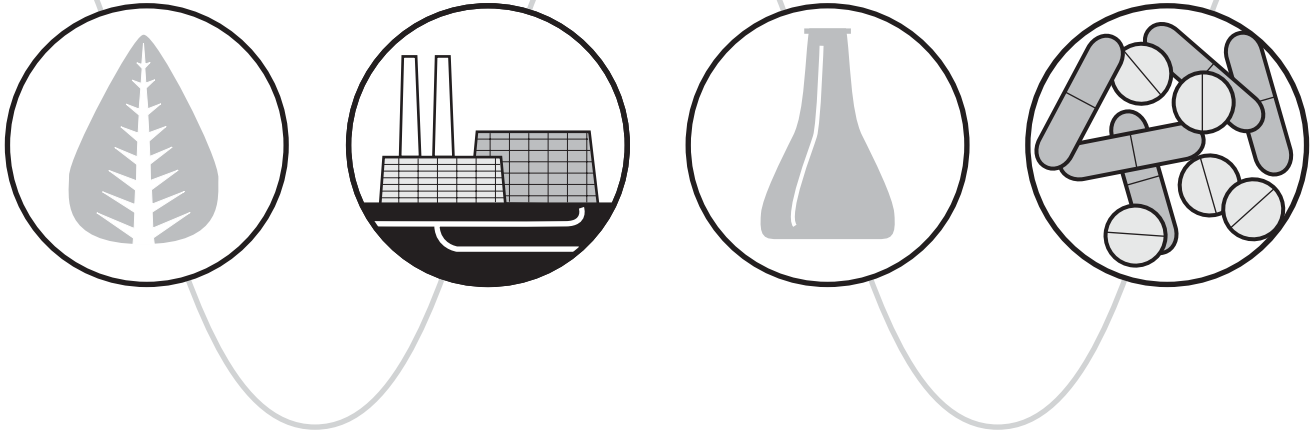
Waters 515 HPLC Pump

Operator's Guide



Waters

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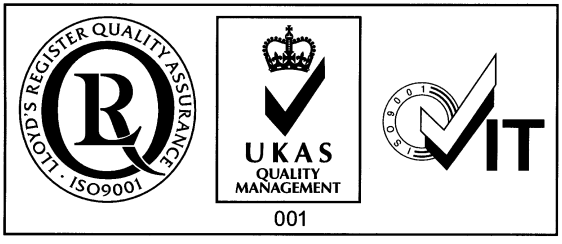


Note: *When you use the instrument, follow generally accepted procedures for quality control and methods development.*

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.*

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: *eventuali modifiche o alterazioni apportate a questa unità e non espressamente approvate da un ente responsabile per la conformità annulleranno l'autorità dell'utente ad operare l'apparecchiatura.*

Atención: *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：**未经有关法规认证部门明确允许对本设备进行的改变或改装，可能会使使用者丧失操作该设备的合法性**。

주의 : 기기 검교정 담당자의 승인 없이 무단으로 기기를 변경 또는 수정하는 경우에는, 그 기기 운영에 대한 허가가 취소될 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、本装置のユーザとしての承認が無効になる可能性があります。

Caution: *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 precaution:*

- *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: *prestare attenzione durante l'utilizzo dei tubi di polimero pressurizzati:*

- *Indossare sempre occhiali da lavoro protettivi nei pressi di tubi di polimero pressurizzati.*
- *Estinguere ogni fonte di ignizione circostante.*
- *Non utilizzare tubi soggetti che hanno subito sollecitazioni eccessive o son stati incurvati.*
- *Non utilizzare tubi non metallici con tetraidrofurano (THF) o acido solforico o nitrico concentrato.*
- *Tenere presente che il cloruro di metilene e il dimetilsolfossido provocano rigonfiamento nei tubi non metallici, riducendo notevolmente la resistenza alla 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：当在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枫会导致非金属管线膨胀，大大降低管线的耐压能力。

경고: 폴리머재질의 튜빙을 압력하에서 사용할 때는 다음 사항에 유의하십시오.

- 압력을 받은 폴리머 튜빙 부근에서는 반드시 보호안경을 착용할 것
- 모든 화기의 접근을 금함
- 늘리거나 뒤틀린 튜빙은 사용하지 말 것
- 비금속 튜빙을 테트라히드로퓨란(THF)이나 염산 및 황산과 함께 사용하지 말 것
- 디글로로메탄(methylene chloride)와 디메틸설폭시드(dimethyl sulfoxide)는 비금속 튜빙을 팽창시켜 쉽게 파열되므로 주의할 것

警告：ポリマーチューブに圧力をかけて取り扱う場合は、次のように注意してください。

- 加圧したポリマーチューブの付近では、常に保護めがねを着用してください。
- 付近の火はすべて消してください。
- 激しい応力やねじれを受けたチューブは使用しないでください。
- テトラヒドロフラン（THF）、濃硝酸、あるいは濃硫酸には、非金属製のチューブを使用しないでください。
- ジクロロメタンやジメチルスルホキシドは非金属製のチューブを膨張させ、チューブの破断圧力を大幅に低下させますので、注意してください。

Caution: *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 Verwenddung des Gerätes unter Umständen nicht ordnungsgemäß funktionieren.*

Attenzione: *l'utente deve essere al corrente del fatto che, se l'apparecchiatura viene usta in un modo specificato dal produttore, la protezione fornita dall'apparecchiatura potrà essere invalidata.*

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制造廠商指定的方式使用，那么該設備所提供的保護將被消弱。

警告: **使用者必须非常清楚如果设备不是按照制造厂商指定的方式使用, 那么该设备所提供的保护将被消弱**

경고 : 제조사가 지정한 것 이외의 방법으로 기기를 사용하는 경우에는, 사용자가 위험으로부터 보호될 수 없는 경우가 발생할 수 있음에 유념하십시오.

警告: ユーザは製造業者が指定していない方法で装置を使用した場合は装置が提供する保護が損なわれることがあるということを承知しているものとします。

Caution: *To protect against fire hazard, replace fuses with those of the same type and rating.*

Attention : *Remplacez toujours les fusibles par d'autres du même type et de la même puissance afin d'éviter tout risque d'incendie.*

Vorsicht: *Zum Schutz gegen Feuergefahr die Sicherungen nur mit Sicherungen des gleichen Typs und Nennwertes ersetzen.*

Attenzione: *per una buona protezione contro i rischi di incendio, sostituire i fusibili con altri dello stesso tipo e amperaggio.*

Advertencia: *sustituya los fusibles por otros del mismo tipo y características para evitar el riesgo de incendio.*

警告：為了避免火災的危險，應更換同种類型及規格的保險絲。

警告: 为了避免火灾的危险, 应更换同种类型及规格的保险丝。

경고 : 화재를 방지하기 위해서는 퓨즈 교체 시 같은 종류, 같은 등급의 것을 사용하십시오.

警告: 火災の危険防止のために、ヒューズの交換は同一タイプおよび定格のもので行なってください。

Caution: *To avoid possible electrical shock, disconnect the power cord before servicing the instrument.*

Attention : *Afin d'éviter toute possibilité de commotion électrique, débranchez le cordon d'alimentation de la prise avant d'effectuer la maintenance de l'instrument.*

Vorsicht: *Zur Vermeidung von Stromschlägen sollte das Gerät vor der Wartung vom Netz getrennt werden.*

Attenzione: *per evitare il rischio di scossa elettrica, scollegare il cavo di alimentazione prima di svolgere la manutenzione dello strumento.*

Precaución: *para evitar descargas eléctricas, desenchufe el cable de alimentación del instrumento antes de realizar cualquier reparación.*

警告：要避免觸電，請在修理或保養器材前把電源線拔出。

警告：为避免可能引起得触电危险，在修理前请切断电源连接。

경고: 전기 충격의 가능성을 피하기 위해서는, 기기를 수리하기 이전에 전원 코드를 차단하십시오.

