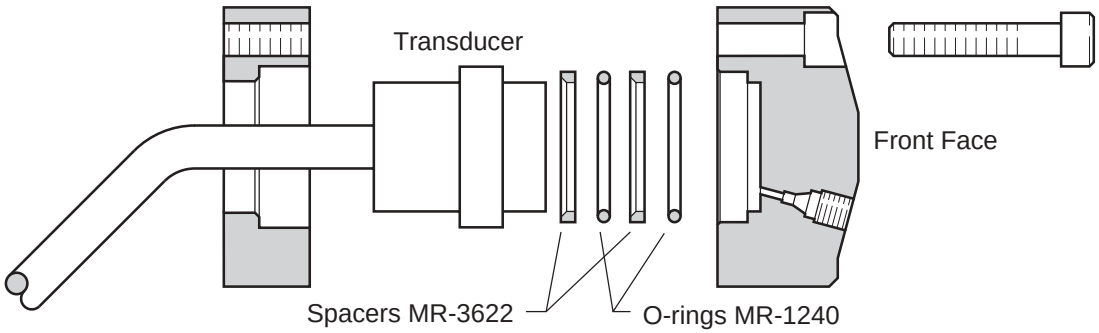
4. Install one steel spacer first. Slide it over the transducer, with the beveled edge facing the transducer and the flat edge facing out.

5. Install the first o-ring next. Use your fingers to slightly stretch the o-ring so it just fits over the transducer. Be careful not to scratch the o-ring with your fingernails or on the edge of the transducer. Slide the o-ring down on the transducer so it lies against the flat edge of the first steel spacer. Repeat with second steel spacer and second o-ring.

6. Wet the o-rings with water. Then install the front face of the assembly onto its back face, observing the original alignment. Tighten the three hex-head screws alternately to drive the face down evenly on the o-rings.

7. Purge the pump (section 4.2).

Figure 6.8. Pressure transducer disassembly.



6.5 PRIME/PURGE VALVE

The prime/purge valve only rarely requires service. If the knurled knob loosens on its shaft, tighten with a hex wrench. If the valve-stem nut loosens, tighten gently with a wrench. If leaks develop, the internal seals must be replaced. The seal kit is part number MF-5406. The replacement procedure is as follows:

1. Switch the START/STOP switch to STOP and allow pressure to drop to zero. Turn the POWER switch off.

2. Open the valve-stem nut (Figure 6.9) all the way, and unscrew the valve stem. The entire stem assembly can now be removed.

3. Place the metal tool provided in the kit across the slots in the seal retainer, and turn counterclockwise to remove. It may be necessary to grasp the tool with a pliers for greater torque. (Some seal retainers are designed to use a hex wrench.)

4. Straighten a paper clip, then form a 1/8" right-angle bend at its tip. Reach into the valve body and carefully remove the old teflon seal. Do not scratch the seat. Clean all parts to be reinstalled.

5. Insert the new teflon seal into the valve body so it rests against the seat.

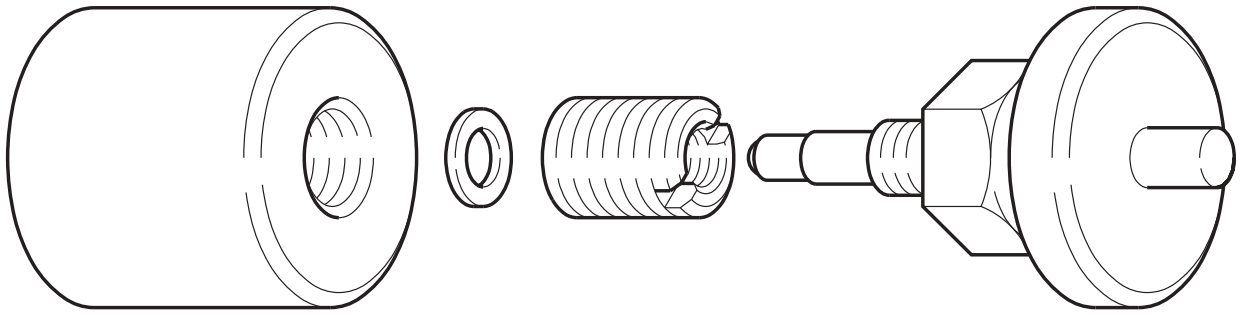
6. Screw the seal retainer back into the body, and tighten firmly with the tool. Do not turn the tool with a pliers.

