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Release history: Revision A August 2008

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**EMC Directive 2004/108/EC**

EMC compliance has been evaluated by TUV Rheinland of North America.

- CISPR 11: 1998
- EN 61000-3-2: 2000
- EN 61000-4-2: 2001
- EN 61000-4-3: 2002
- EN 61000-4-4: 2004
- EN 61000-4-5: 2001
- EN 61000-4-6: 2003
- EN 61000-4-11: 2001
- CFR 47: 2007

**Low Voltage Safety Compliance**

Low voltage safety compliance has been evaluated by TUV Rheinland of North America.


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```
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.
```
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Notice on the Proper Use of Thermo Scientific Instruments

In compliance with international regulations: Use of this instrument in a manner not specified by Thermo Fisher Scientific could impair any protection provided by the instrument.

Notice on the Susceptibility to Electromagnetic Transmissions

Your instrument is designed to work in a controlled electromagnetic environment. Do not use radio frequency transmitters, such as mobile phones, in close proximity to the instrument.

For manufacturing location, see the label on the instrument.

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Conformité DEEE

Ce produit doit être conforme à la directive européenne (2002/96/EC) des Déchets d'Équipements Electriques et Electroniques (DEEE). Il est marqué par le symbole suivant:

<table>
<thead>
<tr>
<th>CAUTION Symbol</th>
<th>CAUTION</th>
<th>VORSICHT</th>
<th>ATTENTION</th>
<th>PRECAUCION</th>
<th>AVVERTENZA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye Hazard: Eye damage could occur from splattered chemicals or flying particles. Wear safety glasses when handling chemicals or servicing the instrument.</td>
<td>Verletzungsgefahr der Augen: Versprühte Chemikalien oder kleine Partikel können Augenverletzungen verursachen. Tragen Sie beim Umgang mit Chemikalien oder bei der Wartung des Gerätes eine Schutzbrille.</td>
<td>Danger pour les yeux: Dex projections chimiques, liquides, ou solides peuvent être dangereuses pour les yeux. Porter des lunettes de protection lors de toute manipulation produe chemique ou pour toute intervention sur l’instrument.</td>
<td>Peligro para los ojos: Las salpicaduras de productos químicos o partículas que salten bruscamente pueden causar lesiones en los ojos. Utilice anteojos protectores al manipular productos químicos o al darle servicio de mantenimiento al instrumento.</td>
<td>Pericolo per la vista: Gli schizzi di prodotti chimici o delle particelle presenti nell’aria potrebbero causare danni alla vista. Indossare occhiali protettivi quando si maneggiano prodotti chimici o si effettuano interventi di manutenzione sull’apparecchio.</td>
<td></td>
</tr>
<tr>
<td>General Hazard: A hazard is present that is not included in the above categories. Also, this symbol appears on the instrument to refer the user to instructions in this manual.</td>
<td>Allgemeine Gefahr: Es besteht eine weitere Gefahr, die nicht in den vorstehenden Kategorien beschrieben ist. Dieses Symbol wird im Handbuch außerdem dazu verwendet, um den Benutzer auf Anweisungen hinzuweisen.</td>
<td>Danger général: Indique la présence d’un risque n’appartenant pas aux catégories citées plus haut. Ce symbole figure également sur l’instrument pour renvoyer l’utilisateur aux instructions du présent manuel.</td>
<td>Peligro general: Significa que existe un peligro no incluido en las categorias anteriores. Este simbolo también se utiliza en el instrumento para referir al usuario a las instrucciones contenidas en este manual.</td>
<td>Pericolo generico. Pericolo non compreso tra le precedenti categorie. Questo simbolo è utilizzato inoltre sull’apparecchio per segnalare all’utente di consultare le istruzioni descritte nel presente manuale.</td>
<td></td>
</tr>
</tbody>
</table>

When the safety of a procedure is questionable, contact your local Technical Support organization for Thermo Fisher Scientific San Jose Products.
<table>
<thead>
<tr>
<th>CAUTION Symbol</th>
<th>CAUTION</th>
<th>危険警告</th>
<th>危険警告</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Shock:</td>
<td>This instrument uses high voltages that can cause personal injury. Before servicing, shut down the instrument and disconnect the instrument from line power. Keep the top cover on while operating the instrument. Do not remove protective covers from PCBs.</td>
<td>電撃：この計測器は高電圧を使用し、人体に危害を与える可能性があります。保守・修理は、必ず操作を停止し、電源を切ってから実施して下さい。上部カバーを外したままで計測器を使用しないで下さい。プリント配線板の保護カバーを外さないで下さい。</td>
<td>電撃：儀器設備使用時造成人身傷害的高壓電壓。在維修之前，必須先關儀器設備並切斷電源，務必在頂蓋蓋上的情況下操作儀器。請勿拆除PCB保護蓋。</td>
</tr>
<tr>
<td>Chemical:</td>
<td>This instrument might contain hazardous chemicals. Wear gloves when handling toxic, carcinogenic, mutagenic, or corrosive or irritant chemicals. Use approved containers and proper procedures to dispose waste oil.</td>
<td>化学物質：危険な化学物質が計測器中に存在している可能性があります。毒物、発がん性、癌変性、遺伝性・変異性のある薬品を取り扱う際は、手袋を着用して下さい。廃油の処分には、規則の容器と手順を使用して下さい。</td>
<td>化学品：儀器設備中可能存在有危險性的化學物質。接觸毒性癌症、誘発成発癌／刺激性化學品時，請配戴手套。處置廢油時，請使用經過許可的容器和程序。</td>
</tr>
<tr>
<td>Heat:</td>
<td>Before servicing the instrument, allow any heated components to cool.</td>
<td>熱: 熱くなった部品は冷えるのを待ってから保守・修理を行って下さい。</td>
<td>高溫：請先等高溫零件冷卻之後再進行維修。</td>
</tr>
<tr>
<td>Fire:</td>
<td>Use care when operating the system in the presence of flammable gases.</td>
<td>火災：可燃性のガスが存在する場所でシステムを操作する場合は、充分な注意を払って下さい。</td>
<td>火災：在有易燃氣體的場所操作該系統時，請務必小心謹慎。</td>
</tr>
<tr>
<td>Eye Hazard:</td>
<td>Eye damage could occur from splattered chemicals or flying particles. Wear safety glasses when handling chemicals or servicing the instrument.</td>
<td>眼に対する危険: 化学物質や微粒子が飛散して眼を傷つける危険性がありま</td>
<td>眼睛傷害危険：飛濺的化學品或顆粒可造成眼睛傷害。處理化學品或儀器設備時請佩戴安全眼鏡。</td>
</tr>
<tr>
<td>General Hazard:</td>
<td>A hazard is present that is not included in the above categories. Also, this symbol appears on the instrument to refer the user to instructions in this manual.</td>
<td>一般的な危険: 本マニュアル中で指示を参照して下さい。</td>
<td>一般性危険：說明未包括在上述類別中的其他危険。此外，儀器設備上使用這個標誌，以指示用戶本使用手冊中的說明。</td>
</tr>
</tbody>
</table>

When the safety of a procedure is questionable, contact your local Technical Support organization for Thermo Fisher Scientific San Jose Products.

安全を確保する手順がよくわからない時は、作業を一時中止し、お近くのサーモフィシャーステラックス製品のテクニカルサポートセンターをご連絡ください。

如对安全程序有疑问，请在操作之前与当地的菲尼根技术服务中心联系。
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Preface

This guide describes how to install and maintain the SpectraSYSTEM P1000 isocratic pump, as well as how to control the gradient pump from the front panel keypad.

Safety and Special Notices

Caution!

A caution alerts you to situations that could result in personal injury. It also tells you how to avoid them.

High Voltage!

A high voltage caution alerts you to the presence of high voltage and to the potential injury that could occur from electrical shock were you to come in contact with a specific instrument area or component. It also tells you how to avoid contact with the high-voltage areas in your instrument.

Hot Surface!

A hot surface caution alerts you to potential injury that could occur from coming in contact with a heated surface or area on or in an instrument. It also tells you how to avoid contact with the heated surfaces in your instrument.

Note

Notes alert you to the correct operating or maintenance procedures needed to prevent equipment or data damage. They also alert you to important exceptions, side effects, or unexpected occurrences that may result from certain action(s).

Hint

Hints call out general rules or shortcuts. They specify ways to obtain the best performance and results from your instrument.
Manual Conventions

This manual uses several conventions. Among them are menu displays, text conventions (brackets, slashes, and so on), and standard words.

Displays

We will depict the two-line display as shown below. Note that in menu illustrations, the triangular cursor location is indicated by a caret (>).