警告：感電の危険性を避けるために、装置の保守を行う前には装置の電源コードを引き抜いてください。

Commonly Used Symbols

⎓	Direct current Courant continu Gleichstrom Corrente continua Corriente continua 直流電 直流电 직류 直流
~	Alternating current Courant alternatif Wechselstrom Corrente alternata Corriente alterna 交流電 交流电 교류 交流
⏚	Protective conductor terminal Borne du conducteur de protection Schutzleiteranschluss Terminale di conduttore con protezione Borne del conductor de tierra 保護的導線端子 保护性的接地端 보호 도체 단자 接地

Commonly Used Symbols (Continued)

	Frame or chassis terminal Borne du cadre ou du châssis Rahmen- oder Chassisanschluss Terminale di struttura o telaio Borne de la estructura o del chasis 結構或底盤端子 机架或底盘接地端 프레임 또는 틀 단자 フレームまたはシャーシアース
	Caution or refer to manual Attention ou reportez-vous au guide Vorsicht, oder lesen Sie das Handbuch Prestare attenzione o fare riferimento alla guida Actúe con precaución o consulte la guía 小心或查閱手冊 小心或查阅手册 경고 또는 사용설명서 참조 警告またはマニュアルを参照
	Caution, hot surface or high temperature Attention, surface chaude ou température élevée Vorsicht, heiße Oberfläche oder hohe Temperatur Attenzione, superficie calda o elevata temperatura Precaución, superficie caliente o temperatura elevada 警告，熱表面或高溫 警告,热表面或高温 경고, 뜨거운 표면 또는 고온 警告、熱くなっている面、あるいは高温

Commonly Used Symbols (Continued)

	Caution, risk of electric shock (high voltage) Attention, risque de commotion électrique (haute tension) Vorsicht, Elektroschockgefahr (Hochspannung) Attenzione, rischio di scossa elettrica (alta tensione) Precaución, peligro de descarga eléctrica (alta tensión) 警告，小心触電（高壓電） 警告,小心触电（高压电） 경고, 전기충격의 위험 (고압) 警告、電気ショックの危険性（高電圧）
	Caution, risk of needle-stick puncture Attention, risques de perforation de la taille d’une aiguille Vorsicht, Gefahr einer Spritzenpunktierung Attenzione, rischio di puntura con ago Precaución, riesgo de punción con aguja 警告，小心尖狀物刺傷 警告,小心尖状物刺伤 경고, 뾰족한 것으로부터의 상해 위험 警告、ニードルで穴をあける危険性
	Caution, ultraviolet light Attention, rayonnement ultrviolet Vorsicht, Ultraviolettes Licht Attenzione, luce ultravioletta Precaución, emisiones de luz ultravioleta 警告，紫外光 警告,紫外光 경고, 자외선 警告、紫外線

Commonly Used Symbols (Continued)

	Fuse Fusible Sicherung Fusibile Fusible 保險絲 保险丝 퓨즈 ヒューズ
1	Electrical power on Sous tension Netzschalter ein Alimentazione elettrica attivata Alimentación eléctrica conectada 開啓電源 接通电源 전원 켜기 電源オン
0	Electrical power off Hors tension Netzschalter aus Alimentazione elettrica disattivata Alimentación eléctrica desconectada 關閉電源 切断电源 전원 끄기 電源オフ

United States – FCC Emissions Notes

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

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.

Note: *This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- *Reorient or relocate the receiving antenna.*
- *Increase the separation between the equipment and receiver.*
- *Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.*
- *Consult the dealer or an experienced radio TV technician for help.*

Shielded cables must be used with this unit to ensure compliance with the Class B FCC limits.

Canada – Spectrum Management Emissions Notes

Cet appareil numérique de la classe B est conforme à la norme NMB-003.

This Class B digital apparatus complies with Canadian ICES-003.

515 HPLC Pump Information

Intended Use

The Waters® 515 HPLC Pump can be used for in-vitro diagnostic testing to analyze many compounds, including diagnostic indicators and therapeutically monitored compounds. When you develop methods, follow the "Protocol for the Adoption of Analytical Methods in the Clinical Chemistry Laboratory," *American Journal of Medical Technology*, 44, 1, pages 30–37 (1978). This protocol covers good operating procedures and techniques necessary to validate system and method performance.

Biological Hazard

When you analyze physiological fluids, take all necessary precautions and treat all specimens as potentially infectious. Precautions are outlined in "CDC Guidelines on Specimen Handling," *CDC – NIH Manual*, 1984.

Calibration

Follow acceptable methods of calibration with pure standards to calibrate methods. Use a minimum of five standards to generate a standard curve. The concentration range should cover the entire range of quality-control samples, typical specimens, and atypical specimens.

Quality Control

Routinely run three quality-control samples. Quality-control samples should represent subnormal, normal, and above-normal levels of a compound. Ensure that quality-control sample results are within an acceptable range, and evaluate precision from day to day and run to run. Data collected when quality-control samples are out of range may not be valid. Do not report this data until you ensure that chromatographic system performance is acceptable.

Table of Contents

Preface

The *Waters 515 HPLC Pump Operator's Guide* describes the procedures for unpacking, installing, using, maintaining, and troubleshooting the Waters 515 HPLC Pump. It also includes appendixes for specifications, spare parts, and eluent considerations.

This guide is intended for use by individuals who need to install, operate, maintain, and/or troubleshoot the Waters 515 HPLC Pump.

Organization

This guide contains the following:

Chapter 1 describes the Waters 515 HPLC Pump, including features and options.

Chapter 2 describes how to unpack and install the Waters 515 HPLC Pump.

Chapter 3 describes how to power on the Waters 515 HPLC Pump, prepare and operate the pump, and power off the pump.

Chapter 4 describes routine maintenance, diagnostics, and troubleshooting procedures.

Appendix A provides the specifications of the Waters 515 HPLC Pump.

Appendix B lists recommended and optional spare parts.

Appendix C provides general and specific information about properly preparing and using eluents.

Related Documentation

***Waters Licenses, Warranties, and Support*:** Provides software license and warranty information, describes training and extended support, and tells how Waters handles shipments, damages, claims, and returns.

Documentation on the Web

Related product information and documentation can be found on the World Wide Web. Our address is http://www.waters.com.

Documentation Conventions

The following conventions can be used in this guide:

Convention	Usage
Italic	Italic indicates information that you supply such as variables. It also indicates emphasis and document titles. For example, “Replace *file_name* with the actual name of your file.”
`Courier`	Courier indicates examples of source code and system output. For example, “The `SVRMGR>` prompt appears.”
`Courier Bold`	Courier bold indicates characters that you type or keys you press in examples of source code. For example, “At the `LSNRCTL>` prompt, enter **`set password oracle`** to access Oracle.”
Keys	The word *key* refers to a computer key on the keypad or keyboard. *Screen keys* refer to the keys on the instrument located immediately below the screen. For example, “The A/B screen key on the 2414 Detector displays the selected channel.”
…	Three periods indicate that more of the same type of item can optionally follow. For example, “You can store *filename1, filename2,* … in each folder.”
>	A right arrow between menu options indicates you should choose each option in sequence. For example, “Select File > Exit” means you should select File from the menu bar, then select Exit from the File menu.

Notes

Notes call out information that is helpful to the operator. For example:

Note: *Record your result before you proceed to the next step.*

Attentions

Attentions provide information about preventing damage to the system or equipment. For example:

Attention: *To avoid damaging the detector flow cell, do not touch the flow cell window.*

Cautions

Cautions provide information essential to the safety of the operator. For example:

Caution: *To avoid burns, turn off the lamp at least 30 minutes before removing it for replacement or adjustment.*

Caution: *To avoid electrical shock and injury, unplug the power cord before performing maintenance procedures.*

Caution: *To avoid chemical or electrical hazards, observe safe laboratory practices when operating the system.*

Chapter 1
Waters 515 Pump 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. Figure 1-1 shows a Waters 515 HPLC Pump.

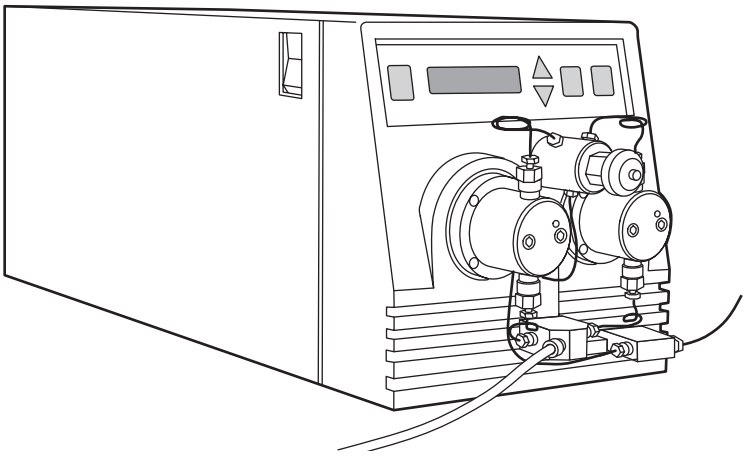


Figure 1-1 Waters 515 HPLC Pump

1.1 Fluid-Handling Components

Before you install the Waters 515 pump, familiarize yourself with its components. Figure 1-2 identifies the fluid-handling components of the Waters 515 pump and Table 1-1 describes their functions.

