

515 HPLC Pump

Operator's Guide

WAT068980/Revision 5

Waters

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Contacting Waters

Contact Waters[®] with enhancement requests or technical questions regarding the use, transportation, removal, or disposal of any Waters product. You can reach us via the Internet, telephone, or conventional mail.

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|-------------------|---|
| Internet | The Waters Web site includes contact information for Waters locations worldwide. Visit www.waters.com . |
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| Conventional mail | Waters Corporation 34 Maple Street Milford, MA 01757 USA |

Safety considerations

Some reagents and samples used with Waters instruments and devices can pose chemical, biological, and radiological hazards. You must know the potentially hazardous effects of all substances you work with. Always follow Good Laboratory Practice, and consult your organization's safety representative for guidance.

Considerations specific to the 515 HPLC Pump

Note: When you use the instrument, follow generally accepted procedures for quality control and methods development.

If you observe a change in the retention of a particular compound, in the resolution between two compounds, or in peak shape, immediately determine the reason for the changes. Until you determine the cause of a change, do not rely on the separation results.

Note: The Installation Category (Overvoltage Category) for this instrument is Level II. The Level II Category pertains to equipment that receives its electrical power from a local level, such as an electrical wall outlet.







Safety advisories

Consult [Appendix A](#) for a comprehensive list of warning and caution advisories.

Operating this instrument

When operating this instrument, follow standard quality-control (QC) procedures and the guidelines presented in this section.

Applicable symbols

| Symbol | Definition |
|--|--|
|  Waters Corporation 34 Maple Street Milford, MA 01757 U.S.A. | Manufacturer location |
|  | Authorized representative of the European Community |
|  | Confirms that a manufactured product complies with all applicable European Community directives |
|  ABN 49 065 444 751 | Australia C-Tick EMC Compliant |
|  | Confirms that a manufactured product complies with all applicable United States and Canadian safety requirements |
|  | Consult instructions for use |

Audience and purpose

This guide is intended for personnel who install, operate, and maintain the Waters 515 HPLC Pump.

Intended use of the Waters 515 HPLC Pump

The Waters 515 HPLC Pump is for research use only.

Calibrating

To calibrate LC systems, follow acceptable calibration methods using at least five standards to generate a standard curve. The concentration range for

standards should include the entire range of QC samples, typical specimens, and atypical specimens.

When calibrating mass spectrometers, consult the calibration section of the operator's guide for the instrument you are calibrating. In cases where an overview and maintenance guide, not operator's guide, accompanies the instrument, consult the instrument's online Help system for calibration instructions.

Quality-control

Routinely run three QC samples that represent subnormal, normal, and above-normal levels of a compound. Ensure that QC sample results fall within an acceptable range, and evaluate precision from day to day and run to run. Data collected when QC samples are out of range might not be valid. Do not report these data until you are certain that the instrument performs satisfactorily.

ISM classification

ISM Classification: ISM Group 1 Class B

This classification has been assigned in accordance with CISPR 11 Industrial Scientific and Medical (ISM) instruments requirements. Group 1 products apply to intentionally generated and/or used conductively coupled radio-frequency energy that is necessary for the internal functioning of the equipment. Class B products are suitable for use in both commercial and residential locations and can be directly connected to a low voltage, power-supply network.

EC authorized representative



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Waters 515 Pump Overview

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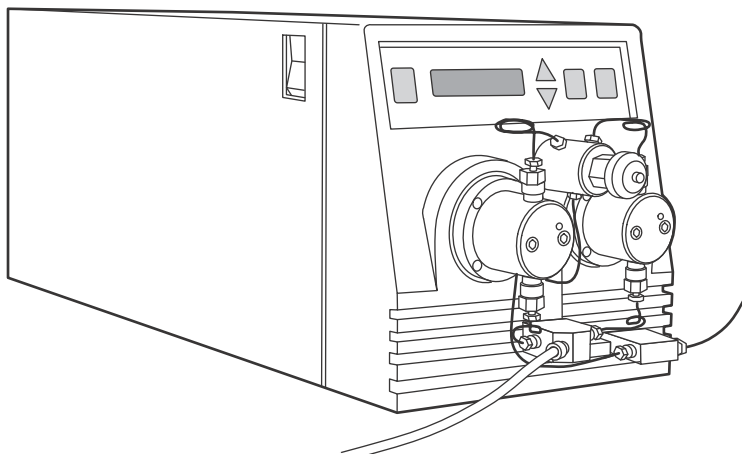
Overview

The Waters 515 HPLC Pump combines the most important aspects of eluent delivery for HPLC: high precision, reliability, smooth eluent flow, and proven performance. A single 515 pump in an HPLC system is ideal for high-throughput isocratic analyses. When you control two or three 515 pumps through a data system or external controller, you can achieve reproducible, multipump gradient delivery with exceptionally smooth concurrent-stream blending.

The microprocessor-controlled stepper motor and noncircular gears of the 515 pump mechanics ensure smooth and precise flow regardless of backpressure, flow-rate setting, or eluent compressibility.

A keypad and LCD display lets you quickly enter parameters for the run. In addition, the display provides a readout of status, diagnostic, and monitoring information for the pump. The figure below shows a Waters 515 HPLC Pump.

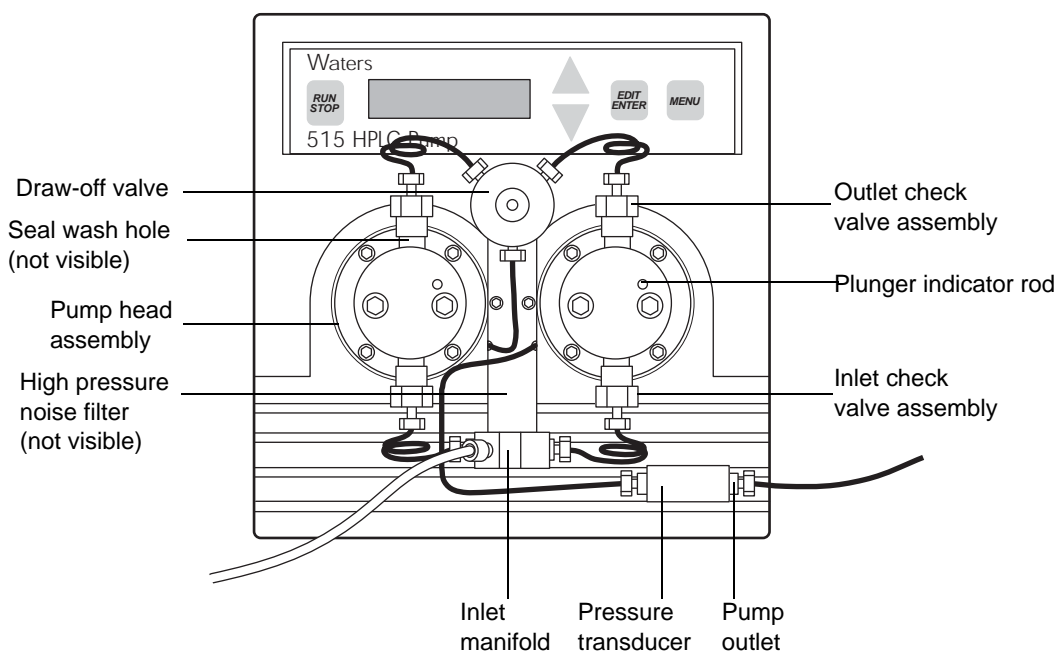
Waters 515 HPLC Pump



Fluid-handling components

Before you install the Waters 515 pump, familiarize yourself with its components. The figure below identifies the fluid-handling components of the Waters 515 pump and the [table titled “Fluid-handling components” on page 1-3](#) describes their functions.


Pump fluid-handling components



Fluid-handling components

| Component | Function |
|------------------------|--|
| Draw-off valve | Combines eluent flow from the two pump heads. Also enables you to attach a syringe and draw eluent through the pump for purging. |
| Pump head assemblies | Draw in and deliver eluent. |
| Plunger indicator rods | Show position of each pump head plunger. |
| Seal wash holes | Allow you to flush and clean the plunger seals. |

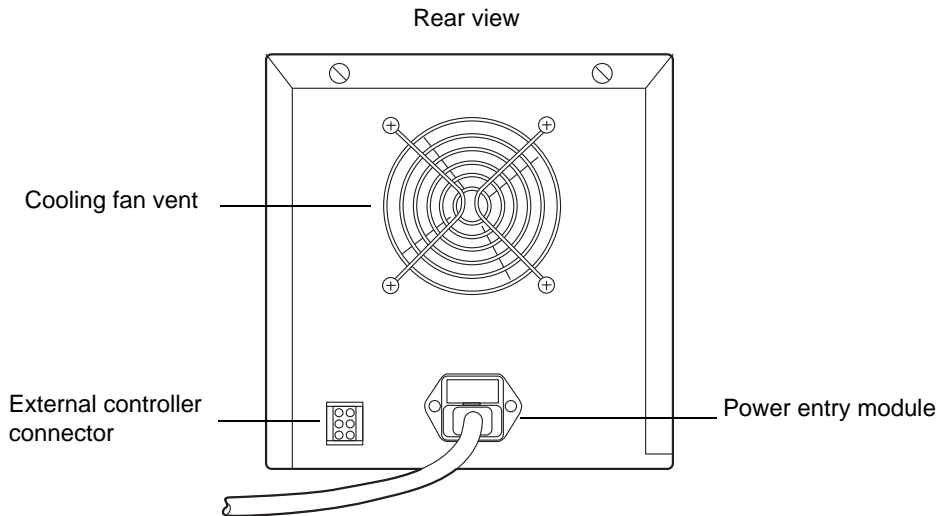
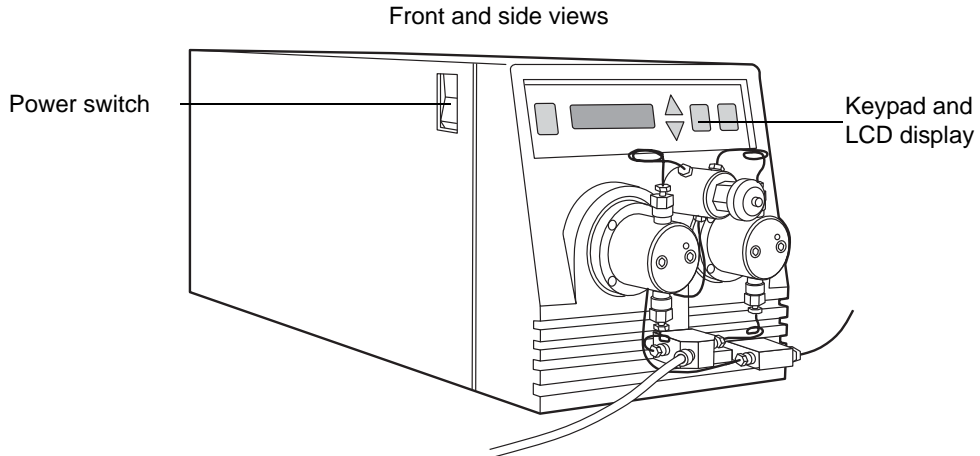
Fluid-handling components (Continued)

| Component | Function |
|---|---|
| Inlet and outlet check valve assemblies | Maintain flow direction by opening in one direction only. |
| High-pressure noise filter | Dampens operating pressure fluctuations. |
| Inlet manifold | Provides connection for eluent inlet tubing and routes eluent to the inlet check valve on each pump head. |
| Pressure transducer | Senses operating pressure and converts value to electronic signal for monitoring. |
| Pump outlet | Routes eluent to injector, column, and detector.  Caution: To prevent eluent from leaking out of the pump outlet, make sure you position the eluent reservoir below the pump inlet manifold before you disconnect the pump outlet fitting. |

Electronics components

Before you install the 515 pump, familiarize yourself with its electronics components as illustrated in the figure below. The [table titled “Electronics components” on page 1-5](#) describes the functions of the electronics components.

Pump electronics components



Electronics components

| Component | Function |
|-------------------------------|--|
| Cooling fan vent | Exhausts air for cooling internal electronics. |
| External controller connector | Provides connection for the pump control cable, which connects the pump to an external control device. |

Electronics components (Continued)

| Component | Function |
|--------------------|--|
| Power entry module | Provides receptacles for power cord connection and fuses. |
| Keypad | Used to enter pump operating parameters and calibration factors. |
| LCD display | Provides a readout of status, diagnostic, and monitoring information for the pump. |
| Power switch | Used to power the pump on and off. |

Operating modes

The 515 HPLC Pump can operate in two control modes:

- Stand-alone mode
- Remote control mode (under the control of a data system or external controller)

Stand-alone mode

In the stand-alone mode, the 515 Pump manually controls isocratic analyses based on the parameter values you input through the keypad of the pump. See Chapter 3 for information on using the keypad and LCD display.

Remote control mode

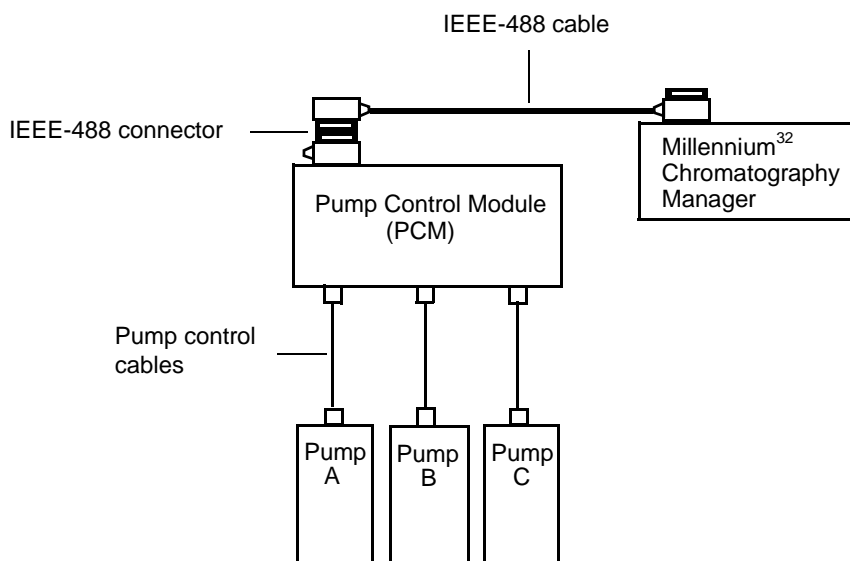
In the remote control mode, the 515 Pump is controlled by any one of the following:

- A data management system such as Millennium[®] Chromatography Manager in conjunction with a Pump Control Module (PCM)
- ExpertEase[™] software in conjunction with a PCM
- An external controller such as a Waters 680 Automated Gradient Controller

In remote mode, you input pump parameter values through the data system software or through the front panel of the external controller. Remote mode lets you operate two or three pumps in a high-pressure gradient configuration.

For example, the figure below illustrates a three-pump configuration under the control of a Millennium³² Chromatography Manager workstation.

Three-pump configuration under Millennium³² Chromatography Manager control (using the PCM)



2 Installing the Waters 515 Pump

This chapter provides a list of site requirements for your Waters 515 HPLC Pump, and describes how to unpack and install the pump.

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Site requirements

Install the 515 HPLC Pump at a site that meets the specifications indicated in the table below.

Installation site requirements

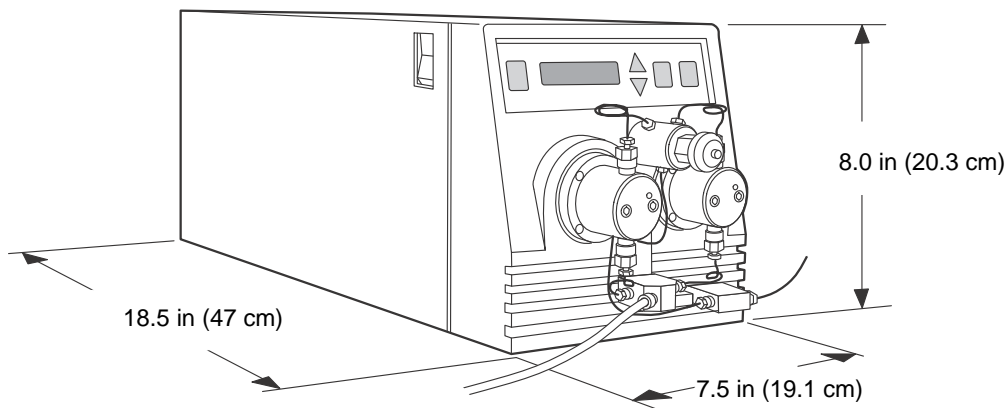
| Factor | Requirement |
|-----------------------------|---|
| Temperature | 4 to 40 °C (39 to 104 °F) |
| Relative humidity | 20 to 80%, noncondensing |
| Bench space | Width: 7.5 in. (19.1 cm) Depth: 18.5 in. (47 cm) Height: 8.0 in. (20.3 cm) |
| Vibration | Negligible |
| Clearance | At least 6 in. (15 cm) at rear for ventilation and cable connections |
| Static electricity | Negligible |
| Input voltage and frequency | Grounded AC, 85 to 264 VAC, 47 to 63 Hz, single phase |
| Electromagnetic fields | No nearby source of electromagnetic noise, such as arcing relays or electric motors |
| Power requirement | 110 VA (max) |

The figure below shows the dimensions of a 515 pump.



Caution: To avoid overheating and to provide clearance for cable connections, make sure there is at least 3 inches (7.6 cm) of clearance at the rear of the 515 pump.

Pump dimensions



Unpacking

The Waters 515 HPLC Pump is shipped in one carton that contains the following items:

- Waters 515 Pump
- Startup Kit
- Certificate of Validation
- Operator's Guide

To unpack the pump:

1. Open the carton and remove the Startup Kit and other items from the slot at one end of the carton.
2. Using both hands, lift the pump (and its foam packing material) out of the carton.
3. Carefully set the pump down, then remove the foam packing material from the ends of the pump.
4. Check the contents of the Startup Kit against the Startup Kit parts list to confirm that all items are included.

5. Verify that the serial number on the pump matches the serial number on the Certificate of Validation. Keep the Certificate of Validation with this guide for future reference.
6. Inspect all items for damage. Immediately report any shipping damage to both the shipping company and your Waters representative. Contact Waters Technical Service at 800 252-4752, *Canadian and U.S. customers only*. Other customers, call your local Waters subsidiary or call Waters corporate headquarters for assistance in Milford, Massachusetts (U.S.A.). See the *Waters Licenses, Warranties, and Support* document for complete information on reporting shipping damages and submitting claims.

Making electrical connections

For proper operation, the 515 HPLC Pump requires:

- Installed fuses
- A grounded AC power supply with no abrupt voltage fluctuations
- A connection to an external controller or pump control module (for remote operation only)

Required materials

- Small flat-blade screwdriver
- Fuses (if replacing fuses)
- Pump control cable from external controller (if connecting for remote operation)
- Power cord (Startup Kit)

Replacing the power supply fuses

The 515 pump is shipped with two 3.15 A fuses installed.