7. Remove the old plastic tip from the valve stem with forceps or pliers. Push the new tip onto the stem by hand.

8. Screw the stem back into the body, then tighten the valve-stem nut gently with a wrench. Then check that the valve stem turns without binding.

9. Purge the pump (section 4.2). Close the prime/purge valve firmly and check for leakage during normal operation.

Figure 6.9. Prime/Purge valve disassembly.



6.6 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 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:

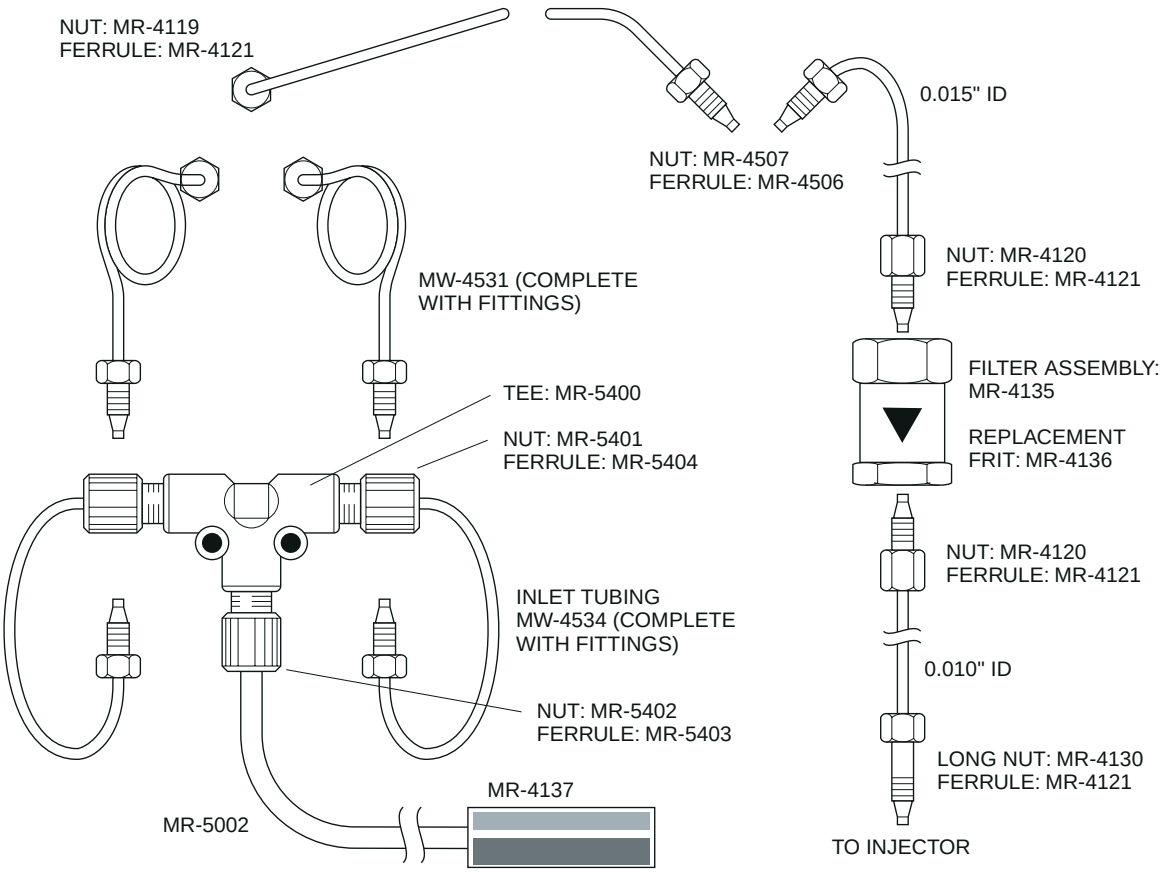
1. The nut may break off with its threads still in the hole. A machinist will have to get it out for you, and if you're very lucky the part won't be damaged.

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 6.10 gives part numbers and ferrule types for all tubing used in the PM-80 pump.

Figure 6.10. Tubing and fittings used in the PM-80 pump.



6.7 IN-LINE SOLVENT FILTER

The in-line filter (Figures 6.10 and 6.11) should be suspected whenever system pressure rises above normal. (See Section 7.5 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 drop to zero.

2. Remove the inlet and outlet tubing to the filter assembly. Be sure to note the flow direction (Figure 6.11).

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.