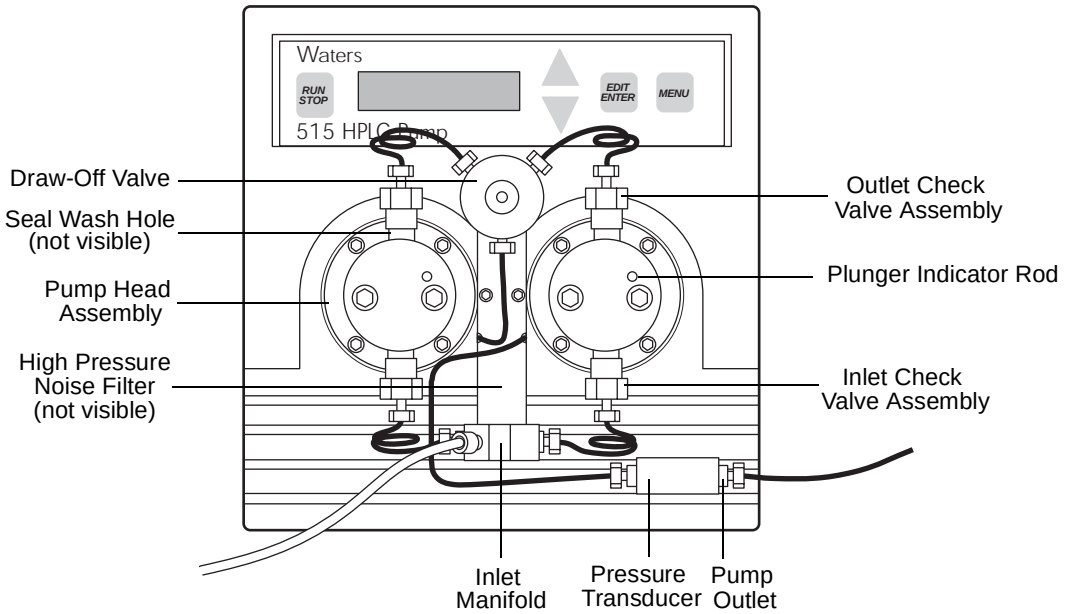


Figure 1-2 Pump Fluid-Handling Components

Table 1-1 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.

Table 1-1 Fluid-Handling Components (Continued)

Component	Function
Seal wash holes (not visible in Figure 1-2)	Allow you to flush and clean the plunger seals.
Inlet and outlet check valve assemblies	Maintain flow direction by opening in one direction only.
High-pressure noise filter (not visible in Figure 1-2)	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.*

1.2 Electronics Components

Before you install the 515 pump, familiarize yourself with its electronics components as illustrated in Figure 1-4. Table 1-2 describes the functions of the electronics components.

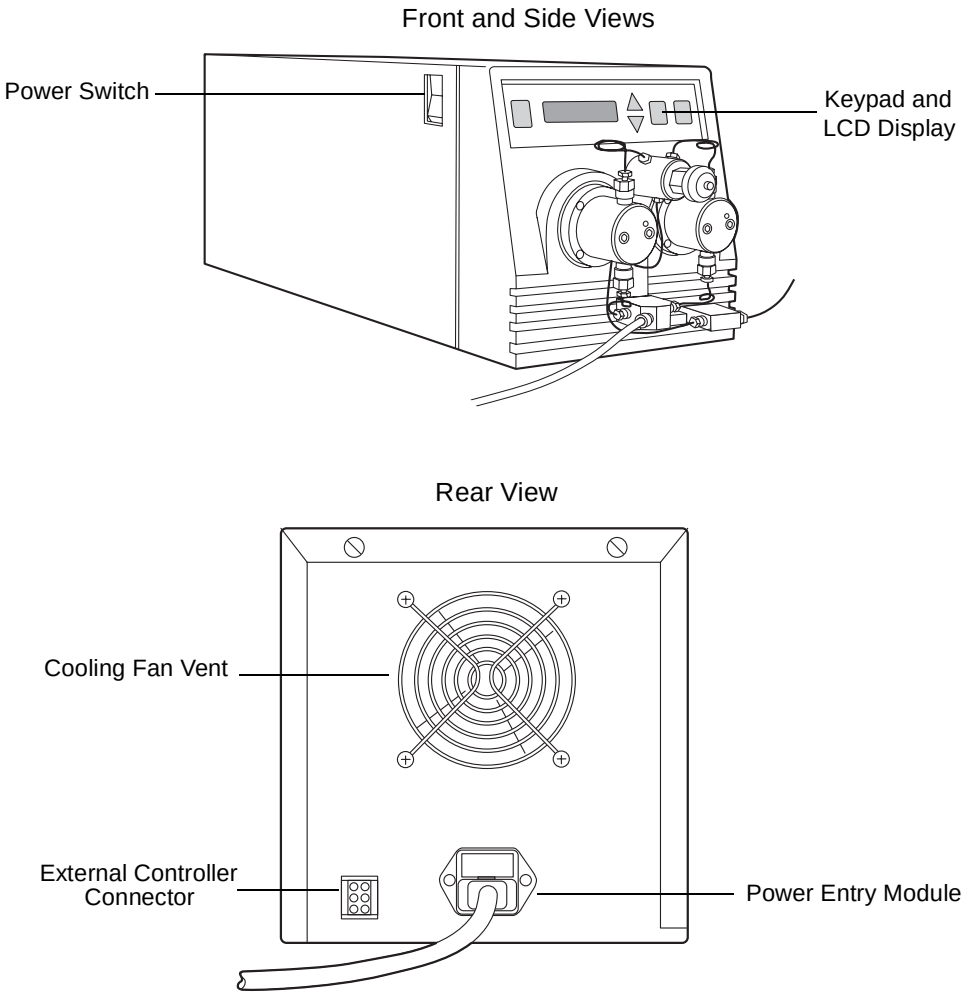


Figure 1-3 Pump Electronics Components

Table 1-2 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.
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.

1.3 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 Section 3.2 on page 18, 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, Figure 1-4 illustrates a three-pump configuration under the control of a Millennium^{32} Chromatography Manager workstation.

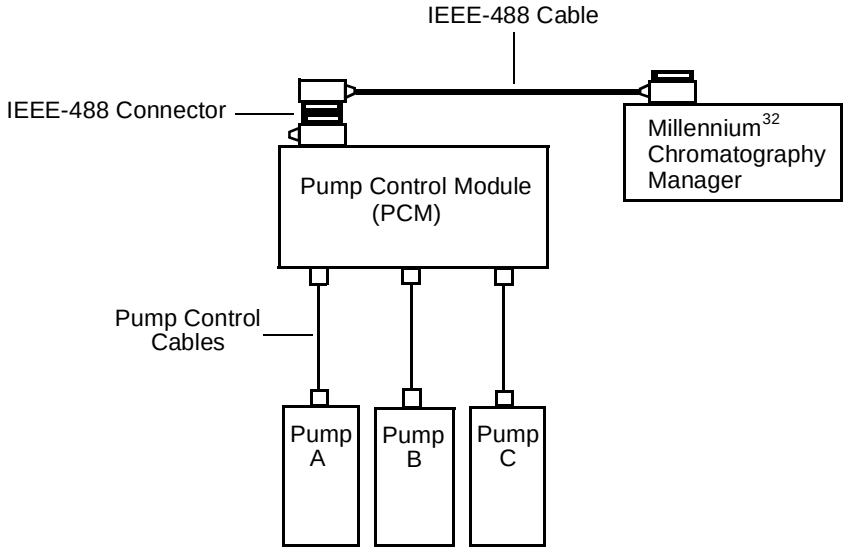


Figure 1-4 Three-Pump Configuration Under Millennium^{32} Chromatography Manager Control (using the PCM)

Chapter 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.

2.1 Site Requirements

Install the 515 HPLC Pump at a site that meets the specifications indicated in Table 2-1.

Table 2-1 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)

Figure 2-1 shows the dimensions of a 515 pump.

Attention: *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.*

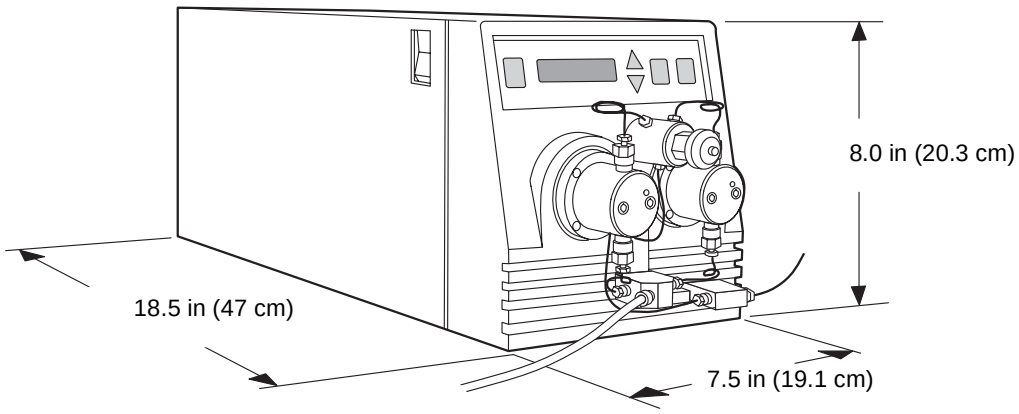


Figure 2-1 Pump Dimensions

2.2 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.