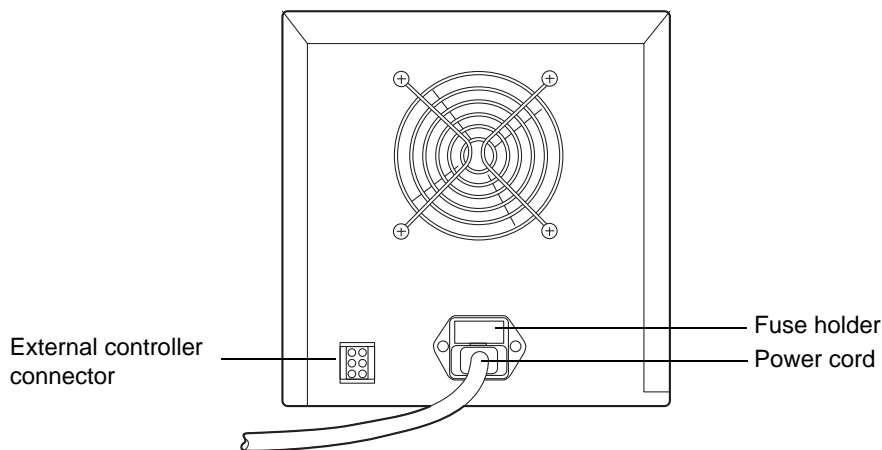


Warning: To avoid electrical shock and possible injury, remove the power cord from the rear panel of the instrument before you perform the procedure in this section.

To replace the power supply fuses in the 515 pump:

1. If necessary, power off the pump by turning the On/Off switch to the 0 position, then remove the power cord from the rear panel of the instrument.

Rear panel of the 515 pump



2. Use the small flat-blade screwdriver to remove the fuse holder located just above the power cord connector.
3. Remove the fuses from the holder.
4. Install new fuses (3.15 A, fast blow, part number WAT163-16).



Warning: For continued protection against fire hazard, replace fuses with the appropriate type and rating.

5. Install the fuse holder in its receptacle.

Connecting the power supply

The 515 HPLC Pump automatically adjusts for AC input voltage in the range from 85 to 264 VAC at 47 to 63 Hz.

To connect the power supply:

1. Insert the 115 V or 230 V power cord into the power connector on the rear of the pump.

2. Insert the other end of the power cord into a grounded power outlet.

Connecting for remote operation

If you are using a remote data system with a Pump Control Module (PCM) or a 680 Automated Gradient Controller, connect the 515 pump to the control device as described below.

To connect the pump to an external control device:

1. Attach either end of the pump control cable to the External Controller Connector on the rear of the 515 pump.
2. Attach the other end of the cable to connector A, B, or C on the external control device. If necessary, see the *Waters Pump Control Module Operator's Manual* or the *Waters Model 680 Automated Gradient Controller Operator's Manual* for more information.

Making fluidic connections

This section describes how to make fluidic connections to the Waters 515 pump. The steps include:

- Connecting the eluent supply
- Connecting the pump outlet
- Connecting for high-pressure gradients

Connecting the eluent supply

Follow the instructions in this section to connect the pump inlet to the eluent reservoir or in-line degasser.

Tip: If you are using an in-line degasser, see the degasser operator's guide for details on connecting the degasser to the reservoir and pump.

Required materials

- One Tefzel[®] reverse ferrule and compression screw (Startup Kit)
- 1/8-inch OD PTFE tubing (Startup Kit)
- 0.149-inch OD x 3-inch length PTFE tubing (Startup Kit)

- Reservoir containing filtered, degassed eluent
- Stainless steel solvent filter (Startup Kit)
- Plastic tubing cutter (part number WAT031795)
- Razor blade

Connecting eluent tubing to the pump inlet

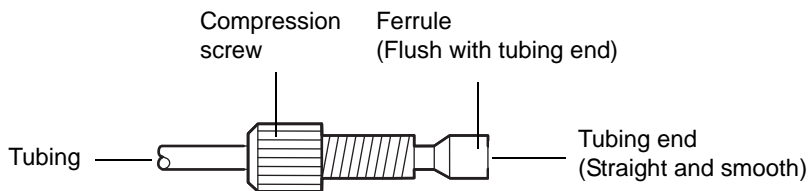
To connect the eluent tubing to the pump inlet:

1. Measure the length of 1/8-inch PTFE tubing required to connect the reservoir to the inlet manifold on the pump. Use a reservoir location that ensures the bottom of the reservoir is about 4 inches (10.2 cm) higher than the pump inlet. If you are using an in-line degasser, see the degasser operator's guide for details on connecting to the reservoir and pump.

Tip: It may be necessary to substantially increase reservoir height if you use high-viscosity eluents (18 to 24 inches above the inlet manifold is not uncommon).

2. Insert the PTFE tubing into the 1/8-inch diameter hole of the tubing cutter, making sure that the tubing that extends from the metal side of the cutter is the correct length.
3. Insert the razor blade into the cutter and press down to cut the tubing. Make sure the cut end is straight and free from burrs.
4. Slide a compression screw over one end of the tubing, followed by a ferrule with its tapered end facing away from the tubing end, and its wide end flush with the tubing end, as shown in the figure below.

Reverse ferrule and compression screw assembly



5. Firmly seat the tubing end into the inlet manifold on the pump, then finger-tighten the compression screw.



Caution: To avoid damaging the ferrule, do not overtighten the compression screw.

Connecting eluent tubing to the eluent reservoir



Caution: To avoid having eluent leak from the pump outlet, position the eluent reservoir below the pump inlet manifold until the pump outlet is connected to the system.

To connect the eluent tubing to the eluent reservoir:

1. Insert the free end of the 1/8-inch PTFE inlet tubing into the cap of the eluent reservoir.
2. Cut the 3-inch section of 0.149-inch OD PTFE tubing at its midpoint and slide one of the resulting 1.5-inch sections over the end of the 1/8-inch PTFE tubing for about 3/4 of an inch (1.9 cm).
3. Insert the stainless tubing fitting on the solvent filter into the open end of the 0.149-inch OD tubing.
4. Install the cap onto the eluent reservoir and push the tubing through the cap until the filter reaches the bottom of the reservoir.

Connecting the pump outlet



Caution: To avoid having eluent leak from the pump outlet, position the eluent reservoir below the pump inlet manifold until the pump outlet is connected to the system.

Follow the instructions in this section to connect the pump outlet to the next instrument in the flow path. If you are configuring multiple pumps for high-pressure gradient delivery, also see [“Connecting for high-pressure gradient operation” on page 2-11.](#)

Connecting the pump outlet involves:

- Cutting the tubing
- Attaching a compression fitting to each end of the tubing
- Connecting each end of the tubing

Required materials

- Two stainless ferrules and standard compression screws (Startup Kit)
- 1/16-inch OD stainless tubing (Startup Kit)
- Circular tubing cutter (part number WAT022384), or knife-edge file
- Needlenose pliers (two pairs if cutting tubing with a knife-edge file)
- 5/16-inch open-end wrench (Startup Kit)

Cutting the tubing to length

To cut the tubing to length:

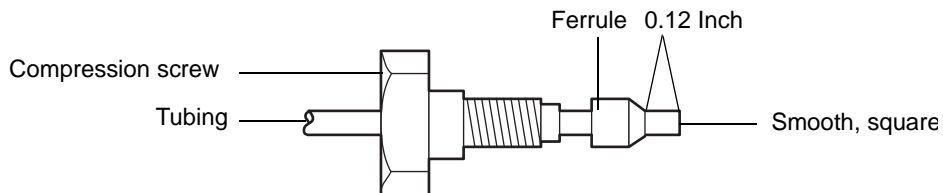
1. Measure the length of stainless tubing required to connect the pump outlet to the injector or other instrument.
2. Use a knife-edge file to scribe the circumference of the tubing at the desired break. Whenever possible, use a circular tubing cutter instead of the knife-edge file to obtain a clean, square cut.
3. Grasp the tubing on both sides of the scribe mark with cloth-covered pliers (to prevent marring of the tube surface) and gently work the tube back and forth until it snaps. Ensure that the break is square and free of burrs.

Attaching the compression fittings to the tubing ends

To attach the compression fittings to the tubing ends:

1. Remove the black plastic cap from the pump outlet fitting.
2. Slide a compression screw onto one end of the tubing, then slide a ferrule onto the tubing with the large end of the taper toward the screw, as shown in the figure below.

Standard ferrule and compression screw assembly



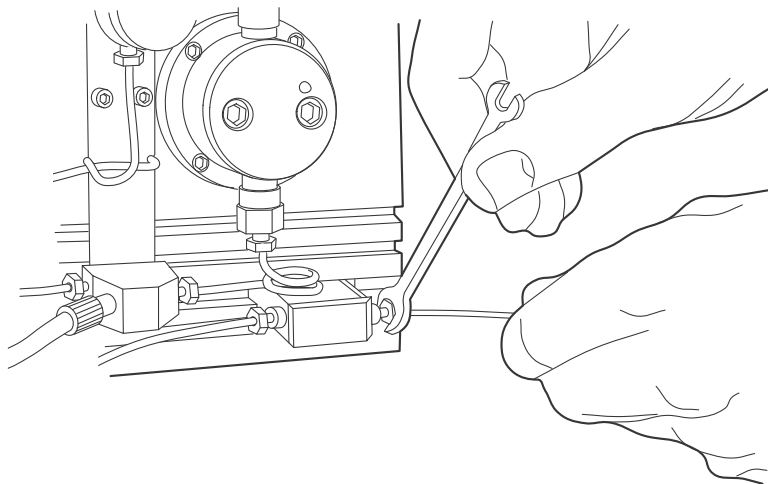
3. While firmly pressing the tubing into the pump outlet or other system component, finger-tighten the compression screw.
4. Use the 5/16-inch wrench to tighten the screw another 1/4-turn. This seats the ferrule against the tubing.
5. Unscrew the assembled fitting and verify that the length of tubing extending beyond the ferrule is 0.12 inch (3 mm).
6. Repeat steps 2 through 5 for the other end of the stainless tubing.

Connecting the stainless tubing assembly

To connect the stainless tubing assembly:

1. While pressing one end of the tubing assembly into the pump outlet fitting, finger-tighten the compression screw, then use the 5/16-inch wrench to tighten the screw another 1/8-turn.

Connecting the outlet tube



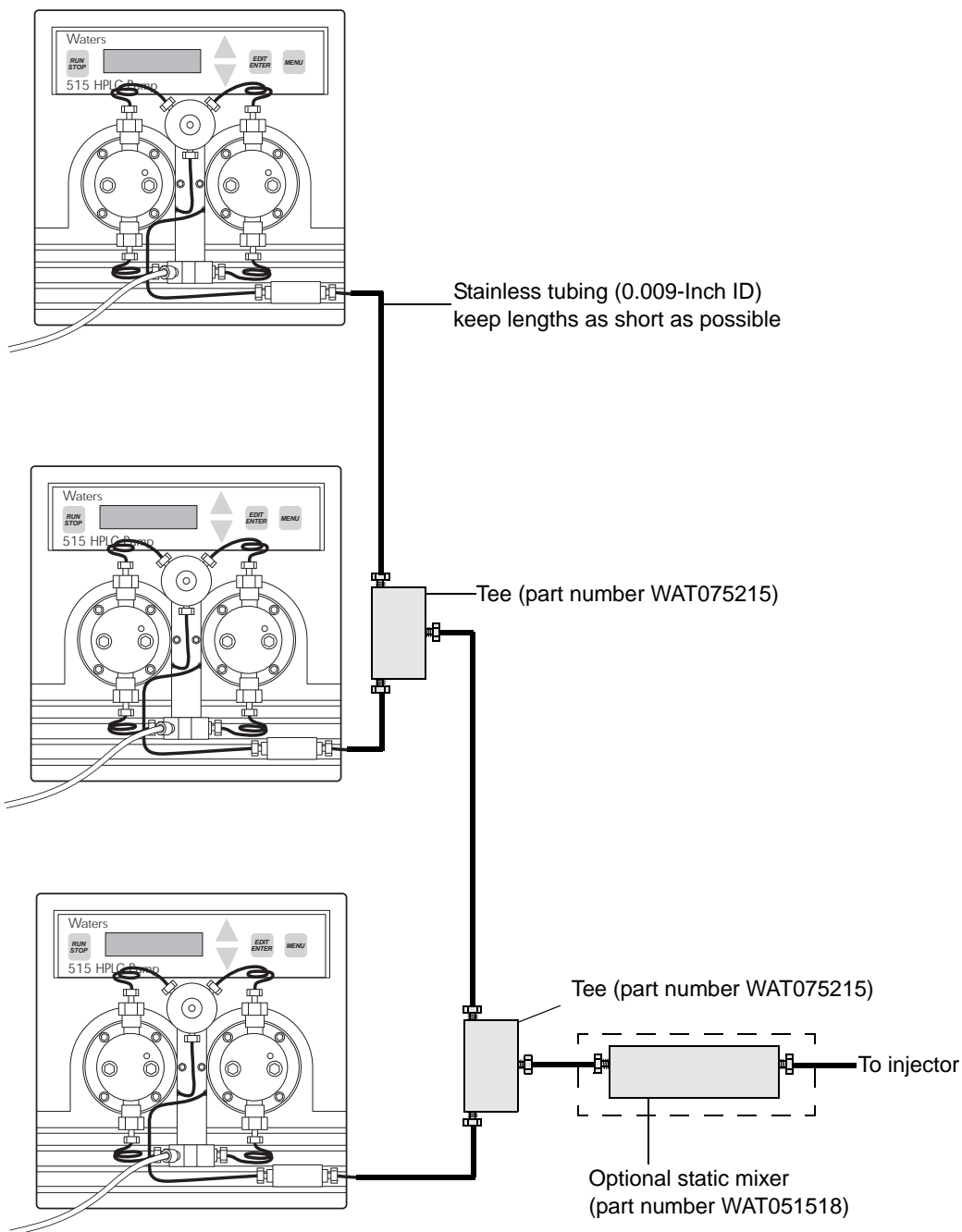
Tip: Leave the instrument end of the outlet tubing disconnected until you have primed the pump and flushed the system as described in “Preparing the 515 pump” on page 3-13.

2. After you prime the pump and purge the system, press the free end of the tubing assembly into the injector or next device in your HPLC system and finger-tighten the compression screw. Then use the 5/16-inch wrench to tighten the screw another 1/8 turn.

Connecting for high-pressure gradient operation

The figure below shows recommended plumbing configurations when you use two or three remotely controlled 515 pumps for high pressure gradients. If your application requires high-pressure gradient delivery with minimal delay volumes, plumb the pumps as shown in the figure below (without using the optional mixer). If your application requires high-pressure gradient delivery with minimal compositional ripple, install the optional mixer, part number WAT051518.

Three-pump, high-pressure gradient configuration with optional mixer



3

Using the Waters 515 Pump

This chapter describes how to prepare and operate the Waters 515 HPLC Pump. Where appropriate, instructions are provided for both stand-alone and remote operation.

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Powering on the pump

Tip: If your 515 pump is connected to a Waters 680 Automated Gradient Controller, and you power on the controller with the pump running in the Remote mode, you may hear the pump operate briefly. This is due to a spurious signal from the controller when it is powered on. To avoid this situation, power on the controller **before** you power on the pump.

Make sure the pump is installed according to the instructions in “[Installing the Waters 515 Pump](#)”. When the pump is powered on the first time, it displays the factory default setting for each of its operating parameters. See the [table titled “515 pump operating parameters” on page 3-7](#) for parameter details.

To power on the pump, locate the power switch on the left side panel and set it to the 1 (ON) position. The power-on diagnostics begin.

Power-on diagnostics

Each time you turn power on, the pump automatically runs its internal power-on diagnostics (the display does not indicate that the diagnostics are running). The power-on diagnostics perform these tests and checks:

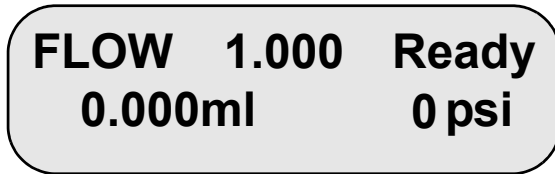
- EPROM check – Runs a checksum of the EPROM to confirm correct EPROM data
- RAM test – Writes and confirms a series of bit patterns to the MPU RAM
- MPU mode check – Confirms that the microprocessor unit is in the correct mode
- FPGA configuration check – Confirms the proper configuration of the Field Programmable Gate Array
- EEPROM check¹ – Runs a checksum of the EEPROM to confirm correct EEPROM data

Once the unit successfully performs its internal power-on diagnostics, the LCD display briefly (5 seconds) shows the pump model number (515), head size (100- μ L or 225- μ L), and firmware version (Ver n.n). The display then appears in its Ready state, as shown in the figure below. To redisplay the

1. In addition to running at power on, the EEPROM check runs every time you press the RUN/STOP key, and once for every 5 hours that the pump has power.

initial screen (the screen showing model and version information), simultaneously press the Down and Menu keys. This has no effect on pump operation, and can be performed at any time.

LCD display - ready state



Diagnostics failure

A diagnostics failure is indicated by one of the following conditions:

- The LCD display shows no information and the pump does not operate. This condition occurs during an EPROM check failure, a RAM test failure, an FPGA check failure, or an MPU check failure.
- The LCD display indicates an EEPROM check failure and prompts you to press the Menu key. Pressing the Menu key acknowledges the failure and sets all parameters to their factory defaults.

See [“Maintaining and Troubleshooting the Waters 515 Pump”](#), for more information about dealing with EEPROM diagnostics failures.

Keypad and display overview

Use the keypad and LCD display to enter or edit operating parameters for the pump. This section provides detailed information about the keypad and display, and describes their use with the pump.

Local and remote operation

You can program the 515 pump for local (stand-alone) or remote operation by setting the Mode parameter to the Local or Rem setting, respectively. Although you can edit or enter all 515 pump parameters when it is in the Rem mode, the values of some pump parameters (flow rate, high-pressure limit, and low-pressure limit) are superseded by the values communicated from the external control device. See the Flow, HPL, and LPL parameters in the [table titled “515 pump operating parameters” on page 3-7](#) for more details.



Keypad

The table below describes the functions of the keys on the 515 pump keypad.