```
>FILES                         QUEUE                     TESTS
      COMMANDS                   OPTIONS
```

A two-line menu display

Frequently the two lines shown on the display are only part of a longer menu which you would see by pressing the down-arrow key. In this manual, menus having more than two lines are represented as follows:

```
Edit File                  1
File Name

>Solvent Program
Options
Timed Events
```

A menu longer than two lines

Text Conventions

Three typographic conventions are used to differentiate between keys, menus, and fields.

Brackets

Brackets, [ ], indicate instrument keys, For example: Press the [MENU] key.

Slashes

Slashes, / /, are text conventions used around menu choices. For example: From the Main Menu, select /FILES/, /Edit/.

Capitalization

Capitalization is used to make field and menu names appear just as they do on the display. Generally the first letters of field names are capitalized. For example: In /Solvent Program/ go to the Flow field.
Standard Words

We have also standardized the meanings of two words: “select” and “enter.”

Select

The word “select” is used when you need to choose from among available options. For example, to select a particular menu choice, you would move the cursor to the appropriate choice and press [ENTER]. To “select” a field entry, move the cursor to the appropriate field and use the [+] and [-] keys to scroll to the desired choice.

Enter

The word “enter” is used when you need to specify individual alphanumeric digits. To “enter” a particular value, move the cursor to the field and use the [+] and [-] keys to increment or decrement each digit in the field until the desired value or letter appears.

Good Laboratory Practices

To obtain optimal performance from your LC system and to prevent personal injury or injury to the environment, do the following:

• Keep good records

• Read the manufacturers’ Material Safety Data Sheets for the chemicals being used in your laboratory

• Remove particulate matter from your samples before you inject them into the liquid chromatograph

• Use HPLC grade solvents

• Connect the drainage tubes from the pump, autosampler, and detector to an appropriate waste receptacle. Dispose of solvents as specified by local regulations

Keep Good Records

To help identify and isolate problems with either your equipment or your methodology, keep good records of all system conditions (for example, % RSDs on retention times and peak areas, peak shape and resolution). At a minimum, keep a chromatogram of a typical sample and standard mixture, well documented with system conditions, for future reference. Careful comparison of retention times, peak shapes, peak sensitivity, and baseline noise can provide valuable clues to identifying and solving future problems.
Chemical Toxicity

Although the large volume of toxic and flammable solvents used and stored in laboratories can be quite dangerous, do not ignore the potential hazards posed by your samples. Take special care to read and follow all precautions that ensure proper ventilation, storage, handling, and disposal of both solvents and samples. Become familiar with the toxicity data and potential hazards associated with all chemicals by referring to the manufacturers’ Material Safety Data Sheets (MSDS).

Sample Preparation

Always consider the solubility of your sample in the solvent/mobile phase. Sample precipitation can plug the column, tubing or flowcell causing flow restriction. This obstruction can result in irreparable damage to the system. To avoid damage caused by particulate matter, filter samples through 0.45 or 0.2 micron (or less) filters.

Solvent Requirements

Many chemical manufacturers provide a line of high-purity or HPLC-grade reagents that are free of chemical impurities. Routine filtration of all solvents or eluents through a 0.45 or 0.2 micron (or less) fluorocarbon filter before placing them in the solvent reservoir significantly prolongs the life and effectiveness of the inlet filters, check valves and seals, injector, and column. Typically, HPLC-grade solvents do not require filtration.

Choose a mobile phase that is compatible with the sample and column you have selected for your separation. Remember that some solvents are corrosive to stainless steel.

Solvent Disposal

Make sure you have a solvent waste container or other kind of drain system available at or below the benchtop level. Most solvents have special disposal requirements and should not be disposed of directly down a drain. Follow all governmental regulations when disposing of any chemical.

High-pressure Systems and Leaks

LC systems operate at high pressures. Because liquids are not highly compressible they do not store much energy. Accordingly, there is little immediate danger from the high pressures in an LC system. However, if a leak occurs, correct it as soon as possible. Always wear eye and skin protection when operating or maintaining an LC system. Always shut down the system and return it to atmospheric pressure before attempting any maintenance.
Contacting Us

There are several ways to contact Thermo Fisher Scientific for the information you need.

❖ To contact Technical Support

Phone 800-532-4752  
Fax 561-688-8736  
E-mail us.techsupport.analyze@thermofisher.com  
Knowledge base www.thermokb.com

❖ Find software updates and utilities to download at mssupport.thermo.com.

❖ To contact Customer Service for ordering information

Phone 800-532-4752  
Fax 561-688-8731  
E-mail us.customer-support.analyze@thermofisher.com  
Web site www.thermo.com/ms

❖ To copy manuals from the Internet

Go to mssupport.thermo.com and click Customer Manuals in the left margin of the window.

❖ To suggest changes to documentation or to Help

• Fill out a reader survey online at www.thermo.com/lcms-techpubs.
• Send an e-mail message to the Technical Publications Editor at techpubs-lcms@thermofisher.com.
1

Installation and Specifications

Introduction

This chapter contains information necessary to install your Thermo Scientific, SpectraSYSTEM™ P1000 isocratic pump properly. The step-by-step instructions describe how to set the voltage for your area, how to connect tubing, and how to prime and purge the pump. Use the checklist on the next page to complete pump installation. Be sure you read the Safety Information at the front of this manual before proceeding with any installation.
Start-up Checklist

This list is a brief summary of tasks that should be completed to install your pump. Complete installation information is contained in this chapter.

☐ Inspect your instrument
☐ Check for parts shortages
☐ Set the voltage
☐ Place the pump
☐ Connect the power cord
☐ Check initial response to power-on
☐ Hardwire to eight-pin port, using external function connector, making electrical connection to other SpectraSYSTEM instruments
☐ Install kits or accessories
☐ Prepare and connect solvents
☐ Connect inlet lines
☐ Prime with solvent
☐ Purge solvent lines
☐ Connect to system

This pump was installed by:

(Name) (Date)
Unpacking

INSPECT YOUR INSTRUMENT

Your pump was shipped in a special container designed to provide excellent protection from routine wear and tear encountered in transit.

After unpacking, inspect your pump and its accessories for missing parts and/or physical damage. If damage is found, notify both the carrier and your sales representative. DO NOT return any goods without prior authorization from Thermo Fisher Scientific.

NOTE: Narrow-bore pumps will have a $3\mu L$ static mixer included.

The contents of your package varies with the model and options purchased. A basic accessory kit is supplied with each pump and includes the following tools and parts.

The contents of your ship kit is as follows:

1  Pump
1  Accessory Kit
1  Tubing Kit
1  SpectraSYSTEM documentation CD
1  Declaration of Conformity

OPTIONS AVAILABLE

A variety of options, kits, and accessories are available for your pump. Refer to Appendix A, Kits and Parts Lists for a full description and parts list of each. If you purchased an inert/biocompatible pump, the correct tubing and liquid ends were installed at the factory before shipment.

For a list of all available accessories, upgrades, and kits, see the insert at the front of this manual or contact your Thermo Fisher Scientific sales representative. Note that all upgrades require installation by Thermo Fisher Scientific.

NOTE: The pump features a bypass valve pre-installed as standard equipment.
Installation

LIFTING AND CARRYING THE PUMP

The correct way to carry the pump is to use the two hand holds, one located underneath the front of the pump, and the other at the top of the back, near the power switch. Grasp the pump well underneath the front when lifting and carrying.

SETTING THE VOLTAGE

All pumps are configured at shipment for 230 VAC (50/60 Hz) operation. Depending upon the country of use, you might need to change the voltage setting.

NOTE: Check the position of the voltage select barrel located on the rear panel (Figure 1.2). If the indicated voltage setting is not consistent with your area, DO NOT CONNECT THE POWER CORD!

The voltage setting can be easily modified as follows:

1. Remove the tape label covering the power entry receptacle.
2. Ensure that the power cord is not connected to the pump.
3. Use a small, flat-blade screwdriver to pry open the power selector/fuse cover to expose the voltage selector barrel. You will probably hear the top edge of the cover snap as it is pried open.
4. Remove the plastic selector barrel by pulling it straight out.
5. Rotate the barrel until you see the desired voltage (either 115 VAC or 230 VAC) and insert the barrel back into the housing with the desired voltage visible.
6. Firmly snap the housing cover back in place. Be sure that the selected voltage is visible in the voltage window (Figure 1.2).

HINT: Use two thumbs to push up on the top half of the cover as you push in. The voltage selected will be visible through the window.
Figure 1.1 Rear panel
The pump weighs approximately 38 pounds (18 kg) and requires at least 6 inches (16 cm) of bench width and at least 19 inches (48 cm) of bench depth. If used with a manual injector bracket, the pump requires 9 inches (23 cm) of bench width. The pump needs a space at least 15 inches (38 cm) high.

Place the pump on a level surface. Leave 2 inches (6 - 7 cm) behind the instrument for good air flow and access to electrical connections. Keep the pump away from heating and cooling ducts, and avoid exposing the pump to direct sunlight. The pump should be placed to the far left of your LC system if it is used with a SpectraSYSTEM autosampler or detector.

Attach the AC power cord. (see the insert at the front of this manual.) Plug the power connector into an appropriately grounded power outlet.

**NOTE:** For safe operation and optimum performance, the pump must be connected to a properly grounded power receptacle.
CHECKING INITIAL RESPONSE TO POWER ON

Turn on the power by pressing the power switch (Figure 1.1). With the pump's front panel facing you, the power switch is located in the back, on the upper right-hand side. The fan starts and a display similar to Figure 1.3 appears for one second.

![Figure 1.3 A brief power-up message](image)

If this message does not appear, double-check the electrical connections and try turning on the pump once more, watching the screen closely. If the message still does not appear, contact your Thermo Fisher Scientific representative.