2.3 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)

2.3.1 Replacing the Power Supply Fuses

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

Caution: *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 (see Figure 2-2).

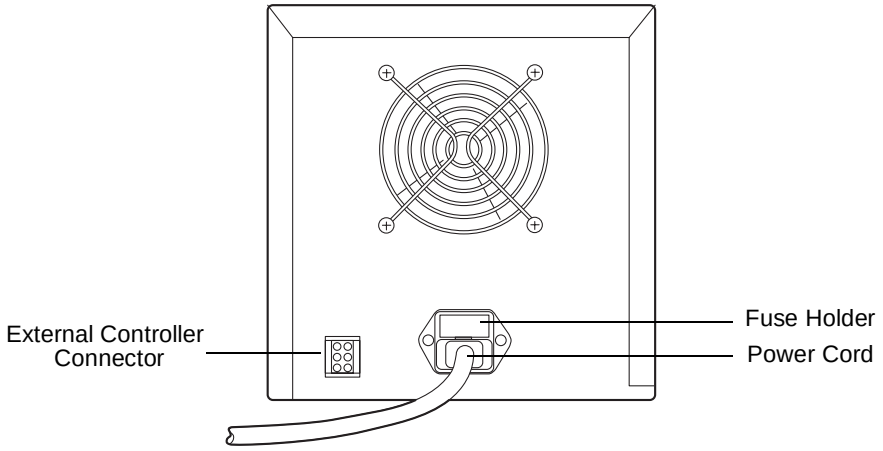


Figure 2-2 Rear Panel of the 515 Pump

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

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

5. Install the fuse holder in its receptacle.

2.3.2 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.

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.

2.3.3 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 (Figure 2-2).
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.

2.4 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

2.4.1 Connecting the Eluent Supply

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

Note: *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

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.

   Note: *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 Figure 2-3.

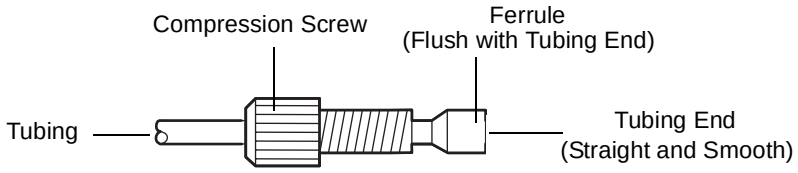


Figure 2-3 Reverse Ferrule and Compression Screw Assembly

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

Attention: *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.*

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.

2.4.2 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 Section 2.4.3, Connecting for High-Pressure Gradient Operation.

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

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

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 Figure 2-4.

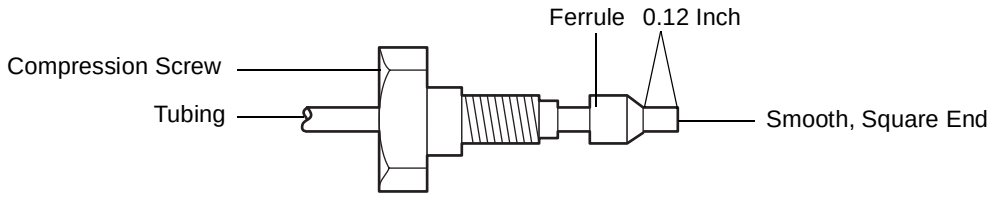


Figure 2-4 Standard Ferrule and Compression Screw Assembly

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). See Figure 2-4.
6. Repeat steps 2 through 5 for the other end of the stainless tubing.

Connecting 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 (see Figure 2-5).

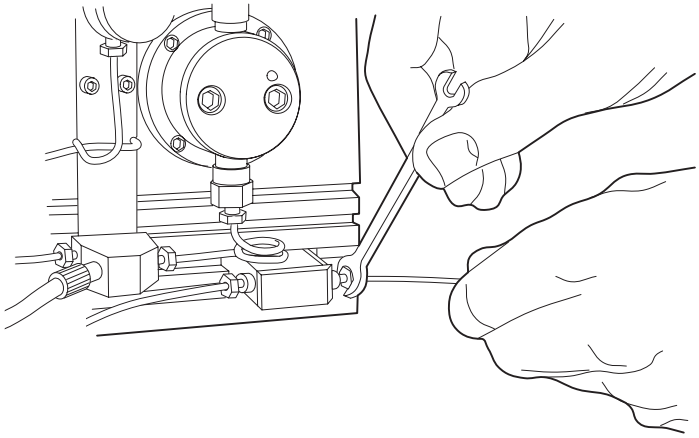


Figure 2-5 Connecting the Outlet Tube

Note: *Leave the instrument end of the outlet tubing disconnected until you have primed the pump and flushed the system as described in* *Section 3.3 on page 28**.*

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.

2.4.3 Connecting for High-Pressure Gradient Operation

Figure 2-6 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 Figure 2-6 (without using the optional mixer). If your application requires high-pressure gradient delivery with minimal compositional ripple, install the optional mixer, part number WAT051518.

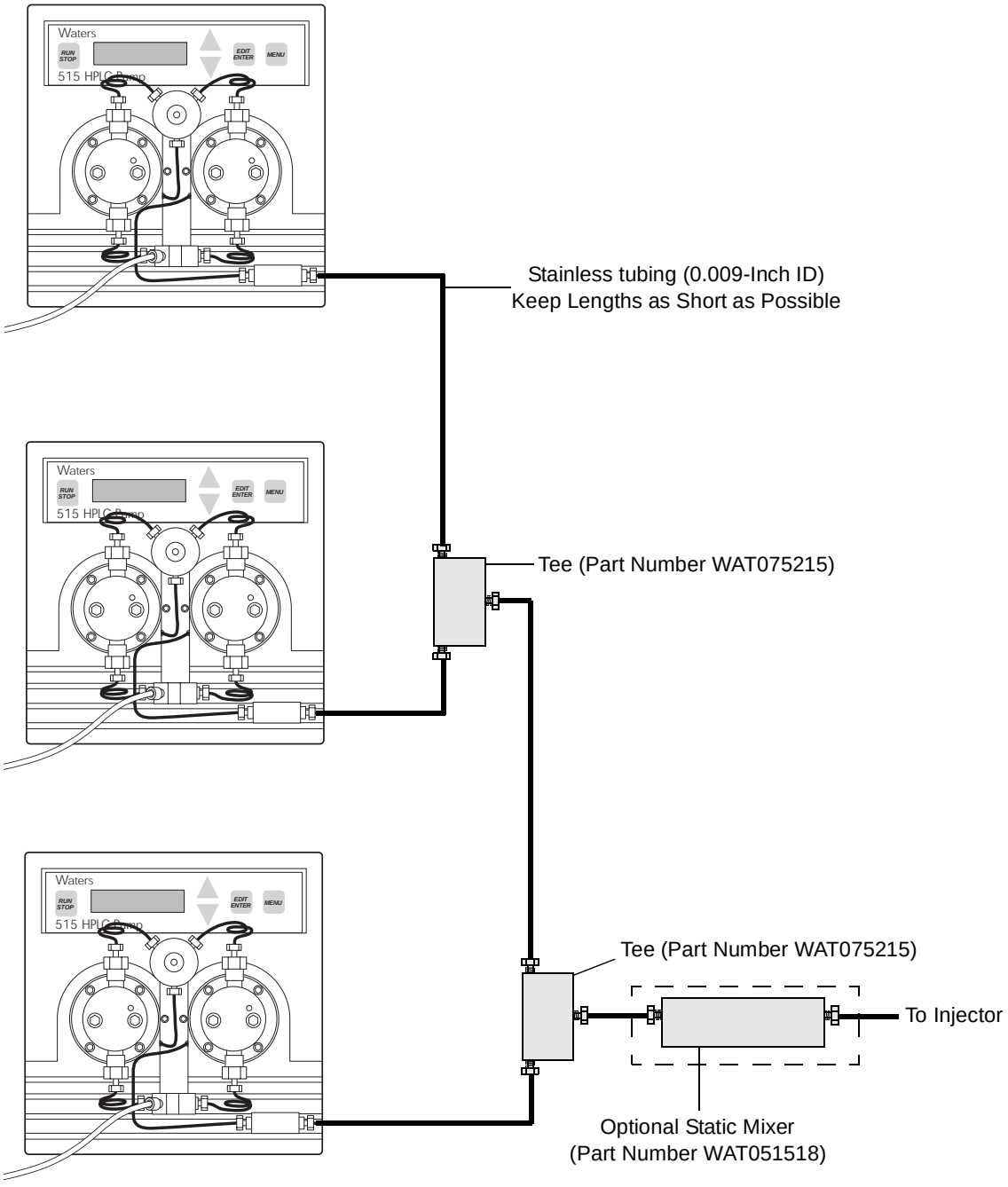


Figure 2-6 Three-Pump, High-Pressure Gradient Configuration with Optional Mixer

Chapter 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.