Keypad functions

| Key | Function |
|--|--|
| <div style="border: 1px solid black; padding: 5px; text-align: center;"> RUN STOP </div> | <p>Local mode: If the unit is not pumping, pressing this key starts the pump using all current parameter settings.*</p> <p>Remote mode: If the unit is not pumping, pressing this key prepares the pump to receive a remote run command.</p> <p>In Local or Remote mode, pressing this key immediately stops the pump.</p> <p>*Refer to the Mode parameter in the table titled “515 pump operating parameters” on page 3-7 for details about Local and Rem parameters.</p> |
| <div style="border: 1px solid black; padding: 5px; text-align: center;"> EDIT ENTER </div> | <p>When pressed the first time, this key positions the blinking cursor in the currently displayed menu item. Pressing this key with the Flow parameter displayed, results in one of the following events:</p> <ul style="list-style-type: none"> • The blinking cursor moves one position to the right. • If the cursor is at the rightmost position, it moves to the leftmost position. <p>When editing in the Calibrate menu:*</p> <ul style="list-style-type: none"> • Press the key twice to enter the submenu. • At the submenu level, press the key to store a parameter or initiate an action. • When you are prompted, press the key to exit the Calibrate menu. <p>*The LCD display provides prompts for when to use the Edit/Enter key while editing in the Calibrate menu. See the table titled “515 pump operating parameters” on page 3-7 for more information about the Calibrate menu.</p> |

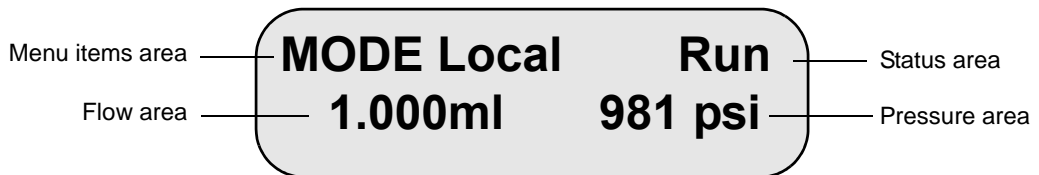
Keypad functions (Continued)

| Key | Function |
|---|--|
|  | <p>Scrolls to the next menu item.</p> <p>If you are editing a menu item (indicated by a blinking cursor), pressing this key stores the current parameter and moves to the next parameter (when you edit the Flow parameter, you need to press Menu twice to move to the next parameter).*</p> <p>*The LCD display provides prompts for when to use the Menu key while in the Calibrate menu. See the table titled “515 pump operating parameters” on page 3-7 for more information about the Calibrate menu.</p> |
|  | <p>If you are editing a menu item (indicated by a blinking cursor), pressing the Up key increases the parameter value; pressing the Down key decreases the parameter value. If the parameter is not numeric (Mode for example), pressing the Up or Down key displays a new parameter selection.</p> <p>When there is no blinking cursor in the display, pressing the Up key scrolls back to the previous menu item; pressing the Down key scrolls forward to the next menu item.</p> |

LCD display

The LCD display, as shown in the figure below, is divided into four information areas.

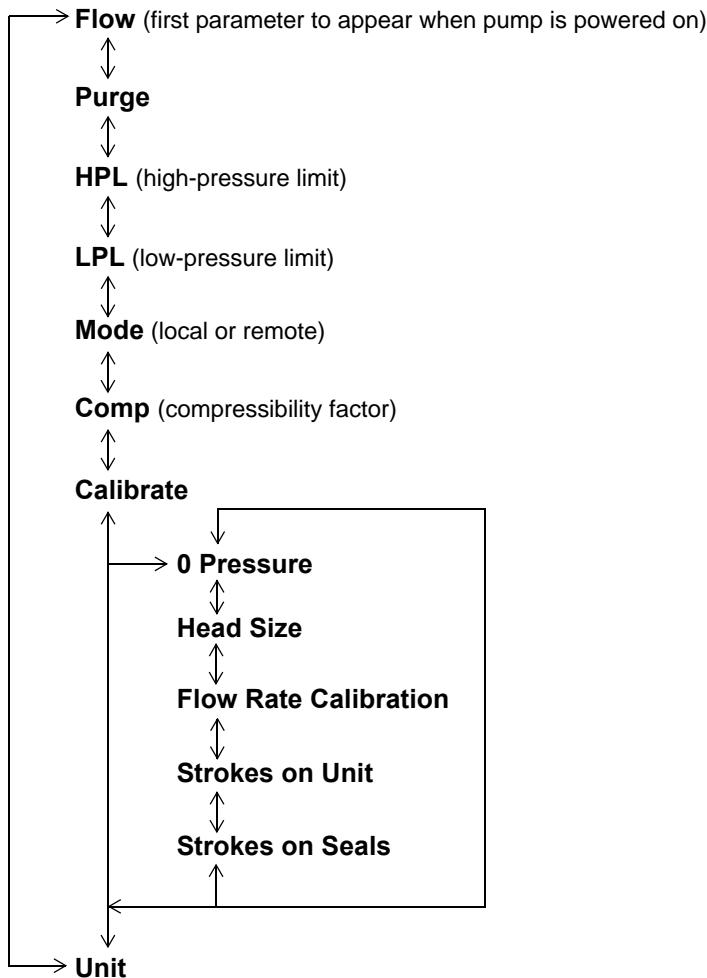
LCD display information areas



Menu items area

The menu items area provides access to all pump operating parameters. The figure below shows a menu tree for all 515 pump parameters accessible in this area of the display. Use the Up, Down, Edit/Enter, and Menu keys, as necessary, to navigate through the parameters (see [table titled “Keypad functions” on page 3-4](#) for keypad functions). Functions and details for all pump parameters are provided in the [table titled “515 pump operating parameters” on page 3-7](#).

515 pump operating parameters menu tree



515 pump operating parameters

| Parameter | Function | Details |
|-----------|---|--|
| Flow | Selects flow rate for local (stand-alone) operation | <p>The flow rate range is 0.000 to 10.000 mL/min. The default setting is 1.000 mL/min. With the optional 225-μL head, the flow rate range is 0.000 to 22.500 mL/min.</p> <p>In Rem mode, the flow rate parameter set at the external control device supersedes this parameter.*</p> <p>*Refer to the Mode parameter section in this table for information about Local and Rem modes.</p> |
| Purge | Starts a purge cycle in which the pump purges at 5 mL/min for 5 minutes. (Once the purge cycle starts, the display shows the time remaining for the purge). | <p>When the Purge cycle finishes, the pump returns to its previous mode and run status. See “Purging the system” on page 3-17 for details.</p> <p>You can run Purge in both the Local and Rem modes.* Refer to the Mode parameter section in this table for information about Local and Rem modes.</p> <p>If Purge is running, pressing the Edit/Enter key once restarts Purge for another 5-minute cycle.</p> <p>To stop the purge cycle, press the Run/Stop key. When stopped in Local mode, the pump status switches to Ready. When stopped in Rem mode, the pump status switches to Rem/Stop. To restart Purge for another 5-minute cycle, press the Edit/Enter key once.</p> <p>*Refer to the Mode parameter section in this table for information about Local and Rem modes.</p> |

515 pump operating parameters (Continued)

| Parameter | Function | Details |
|-----------|---------------------------------|--|
| HPL | Selects the high-pressure limit | <p>In Local mode: Pressure greater than or equal to the HPL for 1.2 sec stops the pump.*</p> <p>In Rem mode: Pressure greater than or equal to the HPL for 1.2 sec causes the pump to send a pressure-limit output signal to the external controller. Programming at the controller determines whether to stop the pump or continue running.*</p> <p>As a fail-safe, if the pump pressure exceeds maximum for 1.2 sec in either Local or Rem mode, the pump stops.</p> <p>The HPL default setting is:</p> <ul style="list-style-type: none"> • 6000 psi (41370 kPa, 401 bars) for 100-μL heads • 3000 psi (20685 kPa, 200.5bars) for 225-μL heads <p>These are the maximum HPL settings. When you change the value of the HPL parameter, the increment of change varies according to the Unit selected (see the Unit parameter section in this table).</p> <p>*Refer to the Mode parameter section in this table for information about Local and Rem mode.</p> |

515 pump operating parameters (Continued)

| Parameter | Function | Details |
|-----------|---|--|
| LPL | Selects the low-pressure limit | <p>In Local mode: Pressure less than or equal to the LPL for 90 sec stops the pump.*</p> <p>In Rem mode: Pressure less than or equal to the LPL for 90 sec causes the pump to send a pressure-limit output signal to the external controller. Programming at the controller determines whether to stop the pump or continue running.*</p> <p>The default setting of 0 psi disables all low-pressure limit checking. When you change the value of the LPL parameter, the increment of change varies according to the Unit selected (see the Unit parameter section in this table).</p> <p>* Refer to the Mode parameter section in this table for information about Local and Rem mode.</p> |
| Mode | Selects Local mode (for stand-alone operation) or Rem mode (for external control operation) | <p>If you change Mode while the pump is running, the pump parameters set at the controlling device take immediate effect. For example, if you change to Local Mode while the pump is running in Rem mode, the pump runs at the locally set flow rate immediately after you press the Menu or Edit/Enter key to store the change (in Mode).</p> <p>The default setting for Mode is Local. Refer to the HPL and LPL parameter sections in this table for more information about Local and Rem operation.</p> |

515 pump operating parameters (Continued)

| Parameter | Function | Details |
|-----------------------|---|--|
| Comp | Sets the compressibility factor to compensate for differences in eluent compressibility | The Comp range is from -25 to +25% in 1% increments; the default setting is 0%. You can set the Comp factor while the pump is idle or running in either Local or Rem mode. When you change to less compressible eluents, enter a more negative Comp factor. |
| Calibrate | Provides access to the Calibrate submenu selections | Press the Edit/Enter key twice to access the Calibrate submenu selections. |
| 0 Pressure | Sets zero pressure for the pump | The pressure reading displayed is the true pressure with no rounding. This parameter comes factory set. See “Setting zero pressure” on page 4-5 , for details. |
| Head Size | Selects the size of the installed pump head: 100- μ L or 225- μ L | The default setting is 100 μ L. See “Setting the head size” on page 4-6 for details. |
| Flow Rate Calibration | Recalibrates the pump flow rate after head replacement | The initial value shown in the display reflects the default setting for degassed methanol at 1 mL/min and 1000 to 2000 psi (6895 to 13,790 kPa, 66.8 to 133.6 bars). You can make adjustments in 0.1% increments. See “Calibrating the flow rate” on page 4-7 for details. |
| Strokes on Unit | Displays the total number of plunger strokes for the pump | The value is the total number of plunger strokes. This value is for reference only and cannot be reset. |

515 pump operating parameters (Continued)

| Parameter | Function | Details |
|------------------|---|--|
| Strokes on Seals | Displays the accumulated number of plunger strokes for the current set of plunger seals. Reset is performed after seal replacement. | The value shown is the total number of plunger strokes accumulated since the parameter was last reset. “Resetting strokes on seals” on page 4-8 for details. |
| Unit | Selects the units of pressure: psi, kPa, or bar | Once you make this selection, all pressure references for the pump change to the selected Unit. Psi is the default setting. |

Status area

This area displays the real-time status of the pump. When you first power on the pump, this area shows Ready. The table below lists all Status area messages and their meanings.

Status area messages

| Message | Meaning |
|---------|--|
| Ready | Indicates the pump is powered on but not running in the Local mode. |
| Run | Indicates the pump is running in the Local mode. |
| Stop | Indicates that the pump is stopped in the Local mode. A stop could result from: <ul style="list-style-type: none"> Pressing the Run/Stop key. When you press Run/Stop, the Stop message appears briefly before it is replaced with the Ready message. Fluid pressure exceeding the high-pressure limit for the required time. Fluid pressure dropping below the low-pressure limit for the required time. |

Status area messages (Continued)

| Message | Meaning |
|----------|---|
| Rem/Run | Indicates the pump is in the Remote mode (Rem and Run alternately appear in the Status area). If the flow area of the display reads Flow, then the pump is running. If the display reads No Flow, then the pump is waiting for the data system or external controller to issue a run signal. |
| Rem/Stop | Indicates the pump is stopped in the Remote mode (Rem and Stop alternately appear in the Status area). A Stop could result from: <ul style="list-style-type: none">• Pressing the Run/Stop key.• Fluid pressure exceeding the high-pressure limit for the required time.• Fluid pressure dropping below the low-pressure limit for the required time. |

Flow area

This area of the LCD display provides information about the pump flow rate.

- In Local mode, the display shows the flow rate that was entered for the Flow parameter. The value is displayed in mL/min.
- In Remote mode, actual flow rate is not displayed. Instead, the display reads Flow or No Flow.

Pressure area

This area of the LCD display shows the pump pressure in the units selected in the Unit parameter (psi, KPa, or bar). When running in Remote mode, the pressure reading value that appears on the 515 LCD display may differ slightly from the value that appears on the remote device.

Editing or entering parameters in local or remote modes

1. Press the Up, Down, or Menu key to display the appropriate parameter in the menu items area.
2. Press the Edit/Enter key to position the blinking cursor within the parameter.

Tip: When you need to edit a digit in the Flow parameter setting, press the Edit/Enter key until the cursor is positioned over the digit you want to change. You cannot move the cursor directly to the left; if you need to edit a digit to the left of the blinking cursor, simply continue to press Edit/Enter until the cursor wraps to the appropriate digit.

3. Use the Up or Down key to increase or decrease the value of the digit, respectively. If the parameter value is not numeric (psi, for example), use the Up or Down key to display a different parameter selection (bar, for example).
4. If necessary, repeat steps 2 and 3 until all parameter values are correct.
5. Press Menu to store the parameter and display the next menu item.

Tip: In Rem mode, flow rate, high-pressure limit, and low-pressure limit parameters set at the pump are superseded by corresponding settings at the remote device.

Preparing the 515 pump

Overview

The procedures to prepare your pump for operation depend on the status of your chromatography system. Use the table below as a quick reference guide for determining when to perform certain preparation procedures.

Pump preparation recommendations

| Status | Prime ¹ | Purge ¹ | Equilibrate ¹ |
|------------------------------------|--------------------|--------------------|--------------------------|
| Initiating operation | ✓ | ✓ | ✓ |
| Changing eluent | ✓ | ✓ | ✓ |
| Adding fresh eluent | | ✓ | ✓ |
| Changing columns | | | ✓ |
| System has been idle for some time | ✓ | ✓ | ✓ |

1. Priming, purging, and equilibrating procedures are described in detail later in this section.

Eluent guidelines

When you prepare a 515 pump for operation, keep in mind the following eluent guidelines:

- Use methanol to prime a new pump, or one that has been stored for an extended period.
- Use an intermediate solvent when you change between eluents that are not miscible.
- Use only chromatography-grade eluents to obtain accurate, reproducible chromatograms.
- To prevent air from being drawn into the pump, keep the eluent level in the reservoir at least 4 inches (10 cm) higher than the inlet manifold. Do not place eluent reservoirs on top of the Waters 515 pump.
- Use only filtered, degassed eluents.
- After use with a buffer, purge the pump with distilled water.
- When possible, use eluents of similar viscosity when you run a gradient.
- Know the properties of your eluents. For example, cyclohexane solidifies at 3.5 K psi.
- Consider column chemistry. If the column can be damaged by an intermediate or new eluent, remove the column from the system and substitute a union. See the care and usage guide for your column.
- Dedicate an eluent supply tube and filter assembly for each eluent. If this is not possible, purge the tube and filter of any remaining eluent before you use a new eluent.
- To prevent cross contamination of eluents, dedicate a set of glassware for preparing, storing and supplying each eluent. Once a container has been used for an eluent, do not use it for any other eluent unless it has been thoroughly cleaned.



Warning: To avoid chemical hazards, observe safe laboratory practices when you handle eluents. See the Material Safety Data Sheets for the eluents you use. For more information on eluent properties, see [Appendix D, Eluent Considerations](#).

Priming the pump

Priming is necessary to ensure proper pump operation when:

- You start the pump for the first time.
- You change eluent.
- The system has been idle for some time.

Before priming

- Locate the priming syringe from the Startup Kit.
- Check that the pump is in the Ready (idle) state.

Priming

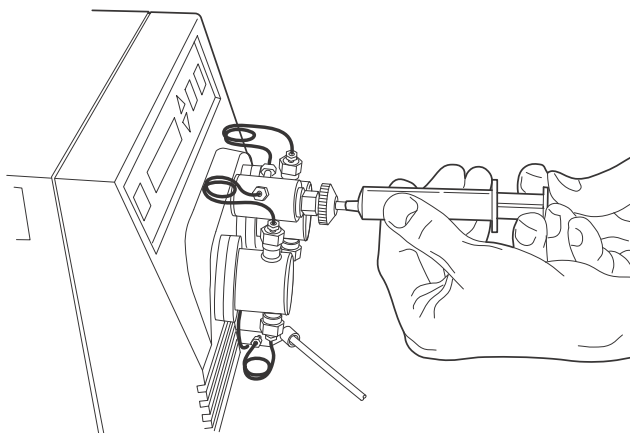
To prime the pump:

1. Press the Up, Down, or Menu key to display the Flow parameter. Set the pump Flow parameter to 3.000 mL/min. If the pump is dry, start with a lower Flow rate such as 1.000 mL/min.
 - a. Press the Edit/Enter key until the blinking cursor is positioned over the first digit that you need to edit.
 - b. Use the Up or Down key to increase or decrease the value of the digit.
 - c. If necessary, repeat steps a and b until the Flow parameter value is correct.
 - d. Press Menu to store the parameter value.

Tip: Do not press Run/Stop to start the pump at this point in the procedure.

2. Fully depress the priming syringe plunger to remove all air from the syringe, then insert the syringe into the luer fitting at the center of the draw-off valve handle.

Priming the pump



3. Turn the draw-off valve handle counterclockwise about 1/2-turn to open the valve.
4. Withdraw several milliliters of eluent with the syringe, then close the valve handle. Expel the contents of the syringe into a suitable waste container.
5. Press the Run/Stop key to start the pump.
6. Let the pump run for about a minute, then verify normal pump pressure for the selected eluent and flow rate.
7. If the pump pressure is not correct, repeat steps 2 through 6 as necessary.
8. Press the Run/Stop key to stop the pump.



Caution: To prevent eluent flow through the pump heads under gravity pressure, never leave the pump unattended with the draw-off valve in the open position.

Purging the system

Purging ensures that all eluent in the fluidic path is replaced with new eluent before you run samples. Purge the system when:

- You start the pump for the first time.
- You change eluent or add fresh eluent.
- You left the system idle for some time.

Before purging

- Make sure the eluent is filtered and degassed.
- Prime the pump with fresh eluent as described in [“Priming the pump” on page 3-15](#). Once the pump has been primed, install a union in place of the column.

Tip: When you change between two eluents that are not totally miscible, perform the steps in this procedure with an intermediate eluent before purging with the final eluent. See [Appendix D, Eluent Considerations](#) for more information.

Purging



Caution: To avoid damaging the column, be sure you install a union in place of the column before you start the pump.

To purge the system:

1. Press the Up, Down, or Menu key until the Purge parameter appears.¹
2. Press Edit/Enter to access the Purge parameter.
3. Press Edit/Enter again to start the Purge. Purge runs the pump at 5 mL/min for 5 minutes. You can stop Purge at any time by pressing Run/Stop.
4. When the purge is finished, disconnect the union and reconnect the column.

1. As an alternative to running Purge, you can manually set the Flow parameter and run the pump for the desired time.

Equilibrating the system

Equilibrate your HPLC system when one or more of the following conditions occur:

- You start your system for the first time.
- After you change eluents or add fresh eluent.
- After you change columns.
- After you leave the system idle for some length of time.