Next, the display shows the Status Screen, similar to Figure 1.4.

<table>
<thead>
<tr>
<th>Status</th>
<th>Flow</th>
<th>PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP</td>
<td>1.00</td>
<td>154</td>
</tr>
</tbody>
</table>

![Figure 1.4 P1000 Status Screen](image)

HARDWIRING EXTERNAL EVENTS

Pin 6 of the eight-pin port on the back of the pump (Figure 1.1) allows you to control another device, such as a column switching valve or fraction collector. If you plan to control such a device or instrument using the pump's Timed Events feature, insert the external function connector into the eight-pin port.

The pins are labeled both on the port and on the external function connector. Ensure that the pin numbers match whenever plugging the connector into the port.

Hardwire your device using the 4-connection cable. Loosen pin 6's small screw, insert the wire, then tighten the screw.

You must also insert the external function connector if you use a SpectraSYSTEM autosampler. More information about making hardwire connections to an autosampler is found on page 16, and in the SpectraSYSTEM AS3000 Autosampler User Guide.

Pin assignments for the eight-pin port are shown in Table 1.1.
Table 1.1 Eight-pin port pin assignments

<table>
<thead>
<tr>
<th>Pin #</th>
<th>Assignment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>READY (Output)</td>
</tr>
<tr>
<td>2</td>
<td>+5 VDC 100 mA MAX</td>
</tr>
<tr>
<td>3</td>
<td>GROUND</td>
</tr>
<tr>
<td>4</td>
<td>PRESSURE 0.1 V/1000 PSI</td>
</tr>
<tr>
<td>5</td>
<td>STOP (Input)</td>
</tr>
<tr>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>RUN (Input)</td>
</tr>
<tr>
<td>8</td>
<td>INJ HOLD (Output)</td>
</tr>
</tbody>
</table>

All outputs (pin 1, pin 6, and pin 8) are open-collector type, capable of sinking up to 30 mA at a maximum of 30 VDC.

INSTALLING KITS OR ACCESSORIES

Refer to Appendix C for complete instructions for installing the Manual Injection Valve Bracket (column holder).

PREPARING AND CONNECTING SOLVENTS

If you did not purchase a solvent degassing apparatus or solvent bottles from Thermo Fisher Scientific, skip this section. Continue with Connecting Inlet Lines on the next page.

Solvent Bottles

Prepare your solvent bottle(s) as follows:

1. Rinse the bottle(s) with LC-grade solvent to remove any dust.
2. Fill the bottle(s) with appropriate LC-grade solvent(s).
3. The bottle caps are pre-assembled to include an inlet line and filter. Ensure that each filter is tightly assembled to its fitting, and the filter fitting is firmly attached to the inlet line. Place the solvent filter/inlet line into each bottle, making sure that the inlet filter rests on the bottom of the bottle. Cap the bottle.
4. Attach the appropriate label to each solvent bottle cap to identify it.
5. Run vent lines from each bottle to an appropriate exhaust apparatus.
Degassing

There are two recommended methods for degassing solvents for use with your pump: vacuum degassing and helium degassing.

NOTE: Solvent degassing is recommended for isocratic applications because it results in improved detector performance.

If you purchased a Thermo Scientific degasser, set up your degasser as described in the degasser manual and continue the pump installation when you have a supply of degassed solvent available.

CONNECTING INLET LINES

Refer to Figure 1.5 when connecting the inlet lines. The P1000 has one inlet. Connect the pump's inlet line (Figure 1.5) to your solvent supply.
Figure 1.5 Front panel, cover removed
BYPASS VALVE

The bypass valve is shown in Figure 1.6. Do not attach a line to the waste/prime port (the middle port) now, but have the solvent waste tube (provided in the accessory kit) ready. You will attach the tube to the waste/prime port after priming the pump.

PRIMING AND PURGING

The P1000 pump is shipped with methanol in the pump heads and connecting tubing. If the first solvent you'll use is not miscible with methanol, first prime the pump with an intermediary solvent. Once primed, you should purge the pump to remove any air bubbles.

**HINT:** It is best to prime the pump initially with methanol to fully wet all internal surfaces. Priming with 100% water can often result in trapped air due to the high surface tension of the water. Trapped air affects flow stability.

**Priming the Pump**

To prime the pump with your solvent and simultaneously flush the methanol out, you will need the 20 mL priming syringe and Luer adapter found in the accessory kit. You will also need a solvent waste container.

1. Remove the waste line from the waste/prime port of the bypass valve, if connected.

2. Install the Luer adapter to the waste/prime port (Figure 1.6). Tighten to finger-tight, then wrench tighten approximately 1/4-turn. (This allows the priming syringe to be attached and detached conveniently.)
3. Make sure that the 20 mL Luer-tip priming syringe is fully depressed. Connect the syringe to the adapter in the waste/prime port twisting the syringe slightly to make a leak-free connection.

4. Position a solvent waste container nearby to collect the syringe discharge, since two or three syringe volumes might be needed to prime the pump. Make sure that all tube connections are airtight.
5. Open the bypass valve by turning the knob fully counterclockwise.

NOTE: Solvents flow through the pump when the pump is purging or when a file is initialized (loaded as a run file).

6. Turn on power to the pump (if it not already on)

7. Press [PURGE]. See Figure 1.5.

NOTE: Purging starts whenever the cursor is moved out of the Purge Menu Time field by pressing [ENTER].

<table>
<thead>
<tr>
<th>Purge</th>
<th>Flow</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>

7. For analytical applications: Move the cursor to the Flow field. Set the flow rate to 10 mL/min. If the purge mode is pressure, set the pressure to 1000 psi (69 bars, 7 Mpa).

For narrow-bore applications: Move the cursor to the Flow field. If the purge mode is pressure, set the pressure to 1000 psi (69 bars, 7 Mpa).
8. Move the cursor to the Time field, then press [ENTER]. You will hear the pump's motor start.

9. Slowly pull the syringe plunger back to create a small vacuum in the solvent lines that will draw the solvent from the solvent bottles (or the vacuum degasser) into the pump heads. *Do not draw back so far as to remove the plunger from the syringe barrel!*

If more than one draw is necessary to prime the pump, *(i.e., the syringe fills with air before solvent enters the pump heads)*, press [STOP], close the bypass valve (turn clockwise), remove the syringe, and depress the plunger. Reconnect the syringe, open the bypass valve, press [PURGE], enter a flow rate or time, press [ENTER], and finish drawing the solvents into the pump as described at the beginning of this step.

If you notice a leak in one of the fittings, or need to stop the solvent flow, press [STOP]. This will immediately stop flow through the pump.

10. When solvent steadily appears in the syringe and no air bubbles are present, press [STOP], then close the bypass valve.

11. Gently remove the syringe and empty it into the solvent waste container.

12. Remove the Luer adapter from the valve port and store it, along with the priming syringe, for later use.

13. Connect the solvent waste line to the waste/prime port of the valve and tighten to finger-tight. Route the waste tubing to an appropriate solvent waste container.

**Purging the Pump**

With the pump primed, purge the lines containing your chosen solvents as follows:

1. Ensure that the solvent inlet filters inside each solvent bottle are in a vertical position so that air within the filter will not be trapped.

2. Fully open the bypass valve.

3. We suggest that you initially purge the lines with a volume of 10 mL.

Follow the steps below to begin the purge operation:

a) Press [PURGE] to reach the Purge Menu. If desired, change the purge mode by pressing [MENU], /OPTIONS/, /More/, Purge Mode. *(The words in the top line of the display will change, depending on your purge mode preference.)*

b) Move the cursor to the Flow or Pressure field.
For analytical applications: If the purge mode is Flow, enter a flow of 10.00 mL/min. [If pressure, set to 1000 psi (69 bars, 7 Mpa).]

For narrow-bore applications: If the purge mode is Flow, enter a flow of 5.00 mL/min. [If pressure, set to 1000 psi (69 bars, 7 MPa).]

c) Press [ENTER] and enter a time of 1.00 minute.
d) Press [ENTER], the pumps motor will start. The pump will automatically stop purging after one minute and then initialize. After you have completed the purge, be sure to close the purge valve.

<table>
<thead>
<tr>
<th>Purge</th>
<th>Flow</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Figure 1.9 The Purge Menu with flow and time values entered

4. When you complete the purge and the pump stops, close the bypass valve.
Once the pump is purged, you can plumb it to the rest of your chromatographic system. Figure 1.5 and Figure 1.6 illustrate the bypass valve, showing the pump's outlet. Using a pre-cut piece of stainless steel tubing (or PEEK tubing if inert/biocompatible), connect the outlet to your autosampler or manual injection apparatus.

If you are using a manual injector valve from Thermo Fisher Scientific, refer to Appendix C for complete information for installing the injector valve bracket.

If you are using a SpectraSYSTEM autosampler, the pump sends a ready signal to the autosampler through pin 1, and receives a stop signal from the autosampler through pin 5. In addition, the ground contact (pin 3) must also be connected to the autosampler's ground contact. For complete information on how to make these connections, refer to the SpectraSYSTEM Autosampler User Guide, Chapter 1. The table below summarizes the hardwire connections necessary between a SpectraSYSTEM autosampler and pump.

Table 1.2 Pump connections to a SpectraSYSTEM autosampler

<table>
<thead>
<tr>
<th>PUMP</th>
<th>AUTOSAMPLER</th>
</tr>
</thead>
<tbody>
<tr>
<td>READY (Output)</td>
<td>Pin 1 to Pin 5</td>
</tr>
<tr>
<td>GROUND</td>
<td>Pin 3 to Pin 1</td>
</tr>
<tr>
<td>STOP (Input)</td>
<td>Pin 5 to Pin 3</td>
</tr>
<tr>
<td>RUN (Input)</td>
<td>Pin 7 to Pin 4</td>
</tr>
<tr>
<td>INJ HOLD (Output)</td>
<td>Pin 8 to Pin 7</td>
</tr>
</tbody>
</table>
Performance Verification

After installing your SpectraSYSTEM pump, it is suggested that you run a performance test to verify that the instrument is working properly. Common tests for pumps include flow accuracy and precision. Procedures for these performance tests are described below.

FLOW ACCURACY

There are many ways to test pump flow accuracy: graduated cylinder vs. time, calibrated flow meter, or gravimetric vs. time. The procedure below describes how to measure the flow accuracy and precision using a gravimetric procedure. In general, you will set the pump to a flow rate, collect eluant for a specified time in a weighed flask, and determine the flow rate and accuracy. The actual flow rate can also be used to calibrate your pump. This test will take approximately 20 minutes.

Test Setup

Column or flow restrictor: To deliver c.a. 1000 psi backpressure
Flow Rate: Any flow rate to be tested for accuracy
Mobile phase: MeOH or other appropriate mobile phase

Experimental

Use the following steps to calculate the flow rate accuracy:

1. Prepare the desired mobile phase for the accuracy test.