3.1 Powering On the Pump

Note: *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 Chapter 2, 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 Table 3-2 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.

3.1.1 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 Progammable Gate Array
- EEPROM check[1] – Runs a checksum of the EEPROM to confirm correct EEPROM data

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.

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-µL or 225-µL), and firmware version (Ver n.n). The display then appears in its Ready state, as shown in Figure 3-1. To redisplay the 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.

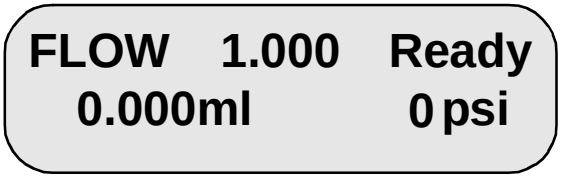


Figure 3-1 LCD Display — Ready State

3.1.2 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 Chapter 4, Maintaining and Troubleshooting the Waters 515 Pump, for more information about dealing with EEPROM diagnostics failures.

3.2 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 Table 3-2 for more details.

3.2.1 Keypad

Table 3-1 describes the functions of the keys on the 515 pump keypad.

Table 3-1 Keypad Functions

Key	Function
RUN STOP	Local mode: If the unit is not pumping, pressing this key starts the pump using all current parameter settings.* Remote mode: If the unit is not pumping, pressing this key prepares the pump to receive a remote run command. In Local or Remote mode, pressing this key immediately stops the pump. *Refer to the Mode parameter in Table 3-2 for details about Local and Rem parameters.
EDIT ENTER	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: • The blinking cursor moves one position to the right. • If the cursor is at the rightmost position, it moves to the leftmost position. When editing in the Calibrate menu:* • 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. *The LCD display provides prompts for when to use the Edit/Enter key while editing in the Calibrate menu. See Table 3-2 for more information about the Calibrate menu.

Table 3-1 Keypad Functions (Continued)

Key	Function
MENU	Scrolls to the next menu item. 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).* *The LCD display provides prompts for when to use the Menu key while in the Calibrate menu. See Table 3-2 for more information about the Calibrate menu.
▲ ▼	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. 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.

3.2.2 LCD Display

The LCD display, as shown in Figure 3-2, is divided into four information areas.

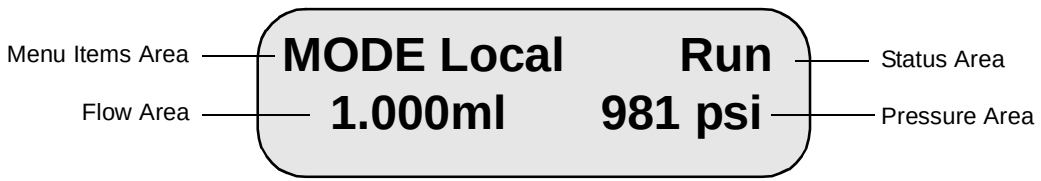


Figure 3-2 LCD Display Information Areas

Menu Items Area

The menu items area provides access to all pump operating parameters. Figure 3-3 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 3-1 for keypad functions). Functions and details for all pump parameters are provided in Table 3-2.

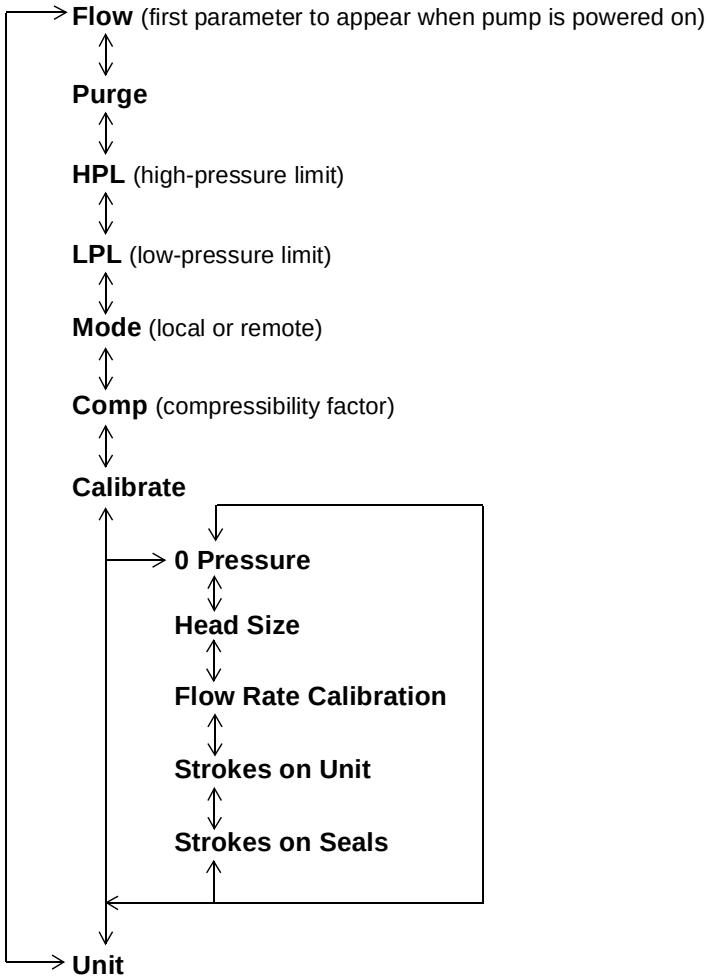


Figure 3-3 515 Pump Operating Parameters Menu Tree

Table 3-2 515 Pump Operating Parameters

Parameter	Function	Details
Flow	Selects flow rate for local (stand-alone) operation	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. In Rem mode, the flow rate parameter set at the external control device supersedes this parameter.* *Refer to the Mode parameter section in this table for information about Local and Rem modes.
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).	When the Purge cycle finishes, the pump returns to its previous mode and run status. See Section 3.3.2, Purging the System, for details. 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. If Purge is running, pressing the Edit/Enter key once restarts Purge for another 5-minute cycle. 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. *Refer to the Mode parameter section in this table for information about Local and Rem modes.

Table 3-2 515 Pump Operating Parameters (Continued)

Parameter	Function	Details
HPL	Selects the high-pressure limit	In Local mode: Pressure greater than or equal to the HPL for 1.2 sec stops the pump.* 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.* As a fail-safe, if the pump pressure exceeds maximum for 1.2 sec in either Local or Rem mode, the pump stops. The HPL default setting is: • 6000 psi (41370 kPa, 401 bars) for 100-µL heads • 3000 psi (20685 kPa, 200.5bars) for 225-µL heads 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). *Refer to the Mode parameter section in this table for information about Local and Rem mode.

Table 3-2 515 Pump Operating Parameters (Continued)

Parameter	Function	Details
LPL	Selects the low-pressure limit	In Local mode: Pressure less than or equal to the LPL for 90 sec stops the pump.* 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.* 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). *Refer to the Mode parameter section in this table for information about Local and Rem mode.
Mode	Selects Local mode (for stand-alone operation) or Rem mode (for external control operation)	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). 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.
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.

Table 3-2 515 Pump Operating Parameters (Continued)

Parameter	Function	Details
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 Section 4.3.1, Setting Zero Pressure, for details.
Head Size	Selects the size of the installed pump head: 100-µL or 225-µL	The default setting is 100µL. See Section 4.3.2, Setting the Head Size, 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 Section 4.3.3, Calibrating the Flow Rate, 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.
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. See Section 4.3.4, Resetting Strokes on Seals, 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. Table 3-3 lists all Status area messages and their meanings.

Table 3-3 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: • 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.
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: • 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.

3.2.3 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.

   Note: *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.

Note: *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.*

3.3 Preparing the 515 Pump

Overview

The procedures to prepare your pump for operation depend on the status of your chromatography system, as indicated in Table 3-4. Use Table 3-4 as a quick reference guide for determining when to perform certain preparation procedures.