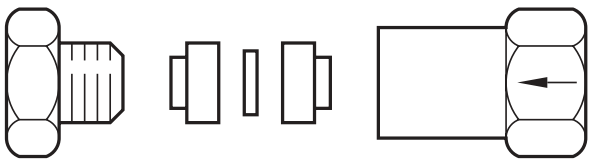
5. The two frit supports and the frit can now be removed from the smaller section. Keep the supports separate so they can be reassembled in the same order: they seal best when installed in the section from which they came.

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 line from the pump to the assembly, observing proper flow direction. Pump some mobile phase through the unit to remove air, then attach the outlet tubing.

Figure 6.11. Exploded view of in-line solvent filter.



6.8 FAN FILTER

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

1. Gently pry off the retaining grid with a screwdriver (Figure 6.12). **WARNING:** do not unscrew the mounting screws!

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 it's ridges facing in towards the filter.

Figure 6.12 Removing the fan filter.

6.9 ROUTINE MAINTENANCE

Regular maintenance will keep pump performance up to specifications. We recommend:

Every Day

Inspect all fittings in the flow path for leaks.

Every Three Months

Replace plunger seals and inspect interior of pump head (Section 6.1).

Every Year

Clean the fan filter (Section 6.7).

Section 7. TROUBLESHOOTING

7.1 POWER WON'T TURN ON

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

7.2 AUDIBLE NOISE

The drive train of the pump can be noisy when there is no load (no high pressure) on it. This audible cue is noticeable, for example, when the purge valve is open.

Drive-train noise during regular operation suggests that pressure is not being maintained. Observe the pressure display, and proceed to section 7.6 if the difference between the highest and lowest pressures is greater than about 100 PSI.

7.3 NO SOLVENT FLOW

Green Led's Don't Alternate

1. Check FLOWRATE and FLOWRANGE controls. Are they set for valid, non-zero ranges (0.1-0.5 or 0.1-5 mL/min)?
2. Is the START/STOP switch in the START position?
3. Is the LOCAL/REMOTE switch in the LOCAL position?
4. Is the high- or low-pressure LED on? If so, see section 7.4 or 7.5.
5. Is there an error message on the display? If so, call BAS.

Green Led's Do Alternate

1. Air in the pump. Check for loose connections on the inlet side of the pump. Purge with freshly degassed mobile phase (section 4.2).
2. Mobile phase reservoir is empty. Purge with fresh mobile phase (section 4.2).
3. Solvent-uptake frit is clogged.

7.4 PUMP STOPS: LOW-PRESSURE LIMIT

1. The mobile-phase reservoir is empty. Make fresh mobile phase and purge (section 4.2).
2. The MINIMUM potentiometer is set too high. Reset to 200 PSI or a reasonable value for your conditions.
3. There's a leak in the system. Check all connections.

7.5 PUMP STOPS: HIGH-PRESSURE LIMIT

1. The MAXIMUM potentiometer 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. Have you changed to a more viscous mobile phase (e.g., one with methanol)?

4. There's a clog in the flowpath. 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.)

7.6 PRESSURE FLUCTUATIONS

1. Purge the pump (section 4.2) with freshly degassed mobile phase to remove air from the check valves. 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 could be sucked in.

2. Switch the inlet check valves between the two heads. 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 6.3.

3. 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.

4. One or both pump heads may need an overhaul. See section 6.1.

5. One of the outlet lines from the pump to the pressure transducer may be clogged. Remove and examine. Replace as necessary.

7.7 FLUID LEAKS

1. Fluid leaks from (or salt accumulates around) fittings. Leaks indicate that fittings need to be tightened or replaced (section 6.6)

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 6.1.4) 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 6.4).

4. Fluid leakage (or salt accumulation) at the prime/purge valve. Replace the seals.

7.8 OVERHEATING

If the pump heads or cabinet feel warm, clean the fan filter (section 6.7) and check that the fan is operating.

Section 8. SPECIFICATIONS

HEIGHT:	6.6 inches
LENGTH:	17 inches
WIDTH:	11 inches
WEIGHT:	38 pounds
FLOW RATE:	0.1 - 5.0 mL/min
FLOW PRECISION:	better than 0.3% RSD
FLOW REPEATABILITY:	0.3%
PRESSURE RANGE:	0-6000 PSI (0-40 bar) with selectable limits
INPUT VOLTAGE:	100/120/220/240 vac 50/60 Hz
POWER:	3A (max) @ 120 VAC 50/60 Hz

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