2. Filter and degas the mobile phase.
3. Purge the pump and the column or flow restrictor being used.
4. Set the pump at the desired flow rate and start.

**HINT: A volumetric flask is ideal because it helps to minimize evaporation. Also, wrap tube and top of flask with aluminum foil to help eliminate evaporation.**

5. Weigh a clean flask capable of holding approximately 10 minutes of volume at the set flow rate. Include top and any other items attached to flask.
6. Record this weight.
7. Place the flask under the flow stream from the pump and start timing.

**HINT: Use a stopwatch for the timing portion of the test. The more accurate the stopwatch the better the results.**

8. Collect the pump's eluant for 20 minutes.
9. Re-weigh the flask and record.
10. Calculate the actual flow rate:

\[\text{Flow Rate} = \frac{\text{Weight}_{\text{full}} - \text{Weight}_{\text{empty}}}{\text{Density}} \times \frac{1}{\text{Time}}\]

11. Set a flow rate of 0.5 mL/min using MeOH as the mobile phase.

Flow Rate = \(\frac{22.8577 \text{ g} - 14.8858 \text{ g}}{0.7894 \text{ g/mL}}\) / 19.9687 min
Flow Rate = \(\frac{7.9719 \text{ g}}{0.7894 \text{ g/mL}}\) / 19.9687 min
Flow Rate = 10.0987 mL / 19.9687 min
Flow Rate = 0.506 mL / min

12. Calculate the flow accuracy of the pump:

\[\text{Flow Accuracy} = 100 \times \left| \frac{\text{FR}_{\text{set}} - \text{FR}_{\text{actual}}}{\text{FR}_{\text{set}}} \right|\]

Flow Accuracy = 100 \times 0.006 mL / min

Example

Using the data from step 10 gives the following results:

Flow Accuracy = 100 \times \left| \frac{0.5 \text{ mL/min} - 0.506 \text{ mL/min}}{0.5 \text{ mL/min}} \right|

Flow Accuracy = 100 \times 0.006 mL / 0.5 mL/min

Flow Accuracy = 1.2%

HINT: For flow rates above 0.5 mL/min, it is best to install an in-line 100 μL mixer replacing the 3 μL mixer.

Specification

Typical results for flow precision are less than 1% (absolute). However, results can vary based on temperature, mobile phase, and flow rate.

HINT: When using gravimetric measurements, other correction factors might be used to increase the accuracy of the measurements. These include evaporation rate and the net buoyant effect.

FLOW PRECISION

Flow precision checks the reproducibility of the flow rate. This procedure is simply running the accuracy test 7 or more times and calculating a percent relative standard deviation. This procedure will require at least a couple of hours.
**Test Setup**

Set up the flow precision test above to perform 7 or more replicate runs.

Column or flow restrictor: To deliver c.a. 1000 psi backpressure

Flow rate: Any flow rate that accuracy is to be tested

Mobile phase: MeOH or other appropriate mobile phase

*HINT: For flow rates above 0.5 mL/min, it is best to install a 100 μL mixer in-line replacing the 3 μL mixer.*

**Experimental**

1. Repeat the flow accuracy test above for 7 or more replicate runs.
2. Determine the flow rate for each replicate.
3. Determine the average flow rate for the replicate runs.
4. Determine the standard deviation for the replicate runs.
5. Determine the relative standard deviation for the replicate runs.

Using the following example values:

Average = 0.502 mL/min

Standard Deviation = 0.004

Relative Standard Deviation (RSD) = 100 × SD/Average

Yields:

\[
RSD = 100 \times \frac{0.004}{0.502 \text{ mL/min}}
\]

\[
RSD = 100 \times 0.00797
\]

\[
RSD = 0.797\%
\]

**Specification**

Typical results for flow precision are less than 1% (absolute). However, results can vary based on temperature, mobile phase, and flow rate.
### Specifications

**P1000:** Isocratic pump using a dual in-line and floating piston design, bayonet-mounted liquid ends, and patented ceramic check valves.

**Physical:** 14.5” (37 cm) × 6” (15 cm) × 18.5” (47 cm) (H × W × D)
38.6 lb. (18 kg)

**Wetted Surfaces:** 316 stainless steel, analytical and narrow-bore PEEK, semi-prep
other surfaces for all pumps: Teflon®, Tefzel®, sapphire, polyethylene

**Delay Volume:** < 800 μL, analytical
< 500 μL, narrow-bore

**Flow Rate Range:**
- 0.01 - 10.00 mL/min, analytical or narrow-bore pumps
- 0.01 - 30.00 mL/min, semi-prep PEEK pumps

**Flow Accuracy:**
- < 1% at 1.0 and 4.0 mL/min, analytical or semi-prep
- < 1% at 0.2 and 1.0 mL/min, narrow-bore

**Flow Precision:** Typically < 0.2% at 0.5 mL/min or greater

**Pressure Range:**
- 42 MPa or 420 bar or 6000 psi, analytical or narrow-bore
- 28 MPa or 280 bar or 4000 psi, semi-prep

**Pressure Pulsation:** Typically < 1.0% at 1 mL/min

**Method Files:** 1 method + 1 Shutdown

**Communications:** Remote Inputs: Ready, Run, Stop
Timed Events
Analog Pressure output
RS-232

**Power:**
- 115/230 VAC, 50/60 Hz
- 1.2/0.6A 200 VA

**Safety/EMC Compliance:** CSA, TÜV, FCC, CE Mark, EMC and Low Voltage Directives
2

A Quick Example

Introduction

This chapter gives you the chance to become familiar with your
pump's screens and menus. It provides you with the three basic rules
you'll need for using your pump menus. It also introduces you to the
instrument's command center and describes the conventions we'll use
in this manual. In this chapter you will set up a few typical options,
purge your solvent lines, and run a flow stability test.

If you already feel comfortable with how to move through menus and
displays, just scan this chapter and proceed to Chapter 3. If you want
more practice with the pump menus, follow the instructions in this
chapter closely. Since the object of this chapter is to become familiar
with the keypad and menus, we won't provide detailed explanations
of the examples shown. More information can be found in one of the
succeeding chapters.

If you haven't installed your pump, be sure that you read the Safety
Information at the front of this manual and follow the procedure in
Chapter 1.

Throughout our explanations, we encourage you to explore the
general architecture of the instrument's menus and screens.

Learning Your
Way Around

AS EASY AS 1-2-3!

It's easy to learn your way around a SpectraSYSTEM or
SpectraSERIES pump. Just remember these three easy rules:

1. The (\&, \|, [<, [>] move the cursor in the direction printed
on the key.

   HINT: Press [MENU] to jump quickly to the top of the menu structure.
2. The shape of the cursor determines how you make a selection:
   • If a triangular cursor appears, press [ENTER]
   • If a blinking square cursor appears, press the [+] or [-] keys to scroll up or down through preset choices, or to increase or decrease alphanumeric entries.

3. There are four ways to accept (and automatically save) an entry. Just move the cursor out of the field by any of the following methods:
   • Pressing [ENTER]
   • Using the arrow keys
   • Pressing [MENU]
   • Pressing [STATUS]

   ![NOTE: If you can't leave a menu, either errors are present or you haven't filled in all the necessary entries.]

**VISUAL CLUES ON DISPLAY**

Several visual clues help you move through the pump's menus and enter values.

1. Top-level menu choices are displayed in all-capital letters; lower-level menu choices are displayed in upper- and lowercase letters.

2. A field's square cursor changes to an underscore cursor when you're scrolling through preset choices or entering numerical values and characters.

3. A solid down-arrow (▼) on the right side of some displays indicates that the current menu continues on additional screens. To access additional menu lines, press the down-arrow key, [▼].

4. The last line of a longer menu is frequently a blank line (without a solid down-arrow).
Instrument Control

Take a look at the keypad and two-line display located on the front panel (Figure 2.1). This is the command center from which you'll access menus and control the instrument's operations. A brief explanation of the keys and the main menus and screens follows.

![Keypad Image]

*Figure 2.1 The P1000 pump keypad*

The keypad of each SpectraSYSTEM instrument consists of twelve keys. Four keys directly control the instrument's operation: [RUN], [STOP], [STATUS], and, on the pump, a blank key called [Purge]. The remaining keys ([MENU], [ENTER], [∧], [∨], [<], [>], [+], [-]) either access commands or are used to set parameters and move around the display. The function of each is explained below.

**[RUN]**

Generally, pressing [RUN] starts a run or sets up the conditions specified for the beginning of a run.

The specific [RUN] operation depends on the instrument's state:

If the pump's state is STOP, pressing [RUN] automatically prepares the last file loaded (the P1000 has only one file) to be run and sets the pump to the conditions specified for the start of the run ($t_0$ conditions).
[STOP]
Pressing [STOP] halts an operation in progress. (Specifically, the [STOP] key stops a run in progress by stopping solvent flow through the pump.)

[STATUS]
Pressing [STATUS] displays the Status Screen. From the Status Screen, you can monitor the run in progress. You can also access the Status Menu. See page 26 for more information.

[Purge]
The unlabeled key is the only variable key in the whole SpectraSYSTEM family. On the pump, the blank key is the [Purge] key. The key's name appears on the nameplate below the key.

The [Purge] key brings the PURGE Screen to the display. Purge parameters can be changed and the purge operation started from this display. Refer to Purging Solvent Lines in Chapter 3 and to Priming and Purging the Pump in Chapter 1 for complete information.

[MENU]
Pressing [MENU] displays the Main Menu. Each Main Menu item is explained in detail in the rest of this manual. For FILE(s) and COMMANDS, see Chapter 3. For OPTIONS and TESTS, see Chapter 4.

NOTE: The P1000 Main Menu choices are FILE, OPTIONS, and TESTS.

[ENTER]
Pressing [ENTER] accepts a selected choice or menu entry. The [ENTER] key also advances the cursor to a new field, either on the same line of the display or in the line below.

[∧], [∨], [<], and [>]
Pressing any arrow key (up, down, left, or right) moves the cursor in the direction indicated on the key. If the cursor is on the first or the last line of a menu, the up- and down-arrow keys move you "up" or "down" in the menu structure.
[+] and [-]

Pressing the [+] and [-] keys scrolls you through a field's available choices or changes the value of alphanumeric entries. Holding down either key will continuously scroll the list of choices forward or backward until you release the key.

In fields that require numeric entries, the value of the selected digit is increased or decreased by one unit each time you press the [+] or [-] key. In fields that accept either numeric or alphabetic entries, such as the File Name field, the [+] and [-] key scroll through the alphabet from A to Z, then through the numbers 0 to 9, and finally to a slash, hyphen and blank space.

In other fields, the [+] key advances you through a preset list of choices while the [-] key takes you back through the list.

MENUS AND SCREENS

Your pump has two kinds of displays: menus and screens. Menus require you to make selections or enter specific values. Screens display information that cannot be edited. The Menu Tree in from pocket of your manual illustrates the structure and content of the pump's menus and screens.

Main Menu

The Main Menu is the top level of the menu structure. The Main Menu gives you access to several other menus. In the P1000 there are three menus: FILE, TESTS, and OPTIONS. To see the Main Menu, press the [MENU] key at any time.