Table 3-4 Pump Preparation Recommendations

Status	Prime[a]	Purge[a]	Equilibrate[a]
Initiating operation	✓	✓	✓
Changing eluent	✓	✓	✓
Adding fresh eluent		✓	✓
Changing columns			✓
System has been idle for some time	✓	✓	✓

a. 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.

Caution: *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 C, Eluent Considerations.*

3.3.1 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

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.

   Note: *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 (see Figure 3-4).

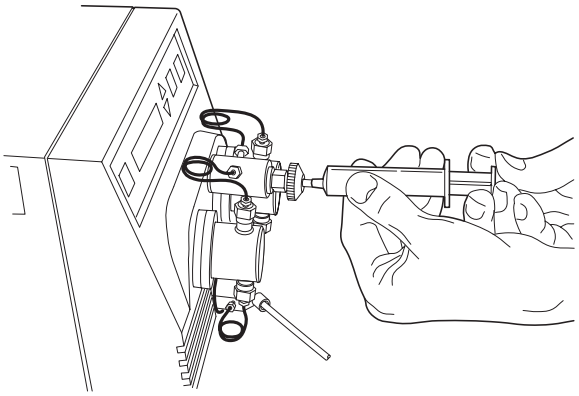


Figure 3-4 Priming the Pump

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.*

3.3.2 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 Section 3.3.1, Priming the Pump.
- Once the pump has been primed, install a union in place of the column.

Note: *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 C, Eluent Considerations, for more information.*

Purging

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

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.

3.3.3 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.

1. As an alternative to running Purge, you can manually set the Flow parameter and run the pump for the desired 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 33.

Before Equilibrating

- Make sure the eluent is filtered and degassed.
- Prime the pump with fresh eluent as described in Section 3.3.1, Priming the Pump.
- Allow the eluent and the system to reach proper temperature before pump operation.

Equilibrating 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.

Attention: *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

Attention: *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.*

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.

   Attention: *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 Millennium[32] 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 Millennium[32] 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)*.

   Note: *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.

3.4 Operating the Pump

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

3.4.1 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 Section 3.3, Preparing the 515 Pump.
- Eluent reservoirs are filled with filtered, degassed eluent.

Caution: *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 C, 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 Section 3.6, Adjusting for Eluent Compressibility, 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.

   Note: *To immediately stop the pump, press the Run/Stop key.*

3.4.2 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 Section 3.3, Preparing the 515 Pump.
- 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.

Caution: *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 C, 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.

   Note: *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 Section 3.6, Adjusting for Eluent Compressibility, 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 Millennium[32] system through a PCM, the pump parameters are part of the instrument method in the Millennium[32] 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.

Note: *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.*

3.5 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 Section 3.2.3, Editing or Entering Parameters in Local or Remote Modes. 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 Table 3-2 for more details about the Flow, HPL, and LPL parameters in Rem mode.

3.6 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.

3.7 Powering 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.

Note: *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.

Note: *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.*

Chapter 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.

4.1 Maintenance Considerations

Safety and Handling

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

Caution: *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.*

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

Caution: *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.*

Proper Operating Procedures

To keep your 515 pump running smoothly, follow the operating procedures and guidelines in Section 3.3, Preparing the 515 Pump.

Spare Parts

See Appendix B, Accessories and Spare Parts, for spare parts information. Parts not included in Appendix B 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.).

4.2 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

4.2.1 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.

4.2.2 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 Section 3.3.2, Purging the System.
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. Remove and clean the inlet and outlet check valves (see Section 4.5, Cleaning and Replacing 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.

4.3 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.

4.3.1 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 Section 4.7, Troubleshooting

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.

   Note: *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.

   Note: *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.

4.3.2 Setting the Head Size

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

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.

4.3.3 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.

Note: *To adjust for differences in eluent compressibility, use only the Comp parameter; do* ***not*** *adjust the Flowrate calibration parameter. See Section 3.6, Adjusting for Eluent Compressibility.*

Required Materials

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

Procedure

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 ±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 ±1%.
11. When you finish, press Menu until you are prompted to exit.
12. Press Edit/Enter to exit the Calibrate menu.

4.3.4 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 (see Section 4.4, Cleaning and Replacing Seals and Plungers).

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.

4.4 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 Section 4.7, Troubleshooting.

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.

4.4.1 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 Section 4.3.4, Resetting Strokes on Seals, 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 B, Accessories and Spare Parts, for part numbers)
- Methanol

Removing the Pump Head

1. Purge the pump with methanol as described in Section 3.3.2, Purging the System. 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 (Figure 4-1).

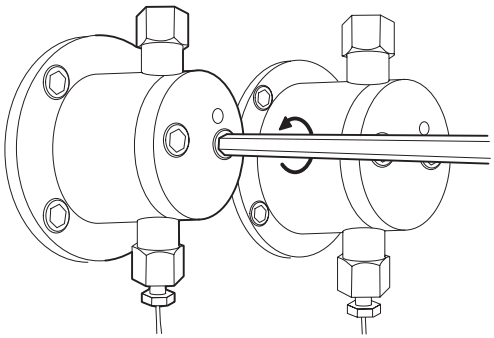


Figure 4-1 Unscrewing the Pump Head Mounting Bolts

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

Replacing the Plunger Seal

1. Use the seal insertion tool to pry the seal and washer out of the pump head (see Figure 4-2).

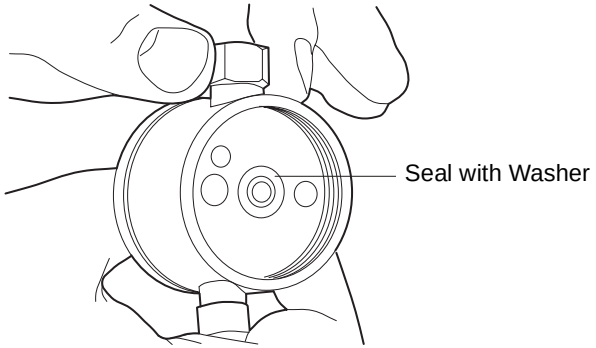


Figure 4-2 Plunger Seal and Washer

2. Place the new washer on the new plunger seal, then insert the seal and washer onto the seal insertion tool. For 225-µL 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 Section 4.3.4, Resetting Strokes on Seals.
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 Section 3.3.1, Priming the Pump. If you notice leaks, verify pump head and plunger seal installation.
    e. Recalibrate the pump flow rate as described in Section 4.3.3, Calibrating the Flow Rate.

4.4.2 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

Caution: *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.*

1. Remove the pump head as described in Section 4.4.1, Replacing the Plunger Seals.
2. Remove the four head support screws with the 9/64-inch Allen wrench (see Figure 4-3), then carefully slide the head support assembly and the indicator rod off the pump. Set the head support assembly on the benchtop.

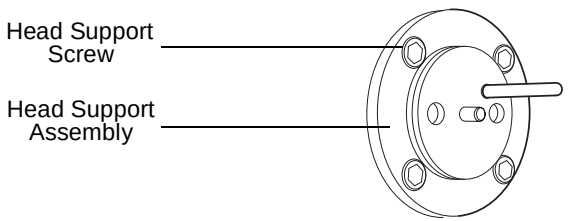


Figure 4-3 Exposed Head Support Assembly

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 (see Figure 4-4).

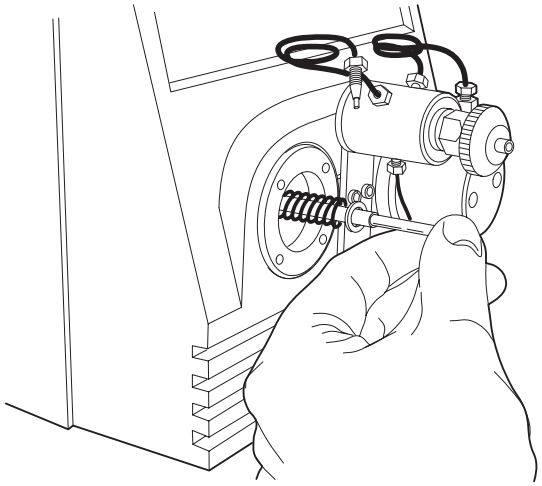


Figure 4-4 Removing the Plunger Assembly

Cleaning the Plunger

Caution: *To avoid injury, 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 Figure 4-5.

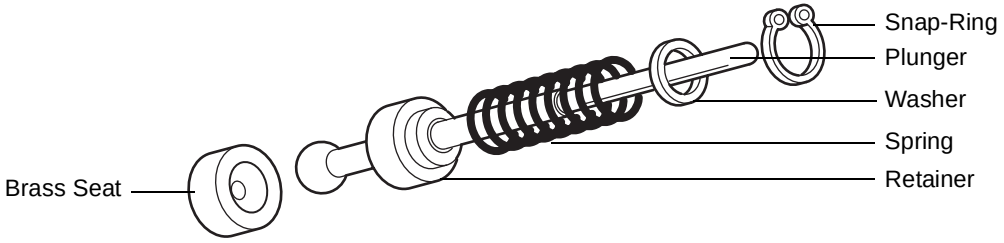


Figure 4-5 Disassembled Plunger

Inspecting the Plunger

Caution: *To avoid possible 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.