Follow the equilibration procedure (described below) that is appropriate for your HPLC system:

- If your pump is running in the Local mode (not remotely controlled by a data system or external controller), follow the procedure in “Equilibrating for Stand-Alone Operation.”
- If your pump is running in the Rem mode (controlled by a data system or external controller), follow the procedure in [“Equilibrating for remote operation” on page 3-19.](#)

Before equilibrating

- Make sure the eluent is filtered and degassed.
- Prime the pump with fresh eluent as described in [“Priming the pump” on page 3-15.](#)
- Allow the eluent and the system to reach proper temperature before pump operation.

Equilibrating for stand-alone operation

To equilibrate for stand-alone operation:

1. Press the Up, Down, or Menu key to display the Flow parameter.
2. Set the pump Flow parameter to the desired rate.
 - a. Press the Edit/Enter key until the blinking cursor is positioned over the first digit that you need to edit.
 - b. Use the Up or Down key to increase or decrease the value of the digit.
 - c. If necessary, repeat steps a and b for the other digits until the

parameter value is correct.

- d. Press Menu to store the parameter.
3. Press Menu until the HPL parameter appears. Press Edit/Enter, then use the Up or Down key to increase or decrease the value of the parameter. Note that the increment of change varies according to the selected Unit parameter.
4. Press Menu until the LPL parameter appears. Press Edit/Enter, then use the Up or Down key to increase or decrease the value of the parameter. Note that the increment of change varies according to the selected Unit parameter.



Caution: Be sure that the entered values for Flow, HPL (high-pressure limit), and LPL (low-pressure limit) are appropriate for your column. Some columns require a flow ramp up. See the Care and Use Manual for your column.

5. Press Menu until the Mode parameter appears. If required, press the Edit/Enter key, then the Up or Down key to set the parameter to Local. Press Menu to store the parameter setting.
6. Press Run/Stop to start the pump.
7. Equilibrate the pump for at least 10 column volumes.
8. When you finish, press Run/Stop to stop the pump.

Equilibrating for remote operation



Caution: If your 515 pump is connected to a Waters 680 Automated Gradient Controller, do not power off the controller if the pump is running. Doing so may damage the column due to a spurious pressure output signal from the controller when it is powered off. To avoid this situation, power off the pump before you power off the controller.

To equilibrate for remote operation:

1. Press the Up, Down, or Menu key to advance past the Flow, HPL, and LPL parameters. These pump parameters are set from the data system or external controller.



Caution: Be sure that the entered values for flow rate, high-pressure limit, and low-pressure limit are appropriate for your column. Some columns require a flow ramp up. See the Care and Use Manual for your column.

- If the pump is connected to a Waters Millennium³² system through a PCM, use the Equilibrate function and an appropriate method set, or use the Monitor Baseline control button and an instrument method to handle equilibration. See the Millennium³² documentation.
- If the pump is connected to a Waters ExpertEase system through a PCM, use the Monitor Baseline selection and a specified method to handle equilibration. See the ExpertEase documentation.
- If the pump is connected to a Waters 680 Automated Gradient Controller (AGC), set the pump parameters at the controller keypad (see the *Waters Model 680 Automated Gradient Controller Operator's Manual*).

Tip: When the 515 pump is connected to a Waters 680 Automated Gradient Controller, make sure the pump HPL parameter is set to 6000 psi (41370 kPa, 401 bars) and the pump Comp parameter is set to 0 (zero). In addition, you must set the flow rate, high-pressure limit, and low-pressure limit at the controller.

2. Press Menu until the Mode parameter appears. If required, press the Edit/Enter key, then the Up or Down key to set the parameter to Rem. Press Menu to store the parameter.
3. Press Run/Stop. This places the pump in the Run – Rem mode, and the Flow area of the display reads No Flow. The pump is ready to receive a remote run signal to start the equilibration.
4. Start the equilibration from the data system or from the external controller. The pump starts and the Flow area of the pump display reads Flow.

Operating the pump

This section describes how to operate the 515 pump in either a stand-alone or remote configuration.

Stand-alone pump operation

Follow the steps in this procedure if your HPLC system is set up in an isocratic configuration where you manually control the operation of the 515 pump from the pump keypad.

Before operation

Before you operate the pump in a stand-alone configuration, make sure:

- You have already completed any required priming, purging, and equilibrating as described in [“Preparing the 515 pump” on page 3-13](#).
- Eluent reservoirs are filled with filtered, degassed eluent.



Warning: To avoid chemical hazards, observe safe laboratory practices when you handle eluents. See the Material Safety Data Sheets for the eluents you use. For more information on eluent properties, see [Appendix D, Eluent Considerations](#).

Operating

To operate the 515 pump in a stand-alone configuration:

1. Press the Up, Down, or Menu key to display the Flow parameter. If the setting is correct, go to step 3.
2. To change the Flow parameter:
 - a. Press the Edit/Enter key until the blinking cursor is positioned over the first digit that you need to edit.
 - b. Use the Up or Down key to increase or decrease the value of the digit.
 - c. If necessary, repeat steps a and b for the other digits until the parameter value is correct.
 - d. Press Menu to store the parameter.

3. Press Menu until the HPL parameter appears. Press Edit/Enter, then use the Up or Down key to increase or decrease the value of the parameter. Note that the increment of change varies according to the selected Unit parameter.
4. Press Menu until the LPL parameter appears. Press Edit/Enter, then use the Up or Down key to increase or decrease the value of the parameter. Note that the increment of change varies according to the selected Unit parameter.
5. Press Menu until the Mode parameter appears. Press Edit/Enter, then use the Up or Down key to set the parameter to Local. Press Menu to store the parameter setting and display the next menu item (Comp).
6. If you need to change the Comp setting for your run, press Edit/Enter to activate the blinking cursor, then use the Up or Down key to enter the desired setting. See [“Adjusting for eluent compressibility” on page 3-24](#), for instructions on how to adjust the Comp setting for a change in run conditions. When you finish, press Menu to store the parameter setting and display the next menu item (Calibrate).
7. Press Menu until the Unit parameter appears. If you need to change the Unit, press Edit/Enter to activate the blinking cursor, then use the Up or Down key to enter the desired setting. Press Menu to store the parameter.
8. Once all parameters values are correctly set, press Run/Stop to start the pump. Operation continues until you press Run/Stop to stop the pump.
Tip: To immediately stop the pump, press the Run/Stop key.

Remote pump operation

Follow the steps in this procedure if your HPLC system is set up so that you remotely control the operation of the 515 pump through a data management system or external controller.

Before operation

Before you operate the pump in a remote configuration, make sure:

- You have already completed any required priming, purging, and equilibrating as described in [“Preparing the 515 pump” on page 3-13](#).
- Eluent reservoirs are filled with filtered, degassed eluent.

- If your pump is connected to a Waters 680 Automated Gradient Controller, the controller is powered on *before* you power on the pump.



Warning: To avoid chemical hazards, observe safe laboratory practices when you handle eluents. See the Material Safety Data Sheets for the eluents you use. For more information on eluent properties, see [Appendix D, Eluent Considerations](#).

Operating

To operate the pump in a remote configuration:

1. Press the Up, Down, or Menu key to advance past the Flow, HPL, and LPL parameters. Since you set these parameters at the data system or external controller, the local parameters at the pump are not used.
Tip: When the 515 pump is connected to a Waters 680 Automated Gradient Controller, make sure the pump HPL parameter is set to 6000 psi (41370 kPa, 401 bars) and the pump Comp parameter is set to 0 (zero). In addition, you must set the flow rate, high-pressure limit, and low-pressure limit at the controller.
2. Press Menu until the Mode parameter displays. If required, press the Edit/Enter key, then the Up or Down key to set the parameter to Rem. Press Menu to store the parameter and display the next menu item (Comp).
3. If you need to change the Comp setting for your run, press Edit/Enter to activate the blinking cursor, then use the Up or Down key to enter the desired setting. See [“Adjusting for eluent compressibility” on page 3-24](#) for instructions on how to adjust the Comp parameter for a change in run conditions. When you finish, press Menu to store the parameter.
4. Press Menu until the Unit parameter appears. If you need to change the Unit of pressure measurement, press Edit/Enter to activate the blinking cursor, then use the Up or Down key to enter the desired setting. When you finish, press Menu to store the parameter. The Unit selection does *not* affect the units displayed at the remote device.
5. Once all parameters are correct, press Run/Stop. This places the pump in the Run – Rem mode, and the Flow area of the display reads No Flow. The pump is ready to receive a remote run signal.

6. Set the flow rate, high-pressure limit, and low-pressure limit at the data system or external controller. For example, if the pump is connected to a Waters Millennium³² system through a PCM, the pump parameters are part of the instrument method in the Millennium³² software. See the documentation that comes with your data system or external controller.
7. Start the run from the data system or from the external controller. The pump starts and the Flow area of the pump display reads Flow. To immediately Stop the pump at any time, press the Run/Stop key.

Tip: If your 515 pump is connected to a Waters 680 Automated Gradient Controller, and you power on the controller with the 515 pump running in the Remote mode, you may hear the pump operate briefly. This is due to a spurious signal from the controller when it is powered on. To avoid this situation, power on the controller **before** you power on the pump.

Changing parameters during a run

You can change pump parameters while the pump is running in either Local or Rem mode. To change parameter settings while the pump is running, follow the steps in [“Editing or entering parameters in local or remote modes” on page 3-12](#). Note that changing the Flow parameter at the pump when the pump is in the Rem mode does *not* change the pump flow rate (the flow rate set at the external control device supersedes the rate set at the pump). See the [table titled “515 pump operating parameters” on page 3-7](#) for more details about the Flow, HPL, and LPL parameters in Rem mode.

Adjusting for eluent compressibility

Eluents exhibit different compressibility characteristics in response to changes in pressure. The change in compressibility can result in changes in flow rate. The Comp parameter allows you to easily adjust for the change in delivered flow resulting from eluent compression and system expansion at higher pressures.

The Comp parameter for the 515 Pump is preset to zero at the factory using degassed methanol as an eluent. This section describes how to adjust the Comp parameter for use with other eluents. The procedure describes how to measure flow rate using a volumetric flask and a stopwatch. An alternate method would be to use a calibrated flowmeter.

Required materials

- 10-mL volumetric flask
- Stopwatch
- Degassed reservoir of selected eluent

Procedure

To adjust for compressibility:

1. Disconnect the 515 pump outlet from the column to eliminate all system backpressure.
2. Select the flow rate specified by your separations method, then simultaneously press the Run/Stop key and start the stopwatch.
3. Record the time it takes to fill the flask with the column disconnected.
4. Reconnect the column, then record the time it takes to fill the flask with the column connected.
5. Determine the percent difference between the times with and without the column installed. Use the following formula:

$$\frac{\text{Time with column} - \text{Time without column}}{\text{Time with column}} \times 100 = \% \text{ Difference in Time}$$

If the difference is acceptable for your application, you do not need to change the Comp parameter.

6. If the percent difference is not acceptable, for example, if the time measured with the column installed was 9% greater than the time measured without the column installed, do the following:
 - a. Press the Menu key until the Comp menu appears.
 - b. Press Edit/Enter to access the Comp parameter.
 - c. Press the Up key the number of times equal to the percent difference (in time), in this example, nine times.
 - d. Press Menu to store the parameter.
7. Repeat steps 4 through 6 until the collection times are acceptable.

Powering off the pump

To power off the pump:

1. If you have been using buffers, purge the buffer from the pump and other HPLC system components with HPLC-grade water. If the pump has been idle for more than one day, purge with a methanol/water solution to prevent the growth of organisms.
2. If the pump is running, press the Run/Stop key.

Tip: If your 515 pump is connected to a Waters 680 Automated Gradient Controller, and you power on the controller with the 515 pump running in the Remote mode, you may hear the pump operate briefly. This is due to a spurious signal from the controller when it is powered on. To avoid this situation, power on the controller before you power on the pump.

3. Turn the power switch to the **0** (Off) position.

Tip: Except for the Flow and Mode parameter values, all other 515 pump parameter values are saved when power is turned off. When you power on the pump again, Flow is set to its default value of 1.000, and Mode is set to its default setting of Local.

4

Maintaining and Troubleshooting the Waters 515 Pump

This chapter provides important safety and handling considerations for the 515 pump, describes how to run various diagnostics and set pump calibration parameters, describes how to clean and replace pump components, and explains how to diagnose and resolve pump problems.

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| Cleaning and replacing seals and plungers | 4-9 |
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Maintenance considerations

Safety and handling

When you perform maintenance procedures on your 515 pump, keep the following safety considerations in mind.



Warning:

- To prevent injury, always observe good laboratory practices when you handle eluents, change tubing, or operate the 515 HPLC Pump. Know the physical and chemical properties of the eluents. See the Material Safety Data Sheets for the eluents in use.
- To avoid the possibility of eye injury or cuts, handle the plunger with care. Wear safety glasses and use the plunger insertion tool. Be aware that pieces of a broken plunger are very sharp.



Warning: To avoid the possibility of electric shock, do not remove the cover. The interior of the pump does not contain user-serviceable parts.

Proper operating procedures

To keep your 515 pump running smoothly, follow the operating procedures and guidelines in the [“Preparing the 515 pump” on page 3-13](#).

Spare parts

See [Appendix C, Accessories and Spare Parts](#), for spare parts information. Parts not included in Appendix D are not recommended for replacement by the customer.

Contacting Waters technical service

If you encounter any problems replacing parts in the 515 Pump, contact Waters Technical Service at 800 252-4752, *Canadian and U.S. customers only*. Other customers, call your local Waters subsidiary or call Waters corporate headquarters for assistance in Milford, Massachusetts (U.S.A.).

Diagnostic tests

Regular diagnostic tests can help you to track system performance and prevent or identify potential problems before they interfere with operation. Common tests include:

- Retention time stability tests
- Ramp-and-decay test

Retention time stability monitoring

Observing retention time stability during system suitability tests is useful for determining the performance of your HPLC system and its components, including the pump. Erratic or changing retention times could be a result of dirty or malfunctioning check valves, worn plungers or plunger seals, air bubbles in the lines, incorrectly set flow rate, leaks, or other pump-related problems. Be aware that other factors, such as system and column equilibration, column age, operating temperature, and so on, can also affect retention time stability. See your system suitability documentation for more information about retention time stability.

Performing the ramp-and-decay test

Use the ramp-and-decay test to monitor check valve performance. Ensure that the pump is in the Local mode for this test.

Required materials

- Compression plugs (2) and a tissue
- 5/16-inch open-end wrench (Startup Kit)
- HPLC-grade methanol

Procedure

1. Disconnect the pump outlet tubing from the injector or column and place the end of the pump outlet tubing in a waste container.
2. Purge the pump with 100% methanol. Use an intermediate eluent to purge if your eluent is not miscible with methanol. If necessary, see [“Purging the system” on page 3-17](#).

3. Remove the pump outlet tubing and install a compression plug in the pump outlet.
4. Disconnect the left pump head outlet from the draw-off valve. Install a compression plug in the open port on the draw-off valve.
5. Place a tissue under the disconnected pump head outlet tubing (to catch drips).
6. Set the following pump parameter values:
 - Flow parameter: 0.3 mL/min
 - HPL parameter: 6000 psi (41,370 kPa, 401 bars)
7. With the 100% methanol reservoir still connected to the pump inlet, press Run/Stop to start the pump. Observe pump pressure on the LCD display:
 - If the check valves are operating properly, pressure rises with each plunger stroke on the connected head, then holds as the plunger recedes.
 - If there is a bad inlet check valve, pressure may stop at a certain point, or may not rise at all.
 - If there is a bad outlet check valve, pressure may increase, then immediately decrease as the plunger recedes.
 - If the pressure does not rise to the high-pressure limit, try repriming the pump or increasing the Flow parameter setting.
8. Allow the pump to reach the high-pressure limit. The pump should stop flow automatically. Press the Up or Down key to clear the “Hi Press” (high-pressure) message. The LCD display shows actual pump pressure.
9. After 2 minutes, record the pressure (P1). One minute later, record the pressure again (P2). Calculate system pressure decay with the formula $(P1 - P2)/P1$. Verify that system pressure decay is 0.15 or less.
10. Slowly relieve system pressure by opening the draw-off valve.
11. Disconnect the right pump head outlet from the draw-off valve, transfer the compression plug from the left port of the draw-off valve to the right port of the draw-off valve, then reconnect the left pump head outlet to the left port.
12. Repeat steps 5 through 11 to test the left pump head.

13. If the pressure decay for either pump head is greater than 0.15, you may have dirty check valves (see [“Cleaning and replacing check valves” on page 4-18](#)). Remove and clean the inlet and outlet check valves. If the pump problem persists, replace the check valves.
14. When you finish, remove the compression plugs from the draw-off valve and pump outlet, reconnect the right pump head outlet to the draw-off valve, then reconnect the pump to the HPLC system.

Calibrating the pump

The Calibrate menu selections let you set or calibrate the following pump parameters:

- Zero Pressure
- Head size
- Flow rate
- Strokes on seals

These parameters are set at the factory and do not require regular adjustment. Adjustment *is* necessary if you have recently replaced a pump component or performed a maintenance procedure that affects pump performance (cleaning or replacing pump seals, for example). See the procedures that follow for more details.

Setting zero pressure

The following procedure describes how to set the Zero Pressure parameter for the 515 Pump. Set the Zero Pressure parameter if either of the following conditions occurs:

- You notice significant pressure (or any negative pressure) displayed on the pump at zero flow rate with no backpressure.
- You were referred to this procedure from [“Troubleshooting” on page 4-26](#).

To set the zero pressure for the pump:

1. To eliminate backpressure, disconnect the pump outlet from any HPLC system components.

2. Press the Up, Down, or Menu key to display the Flow parameter. Set Flow to 0.0 mL/min.
3. Press the Run/Stop key to start the pump.
4. Press the Up, Down, or Menu key until the Calibrate menu appears.
5. Press Edit/Enter twice to access the submenu selections. The 0 Pressure submenu appears. The displayed pressure reading reflects the output of the pressure transducer.

Tip: If the pressure reading is greater than 100 psi (689.5 kPa or 6.68 bars), or less than -100 psi (-689.5 kPa or -6.68 bars), contact Waters Technical Service.

6. Press Edit/Enter. When prompted, press Edit/Enter again to set the 0 Pressure parameter.

Tip: The displayed pressure reading does **not** change to zero when you press Edit/Enter. The reading continues to reflect the true (un-zeroed) output of the pressure transducer. Once you exit the Calibration menu, the displayed pressure reading shows 0 (zero) to reflect the setting of the 0 Pressure parameter. If your pump is connected to an external control device, setting the 0 Pressure parameter does not affect the pressure reading displayed at the external device.

7. Press Menu until you are prompted to exit.
8. Press Edit/Enter to exit from the Calibrate menu.
9. Confirm that the displayed pressure reading (with no backpressure) is zero.