```
>FILE    TESTS
OPTIONS
```

Figure 2.2 Main Menu (P1000)

From the File Menu you can edit, load, or delete a file. In the Options Menu, you can set up or change your instrument's configuration. The Tests Menu provides access to performance-related diagnostic tests and maintenance-related menus. Refer to Chapters 3 and 4 for more information on any of the instrument menus.
**Status Screen**
The status screen automatically appears whenever you turn on the instrument or press the [STATUS] key. The P1000 Status Screens (Figure 2.3) show the pump's state (or purge time), flow, and pressure. Below either Status Screen is the Status Menu, described next.

<table>
<thead>
<tr>
<th>Status</th>
<th>Flow</th>
<th>PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>READY</td>
<td>1.00</td>
<td>1250</td>
</tr>
</tbody>
</table>

*Figure 2.3 The Status Screen (P1000)*

**Status Menu**
Just below the Status Screen is the Status Menu. To access the Status Menu, press the down-arrow key from the Status Screen. The Status Menu lets you review and edit run parameters during a run (Chapter 3).

**MESSAGES**

Three kinds of messages can appear on the pump's display: user messages, confirmation messages, and error messages.

**User messages**
User messages (Figure 2.4) tell you about an existing instrument condition or ask for further action. Some of these will only appear on the display for three seconds. An example of a message requiring further action is shown in Figure 2.4.

*To install or remove liquid ends, press ENTER*

*Figure 2.4 An example of a user message*

**Confirmation messages**
Confirmation messages (Figure 2.5) indicated on the display by asterisks appear for one second after an operation has been carried out successfully.

* * File Loaded * *

*Figure 2.5 An example of a confirmation message*
**Error messages**

Error messages (Figure 2.6), indicated on the display by exclamation points, are displayed whenever an undesirable condition exists that prevents the instrument from carrying out an operation. Error messages remain on the display until you press a key.

![Max Pressure Exceeded](image)

*Figure 2.6 An example of an error message*

**Practice Examples**

This section will take you step-by-step through four operations:

1. Setting a display option.
2. Creating a file.
3. Purging a solvent line.
4. Running a flow stability test.

These examples assume that the pump is properly installed using the procedures in Chapter 1 and that the bypass valve’s outlet is routed to a solvent waste container.

**SETTING A DISPLAY OPTION (CHANGING PRESSURE UNITS)**

The pump’s default display can be changed to suit your own needs. For example, you can use the steps below to change the pressure units from the default in PSI to megapascals.

1. Press [MENU]. Press [>] to move the cursor to /Options/, then press [ENTER] to access the Options Menu.
2. Press the down-arrow key [∨] until you see the /More/ selection. With the cursor next to /More/, press [ENTER] to access the More Menu.
3. The display now looks similar to Figure 2.7:

<table>
<thead>
<tr>
<th>Pressure Units</th>
<th>PSIv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Purge Mode</td>
<td>Flow</td>
</tr>
</tbody>
</table>

*Figure 2.7 The More Menu*
4. The cursor should be to the right of the value in the Pressure Units field (PSI). Press [+ ] until the field shows MPa.
   You have just changed the display so that all pressures will be shown in megapascals. If you prefer other units, press [+ ] until you see another preset choice that suits you.

5. You’ll also need to move the cursor between fields to set method parameters. For example, move the cursor down to the Purge Mode field. Use [+ ] to see the Pressure selection (pressure). Press [+ ] once more, to change the Purge Mode selection back to Flow.

6. You can exit the More Menu in several ways. This time, press [STATUS] to exit the menu.

7. Press [ ] to display the Status Menu, which shows the run file.

EDITING A FILE

Editing a simple file is a good way to become familiar with entering values and moving the cursor between menus.

1. Press [MENU].
2. With the caret (>) next to /FILE(S)/, press [ENTER] to access the File Menu.
3. The cursor should be on the /Edit/ selection. Press [ENTER] to access the Edit Menu. The cursor is in the Flow Rate field (P1000).
4. For the P1000 (Figure 2.8), use the [+ ] key to enter a flow rate of 1.50 mL/min in the Flow Rate field.

   | Flow Rate | 1.50 |
   | Maximum Pressure | 6000 |
   | Minimum Pressure | 0 |

   Figure 2.8 The Edit Menu (P1000)

5. Press [ ] until you return to the File(s) Menu.
PURGING A SOLVENT LINE

You might already be familiar with the purge operation from Appendix A. If so, skip this example and go on to Running a Flow Stability Test.

In this example, you will purge a solvent line.

1. Open the bypass valve on the pump. Make sure that the bypass valve outlet is routed to a solvent waste container.

2. Press [STATUS]. The Status Screen should show that the pump is stopped (Figure 2.9)

<table>
<thead>
<tr>
<th>Status</th>
<th>Flow</th>
<th>MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP</td>
<td>1.50</td>
<td>1</td>
</tr>
</tbody>
</table>

---

<table>
<thead>
<tr>
<th>Flow</th>
<th>MaxP</th>
<th>MinP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.50</td>
<td>21</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 2.9 Status Screen and Status Menu (P1000)

3. Leave the Status Screen and go to the Purge Menu by pressing [PURGE] (the blank key). The cursor should be in the Purge field. Note that the screen displays the flow rate in mL/min and the purge time in min. See Figure 2.10.

<table>
<thead>
<tr>
<th>Purge</th>
<th>Flow</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.50</td>
<td></td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 2.10 The Purge Menu (P1000)

Now you will actually begin the purge cycle.

4. Move the cursor to the Time field either by pressing [ENTER] or [>] . Enter 2.00 minutes in the Time field, then press [ENTER].

The pump motor will start. The pump will purge solvent for two minutes at the flow rate shown in the Flow field. You can stop the purge operation at any time by pressing [STOP]. After the purge is complete, the pump will automatically initialize the run file.

Remember to close the bypass valve immediately following the purge so that solvent flow returns to the LC.

RUNNING A FLOW STABILITY TEST

The flow stability test is a common test of the pump's performance. The pump must be running, or be in a READY or EQUIL state for this test to be initiated, and the flow rate must be greater than
0 mL/min. If you need to change the flow rate, edit the flow setting from the Status Menu, then proceed with the steps below.

NOTE: The Flow Stability test can be completed only when the pump is in a READY state although it might be initiated while the pump is in any of the states mentioned above.

1. When the Status Screen shows READY, press [MENU] and select /TESTS/.
2. Select /Diagnostics/ from the Tests Menu.
3. The cursor should be on /Flow Stability/. Press [ENTER].

After a short time, the flow stability rating followed by a numerical value will appear. STABLE flow corresponds to a reading between 0 and 25, ACCEPTABLE is between 26 and 90, and UNSTABLE is a value greater than 90.
Basic Operations

Introduction

This chapter contains a general theory of LC pump operations, recommended laboratory practices, and how to perform routine operations on your SpectraSYSTEM P1000 pump. Specifically included are procedures for editing, loading and running a file, and reviewing the pump operations status.

Before beginning this chapter, be sure that you have properly installed the pump using the procedures in Chapter 1 and that you are familiar with the pump keypad and menus as discussed in Chapter 2.

Theory of Operation

The pump is typically the second of five components in an LC system (degasser is the first). A pump delivers a steady flow of one or more solvents to a sample-injection instrument (generally an autosampler). This solvent flow continues through the column and on to a detector. From the detector, a signal is passed to an integrator, a recorder, or another kind of data system capable of collecting the data and allowing the data of the injected sample to be analyzed. The P1000 isocratic pump precisely and accurately delivers a mobile phase to the LC.

Solvent flow rate is specified in the run file. The solvent travels to the pump head where a piston meters the flow of the mixture to an outlet tube. The pump's outlet tubing then connects the solvent stream to an automatic or manual injector.

SpectraSYSTEM P1000 Isocratic Pump

The SpectraSYSTEM pump has been designed for ease of use and unsurpassed performance. Any one of them can be used as a stand-alone pump or as a module in a totally automated LC system.

The P1000 is a single-solvent isocratic pump. Rugged, reliable, and easy to use, it features a Shutdown option and Maintenance Log. The P1000 can be connected to other SpectraSYSTEM modules through RS-232 communication.
The SpectraSYSTEM P1000 pump is engineered for reliability and ease of maintenance. Easy maintenance helps to ensure that your chromatography results are accurate and remain accurate. The built-in, patented Maintenance Log (Chapter 5) allows you to follow the life span and use of seals, pistons, and check valves. If service is ever required, the resident diagnostics and modular design of the pump will keep downtime to a minimum. The simplicity and durability of the pump means that a minimum of spare parts needs to be kept on hand.

Table 3.1 File Characteristics for P1000 Pump

<table>
<thead>
<tr>
<th>File Characteristics</th>
<th>P1000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Lines/File</td>
<td>0</td>
</tr>
<tr>
<td>Total Number Files</td>
<td>1</td>
</tr>
<tr>
<td>Total Time Lines</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>(flow rate only)</td>
</tr>
</tbody>
</table>

OPTIONS

Narrow-bore

LC refers to the use of narrow-ID, 2.0-3.0 mm columns for LC separations. To optimize LC instruments for narrow-bore LC, standard LC hardware must be modified to reduce extra-column volume. Specific hardware modifications include minimizing the pump’s dead volume, the detector flowcell’s volume, and the volume contained in any interconnecting tubing and fittings. The lower system volume of narrow-bore LC increases sample concentration, which results in greatly improved sensitivity. Decreased solvent consumption reduces operating costs as compared to standard (4.0-4.6 mm ID) LC separation techniques.

NOTE: For narrow-bore applications we recommend you use a 20 \( \mu \)L sample loop in Thermo Scientific autosamplers.

Hardware Modifications

Autosamplers: For the SpectraSYSTEM narrow-bore autosamplers the pump-to-autosampler tubing (~ 6 inches long) and pre-heat tubing (~ 24 inches long) has been changed from 0.020-inch ID to 0.007-inch ID.

Operational Considerations

Injection Mode: We recommend that you consider the following in setting up your methods and LC instrumentation. Due to the manner in which the pump firmware stores certain values and references the hardware, the minimum operating pressure for the P1000 pump is 200 psi.
We recommend that you use the PushLoop® mode for most narrow-bore applications; however, depending on your sample volume, other injection modes might be more beneficial in some cases (see below).

The following algorithms define the amount of sample needed for your injection volume:

- PushLoop (Injection Volume + 15 μL)
- Pull Loop (Injection Volume + 1.1 μL)
- Full Loop (Injection Volume x 1.33) + 70 μL

In PushLoop mode, the smallest settable sample volume is 0.1 μL. Allowed volume increments are also 0.1 μL. You should not inject more than 10 μL without changing the standard 20 μL loop. The autosampler is supplied with a 20 μL loop.

**Reducing Extra Column Volume:** Minimizing extra column volume maximizes analytical efficiency. Band-broadening can occur in several ways. With narrow-bore columns, it is vital that good plumbing connections are made. Otherwise, a dead volume created by a bad fitting can result in much lower than expected efficiency and peak resolution. Use zero dead volume (ZDV) fittings only with the proper nuts and ferrules. Cut and debur tubing with the proper tools. For polymer tubing (for example PEEK), use a "guillotine" cutter to ensure straight, right-angle cuts.

The flowcell volume is probably the single largest contributor to extra column volume in a narrow-bore system. Use the smallest internal volume cell you can find, subject to path length requirements.

**Instrument Startup**

Be sure you have installed the pump according to Chapter 1 and have completed the Startup Checklist.

When you turn on the pump, the Status display appears. This allows you to check the instrument settings before entering your parameters. As described in Chapter 2, it is possible to edit a file under the Status Menu. If you have turned on the pump before, and have used this editing capability, the Status Menu will contain the parameters last saved.

At powerup, there are no messages to alert you that a file is being loaded, but you can check the file number and name by pressing the [STATUS] key. Then use the down-arrow key to scroll to the file listing. (Both the [STATUS] key and the creation of files are discussed later in this chapter.)
Some Routine Operations

Ordinarily, you perform these operations with your pump every day:

- Edit a file (or create a new file) and load a file to run
- Run your samples
- Purge the solvent lines
- Check the pump's status
- Monitor pump performance
- Shut down the pump at the end of the day

The rest of this chapter is devoted to explaining these basic operations. If you need to, refer to the keypad “rules” in Chapter 2. You might also want to refer to the basic menu structure presented on the quick reference cards in the front pocket of your manual.

The File Menu

In this section we describe how to set up the files that control pressures, flow rates, and run times. Each of the file operations accessed from the File Menu is briefly defined, then described in detail.

To access the File Menu, press [MENU] and select /FILE/. The File Menu is shown in Figure 3.1.

![Figure 3.1 The File Menu (P1000)](image)

*Edit · Load · Delete*

**Edit**
Select /Edit/ if you want to change the parameters in an existing file, or create a new file.

**Load**
Select /Load/ to load the file you want the pump to use when in operation. The loaded file is referred to as the run file.

**Delete**
Select /Delete/ to return all file parameters to their default values. An information message allows you to cancel the delete operation before the file is deleted. The default file parameters are as follows:
- Flow rate = 1.00 mL/min
- Maximum Pressure = 6000 (depending on the selected pressure units)