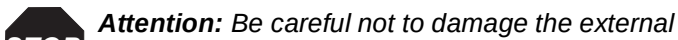
If the plunger is not scratched or otherwise damaged, reassemble the plunger with new seals. If the plunger is damaged, replace the plunger and the seals.

Replacing the Plunger

Caution: *To avoid possible 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.*

Whether you are reinstalling a plunger after cleaning and inspecting it, or replacing a damaged plunger with a new one, use the following procedure:

1. Reassemble the components of the plunger assembly as shown in Figure 4-5. 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 (see Figure 4-6).



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

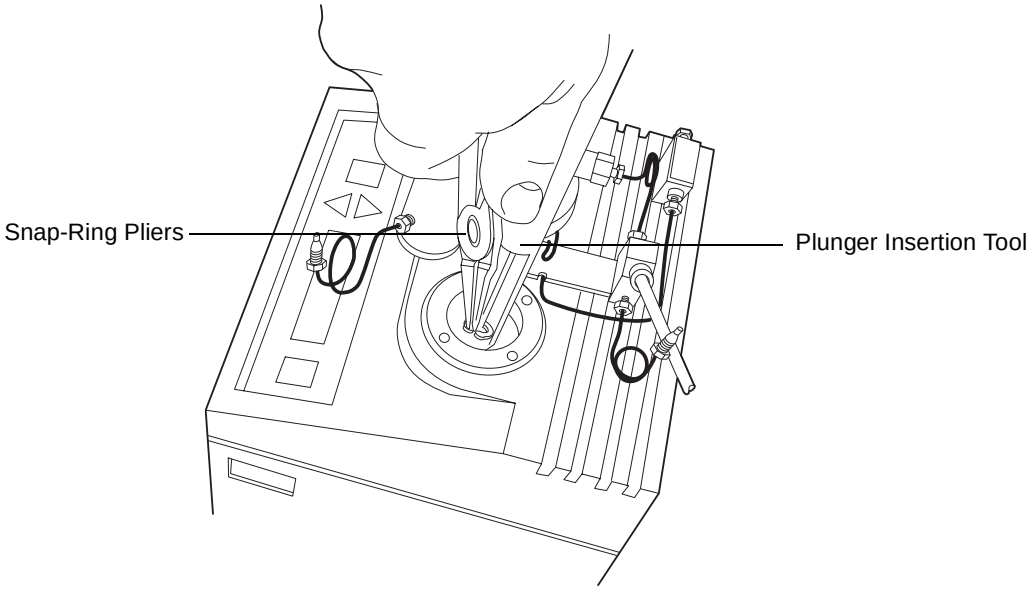


Figure 4-6 Inserting the Plunger

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 Section 3.3.1, Priming the Pump. If you notice leaks, verify pump head and plunger seal installation.
13. Recalibrate the pump flow rate as described in Section 4.3.3, Calibrating the Flow Rate.

4.5 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.

4.5.1 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

1. Purge the pump with methanol as described in Section 3.3.2, Purging the System. 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.

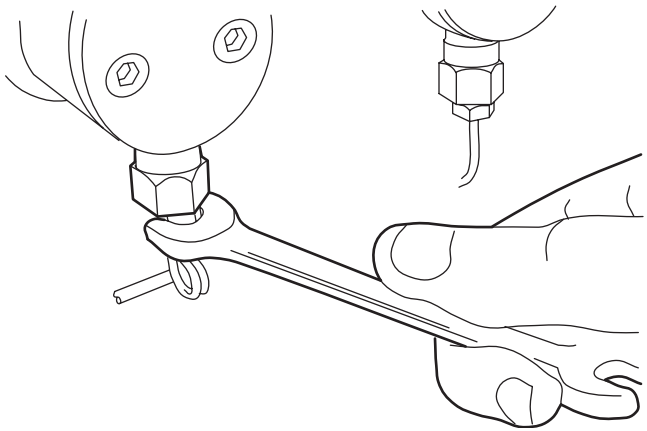


Figure 4-7 Disconnecting the Inlet Tubing

7. Remove the pump head as described in Section 4.4.1, Replacing the Plunger Seals.
8. Use the 1/2-inch open-end wrench to remove the inlet check housing from the pump head (see Figure 4-7).
9. Remove the cartridge from the housing and replace it with a new cartridge.

STOP ***Attention:*** *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.*

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

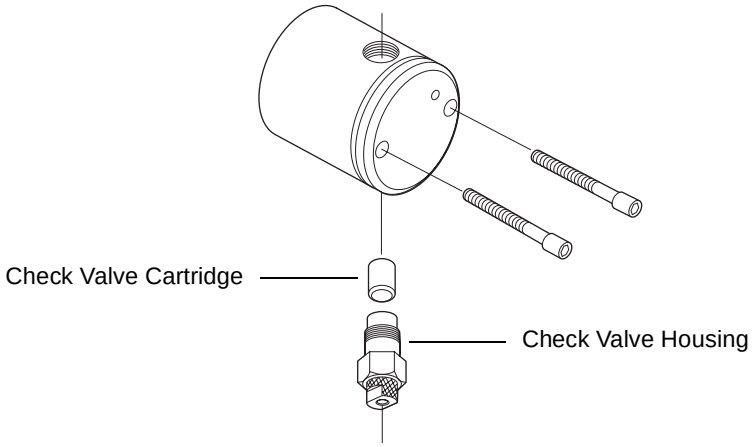


Figure 4-8 Check Valve Housing and Check Valve Cartridge

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 Section 4.4.1, Replacing the Plunger Seals.
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 Section 3.3.1, Priming the Pump. Check for leaks.

4.5.2 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

1. Purge the pump with methanol as described in Section 3.3.2, Purging the System. 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 (see Figure 4-9). 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.

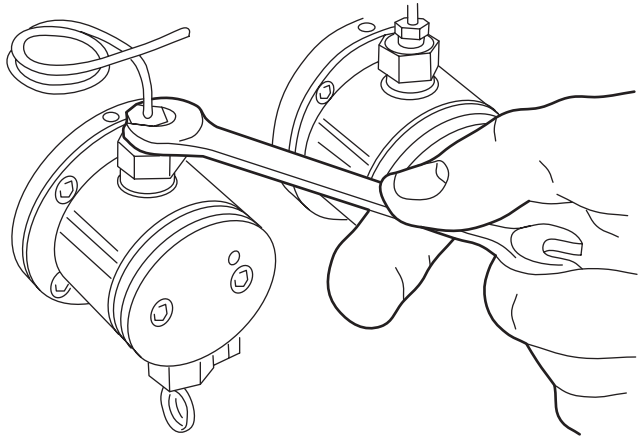


Figure 4-9 Disconnecting the Outlet Tubing

7. Remove the pump head as described in Section 4.4.1, Replacing the Plunger Seals.
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 Figure 4-10).

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

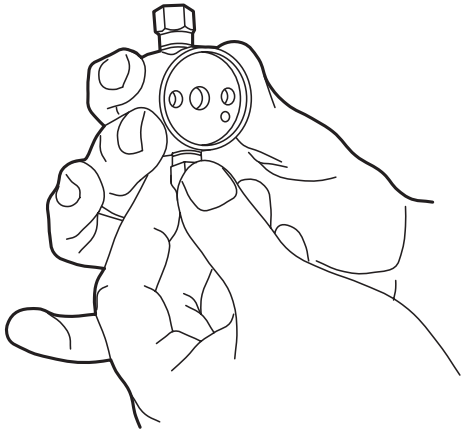


Figure 4-10 Removing the Outlet Check Valve

Attention: *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.*

Note: *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 Section 4.4.2, Cleaning and Replacing the Plungers.
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 Section 3.3.1, Priming the Pump. Check for leaks.

4.6 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

1. Purge the pump with methanol as described in Section 3.3.2, Purging the System. 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 (see Figure 4-11).