Setting the head size

The following procedure describes how to set the head size (100- μ L or optional 225- μ L) for the pump. This parameter is set at the factory for the 100- μ L head size. Set this parameter value after you change to a new head size.

To set the head size for the pump:

1. Press the Up, Down, or Menu key until the Calibrate menu appears.
2. Press Edit/Enter twice to access the submenu selections.
3. Press Menu to scroll to the Head Size parameter.

4. Press Edit/Enter to access the Head Size submenu.
5. Press the Up or Down key to change the Head size parameter to the correct value.
6. Press Menu to store the parameter.
7. Press Menu until you are prompted to exit.
8. Press Edit/Enter to exit the Calibrate menu.
9. Check the HPL and LPL parameter settings, and adjust them if necessary for the new head size.

Calibrating the flow rate

The following procedure describes how to calibrate the pump flow rate. The Flowrate Calibration parameter value is factory set and does not require routine adjustment. Adjust the Flowrate Calibration parameter when you replace a pump head or pump seals.

Tip: To adjust for differences in eluent compressibility, use only the Comp parameter; do not adjust the Flowrate calibration parameter. See [“Adjusting for eluent compressibility” on page 3-24](#).

Required materials

- 25-mL volumetric flask
- Stopwatch
- Reservoir of degassed methanol connected to the pump inlet
- Methanol-compatible column connected to pump outlet

To calibrate the pump flow rate:

1. Press the Up, Down, or Menu key to display the Flow parameter. Set Flow to 1.000 mL/min.
2. Direct the outlet of the column into the 25-mL volumetric flask.
3. Simultaneously press the Run/Stop key and start the stopwatch (to time how long it takes to collect 25 mL).
4. Simultaneously press the Run/Stop key and stop the stopwatch when you have collected 25 mL of methanol.

5. Convert the recorded time to seconds (for example, 24 min 25 sec = 1465 sec).
6. Use the following formula to determine the percent error:

Formula:
$$\frac{\text{Recorded time (in sec)} - 1500}{1500} \times 100 = \% \text{ error}$$

Example:
$$\frac{1465 - 1500}{1500} \times 100 = -2.3\% \text{ error}$$

7. If the percent error is more than $\pm 1\%$, do the following:
 - a. Press the Menu key until the Calibrate Menu appears.
 - b. Press Edit/Enter twice to access the submenu selections.
 - c. Press Menu to scroll to the Flowrate Calibration parameter.
 - d. Press Edit/Enter to access the Flowrate Calibration submenu.
 - e. If the percent error is negative, press the Down key to decrease the calibration parameter by a percent value equivalent to the percent error (this decreases motor speed and delivery volume). Example: For the -2.3% error in step 6, decrease the calibration parameter by 2.3%.

If the percent error is positive, press the Up key to increase the calibration parameter by a percent value equivalent to the percent error (this increases motor speed and delivery volume).
 - f. Press Menu to store the parameter.
8. Press Menu until you are prompted to exit.
9. Press Edit/Enter to exit the Calibrate menu.
10. Repeat steps 3 through 6 until the percent error is no greater than $\pm 1\%$.
11. When you finish, press Menu until you are prompted to exit.
12. Press Edit/Enter to exit the Calibrate menu.

Resetting strokes on seals

The following procedure describes how to reset the Strokes on Seals parameter. This parameter records the number of accumulated strokes for the

currently installed plunger seals. Perform the procedure *only* after you replace plunger seals.

To reset the strokes on seals parameter:

1. Press the Up, Down, or Menu key until the Calibrate menu appears.
2. Press Edit/Enter twice to access the submenu selections.
3. Press Menu to scroll to the Strokes on Seals parameter. The screen displays the number of plunger strokes for the current seals (assuming this parameter was reset when the seals were last replaced).
4. Press Edit/Enter to access the Strokes on Seals submenu.
5. When prompted, press Edit/Enter to reset the parameter.
6. Press Menu until you are prompted to exit.
7. Press Edit/Enter to exit the Calibrate menu.

Cleaning and replacing seals and plungers

The plungers in the Waters 515 pump are ultra-smooth, chemically inert sapphire rods. Salt crystals that precipitate out from the eluent can form on the plunger and cause wear on the plunger seals and on the plunger itself. The result is a slow leak and a very slight cyclic pressure fluctuation, with a possible increase in retention time. In addition, you may need to replace seals, plungers, or check valves if you were referred to this section from [“Troubleshooting” on page 4-26](#).

For continued high performance of the 515 Pump:

- Replace the plunger seals twice yearly, or as needed.
- Clean and inspect the plunger every 6 months (or sooner if using abrasive eluents).
- Replace the plunger yearly, or as needed.

Replacing the plunger seals

Plunger seals can become worn if the plunger becomes dirty or scratched. To check the number of strokes for the current set of seals, look at the value for the Strokes on Seals parameter (see [“Resetting strokes on seals” on page 4-8](#)

for details). Each time you replace the plunger seals, you need to reset the Strokes on Seals parameter.

Required materials

- 5/16-inch open-end wrench (Startup Kit)
- 5/32-inch Allen wrench (Startup Kit)
- Priming syringe (Startup Kit)
- Seal insertion tool (part number WAT076765)
- Fitting plug (Startup Kit)
- Replacement seal kit (see [Appendix C, Accessories and Spare Parts](#), for part numbers)
- Methanol

Removing the pump head

To remove the pump head:

1. Purge the pump with methanol as described in [“Purging the system” on page 3-17](#). If methanol is not miscible with your current eluent, use an intermediate eluent.

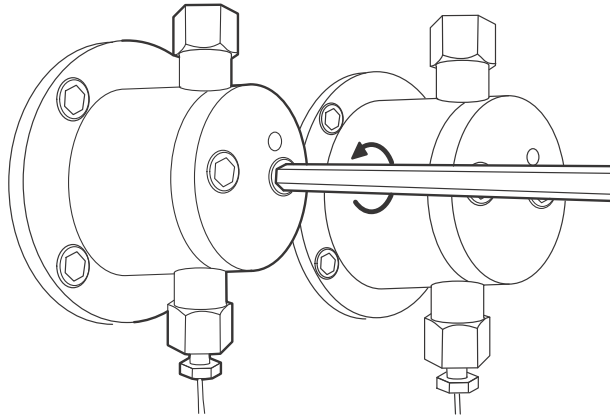


Caution: Before you continue with this procedure, lower the eluent reservoir to eliminate gravity flow of eluent.

2. Disconnect the eluent line from the inlet on the pump. Disconnect the outlet tubing from the pump and install a fitting plug in the outlet. Tighten the plug with the 5/16-inch wrench.
3. Insert the priming syringe into the luer fitting at the center of the draw-off valve handle, then turn the handle counterclockwise about 1/2-turn to open the valve.
4. Use the syringe to withdraw all methanol.
5. Set the Flow parameter to 0.3 mL/min, then press Run/Stop to run the pump.
6. When the indicator rod fully retracts into the pump head, press Run/Stop again to turn off the pump. This ensures that the weight of the pump head does not rest on the plunger while you remove the head.

7. Use the 5/16-inch open-end wrench to remove the inlet and outlet tubing from the check valves on the pump.
8. Use the 5/32-inch Allen wrench to remove the two pump head assembly mounting bolts. Loosen the bolts 1/2-turn at a time for the first two turns.

Unscrewing the pump head mounting bolts



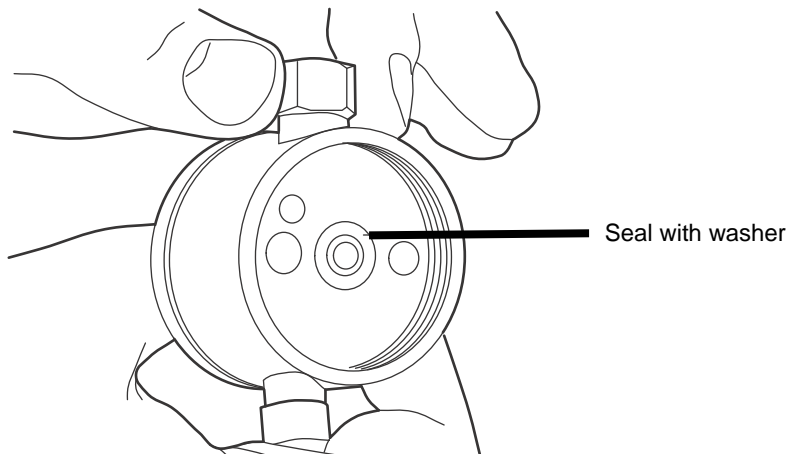
9. Carefully slide the pump head assembly off the pump.

Replacing the plunger seal

To replace the plunger seal:

1. Use the seal insertion tool to pry the seal and washer out of the pump head.

Plunger seal and washer



2. Place the new washer on the new plunger seal, then insert the seal and washer onto the seal insertion tool. For 225- μ L heads, insert the seal so the solid side faces out. The tip holds the plunger seal and washer for correct alignment in the pump head.
3. Wet the seal and washer with methanol.
4. Use the seal insertion tool and guide to firmly seat the seal and washer in the pump head.
5. Rewet the seal and plunger with methanol.
6. Slide the pump head assembly into position over the plunger and reinstall the two pump head mounting bolts. Alternately tighten each bolt, using half turns to evenly align the assembly.
7. Set the Flow parameter to 0.3 mL/min, then press Run/Stop to start the pump. Verify that the indicator rod moves freely.
8. Press Run/Stop to stop the pump.

9. Reset the Strokes on Seals parameter as described in [“Resetting strokes on seals” on page 4-8](#).
10. Perform the following steps:
 - a. Reconnect the inlet and outlet tubing to the pump head.
 - b. Reconnect the eluent line to the pump inlet manifold.
 - c. Remove the fitting plug from the pump outlet, then reposition the eluent reservoir.
 - d. Prime the pump as described in [“Priming the pump” on page 3-15](#). If you notice leaks, verify pump head and plunger seal installation.
 - e. Recalibrate the pump flow rate as described in [“Calibrating the flow rate” on page 4-7](#).

Cleaning and replacing the plungers

The plungers are sapphire rods that require careful handling. Although cleaning the plungers is not difficult, it is important to follow these instructions carefully to avoid damaging the plungers. Assemble all materials and read the procedure thoroughly before you begin.

Required materials

- 5/16-inch open-end wrench (Startup Kit)
- 5/32-inch Allen wrench (Startup Kit)
- 9/64-inch Allen wrench (Startup Kit)
- Snap-ring pliers
- Plunger insertion tool (part number WAT011042)
- Sonicator
- HPLC-grade water
- HPLC-grade methanol
- Replacement plunger
- Replacement plunger seals

Removing the plunger from the pump

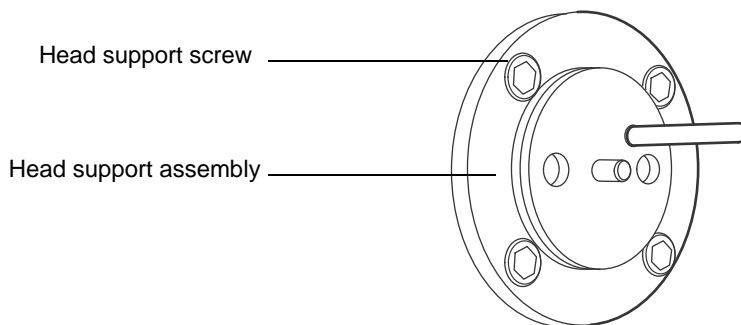


Warning: To avoid the possibility of eye injury or cuts, handle the plunger with care. Wear safety glasses and use the plunger insertion tool. Be aware that the pieces of a broken plunger are very sharp.

To remove the plunger from the pump:

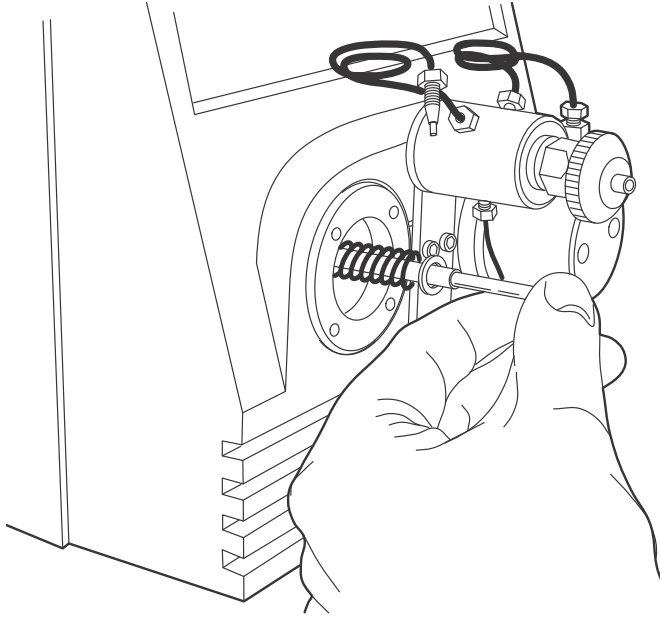
1. Remove the pump head as described in [“Replacing the plunger seals” on page 4-9](#).
2. Remove the four head support screws with the 9/64-inch Allen wrench, then carefully slide the head support assembly and the indicator rod off the pump. Set the head support assembly on the benchtop.

Exposed head support assembly




3. Set the Flow parameter to 0.3 mL/min, then press Run/Stop to run the pump. When the plunger is fully extended, press Run/Stop again to stop the pump.
4. Use the snap-ring pliers to remove the snap-ring that holds the plunger in place.
5. Remove the plunger assembly and set it aside.

Removing the plunger assembly

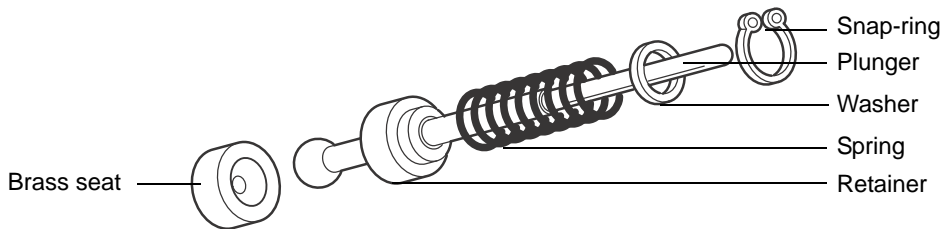


Cleaning the plunger

 **Warning:** To avoid the possibility of eye injury or cuts, handle the plunger with care. Wear safety glasses and use the plunger insertion tool. Be aware that the pieces of a broken plunger are very sharp.

Clean the plunger by sonicating the plunger in 50:50 methanol/water for a few minutes. The parts of the plunger assembly are shown in the figure below.

Disassembled plunger



Inspecting the plunger



Warning: To avoid the possibility of eye injury or cuts, handle the plunger with care. Wear safety glasses and use the plunger insertion tool. Be aware that the pieces of a broken plunger are very sharp.

After you clean the plunger, inspect it for damage by holding it under a bright white light and looking down its length for nicks and scratches. It is easier to see scratches under a bright light than to feel them with your fingers.

If the plunger is not scratched or otherwise damaged, reassemble the plunger with new seals. If the plunger is damaged, replace the plunger and the seals.

Replacing the plunger



Warning: To avoid the possibility of eye injury or cuts, handle the plunger with care. Wear safety glasses and use the plunger insertion tool. Be aware that the pieces of a broken plunger are very sharp.

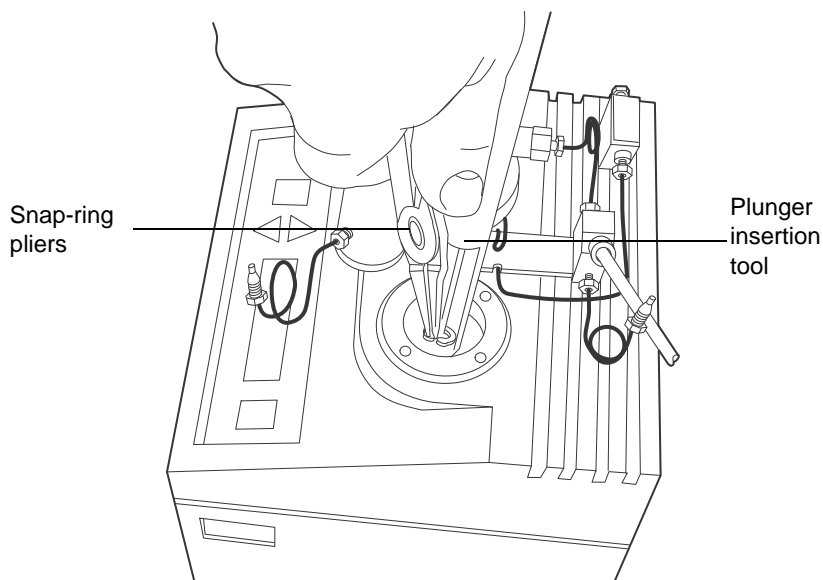
To replace the plunger:

1. Reassemble the components of the plunger assembly as shown in the [figure “Disassembled plunger” on page 4-15](#). Make sure the brass seat is located at the bottom of the piston.
2. Use the plunger insertion tool and snap ring pliers to insert the plunger assembly into the pump. You may find this step easier if you set the pump on its back.



Caution: Be careful not to damage the external controller connector if you set the pump on its back.

Inserting the plunger



3. Press Run/Stop to start the pump. When the plunger is fully retracted, press Run/Stop again to stop the pump.
4. With the indicator rod hole oriented to the upper right, reinstall the head support assembly. Alternately tighten the four screws. Do not overtighten.
5. Wet the plunger seal and plunger with methanol.
6. Gently slide the pump head onto the plunger and alternately tighten the two bolts. Check for even head alignment by observing the gap between the pump head and the pump head support assembly.
7. Set the Flow parameter to 0.3 mL/min, then press Run/Stop to start the pump. Pull out and release the indicator rod. If the rod does not snap back easily, the head is misaligned. Stop the pump, loosen the pump head, then repeat steps 6 and 7.
8. Press Run/Stop to stop the pump.
9. Reconnect the inlet and outlet tubing to the pump head.
10. Reconnect the eluent line to the pump inlet manifold.
11. Remove the fitting plug from the pump outlet, then reposition the eluent reservoir.

12. Prime the pump as described in “[Priming the pump](#)” on page 3-15. If you notice leaks, verify pump head and plunger seal installation.
13. Recalibrate the pump flow rate as described in “[Calibrating the flow rate](#)” on page 4-7.

Cleaning and replacing check valves

Clean the inlet and outlet check valves every 6 months, or more frequently if required by your application. It is a good idea to keep a spare set of clean check valves on hand. If you need to remove the check valves for cleaning, you can install the spare check valves immediately, then clean the dirty check valves at a convenient time.

This section describes how you:

- Remove and install inlet check valves for cleaning or replacement.
- Remove and install outlet check valves for cleaning or replacement.