- Minimum Pressure = 0
EDITING A FILE

The P1000 contains only one file and its Edit Menu (Figure 3.2) consists of three fields.

<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>1.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Pressure</td>
<td>6000</td>
</tr>
<tr>
<td>Minimum Pressure</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 3.2 The Edit Menu (P1000)

**Flow Rate:** Enter a flow rate in mL/min. The maximum flow rate is determined by the liquid ends and head type. The head type is preset in the Maintenance Log Head Type field by Thermo Fisher Scientific. The flow range of your liquid ends was preset by Thermo Fisher Scientific.

*NOTE:* If you change the liquid ends, refer to the Maintenance Log description in Chapter 5.

**Maximum, Minimum Pressures:** Change the pressure levels as desired. The maximum value is 6000 psi, the minimum is 0 psi. (The allowed values depend on the pressure units.) The maximum pressure value must be greater than the minimum pressure. The pump will not allow you to set maximum and minimum pressures to values that are inconsistent. If you are unable to edit one value, try to edit the maximum valve first.

*NOTE:* Select pressure units (psi, bar, or MPa) from the Main Menu. Press /Menu /OPTIONS/, /More/ as described in Chapter 4.

Creating the Run File - A P1000 Example

Enter run parameters in the P1000 by first selecting /FILE/, /Edit/. The Edit Menu is shown in Figure 3.3.

<table>
<thead>
<tr>
<th>Flow Rate</th>
<th>2.50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Pressure</td>
<td>4000</td>
</tr>
<tr>
<td>Minimum Pressure</td>
<td>0</td>
</tr>
</tbody>
</table>

Figure 3.3 Example P1000 Edit Menu

Simply enter a flow rate, and the maximum and minimum operating pressures.

*NOTE:* Parameters are also easily changed from the Status Menu. Press [STATUS], then [v] to access active fields.

SHUTDOWN FILE

The Shutdown file in the P1000 is accessed from /OPTIONS/, /Shutdown/.
Making use of the Shutdown file assists you with the proper maintenance of the pump. Since your pump and column should never be allowed to sit idle with salts or corrosive materials in them (including water), the Shutdown file lets you automatically flush the pump and the column at the completion of a series of samples.

Whenever the pump detects that it has been in a READY state, without a run being initiated for a specified period of time, it automatically loads, initializes, and runs the Shutdown file when time from Ready has been reached.

**NOTE:** The pump’s clock is reset any time the [STOP] key is pressed.

Some instances when you might want to use a shutdown file are:
- to keep solvent at a very low flow rate flowing through the LC
- to clean the column and keep the pump running
- to clean the column, then stop solvent flow through the LC

**NOTE:** If the pump will be operated unattended for an extended period of time, ensure that the solvent reservoir and waste containers have sufficient capacity.

If you use an autosampler, specify the time interval to be longer than the cycle time on the autosampler (for example, \[1.5 \times \text{cycle time}\], or \[\text{cycle time} + 20 \text{ minutes}\]). If you perform manual injections, set the time interval to the maximum time likely between injections. Depending on your own circumstances, you might want to turn the Time from Ready to "Off."

The P1000 Shutdown Menu is shown in Figure 3.4. The Flow field contains the flow rate parameter. The Time field contains 11 preset choices: Off, and ten time values, ranging from 5 to 480 minutes. The value selected in the Time field is the length of time the pump will remain in a READY state before it automatically loads and runs a shutdown file. So, for example, if you select 60 minutes, then whenever the pump senses that it has been READY for 60 minutes without a run being started, it will load and run the Shutdown parameters.

<table>
<thead>
<tr>
<th>Flow</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>20</td>
</tr>
</tbody>
</table>

*Figure 3.4 The Shutdown Menu (File), accessed from /OPTIONS/, /Shutdown/*

**When the Shutdown File Loads Automatically**

If the Shutdown file is loaded automatically, when it reaches the last time line of the Shutdown file, the pump will maintain (Hold) the last
time line's flow rate indefinitely if the flow rate is greater than zero (> 0.0).

LOADING A FILE

For the P1000, select /LOAD/ and the file is loaded. A message will confirm that the file was loaded. A loaded file is referred to as the run file.

As soon as a file is loaded, the pump will initialize the file, that is, bring the pump to the conditions specified on the zero (0.0) time line of the file. The Status Screen shows INIT. If an equilibration has been specified, the pump will then show EQUIL until the equilibration time has been reached.

After initialization and equilibration, the Status Screen then shows that the pump is READY. The pump's clock will not start unless a run is triggered either manually by pressing [RUN] or from a properly connected (hardwired) autosampler.

DELETING A FILE

For the P1000, selecting /DELETE/ will delete the file.

When you delete a file you are actually returning all parameters in the file to their default values.

Purging Solvent Lines

If the solvent line contains air, refer to Priming the Pump in Chapter 1.

Air will slowly diffuse through the thin-wall Teflon inlet tubing, and into the solvent. If the pump flow has been turned off or if the solvent line has not been used in the past several hours, the line should be purged with degassed solvent before use.

The purge operation can be activated when the pump is in any state.

NOTE: Open the bypass valve prior to purging, or else ensure that your chromatographic column can withstand the purge parameters you set before performing any purge.
THE PURGE MENU

Pressing the [PURGE] key displays the Purge Menu.

NOTE: DO NOT move the cursor out of the Time field using the [ENTER] key unless your LC is ready to start a purge.

<table>
<thead>
<tr>
<th>Purge</th>
<th>Flow</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Figure 3.5 The Purge Menu (P1000)

Purging can be accomplished in any of three purge modes: Flow, Pressure, or Both. Table 3.2 describes purging across the three modes.

Table 3.2 Purging mechanisms for the three purge modes

<table>
<thead>
<tr>
<th>Modes</th>
<th>Purging requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Mode</td>
<td>Regulated by the flow rate from the pump</td>
</tr>
<tr>
<td>Pressure Mode</td>
<td>Accomplished at a specific pressure</td>
</tr>
<tr>
<td>Both Mode</td>
<td>Uses both flow and pressure parameters</td>
</tr>
</tbody>
</table>

Internal limits are designed to protect your LC system: in flow mode, the pump will accept rates of 0.01 to 10.0 mL/min. The maximum pressure the pump allows in flow mode is the maximum pressure value from the current run file; in pressure mode, the maximum flow the pump will reach in attaining the set pressure is 6 mL/min.

NOTE: Purging in Pressure or Both modes with the bypass valve open might not allow sufficient pressure to be generated in the system. The pump will operate at maximum flow, but the target purge pressure might not be achieved. Ensure that your analytical column can withstand the purge pressure (or use a flow restrictor or old column), and do not open the bypass valve.

The purge mode is changed from /OPTIONS/, /More/, Purge Mode.

The top line of the Purge Menu will show either Flow or pressure units (PSI, BAR, MPa), depending on the purge mode you select.
**Flow or pressure (PSI, BAR, or MPa)**
The flow rate is taken from the last time line of the run file. Use this field to select a flow rate. If the purge mode is pressure, the pressure is automatically set to one-half (50%) of the maximum pressure level set in the run file.

*NOTE: To change the purge mode you must go to /OPTIONS/, /More/, Purge Mode. Refer to Chapter 4 for complete information.*

**Time**
The Time field is used to set the length of time you want the pump to purge. If the field remains 0.0, purging, once started, will continue until you press the [STOP] key.

*NOTE: When you check the purge operation from the Status Screen, the time remaining to complete the purge is shown below the word Status.*

**Starting a Purge**
To initiate a purge cycle, move the cursor out of the Time field by using the [ENTER] key.

The pump will begin to purge solvent. If the time stays set to 0.0, purging will continue until you press [STOP], or a file is initialized. If a time is entered, the pump will purge until the time set. After completing a purge, the pump automatically initializes the run file.

When running in a timed purge mode, the Status Screen will indicate the time remaining to purge (that is, counts backwards toward 0.0). If the [PURGE] key is pressed once more, the Purge Menu is again displayed and the time countdown continues, uninterrupted, unless the cursor is moved out of the Time field by pressing [ENTER], at which point the timer will be reset and purging will restart.

The pump will retain the selections made in the PURGE display as long as the power to the pump is on.

**Stopping a Purge**
There are three ways to stop a purge cycle:

- Press the [STOP] key
- Load (initialize) a file by selecting a file using /FILE(S)/, /Load/
- Allow the pump to complete the purge (if a time has been specified), at which point the pump will automatically initialize the last run file.
Starting a Run

To perform a run:

- Purge the solvent lines if necessary
- Load a file or press [RUN] to establish a READY state,
- Inject the sample, and
- Press [RUN].
- If you are performing a manual injection, fill the injection loop, check that the Status Screen shows READY, inject the sample, and press [RUN] in succession.
- If an autosampler is hardwired to the pump, simply initiate the autosampler run sequence.

**NOTE:** Generally, when operated manually, if the pump is stopped (i.e., the Status Screen shows STOP), the run file can be initialized by pressing [RUN], and then started by pressing [RUN] again when the Status Screen shows READY.

ESTABLISHING READY

The READY state means that the pump has reached the conditions specified on the first line of the solvent program and is ready to start a run.

Initializing a File

To achieve the READY state, initialize a run file, by any of the following methods:

- Load a file by selecting /FILE/, /Load/, and then pressing [ENTER].
- If the pump is stopped (Status Screen shows STOP), press [RUN]. This initializes the run file, without starting the run.

Wait for the pump to reach zero time line conditions. If an equilibration time was specified in the file, the Status Screen will show EQUIL for this period of time.
PRESSING [RUN]

As soon as the pump shows READY, begin the run by pressing the [RUN] key. This starts the pump's clock.

**NOTE:** Even though the pump might be ready, your column and the rest of your LC system might not be! Take into account your own LC application and ensure that your column is at chemical equilibrium and that the other instruments in your system are ready before you proceed with any injection.

STOPPING THE PUMP

There are a number of ways to stop the pump, depending on what you want to do next.

By Pressing [STOP]

If you want to completely stop the pump, press [STOP]. This stops the run and stops solvent flow through the pump. If you want to resume with the same file, you must initialize the run file by pressing [RUN], waiting for the pump to show [READY], then pressing [RUN] again.

While the Pump is Running

There are several messages which can appear in the Status field. These are discussed in detail in the Status section below.

While the pump is running you can do several things without disturbing pump operation:

- Edit files (/FILE(S)/, /Edit/).
- Check some pump performance parameters.
- Edit the run file from the Status Menu. (This has an effect on the current run. See page 42 for more information.)

Status

The Status Screen appears whenever the pump is powered on, a file is initialized, or the [STATUS] key is pressed. The Status Screen, consisting of two lines, shows the pump's current operating values. Below the Status Screen is the Status Menu, where you can view and, if necessary, edit the run file parameters.
STATUS MESSAGES

The P1000 can show any of the following messages:

**Table 3.3 Status Messages**

<table>
<thead>
<tr>
<th>Message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(time)</td>
<td>The time into the run (or time remaining if a timed purge).</td>
</tr>
<tr>
<td>INIT</td>
<td>The pump is initializing a file.</td>
</tr>
<tr>
<td>READY</td>
<td>The pump has achieved the conditions on the first line of the run file, and the equilibration time has elapsed (if set). A run can be started. READY, shown in Status.</td>
</tr>
<tr>
<td>RUN</td>
<td>Appears briefly when the pump begins a run.</td>
</tr>
<tr>
<td>STOP</td>
<td>All mobile-phase flow through the pump is stopped.</td>
</tr>
<tr>
<td>SYNC</td>
<td>This is a remote communications message that appears briefly whenever a run is started. At lower flow rates, it might be seen for longer periods of time.</td>
</tr>
</tbody>
</table>

**STATUS EXAMPLES**

Shown below are two examples of an entire Status Screen and Status Menu.

**P1000**

<table>
<thead>
<tr>
<th>Status</th>
<th>Flow</th>
<th>PSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>READY</td>
<td>1.00</td>
<td>1250</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flow</th>
<th>MaxP</th>
<th>MinP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>6000</td>
<td>0</td>
</tr>
</tbody>
</table>

*Figure 3.6 Example Status Screen and Status Menu*

The first and second lines of the display show the state, flow, and pressure.

**EDITING A RUN FILE**

The remaining lines, which comprise the Status Menu, show the parameters and options of the run file. If the run file and options do not appear, the Status Lock feature has been turned on. (Status Lock is described in Chapter 4, under the OPTIONS, More Menu.)

All time lines of the run file's solvent program can be edited while the pump is running, as can the maximum and minimum pressures, and the equilibration time. Any changes take effect as soon as the cursor leaves each field. However, the changes are saved only when the /Save File/ command is selected from the Status Menu.
Monitoring Pump Performance

SpectraSYSTEM pumps can automatically monitor their own performance and warn you if a flow problem exists. These options (not to be confused with File Options), are described in detail in Chapter 4.

Certain flow conditions are monitored continuously. For example, if a time line with a zero flow rate has been encountered, the pump responds with the appropriate error message shown below. As mentioned earlier, you can select the pump's response to certain conditions.