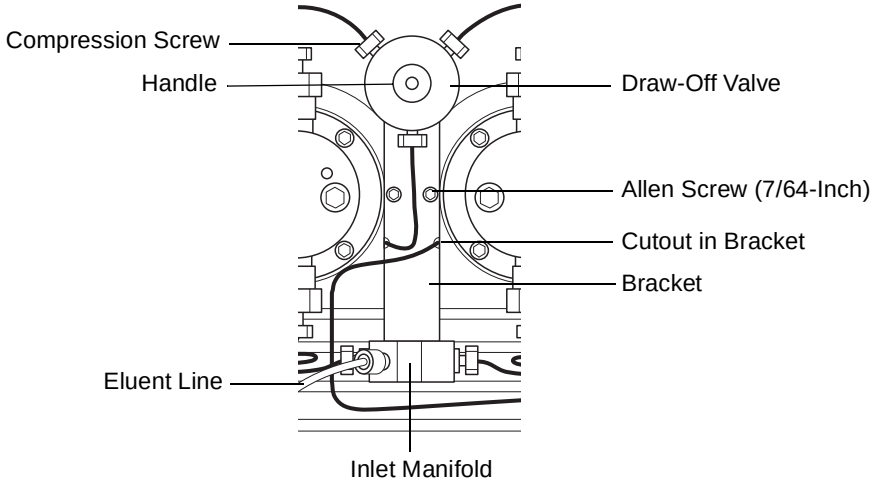


Figure 4-11 Draw-Off Valve/Inlet Manifold Assembly

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 Figure 4-11.
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

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 Figure 4-11.
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 Section 3.3.1, Priming the Pump). Check for leaks.

4.7 Troubleshooting

This section describes:

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

Caution: *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.).

4.7.1 Troubleshooting Error Messages and Pump Malfunctions

Table 4-1 is a guide to troubleshooting pump problems. It lists pump error messages and pump-related symptoms and their possible causes, and suggests corrective actions.

Table 4-1 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 Section 3.3.1, Priming the Pump).
	Incorrect eluent used	Change to correct eluent.
	Visible leaks	Carefully tighten any loose fittings.
	Ambient temperature has changed	Stabilize operating temperature.

Table 4-1 Troubleshooting Error Messages and Pump Malfunctions (Continued)

Symptom	Possible Cause	Corrective Action
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 Section 2.3.1, Replacing the Power Supply Fuses).
LCD display is blank, but fan is running	EEPROM failure	Contact Waters Technical Service.

Table 4-1 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 Section 4.6, Replacing the Draw-Off Valve).
	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 Section 3.3.1, Priming the Pump).
	Pump not connected to external controller	Ensure cable is properly connected to pump controller. ***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.* To avoid component damage, never disconnect the pump from the controller while the two devices are powered on. If pump operates properly, see the controller operator's manual for troubleshooting information.

Table 4-1 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 Section 4.5, Cleaning and Replacing Check Valves).
	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 Section 4.2.2, Performing the Ramp-and-Decay Test. If a head is leaking, replace the plunger seal (see Section 4.4, Cleaning and Replacing Seals and Plungers).
	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 Tubing ID too small	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 Section 3.3.1, Priming the Pump). Use correct tubing.
	Ruptured high-pressure noise filter (indicated by leak at bottom of front bezel)	Contact Waters Technical Service.
	Defective pump motor	Contact Waters Technical Service.
	Defective circuit board	Contact Waters Technical Service.

Table 4-1 Troubleshooting Error Messages and Pump Malfunctions (Continued)

Symptom	Possible Cause	Corrective Action
Leak from pump head	Worn pump plunger seals	Replace defective plunger seals (see Section 4.4, Cleaning and Replacing Seals and Plungers).
	Worn plunger	Replace the plunger (see Section 4.4, Cleaning and Replacing Seals and Plungers).
	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 Section 4.6, Replacing the Draw-Off Valve).
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.

Table 4-1 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 Section 4.5, Cleaning and Replacing Check Valves).
	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 Section 4.4, Cleaning and Replacing Seals and Plungers).
	Worn pump plunger	Replace the plunger (see Section 4.4, Cleaning and Replacing Seals and Plungers).
	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.
	Pump electronics failure	Contact Waters Technical Service.
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.

4.7.2 Identifying and Correcting Noises

Table 4-2 is a guide to troubleshooting and correcting noises in the Waters 515 pump.

Table 4-2 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 Section 4.4, Cleaning and Replacing Seals and Plungers).
	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 Section 4.4, Cleaning and Replacing Seals and Plungers).
	Improper plunger seal	Install correct pump plunger seal (see Section 4.4, Cleaning and Replacing Seals and Plungers).
	Binding piston indicator rod	Replace indicator rod.

4.7.3 Identifying Chromatographic Problems

Table 4-3 is a guide to troubleshooting and correcting chromatographic problems.

Table 4-3 Identifying Chromatographic Problems

Symptom	Possible Cause	Corrective Action
Erratic retention times	Air bubble in pump head	Degas all eluents, prime pump (see Section 3.3.1, Priming the Pump).
	Malfunctioning pump check valves	Clean/replace pump check valves (see Section 4.5, Cleaning and Replacing Check Valves).
	Leaking pump seals	Replace pump seals (see Section 4.4, Cleaning and Replacing Seals and Plungers).
	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 Section 3.3.1, Priming the Pump).
	Clogged eluent filter	Replace filter.

Table 4-3 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.

Table 4-3 Identifying Chromatographic Problems (Continued)

Symptom	Possible Cause	Corrective Action
Baseline noise cycling, short-term (30 sec to 60 sec)	Fluctuating flow rate	Sparge 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 Figure 2-6.
	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.
Baseline noise, random	Eluents not properly degassed or sparged	Degas/sparge eluents.
	Flow erratic, pump not primed	Prime the pump (see Section 3.3.1, Priming the Pump).
		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.

Table 4-3 Identifying Chromatographic Problems (Continued)

Symptom	Possible Cause	Corrective Action
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.

Appendix A Specifications

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

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

Table A-1 Physical Specifications

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

Table A-2 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.

Table A-3 Electrical Specifications

Item	Specification
Power requirements	110 VA (max), 55 VA (typical)
Line voltage	85 to 264 VAC
Frequency	47 to 63 Hz, single phase
Fuses	3.15 A, 250 V, two

Table A-4 Performance Specifications

Item	Specification
Programmable flow rate range: 100-µL heads 225-µL 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-µL heads, 3000 psi (20,685 kPa, 200.5 bars) for 225-µL heads; programmable upper and lower limits
Pressure ripple (one pump)	≤2.0% at 1 mL/min, degassed methanol, at 1000 psi backpressure
Flow precision	±0.1% RSD of retention time at 1 mL/min, 1000 to 2000 psi, paraben PQ test, or 2 seconds SD
Flow accuracy	±1.0% of setting at 1 mL/min, or 30 µL/min, whichever is larger, using degassed methanol at 1000 to 2000 psi backpressure

Table A-5 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: • +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

Appendix B
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 Table B-1 are recommended for customer installation. Any parts not listed in this table may require installation by a trained Waters service representative.

Table B-1 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 Table B-2 to optimize the Waters 515 pump for your application and to simplify common procedures.

Table B-2 Accessories

Item	Quantity	Part Number
Plunger Wash Kit	1	WAT031870
Replacement Pump Head Assembly	1	WAS207006
Extended Flow Range Option Kit	1	WAT207119
Extended Flow Pump Head Assembly	2	WAT060303

Table B-2 Accessories (Continued)

Item	Quantity	Part Number
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) 1/16-inch OD × 0.020-inch ID, 10 feet (3 m)	 1 1	 WAT026973 WAT026804
PTFE Tubing: 1/8-inch OD × 0.062 ID, 25 feet (7.7 m) 0.80-inch OD × 0.058 ID, 25 feet (7.7 m)	 1 1	 WAT026808 WAT026974

The kits listed in Table B-3 contain the parts you need for common maintenance operations.

Table B-3 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 220 V/50 Hz	 1 1	 WAT085113 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
Seal Replacement Kit (black, general-purpose seals)	4	WAT038423
Seal Replacement Kit (for use with aqueous applications)	2	WAT025296

Table B-3 Maintenance and Operation Kits (Continued)

Item	Quantity	Part Number
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

Appendix C
Eluent Considerations

This appendix provides information about preparing and using eluents.

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

C.1 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.

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

C.2 Eluent Miscibility

Before you change eluents, see Table C-1 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.

Table C-1 Eluent Miscibility

Polarity Index	Eluent	Viscosity [η] CP, 20 °C	Boiling Point at 1 atm (°C)	Miscibility Number (M)
–0.3	*n*-decane	0.92	174.1	29
–0.4	Isooctane	0.50	99.2	29
0.0	*n*-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	*p*-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

Table C-1 Eluent Miscibility (Continued)

Polarity Index	Eluent	Viscosity [η] CP, 20 °C	Boiling Point at 1 atm (°C)	Miscibility Number (M)
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
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 Table C-1). 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.

C.3 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.

C.4 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).

C.5 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.

C.5.1 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.

C.5.2 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.

Note: *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.

Caution: *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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