Cleaning and replacing the inlet check valve

Required materials

- 5/16-inch open-end wrench (Startup Kit)
- 1/2-inch open-end wrench (Startup Kit)
- Priming syringe (Startup Kit)
- Fitting plug (Startup Kit)
- Replacement check valve
- Methanol

Replacing the inlet check valve

To replace the inlet check valve:

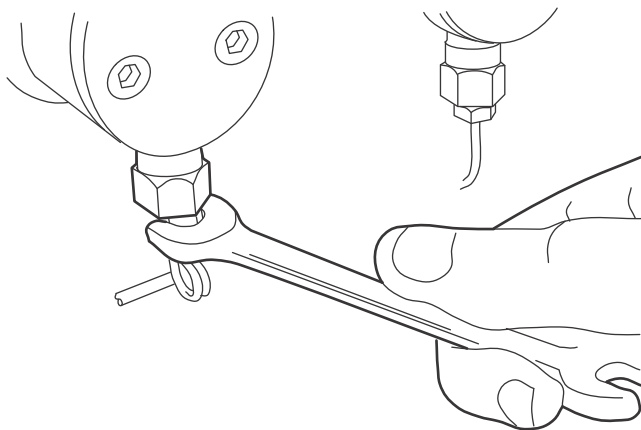
1. Purge the pump with methanol as described in [“Purging the system” on page 3-17](#). If methanol is not miscible with your current eluent, use an intermediate eluent.




Caution: Before you continue with this procedure, lower the eluent reservoir to eliminate gravity flow of eluent.

2. Disconnect the eluent supply line from the inlet manifold on the pump.
3. Disconnect the outlet tubing from the pump and install a fitting plug into the outlet. Tighten the plug with the 5/16-inch wrench.
4. Insert the priming syringe into the luer fitting at the center of the draw-off valve handle, then turn the handle counterclockwise about 1/2 turn to open the valve.
5. Use the syringe to withdraw all the methanol.
6. Use the 5/16-inch open-end wrench to disconnect the tubing from the inlet and outlet check valves of the pump head. If you notice that a check valve turns while you are disconnecting the tubing, use the 1/2-inch wrench to hold the check valve in place.

Disconnecting the inlet tubing

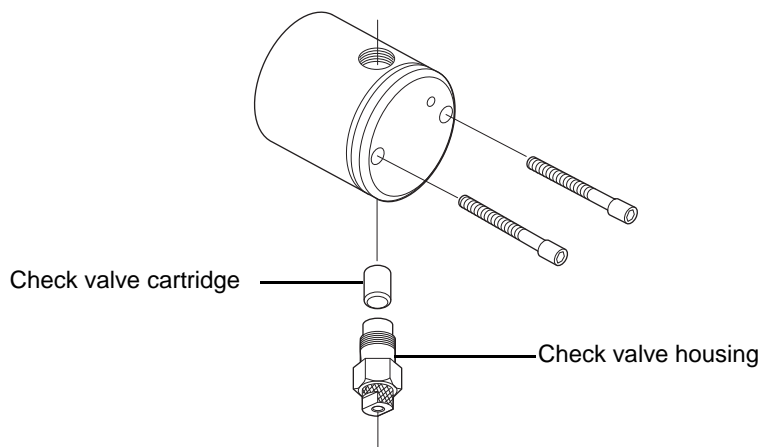


7. Remove the pump head as described in the [“Replacing the plunger seals”](#) on page 4-9.
8. Use the 1/2-inch open-end wrench to remove the inlet check housing from the pump head.
9. Remove the cartridge from the housing and replace it with a new cartridge.

 **Caution:** The arrow printed on the check valve cartridge indicates the direction in which it will allow liquid to flow. Therefore, its direction is critical for proper operation. For all check valve assemblies, the arrow should point upward when installed on the pump.

Tip: To help keep the cartridge sealed within the housing, moisten it with methanol during installation.

Check valve housing and check valve cartridge



10. With the check valve housing held upright to prevent the cartridge from falling out, hand-tighten the housing into the pump head. Tighten the check valve another 1/2-turn with the 1/2-inch wrench.
11. Reinstall the pump head as described in [“Replacing the plunger seals”](#) on page 4-9.

12. Reconnect the inlet and outlet tubing to the pump head. While tightening the compression screw, hold the housing to prevent it from turning.
13. Reconnect the eluent supply line to the inlet manifold on the pump.
14. Remove the fitting plug from the pump outlet, then reposition the eluent reservoir.
15. Prime the pump as described in [“Priming the pump” on page 3-15](#). Check for leaks.

Replacing the outlet check valve

Required materials

- 5/16-inch open-end wrench (Startup Kit)
- Priming syringe (Startup Kit)
- 1/2-inch open-end wrench
- Fitting plug (Startup Kit)
- Replacement check valve
- Methanol

Removing the outlet check valve

To remove the outlet check valve:

1. Purge the pump with methanol as described in [“Purging the system” on page 3-17](#). If methanol is not miscible with your current eluent, use an intermediate eluent.

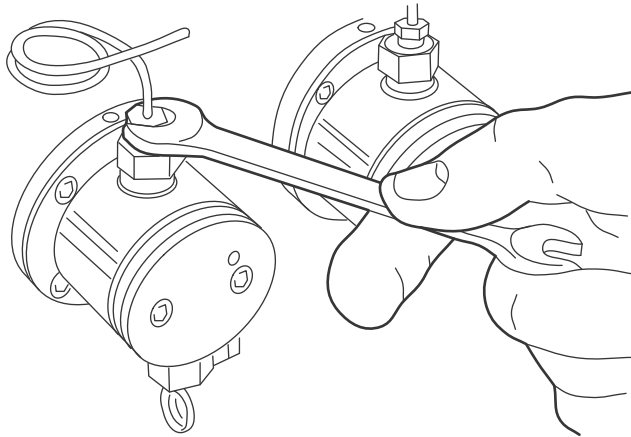


Caution: Before you continue with this procedure, lower the eluent reservoir to eliminate gravity flow.

2. Disconnect the eluent supply line from the inlet manifold on the pump.
3. Disconnect the outlet tubing from the pump and install a fitting plug into the outlet. Tighten the plug with the 5/16-inch wrench.
4. Insert the priming syringe into the luer fitting at the center of the draw-off valve handle, then turn the handle counterclockwise about 1/2-turn to open the valve.

5. Use the syringe to withdraw all the methanol.
6. Use the 5/16-inch wrench to disconnect the tubing from the inlet and outlet check valves of the pump head. If you notice that a check valve turns while you are disconnecting the tubing, use the 1/2-inch wrench to hold the check valve in place.

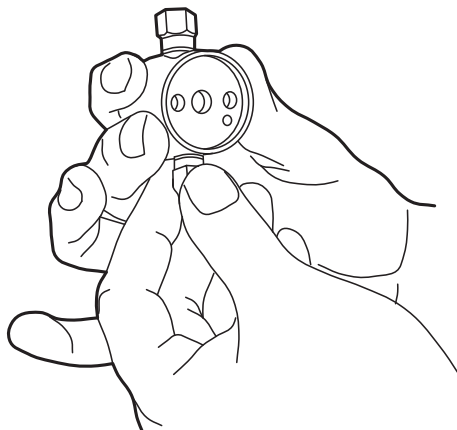
Disconnecting the outlet tubing




7. Remove the pump head as described in [“Replacing the plunger seals” on page 4-9](#).
8. Use the 1/2-inch open-end wrench to loosen the outlet check valve a half-turn. Do not remove the valve.
9. Hold the pump head upside-down in one hand with the outlet check valve housing facing the floor, then remove the housing (see the [figure “Removing the outlet check valve” on page 4-23](#)).

10. Remove the cartridge from the housing and replace it with the new cartridge.

Removing the outlet check valve



 **Caution:** The arrow printed on the check valve cartridge indicates the direction in which it will allow liquid to flow. Therefore, its direction is critical for proper operation. For all check valve assemblies, the arrow should point upward when installed on the pump.

Tip: To help keep the cartridge sealed within the housing, moisten it with methanol during installation.

11. With the check valve housing held upright to prevent the cartridge from falling out, hand-tighten the housing into the pump head. Then, tighten it another 1/2-turn with the 1/2-inch wrench.
12. Reinstall the pump head as described in [“Cleaning and replacing the plungers” on page 4-13](#).
13. Reconnect the inlet and outlet tubing to the pump head. Use the 5/16-inch wrench to tighten the compression screw while holding the housing with the 1/2-inch wrench.
14. Reconnect the eluent line to the inlet manifold on the pump.
15. Remove the fitting plug from the pump outlet, then reposition the eluent reservoir.

16. Prime the pump as described in [“Priming the pump”](#) on page 3-15. Check for leaks.

Replacing the draw-off valve

Replace the draw-off valve if you notice that the valve leaks even after you tighten its handle.

Required materials

- 5/16-inch open-end wrench (Startup Kit)
- Priming syringe (Startup Kit)
- 7/64-inch Allen wrench
- Phillips screwdriver
- Replacement draw-off valve
- Methanol

Removing the draw-off valve

To remove the draw-off valve:

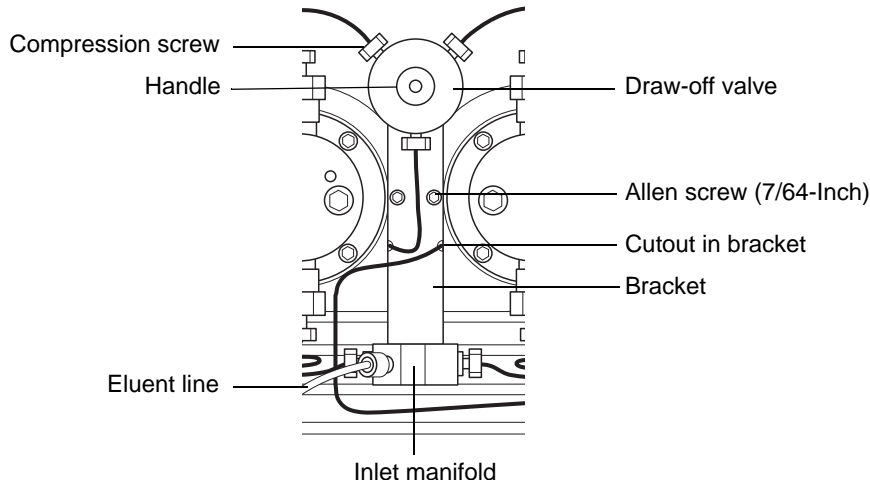
1. Purge the pump with methanol as described in [“Purging the system”](#) on page 3-17. If methanol is not miscible with your current eluent, use an intermediate eluent.



Caution: Before you continue with this procedure, lower the eluent reservoir to eliminate gravity flow

2. Disconnect the eluent supply line from the inlet manifold on the pump.
3. Insert the priming syringe into the luer fitting at the center of the draw-off valve handle, then turn the handle counterclockwise about 1/2-turn to open the valve.
4. Use the syringe to withdraw all the methanol.
5. Use the 5/16-inch open-end wrench to disconnect the three stainless compression screws from the draw-off valve.

Draw-off valve/inlet manifold assembly



6. Use the 5/16-inch open-end wrench to disconnect the two stainless compression screws from the inlet manifold (these screws connect the inlet manifold to the inlet check valves). See the figure above.
7. Use the 7/64-inch Allen wrench to remove the two screws that hold the draw-off valve assembly and bracket to the pump. Carefully remove the assembly.
8. Remove the two Phillips screws that hold the draw-off valve to the bracket.

Installing the draw-off valve

To install the draw-off valve:

1. Attach the new draw-off valve to the bracket using the two Phillips screws. Make sure the new valve is oriented on the bracket as shown in the [figure "Draw-off valve/inlet manifold assembly" on page 4-25](#).
2. Reposition the draw-off valve/inlet manifold assembly onto the pump, being careful not to pinch the stainless tubing behind the bracket. When correctly positioned, the stainless tubing extends through the cutouts on the sides of the bracket.
3. Secure the bracket to the pump with the two Allen screws.

4. Reconnect the inlet tubing to the inlet manifold.
5. Reconnect the outlet tubing to the new draw-off valve.
6. Reposition the eluent reservoir, then prime the pump (see “[Priming the pump](#)” on page 3-15). Check for leaks.

Troubleshooting

This section describes:

- Troubleshooting pump problems based on error messages and malfunctions
- Identifying and correcting noises
- Identifying pump-related chromatographic problems



Warning: To prevent injury, always observe good laboratory practices when you troubleshoot the 515 HPLC Pump.

Contacting Waters technical service

If you encounter problems troubleshooting the 515 Pump that you cannot resolve, contact Waters Technical Service at 800 252-4752, *Canadian and U.S. customers only*. Other customers, call your local Waters subsidiary or call Waters corporate headquarters for assistance in Milford, Massachusetts (U.S.A.).

Troubleshooting error messages and pump malfunctions

The table below is a guide to troubleshooting pump problems. It lists pump error messages and pump-related symptoms and their possible causes, and suggests corrective actions.


Troubleshooting error messages and pump malfunctions

| Symptom | Possible cause | Corrective action |
|---|---|--|
| Error message on the display reads: Hi Press | Pump flow rate set too high | Set to correct flow rate. |
| | HPL set too low | Set HPL to correct value. |
| | Blocked column | Clean column per column care and use manual. |
| | Viscous eluents in use | Check eluent viscosity (the observed pressure may be normal for the column/eluent blend). If necessary, change to less viscous eluent. |
| | Defective pressure transducer | Contact Waters Technical Service. |
| | Blocked outlet tubing or fluid path (in pump outlet, detector, column, or injector) | Locate source of blockage. Clean or replace tubing according to the appropriate operator's manual. |
| | Ambient temperature has changed | Stabilize operating temperature. |
| Error message on the display reads: Lo Press | Pump flow rate set too low | Set to correct flow rate. |
| | LPL parameter set too high | Set LPL parameter to correct value. |
| | Eluent reservoir empty | Fill reservoir. |
| | Air in eluent lines | Prime the pump (see “Priming the pump” on page 3-15). |
| | Incorrect eluent used | Change to correct eluent. |

Troubleshooting error messages and pump malfunctions (Continued)

| Symptom | Possible cause | Corrective action |
|--|--|--|
| Error message on the display reads: Lo Press (continued) | Visible leaks | Carefully tighten any loose fittings. |
| | Ambient temperature has changed | Stabilize operating temperature. |
| Error message on the display reads: EEPROM Error All Parameters have been reset Press Menu to acknowledge | EEPROM failure during startup | Press Menu to acknowledge the error, then contact Waters Technical Service. |
| Error message on the display reads: EEPROM Error Press Menu to acknowledge | EEPROM failure while pump is in a Ready or Run state | If running, press Menu to acknowledge the error. Continue the run while carefully observing pump operation. Contact Waters Technical Service. |
| Pump does not run (fan and LCD display are off) | Pump not connected to power source | Ensure power cable is properly connected to power source and pump. |
| | No power at outlet | Check the outlet by connecting to another electrical unit known to be working. If that unit does not work, relocate the pump to a functioning electrical outlet. |
| | Blown fuse | Replace the fuses (see “Replacing the power supply fuses” on page 2-4). |
| LCD display is blank, but fan is running | EEPROM failure | Contact Waters Technical Service. |

Troubleshooting error messages and pump malfunctions (Continued)

| Symptom | Possible cause | Corrective action |
|----------------------------|--|---|
| Pump not delivering eluent | Draw-off valve open or leaking | Close the draw-off valve. If eluent still leaks, replace the valve (see “Removing the draw-off valve” on page 4-24). |
| | Pump low-pressure limit set higher than operating pressure | Set to the correct low-pressure limit. |
| | Flow rate set to zero | Set desired pump flow rate. |
| | Pressure transducer out of adjustment or defective | With Flow parameter set to zero and with no system backpressure, set the Zero Pressure parameter. If problem continues, contact Waters Technical Service. |
| | Pump not primed | Prime the pump (see “Priming the pump” on page 3-15). |
| | Pump not connected to external controller | <p>Ensure cable is properly connected to pump controller.</p> <p> Caution: To prevent eluent from leaking out of the pump outlet, make sure you position the eluent reservoir below the pump inlet manifold before you disconnect the pump outlet fitting</p> <p>To avoid component damage, never disconnect the pump from the controller while the two devices are powered on.</p> <p>If pump operates properly, see the controller operator’s manual for troubleshooting information.</p> |

Troubleshooting error messages and pump malfunctions (Continued)

| Symptom | Possible cause | Corrective action |
|--|---|--|
| Pump not delivering eluent (continued) | Immiscible eluents in pump head | Purge pump with appropriate eluents. Verify miscibility of eluents being used and change to more miscible eluents. |
| | Dirty or malfunctioning inlet or outlet check valve | Clean the check valves (see “Cleaning and replacing check valves” on page 4-18). |
| | Damaged plunger seal (indicated by eluent leaking from behind the pump head or by salt crystal build-up around the back of the pump head) | Verify if both pump heads can maintain pressure as outlined in “Performing the ramp-and-decay test” on page 4-3). If a head is leaking, replace the plunger seal (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Pump cavitation due to one of the following: Eluent reservoirs positioned at or below the height of the pump Loose, bent, or blocked inlet tubing Improperly degassed eluent Dirty eluent reservoir inlet filter Volatile eluents in pump head | Perform the following corrective action: Raise eluent reservoirs above the pump. Check tubing. Tighten, straighten, or replace tubing. Degas or helium sparge eluents. Replace filter. Prime pump (see “Priming the pump” on page 3-15). |
| | Tubing ID too small | Use correct tubing. |
| | Ruptured high-pressure noise filter (indicated by leak at bottom of front bezel) | Contact Waters Technical Service. |

Troubleshooting error messages and pump malfunctions (Continued)

| Symptom | Possible cause | Corrective action |
|---|---------------------------------------|--|
| Pump not delivering eluent (continued) | Defective pump motor | Contact Waters Technical Service. |
| | Defective circuit board | Contact Waters Technical Service. |
| Leak from pump head | Worn pump plunger seals | Replace defective plunger seals (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Worn plunger | Replace the plunger (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Loose pump head | Tighten the two pump head screws. Ensure that both screws are tightened equally, otherwise seal wear may result. Do not overtighten. |
| | Loose inlet or outlet check valve | Tighten the loose check valve(s). Do not overtighten. |
| Check fittings and ferrules for wear. Replace if necessary. | | |
| Leak from draw-off valve | Draw-off valve open or broken | Close the draw-off valve. If leak continues, replace the valve (see “Replacing the draw-off valve” on page 4-24). |
| Erratic flow rate/pump pulsations | Eluent improperly degassed or sparged | Degas or sparge the eluent and reequilibrate the system. |
| | Pump not primed | Prime the pump. If you are using a volatile eluent (such as hexane), prime the pump with a miscible, less volatile eluent such as THF or methanol. Ensure that the column is disconnected to avoid disrupting equilibrium. |

Troubleshooting error messages and pump malfunctions (Continued)

| Symptom | Possible cause | Corrective action |
|---|--|--|
| Erratic flow rate/pump pulsations (continued) | Reservoir low or out of eluent | Refill reservoir (filter and degas eluent). |
| | Air bubble in pump head | Prime pump to remove bubble. Ensure there are no air bubbles in the inlet lines. Degas eluents. |
| | Dirty or malfunctioning check valve(s) | Clean the check valves (see “Cleaning and replacing check valves” on page 4-18). |
| | Inlet filter or inlet lines blocked | Check lines for blockages. Replace the inlet filter frit. |
| | Pump plunger seal leaking (under pump head) | Replace pump plunger seal (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Worn pump plunger | Replace the plunger (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Immiscible eluents in pump head | See the Corrective Action under the “Pump not delivering eluent” symptom listed above. |
| | Pump cavitation | See the Corrective Action under the “Pump not delivering eluent” symptom listed above. |
| High system pressure due to pump | Pump Flow parameter set too high | Set the correct Flow parameter value. |
| | Pressure transducer out of adjustment or defective | Set Flow parameter to zero and adjust the zero pressure. If problem continues, contact Waters Technical Service. |

Identifying and correcting noises

The table below is a guide to troubleshooting and correcting noises in the Waters 515 pump.