```
!! ZERO FLOW RATE !!
```

```
!! MAX PRESSURE EXCEEDED !!
```

Figure 3.7 Example error messages resulting from flow problems

To choose a pump response, select /OPTIONS/, /Error Recovery/. (See Chapter 4, Options section.)

The pump can also initiate a Flow Stability Test. This test is run by selecting /TESTS/, /Diagnostics/, /Flow Stability/. The results are continuously displayed until another key is pressed. The results consist of two parts. The first is a summary of the performance evaluation (STABLE, ACCEPTABLE, or UNSTABLE) and the second is a number that indicates a position in each range. Further explanation of this test can be found in Chapter 4.
Shutting Down at the End of the Day

Some shut down suggestions when you conclude your work with the pump for the day:

- Do not leave buffers in the pump or in your LC; purge the pump (water is a good solvent) if it has just concluded a run using buffered solutions. (Don't leave water in your LC.)
- Leave the column full of a solvent recommended by the column manufacturer.
- Open the column bypass valve and purge using the same solvent as in the column so that the liquid ends are filled with that solvent.
- Make use of the Shutdown file. The pump will automatically maintain the conditions specified in the last or only line of the file. This is particularly useful if you prefer to have a small but continuous flow of solvent through your LC system while it is idle.
4

Advanced Operations

Introduction

This chapter focuses on three top-level menus: Options, used to set important, yet seldom changed features, and Tests, used to run the built-in diagnostics.

The Options Menu

The Options Menu (accessed from the Main Menu, not from /FILES/), contains seldom-changed features such as the pump's response to certain electrical and flow conditions it detects, user-selected display and operational preferences, and file protection.