Identifying Noises

| Symptom | Possible cause | Corrective action |
|--------------------|------------------------------|---|
| Click or loud snap | Binding plunger seal | If click does not stop and cannot be isolated to one pump head, replace the plunger seals, one at a time (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Worn indicator rod spring | Replace the spring. |
| Squeak | Plunger seals dry | Wet plunger with appropriate eluent through pump head access holes. |
| | Binding plunger seal | Replace plunger seal assembly (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Improper plunger seal | Install correct pump plunger seal (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Binding piston indicator rod | Replace indicator rod. |

Identifying chromatographic problems

The table below is a guide to troubleshooting and correcting chromatographic problems.

Identifying chromatographic problems

| Symptom | Possible cause | Corrective action |
|---------------------------|----------------------------------|--|
| Erratic retention times | Air bubble in pump head | Degas all eluents, prime pump (see “Priming the pump” on page 3-15). |
| | Malfunctioning pump check valves | Clean/replace pump check valves (see “Cleaning and replacing check valves” on page 4-18). |
| | Leaking pump seals | Replace pump seals (see “Cleaning and replacing seals and plungers” on page 4-9). |
| | Separation chemistry | Check eluent, column. |
| | Clogged eluent filters | Replace filters. |
| Increased retention times | Incorrect flow rate | Change flow rate. |
| | Incorrect eluent composition | Change eluent composition. |
| | Column heater not turned on | Turn column heater on. |
| | Incorrect eluent | Use correct eluent. |
| | Column contaminated | Clean/replace column. |
| | Incorrect column | Use correct column. |
| | Air bubble in pump head | Degas all eluents, prime pump (see “Priming the pump” on page 3-15). |
| Clogged eluent filter | Replace filter. | |

Identifying chromatographic problems (Continued)

| Symptom | Possible cause | Corrective action |
|-------------------------|--|---|
| Reduced retention times | Incorrect flow rate | Change flow rate. |
| | Incorrect eluent composition | Change composition. |
| | High column temperature | Reduce column temperature. |
| | Incorrect eluent | Use correct eluent. |
| | Column contaminated | Clean/replace column. |
| | Incorrect column | Use correct column. |
| | Eluent not properly degassed/sparged | Degas/sparge eluent. |
| Reproducibility errors | Eluent not properly degassed/sparged | Degas/sparge eluent. |
| | Incorrect chemistry/integration | Check chemistry/integration. |
| Baseline drift, rapid | Column not equilibrated | Equilibrate column. |
| | Eluent contaminated | Use fresh eluent. |
| | Eluent not properly degassed (rapid or slow drift) | Degas eluent. |
| | Flow fluctuations (rapid or slow drift) | Fix pump problems, replace pump seals, check valves. |
| Baseline drift, slow | Eluent contaminated | Use fresh eluent. |
| | Ambient temperature fluctuations | Stabilize operating environment temperature enough to allow full equilibration. |

Identifying chromatographic problems (Continued)

| Symptom | Possible cause | Corrective action |
|--|---|---|
| Baseline noise cycling, short-term (30 sec to 60 sec) | Fluctuating flow rate | Spurge or degas eluent. Try repriming the pump(s). If necessary, check flow accuracy of the pump(s). |
| | Inadequate eluent blending | Install a mixer as shown in the figure “Three-pump, high-pressure gradient configuration with optional mixer” on page 2-12. |
| | AC power source (short- or long- term cycling) | Disconnect other instruments on the power line; try a different wall outlet; have line voltage checked; use power conditioner. |
| | Radio frequency noise (short- or long-term cycling) | Eliminate interference. |
| Baseline noise cycling, long-term (approximately 1 hour) | Ambient temperature fluctuations | Stabilize ambient temperature. |
| | Integrator or recorder faulty | Check integrator or recorder for excessive baseline noise. |

Identifying chromatographic problems (Continued)

| Symptom | Possible cause | Corrective action |
|-----------------------------|---|--|
| Baseline noise, random | Eluents not properly degassed or sparged | Degas/sparge eluents. |
| | Flow erratic, pump not primed | Prime the pump (see “Priming the pump” on page 3-15). |
| | | Check for air in the pump, failing seals. |
| | Eluents contaminated | Use fresh eluent. |
| | Column contaminated | Clean/replace column. |
| | System improperly grounded | Plug into outlet on different electrical circuit. |
| | | Use power conditioner. |
| Recorder voltage incorrect | Set recorder to correct voltage. | |
| Radio frequency noise | Eliminate interference. | |
| Straight baseline, no peaks | No pump flow | Set pump flow rate. |
| | Leak in eluent path | Repair the leak. |
| Sensitivity loss | Degraded, contaminated, or improperly prepared sample | Use fresh sample. |
| | Column contaminated | Clean/replace column. |
| | Loss of column efficiency | Clean/replace column. |
| | Change in eluent composition | Correct eluent pH or ionic composition. |
| | Incorrect flow rate | Change flow rate. |

A Safety Advisories

Waters instruments display hazard symbols designed to alert you to the hidden dangers of operating and maintaining the instruments. Their corresponding user guides also include the hazard symbols, with accompanying text statements describing the hazards and telling you how to avoid them. This appendix presents all the safety symbols and statements that apply to the entire line of Waters products.

Contents

| Topic | Page |
|---|----------------------|
| Warning symbols | A-2 |
| Caution symbol | A-5 |
| Warnings that apply to all Waters instruments | A-6 |
| Electrical and handling symbols | A-12 |

Warning symbols

Warning symbols alert you to the risk of death, injury, or seriously adverse physiological reactions associated with an instrument's use or misuse. Heed all warnings when you install, repair, and operate Waters instruments. Waters assumes no liability for the failure of those who install, repair, or operate its instruments to comply with any safety precaution.

Task-specific hazard warnings

The following warning symbols alert you to risks that can arise when you operate or maintain an instrument or instrument component. Such risks include burn injuries, electric shocks, ultraviolet radiation exposures, and others.

When the following symbols appear in a manual's narratives or procedures, their accompanying text identifies the specific risk and explains how to avoid it.



Warning: (General risk of danger. When this symbol appears on an instrument, consult the instrument's user documentation for important safety-related information before you use the instrument.)



Warning: (Risk of burn injury from contacting hot surfaces.)



Warning: (Risk of electric shock.)



Warning: (Risk of fire.)



Warning: (Risk of sharp-point puncture injury.)



Warning: (Risk of hand crush injury.)



Warning: (Risk of exposure to ultraviolet radiation.)



Warning: (Risk of contacting corrosive substances.)



Warning: (Risk of exposure to a toxic substance.)



Warning: (Risk of personal exposure to laser radiation.)



Warning: (Risk of exposure to biological agents that can pose a serious health threat.)



Warning: (Risk of tipping.)



Warning: (Risk of explosion.)



Warning: (Risk of eye injury.)

Specific warnings

The following warnings can appear in the user manuals of particular instruments and on labels affixed to them or their component parts.

Burst warning

This warning applies to Waters instruments fitted with nonmetallic tubing.



Warning: Pressurized nonmetallic, or polymer, tubing can burst.

Observe these precautions when working around such tubing:

- Wear eye protection.
- Extinguish all nearby flames.
- Do not use tubing that is, or has been, stressed or kinked.
- Do not expose nonmetallic tubing to incompatible compounds like tetrahydrofuran (THF) and nitric or sulfuric acids.
- Be aware that some compounds, like methylene chloride and dimethyl sulfoxide, can cause nonmetallic tubing to swell, which significantly reduces the pressure at which the tubing can rupture.

Mass spectrometer flammable solvents warning

This warning applies to instruments operated with flammable solvents.



Warning: Where significant quantities of flammable solvents are involved, a continuous flow of nitrogen into the ion source is required to prevent possible ignition in that enclosed space.

Ensure that the nitrogen supply pressure never falls below 690 kPa (6.9 bar, 100 psi) during an analysis in which flammable solvents are used. Also ensure a gas-fail connection is connected to the LC system so that the LC solvent flow stops if the nitrogen supply fails.

Mass spectrometer shock hazard

This warning applies to all Waters mass spectrometers.



Warning: To avoid electric shock, do not remove the mass spectrometer's protective panels. The components they cover are not user-serviceable.

This warning applies to certain instruments when they are in Operate mode.



Warning: High voltages can be present at certain external surfaces of the mass spectrometer when the instrument is in Operate mode. To avoid non-lethal electric shock, make sure the instrument is in Standby mode before touching areas marked with this high voltage warning symbol.

Biohazard warning

This warning applies to Waters instruments that can be used to process material that might contain biohazards: substances that contain biological agents capable of producing harmful effects in humans.



Warning: Waters instruments and software can be used to analyze or process potentially infectious human-sourced products, inactivated microorganisms, and other biological materials. To avoid infection with these agents, assume that all biological fluids are infectious, observe Good Laboratory Practices, and consult your organization's biohazard safety representative regarding their proper use and handling. Specific precautions appear in the latest edition of the US National Institutes of Health (NIH) publication, *Biosafety in Microbiological and Biomedical Laboratories* (BMBL).

Chemical hazard warning

This warning applies to Waters instruments that can process corrosive, toxic, flammable, or other types of hazardous material.



Warning: Waters instruments can be used to analyze or process potentially hazardous substances. To avoid injury with any of these materials, familiarize yourself with the materials and their hazards, observe Good Laboratory Practices (GLP), and consult your organization's safety representative regarding proper use and handling. Guidelines are provided in the latest edition of the National Research Council's publication, *Prudent Practices in the Laboratory: Handling and Disposal of Chemicals*.

Caution symbol

The caution symbol signifies that an instrument's use or misuse can damage the instrument or compromise a sample's integrity. The following symbol and its associated statement are typical of the kind that alert you to the risk of damaging the instrument or sample.



Caution: To avoid damage, do not use abrasives or solvents to clean the instrument's case.

Warnings that apply to all Waters instruments

When operating this device, follow standard quality control procedures and the equipment guidelines in this section.



Attention: Changes or modifications to this unit not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Important: Toute modification sur cette unité n'ayant pas été expressément approuvée par l'autorité responsable de la conformité à la réglementation peut annuler le droit de l'utilisateur à exploiter l'équipement.

Achtung: Jedwede Änderungen oder Modifikationen an dem Gerät ohne die ausdrückliche Genehmigung der für die ordnungsgemäße Funktionstüchtigkeit verantwortlichen Personen kann zum Entzug der Bedienungsbefugnis des Systems führen.

Avvertenza: qualsiasi modifica o alterazione apportata a questa unità e non espressamente autorizzata dai responsabili per la conformità fa decadere il diritto all'utilizzo dell'apparecchiatura da parte dell'utente.

Atencion: cualquier cambio o modificación efectuado en esta unidad que no haya sido expresamente aprobado por la parte responsable del cumplimiento puede anular la autorización del usuario para utilizar el equipo.

注意: 未經有關法規認證部門允許對本設備進行的改變或修改,可能會使使用者喪失操作該設備的權利。

注意: 未經有關法規認證部門明確允許對本設備進行的改變或改裝,可能會使使用者喪失操作該設備的合法性。

주의: 규정 준수를 책임지는 당사자의 명백한 승인 없이 이 장치를 개조 또는 변경할 경우, 이 장치를 운용할 수 있는 사용자 권한의 효력을 상실할 수 있습니다.

注意: 規制機関から明確な承認を受けずに本装置の変更や改造を行うと、本装置のユーザーとしての承認が無効になる可能性があります。



Warning: Use caution when working with any polymer tubing under pressure:

- Always wear eye protection when near pressurized polymer tubing.
- Extinguish all nearby flames.
- Do not use tubing that has been severely stressed or kinked.
- Do not use nonmetallic tubing with tetrahydrofuran (THF) or concentrated nitric or sulfuric acids.
- Be aware that methylene chloride and dimethyl sulfoxide cause nonmetallic tubing to swell, which greatly reduces the rupture pressure of the tubing.

Attention: Manipulez les tubes en polymère sous pression avec précaution:

- Portez systématiquement des lunettes de protection lorsque vous vous trouvez à proximité de tubes en polymère pressurisés.
- Eteignez toute flamme se trouvant à proximité de l'instrument.
- Evitez d'utiliser des tubes sévèrement déformés ou endommagés.
- Evitez d'utiliser des tubes non métalliques avec du tétrahydrofurane (THF) ou de l'acide sulfurique ou nitrique concentré.
- Sachez que le chlorure de méthylène et le diméthylesulfoxyde entraînent le gonflement des tuyaux non métalliques, ce qui réduit considérablement leur pression de rupture.

Vorsicht: Bei der Arbeit mit Polymerschläuchen unter Druck ist besondere Vorsicht angebracht:

- In der Nähe von unter Druck stehenden Polymerschläuchen stets Schutzbrille tragen.
- Alle offenen Flammen in der Nähe löschen.
- Keine Schläuche verwenden, die stark geknickt oder überbeansprucht sind.
- Nichtmetallische Schläuche nicht für Tetrahydrofuran (THF) oder konzentrierte Salpeter- oder Schwefelsäure verwenden.
- Durch Methylenchlorid und Dimethylsulfoxid können nichtmetallische Schläuche quellen; dadurch wird der Berstdruck des Schlauches erheblich reduziert.



Attenzione: fare attenzione quando si utilizzano tubi in materiale polimerico sotto pressione:

- Indossare sempre occhiali da lavoro protettivi nei pressi di tubi di polimero pressurizzati.
- Spegnere tutte le fiamme vive nell'ambiente circostante.
- Non utilizzare tubi eccessivamente logorati o piegati.
- Non utilizzare tubi non metallici con tetraidrofurano (THF) o acido solforico o nitrico concentrati.
- Tenere presente che il cloruro di metilene e il dimetilsolfossido provocano rigonfiamenti nei tubi non metallici, riducendo notevolmente la pressione di rottura dei tubi stessi.

Advertencia: se recomienda precaución cuando se trabaje con tubos de polímero sometidos a presión:

- El usuario deberá protegerse siempre los ojos cuando trabaje cerca de tubos de polímero sometidos a presión.
- Si hubiera alguna llama las proximidades.
- No se debe trabajar con tubos que se hayan doblado o sometido a altas presiones.
- Es necesario utilizar tubos de metal cuando se trabaje con tetrahidrofurano (THF) o ácidos nítrico o sulfúrico concentrados.
- Hay que tener en cuenta que el cloruro de metileno y el sulfóxido de dimetilo dilatan los tubos no metálicos, lo que reduce la presión de ruptura de los tubos.

警告: 當在有壓力的情況下使用聚合物管線時，小心注意以下幾點。

- 當接近有壓力的聚合物管線時一定要戴防護眼鏡。
- 熄滅附近所有的火焰。
- 不要使用已經被壓癟或嚴重彎曲管線。
- 不要在非金屬管線中使用四氫呋喃或濃硝酸或濃硫酸。
- 要了解使用二氯甲烷及二甲基亞楓會導致非金屬管線膨脹，大大降低管線的耐壓能力。



警告: 当有压力的情况下使用管线时, 小心注意以下几点:

- 当接近有压力的聚合物管线时一定要戴防护眼镜。
- 熄灭附近所有的火焰。
- 不要使用已经被压瘪或严重弯曲的管线。
- 不要在非金属管线中使用四氢呋喃或浓硝酸或浓硫酸。
- 要了解使用二氯甲烷及二甲基亚砜会导致非金属管线膨胀, 大大降低管线的耐压能力。

경고: 가압 폴리머 튜브로 작업할 경우에는 주의하십시오.

- 가압 폴리머 튜브 근처에서는 항상 보호 안경을 착용하십시오.
- 근처의 화기를 모두 끄십시오.
- 심하게 변형되거나 꼬인 튜브는 사용하지 마십시오.
- 비금속(Nonmetallic) 튜브를 테트라히드로푸란(Tetrahydrofuran: THF) 또는 농축 질산 또는 황산과 함께 사용하지 마십시오.
- 염화 메틸렌(Methylene chloride) 및 디메틸설폭시드(Dimethyl sulfoxide)는 비금속 튜브를 부풀려 튜브의 파열 압력을 크게 감소시킬 수 있으므로 유의하십시오.

警告: 圧力のかかったポリマーチューブを扱うときは、注意してください。

- 加圧されたポリマーチューブの付近では、必ず保護メガネを着用してください。
- 近くにある火を消してください。
- 著しく変形した、または折れ曲がったチューブは使用しないでください。
- 非金属チューブには、テトラヒドロフラン(THF)や高濃度の硝酸または硫酸などを流さないでください。
- 塩化メチレンやジメチルスルホキシドは、非金属チューブの膨張を引き起こす場合があります、その場合、チューブは極めて低い圧力で破裂します。



Warning: The user shall be made aware that if the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Attention: L'utilisateur doit être informé que si le matériel est utilisé d'une façon non spécifiée par le fabricant, la protection assurée par le matériel risque d'être défectueuses.

Vorsicht: Der Benutzer wird darauf aufmerksam gemacht, dass bei unsachgemäßer Verwendung des Gerätes die eingebauten Sicherheitseinrichtungen unter Umständen nicht ordnungsgemäß funktionieren.

Attenzione: si rende noto all'utente che l'eventuale utilizzo dell'apparecchiatura secondo modalità non previste dal produttore può compromettere la protezione offerta dall'apparecchiatura.

Advertencia: el usuario deberá saber que si el equipo se utiliza de forma distinta a la especificada por el fabricante, las medidas de protección del equipo podrían ser insuficientes.

警告: 使用者必須非常清楚如果設備不是按照製造廠商指定的方式使用，那麼該設備所提供的保護將被削弱。

警告: 使用者必須非常清楚如果設備不是按照製造廠商指定的方式使用，那麼該設備所提供的保護將被削弱。

경고: 제조업체가 명시하지 않은 방식으로 장비를 사용할 경우 장비가 제공하는 보호 수단이 제대로 작동하지 않을 수 있다는 점을 사용자에게 반드시 인식시켜야 합니다.

警告: ユーザーは、製造元により指定されていない方法で機器を使用すると、機器が提供している保証が無効になる可能性があることに注意して下さい。



Warning: To protect against fire, replace fuses with those of the type and rating printed on panels adjacent to instrument fuse covers.



Attention: pour éviter tout risque d'incendie, remplacez toujours les fusibles par d'autres du type et de la puissance indiqués sur le panneau à proximité du couvercle de la boîte à fusible de l'instrument.



Vorsicht: Zum Schutz gegen Feuer die Sicherungen nur mit Sicherungen ersetzen, deren Typ und Nennwert auf den Tafeln neben den Sicherungsabdeckungen des Geräts gedruckt sind.



Attenzione: per garantire protezione contro gli incendi, sostituire i fusibili con altri dello stesso tipo aventi le caratteristiche indicate sui pannelli adiacenti alla copertura fusibili dello strumento.



Advertencia: Para evitar incendios, sustituir los fusibles por aquellos del tipo y características impresos en los paneles adyacentes a las cubiertas de los fusibles del instrumento.



警告: 為了避免火災，更換保險絲時，請使用與儀器保險絲蓋旁面板上所印刷之相同類型與規格的保險絲。



警告: 为了避免火灾，应更换与仪器保险丝盖旁边面板上印刷的类型和规格相同的保险丝。



경고: 화재의 위험을 막으려면 기기 퓨즈 커버에 가까운 패널에 인쇄된 것과 동일한 타입 및 정격의 제품으로 퓨즈를 교체하십시오.







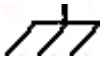
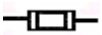



警告: 火災予防のために、ヒューズ交換では機器ヒューズカバー脇のパネルに記載されているタイプおよび定格のヒューズをご使用ください。

Electrical and handling symbols





Electrical symbols

These can appear in instrument user manuals and on the instrument's front or rear panels.

| | |
|---|--|
|  | Electrical power on |
|  | Electrical power off |
|  | Standby |
|  | Direct current |
|  | Alternating current |
|  | Protective conductor terminal |
|  | Frame, or chassis, terminal |
|  | Fuse |
|  | Recycle symbol: Do not dispose in municipal waste. |

Handling symbols

These handling symbols and their associated text can appear on labels affixed to the outer packaging of Waters instrument and component shipments.

| | |
|---|---------------|
|  | Keep upright! |
|  | Keep dry! |
|  | Fragile! |
|  | Use no hooks! |

B Specifications

This appendix provides the following types of specifications for the 515 pump:

- Physical
- Environmental
- Electrical
- Performance
- Instrument control and communication.

Physical specifications

| Item | Specification |
|-------------------------|--|
| Height | 8.0 in. (20.3 cm) |
| Depth | 18.5 in. (47 cm) |
| Width | 7.5 in. (19.1 cm) |
| Weight | 33 lb (15 kg) |
| Wetted surface material | 316 stainless steel, sapphire, reinforced fluorocarbon polymer seals, carbon-reinforced Tefzel |

Environmental specifications

| Item | Specification |
|-----------------------|--|
| Operating temperature | 4 to 40 °C |
| Humidity | 20 to 80%, noncondensing |
| Audible noise | <70 dB(A) at operator position |
| Solvent compatibility | Solvents consistent with materials of construction. Salts and buffers can reduce seal life, especially at pressures in excess of 3000 psi. |

Electrical specifications

| Item | Specification |
|--------------------|-------------------------------|
| Power requirements | 110 VA (max), 55 VA (typical) |

Electrical specifications (Continued)

| Item | Specification |
|--------------|---------------------------|
| Line voltage | 85 to 264 VAC |
| Frequency | 47 to 63 Hz, single phase |
| Fuses | 3.15 A, 250 V, two |

Performance specifications

| Item | Specification |
|---|---|
| Programmable flow rate range: 100- μ L heads 225- μ L heads | 0.000 to 10.000 mL/min, in 0.001-mL/min increments 0.000 to 22.5 mL/min, in 0.001-mL/min increments |
| Maximum operating pressure | 6000 psi (41,370 kPa, 401 bars) for 100- μ L heads, 3000 psi (20,685 kPa, 200.5 bars) for 225- μ L heads; programmable upper and lower limits |
| Pressure ripple (one pump) | \leq 2.0% at 1 mL/min, degassed methanol, at 1000 psi backpressure |
| Flow precision | \pm 0.1% RSD of retention time at 1 mL/min, 1000 to 2000 psi, paraben PQ test, or 2 seconds SD |
| Flow accuracy | \pm 1.0% of setting at 1 mL/min, or 30 μ L/min, whichever is larger, using degassed methanol at 1000 to 2000 psi backpressure |

Instrument control and communication specifications

| Item | Specification |
|--------------------------------|--|
| Operating pressure output | Sends a 0 to -10 V analog output to an external control device |
| Pressure limit shutdown output | Sends a positive or negative voltage signal to an external control device: <ul style="list-style-type: none">• +15 V signal = pressure limit shutdown• -12.52 to -14.07 V signal = pressure within limits |
| External control device input | TTL-level pulse stream from an external control device |

C Accessories and Spare Parts

This appendix describes the accessories and spare parts for the Waters 515 HPLC Pump.

Spare parts

The spare parts listed in the [table titled “Spare parts” on page C-1](#) are recommended for customer installation. Any parts not listed in this table may require installation by a trained Waters service representative.

Spare parts

| Item | Quantity | Part number |
|-------------------------------|----------|-------------|
| Check Valve Assembly | 2 | 700000254 |
| Pump Plunger | 2 | WAS207069 |
| Indicator Rod Assembly | 1 | WAT069506 |
| Pump Head Support Assembly | 2 | WAS207112 |
| Draw-Off Valve Assembly | 1 | WAS207085 |
| Inlet Tubing Assembly (LH) | 1 | WAS207081 |
| Inlet Tubing Assembly (RH) | 1 | WAS207082 |
| Outlet Tubing Assembly (LH) | 1 | WAS207083 |
| Outlet Tubing Assembly (RH) | 1 | WAS207084 |
| Fuses, F 3.15 A/250 V (20 mm) | 2 | WAT163-16 |

Use the accessories listed in the [table titled “Accessories” on page C-1](#) to optimize the Waters 515 pump for your application and to simplify common procedures.

Accessories

| Item | Quantity | Part number |
|------------------|----------|-------------|
| Plunger Wash Kit | 1 | WAT031870 |

Accessories (Continued)

| Item | Quantity | Part number |
|---|----------|-------------|
| Replacement Pump Head Assembly | 1 | WAS207006 |
| Extended Flow Range Option Kit | 1 | WAT207119 |
| Extended Flow Pump Head Assembly | 2 | WAT060303 |
| Extended Flow Plunger Seals | 2 | WAT026644 |
| Extended Flow Outlet Check Valve Assembly | 2 | WAT025216 |
| Eluent Reservoir Filter | 1 | WAT025531 |
| Syringe, 10-mL, Polypropylene | 1 | WAT010337 |
| #316 Stainless Steel Tubing: | | |
| 1/16-inch OD × 0.009-inch ID, 10 feet (3 m) | 1 | WAT026973 |
| 1/16-inch OD × 0.020-inch ID, 10 feet (3 m) | 1 | WAT026804 |
| PTFE Tubing: | | |
| 1/8-inch OD × 0.062 ID, 25 feet (7.7 m) | 1 | WAT026808 |
| 0.80-inch OD × 0.058 ID, 25 feet (7.7 m) | 1 | WAT026974 |

The kits listed in the [table titled “Maintenance and operation kits” on page C-2](#) contain the parts you need for common maintenance operations.

Maintenance and operation kits


| Item | Quantity | Part number |
|---|----------|-------------|
| Outlet Check Valve Rebuild Kit | 1 | WAT026014 |
| Inlet Check Valve Rebuild Kit | 1 | WAT060495 |
| Solvent Clarification Kit: | | |
| 110 V/60 Hz | 1 | WAT085113 |
| 220 V/50 Hz | 1 | WAT085122 |
| Seal Replacement Kit (Clear-100™ ; general purpose seals) | 1 | WAT022934 |
| Seal Replacement Kit (Clear-100™ ; general-purpose seals) | 4 | WAT022946 |
| Seal Replacement Kit (black, general-purpose seals) | 1 | WAT026613 |

Maintenance and operation kits (Continued)

| Item | Quantity | Part number |
|--|----------|-------------|
| Seal Replacement Kit (black, general-purpose seals) | 4 | WAT038423 |
| Seal Replacement Kit (for use with aqueous applications) | 2 | WAT025296 |
| Seal Replacement Kit (for use with aqueous applications) | 4 | WAT025297 |
| Seal Replacement Kit with springs (for use with buffer applications) | 2 | WAT069581 |
| Seal Insertion Tool | 1 | WAT076765 |
| Compression Screw/Ferrule Kit | 5/pkg | WAT025604 |
| Plunger Insertion Tool | 1 | WAT011042 |

D Eluent Considerations

This appendix provides information about preparing and using eluents.

 **Warning:** To avoid chemical hazards, always observe safe laboratory practices when you operate your pump.

Contents

| Topic | Page |
|--------------------|------|
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| Eluent miscibility | D-2 |
| Buffered eluents | D-5 |
| Eluent viscosity | D-5 |
| Eluent degassing | D-5 |

Introduction

Eluent quality

Clean eluents are necessary to obtain reproducible results and operate your HPLC system with minimal instrument maintenance. Dirty eluents can cause baseline noise and drift and block eluent reservoir and inlet filters with particulate matter. Always use HPLC-grade, degassed or sparged eluents to ensure the best possible chromatographic results. Filter eluents through 0.45- μm filters before use.

Using buffers or THF

When you use aqueous buffers, adjust the pH, filter to remove insoluble material, then blend with organic modifier as appropriate. When you use unstabilized THF, ensure that your eluent is fresh. Previously opened bottles of THF contain peroxide contaminants, which cause baseline drift.



Warning: THF contaminants (peroxides) are potentially explosive if concentrated or taken to dryness.

Eluent miscibility

Before you change eluents, see the [table titled “Eluent miscibility” on page D-3](#) to determine the miscibility of the eluents to be used. When you change eluents, keep in mind that:

- Changes involving two miscible eluents may be made directly.
- Changes involving two eluents that are not totally miscible (for example, from chloroform to water), require an intermediate eluent (such as methanol).
- Temperature affects eluent miscibility. If you are running a high-temperature application, consider the effect of the higher temperature on eluent solubility.
- Buffers dissolved in water may precipitate when mixed with organic eluents.

When you switch from a buffer to an organic eluent, flush the buffer out of the system with distilled water before adding the organic eluent.

Eluent miscibility

| Polarity index | Eluent | Viscosity [η] CP, 20 °C | Boiling Point at 1 atm (°C) | Miscibility Number (M) |
|----------------|---------------------|-----------------------------------|--------------------------------|---------------------------|
| -0.3 | <i>n</i> -decane | 0.92 | 174.1 | 29 |
| -0.4 | Isooctane | 0.50 | 99.2 | 29 |
| 0.0 | <i>n</i> -hexane | 0.313 | 68.7 | 29 |
| 0.0 | Cyclohexane | 0.98 | 80.7 | 28 |
| 1.7 | Butyl ether | 0.70 | 142.2 | 26 |
| 1.8 | Triethylamine | 0.38 | 89.5 | 26 |
| 2.2 | Isopropyl ether | 0.33 | 68.3 | — |
| 2.3 | Toluene | 0.59 | 100.6 | 23 |
| 2.4 | <i>p</i> -xylene | 0.70 | 138.0 | 24 |
| 3.0 | Benzene | 0.65 | 80.1 | 21 |
| 3.3 | Benzyl ether | 5.33 | 288.3 | — |
| 3.4 | Methylene chloride | 0.44 | 39.8 | 20 |
| 3.7 | Ethylene chloride | 0.79 | 83.5 | 20 |
| 3.9 | Butyl alcohol | 3.00 | 99.5 | — |
| 3.9 | Butanol | 3.01 | 117.5 | 15 |
| 4.2 | Tetrahydrofuran | 0.55 | 66.0 | 17 |
| 4.3 | Ethyl acetate | 0.47 | 77.1 | 19 |
| 4.3 | 1-propanol | 2.30 | 97.2 | 15 |
| 4.3 | 2-propanol | 2.35 | 117.7 | 15 |
| 4.4 | Methyl acetate | 0.45 | 56.3 | 15, 17 |
| 4.5 | Methyl ethyl ketone | 0.43 | 80.0 | 17 |
| 4.5 | Cyclohexanone | 2.24 | 155.7 | 28 |
| 4.5 | Nitrobenzene | 2.03 | 210.8 | 14, 20 |
| 4.6 | Benzonitrile | 1.22 | 191.1 | 15, 19 |
| 4.8 | Dioxane | 1.54 | 101.3 | 17 |
| 5.2 | Ethanol | 1.20 | 78.3 | 14 |

Eluent miscibility (Continued)

| Polarity index | Eluent | Viscosity [η] CP, 20 °C | Boiling Point at 1 atm (°C) | Miscibility Number (M) |
|----------------|-------------------|--------------------------------|-----------------------------|------------------------|
| 5.3 | Pyridine | 0.94 | 115.3 | 16 |
| 5.3 | Nitroethane | 0.68 | 114.0 | — |
| 5.4 | Acetone | 0.32 | 56.3 | 15, 17 |
| 5.5 | Benzyl alcohol | 5.80 | 205.5 | 13 |
| 5.7 | Methoxyethanol | 1.72 | 124.6 | 13 |
| 6.2 | Acetonitrile | 0.37 | 81.6 | 11, 17 |
| 6.2 | Acetic acid | 1.26 | 117.9 | 14 |
| 6.4 | Dimethylformamide | 0.90 | 153.0 | 12 |
| 6.5 | Dimethylsulfoxide | 2.24 | 189.0 | 9 |
| 6.6 | Methanol | 0.60 | 64.7 | 12 |
| 7.3 | Formamide | 3.76 | 210.5 | 3 |
| 9.0 | Water | 1.00 | 100.0 | — |

How to use miscibility numbers (M numbers)

Use miscibility numbers (M numbers) to predict the miscibility of a liquid with a standard eluent (see the [table titled “Eluent miscibility” on page D-3](#)). A liquid is classified in the M-number system by testing for miscibility with a sequence of standard eluents. A correction term of 15 units is then either added or subtracted from the cutoff point for miscibility.

To predict the miscibility of the two liquids, subtract the smaller value M number value from the larger M number value.

- If the difference between the two M numbers is 15 or less, the two liquids are miscible in all proportions at 15 °C.
- A difference of 16 between the two M number values indicates a critical solution temperature between 25 and 75 °C, with 50 °C as the optimal temperature.
- If the difference between the two M number values is 17 or greater, the liquids are immiscible or their critical solution temperature is above 75 °C.

Some eluents are immiscible with eluents at both ends of the lipophilicity scale. These eluents are assigned two M numbers:

- The first number, always smaller than 16, indicates the degree of miscibility with highly lipophilic eluents.
- The second number, always larger than 16, indicates the degree of miscibility with hydrophilic eluents. A large difference between the two M numbers indicates a limited range of miscibility.

For example, some fluorocarbons are immiscible with all the standard eluents and have M numbers of 0 and 32. Two liquids that each have two M numbers are usually miscible with each other.

Buffered eluents

After you use a buffer, flush the buffer from the pump with at least 10 mL of HPLC-grade water. For shutdowns lasting more than one day, flush the pump with 10% methanol-water to prevent growth of microorganisms.

Eluent viscosity

Generally, viscosity is not important when you operate your HPLC system with a single eluent or under low pressure. However when you run a gradient, the viscosity changes that occur as the eluents are mixed in different proportions can result in pressure changes during the run. For example, a 1:1 mixture of water and methanol produces twice the pressure of either water or methanol alone.

If the extent to which the pressure changes affect the analysis is not known, monitor the pressure during the run using the controller chart output provided for this purpose (select %A or %B).

Eluent degassing

Eluent difficulties account for most liquid chromatographic problems. Degassing eluents is one of the most effective measures to eliminate these problems. Degassing provides:

- Stable baselines and enhanced sensitivity
- Reproducible retention times for eluting peaks

- Reproducible injection volumes for quantitation
- Stable pump operation

This section presents information on the solubility of gases, eluent degassing methods, and eluent degassing considerations.

Gas solubility

The amount of gas that can dissolve in a given volume of liquid depends on:

- The chemical affinity of the gas for the liquid
- The temperature of the liquid
- The pressure applied to the liquid

Changes in the composition, temperature, or pressure of the mobile phase can lead to outgassing.

Effects of intermolecular forces

Nonpolar gases (N_2 , O_2 , CO_2 , He) are more soluble in nonpolar eluents than in polar eluents. Generally, a gas is most soluble in an eluent with intermolecular attractive forces similar to those in the gas (“like dissolves like”).

Effects of temperature

If the heat of solution is exothermic, the solubility of the gas decreases when you heat the eluent. If the heat of solution is endothermic, the solubility of the gas increases when you heat the eluent. For example, the solubility of helium in water decreases with an increase in temperature, but the solubility of helium in benzene increases with an increase in temperature.

Effects of partial pressure

The mass of gas dissolved in a given volume of eluent is proportional to the partial pressure of the gas in contact with the vapor phase of the eluent. If you decrease the partial pressure of the gas, the amount of that gas in solution also decreases.

Eluent degassing methods

You can degas eluents using any of the following methods:

- Sparging with helium
- Heating
- Vacuum sonication

Sparging

Sparging removes gases from solution by saturating the eluent with a less soluble gas, usually helium. Helium sparging brings the eluent to a state of equilibrium (with respect to dissolved gasses). Equilibrium may be maintained by slow sparging or by keeping a blanket of helium over the eluent. Blanketing inhibits reabsorption of atmospheric gases.

Tip: Sparging may change the composition of mixed eluents.

In-line degassing

In-line degassing removes gasses from the eluent as it passes through a gas-permeable membrane enclosed in a vacuum chamber. The vacuum in the chamber accelerates the rate at which the dissolved gas diffuses through the gas-permeable membrane. This method provides an automatic, continuous method of removing dissolved gasses, and allows for quick eluent changeover. Waters makes two in-line degassers: part numbers WAT079700 and WAT079800. Contact Waters for details.

Heating

Heating to remove dissolved gas is usually not effective unless you boil the eluent, and this is not practical or safe for mixed, flammable, or volatile eluents. However, raising the temperature even slightly raises the partial pressure of the eluent, and thereby reduces the rate of resolubilization of a gas.

Vacuum sonication

Sonication in combination with a vacuum degasses eluents very quickly. This technique does not change the composition of mixed eluents appreciably.



Warning: Apply vacuum only to suitable vessels. The brown gallon bottles in which eluent is shipped are not designed for vacuum degassing. There is a high risk of implosion if these bottles are used for vacuum degassing.

Conclusions

With any of the above techniques (except continuous sparging), the eluent reequilibrates to air saturation in 12 to 24 hours, depending on the eluent.

Degassing by vacuum or sonication or both is often performed for improved pump performance in multi-pump gradient applications.

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