```
>FILE  ·TESTS
  †OPTIONS
```

*Figure 4.1  The P1000's Main Menu with /OPTIONS/ selected*

The P1000 Options Menu is shown in Figure 4.2.

```
>Shutdown
  ·Error Recovery
  ---------------------------------------------
  ·More

*Figure 4.2  The Options Menu (P1000)*

ERROR RECOVERY MENU

The pump continuously checks pressure so that problems can be indicated immediately on the display. The pump can also sense a power failure or power interruption. The Error Recovery Menu (Figure 4.3) is used to preset the pump's response to detecting error conditions in any of these three operating parameters.

```
<table>
<thead>
<tr>
<th></th>
<th>Stop</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Power Fail</td>
<td>Stop</td>
</tr>
<tr>
<td>@Maximum Pres</td>
<td>Stop</td>
</tr>
</tbody>
</table>
```

*Figure 4.3  The Error Recovery Menu*
Each field in the Error Recovery Menu can be set to one of three selections:

<table>
<thead>
<tr>
<th>Selection</th>
<th>Pump's Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>The pump stops immediately if the condition is encountered.</td>
</tr>
<tr>
<td>Continue</td>
<td>The pump continues as if the condition had not occurred.</td>
</tr>
<tr>
<td>Shutdown</td>
<td>The pump immediately stops, then loads and runs the Shutdown file.</td>
</tr>
</tbody>
</table>

**AC Power Fail**
The pump might sense a power interruption at any time. Select Stop, Continue, or Shutdown in the AC Power Fail field to stop, continue, or shut down the pump as soon as power is restored.

*NOTE: If the power switch is turned off while the motor is running, the pump considers this a power failure and will respond accordingly as soon as power is restored.*

**@Maximum Pres**
In a file's Options Menu, you can change the maximum pressure level (the default is 6000 psi). If the pump's operating pressure ever exceeds this value, the pump will operate based on your selection in the @Maximum Pres field. Select Stop, Continue, or Shutdown to set the pump's response to sensing operation at maximum pressure.
To access other options, select /More/ (Figure 4.4).

```
> Error Recovery
> More
```

Figure 4.4 Selecting /More/

The More Menu (Figure 4.5) contains additional, miscellaneous, user preferences, such as the units the pressure is displayed in and how quickly field choices scroll when the [+] and [-] keys are pressed and held.

```
Pressure Units     PSI
Purge Mode         Flow

------------------------------------------------------
Cursor Speed       Medium
Status Lock        Off
Ready Output Active H
```

Figure 4.5 The P1000's More Menu

**Pressure Units**
Select either PSI, BAR, or MPa as your preferred units. All menus and screens that show pressure units will reflect the selection.

**Purge Mode**
Select either Flow, Pressure, or Both in the Purge Mode field. Your selection is reflected on the Purge Menu and is used as the primary purge parameter. Select Flow if you want to purge based on a flow rate, Pressure if you want to purge based on an operating pressure, or Both if you want both flow and pressure parameters to govern purging.

Purging in Pressure or Both mode requires a certain amount of back pressure in the system. Ensure that your analytical column can withstand the purge pressure (or use a flow restrictor or old column), and do not open the bypass valve.

*NOTE: You can select the P1000 purge modes from the Purge Menu.*
Cursor Speed
Cursor Speed is used to change how quickly choices scroll on the display when the [+] and [-] keys are pressed and held, and how quickly a menu scrolls (up and down) when the arrow keys are pressed and held. Select Fast, Medium, or Slow.

Status Lock
Status Lock prevents a run file from being edited from the Status Menu.

The Status Screen is unaffected by Status Lock; it can always be viewed.

Ready Output Active
The Ready output, located on the back of the pump, continuously sends an electrical signal to any device hardwired to it. Use the Ready Output Active field to choose whether the signal is either a 5V signal (Hi) or a 0V signal (Lo) whenever the pump is in a READY state. If the pump is not READY the other signal is output. Whenever the pump's Ready Output is hardwired to a SpectraSYSTEM autosampler to coordinate injections, it should be set to provide "Hi" voltage in the READY state.

Shutdown Option (P1000)
The Shutdown Menu (Figure 4.6) contains the parameters the pump uses after it has been in a READY state, without a run being started, for a specified length of time after time from READY has been reached. More information about the Shutdown Menu is found in Chapter 3 on page 35.

<table>
<thead>
<tr>
<th>Flow</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>20</td>
</tr>
</tbody>
</table>

Figure 4.6 The Shutdown Menu
The Tests Menu

The Tests Menu allows you to access the pump’s built-in diagnostics, part of the pump’s advanced features. This section assumes that the source of the problem is known to be the SpectraSYSTEM pump. If you are not certain that the pump is the source of trouble, refer to General LC System Troubleshooting, on page 97.

To access the Tests Menu, select /TESTS/ from the Main Menu (Figure 4.7):

```
- FILE >TESTS
- OPTIONS
```

*Figure 4.7 Main Menu with /TESTS/ selected*

The Tests Menu (Figure 4.8) consists of five items. Tests are divided into three specific menus, for convenience: diagnostic tests, calibration tests, and service tests. The Maintenance Log is described fully in Chapter 5.

```
>Software Version
·Diagnostics
-----------------------------------------------
·Maintenance Log
·Calibration
·Service
```

*Figure 4.8 Tests Menu*

**ABOUT RUNNING TESTS**

Tests are internal computer programs that exercise the pump's hardware and circuitry and verify operation. If any abnormal behavior is found it is reported as a message or an electronic circuit board failure code. In most cases the test isolates the problem to the failed module or component.

**Active and Passive Tests**

There are active and passive tests. Passive tests can be initiated at any time as they do not affect either file memory or pump performance. Passive tests are usually initiated by pressing [ENTER]. Active tests require that the pump be idle before being initiated, since the pump's valves and motor might be engaged during the test. Usually, active tests are initiated by pressing [RUN], and are stopped by pressing [STOP]. Some tests stop by themselves. An active test should not be
performed while the pump is in operation, as it will interfere with pump operation.

NOTE: Pressing [STOP] during a passive test can interrupt pump operation.

Initiating Tests

To initiate a test, move the cursor to the test's name and press [ENTER]. Always follow the instructions displayed on the pump when you initiate a test. In some cases the message, "Pump must be stopped to run test" might be displayed if you attempt to run an active test while the pump is in RUN. Alternately, if the pump is stopped when you initiate a test you might see the message, "The Pump Must Be Running to Perform This Test." In most cases, the pump will initiate an active test if the pump is in INIT, EQUIL, or READY.

Usually you will press [ENTER] to initiate a passive test, or [RUN] to initiate an active test. Some tests display instructions. In these cases, follow the instructions in the message to proceed.

Test Results

After each test is run a message appears advising you of the results of the test. In most cases, if trouble is found, the message indicates the failure or failed component. Specific test menu descriptions begin below.

Flow Stability and Hardware Series Test Routines

Under most circumstances the Flow Stability and Hardware Series tests will provide a thorough evaluation of the condition of your pump. We recommended that these two tests be used first if the performance of the pump is in question. The Flow Stability test is described on page 51 and the Hardware Series Tests is described on page 61.

SOFTWARE VERSION (PASSIVE)

Selecting /Software Version/ displays the version of software contained in the pump. The particular version of software resident in your pump will vary depending upon the date of manufacture or upon the date of software upgrade.
THE DIAGNOSTICS MENU

The Diagnostics Menu (Figure 4.9) contains three items commonly used to evaluate the pump and an additional selection to allow the pressure transducer's output to be zeroed.

> Flow Stability
  · Measured Parameters
  --------------------------------------------------------
  · Check Valve Test
  · Zero Pressure

Figure 4.9 The Diagnostics Menu

Flow Stability

Your pump is constantly monitoring its flow stability while pumping. An internal software program allows the pump to determine when flow stability has been adversely affected by leaking check valves, out-gassing solvents, or other abnormal conditions.

The Flow Stability test (a passive test) evaluates how even the solvent flow is through the pump. The pump must be pumping solvent for this test to be run. The test can be initiated when the Status Screen shows any one of these states: EQUIL, or READY (all pumps). Completion of the test however, is dependent on the pump being in a READY state. When the pump is not in a ready state the Flow Stability screen will read, "Not Ready". When flow stability is being evaluated, the screen will read, "Test in Progress. Please Wait."

The pump's cam must go through at least 10 pump cycles (cam revolutions) to accurately assess stability. The value displayed is affected by the compressibility of the solvent being pumped and the compliancy of the hardware (tubing, column, etc.). Therefore, the results are reported in two ways: a) an overall judgment of the pump performance which appears in the upper left-hand corner of the display and b) a number indicating where, within the range, the result lies. This number is shown in the upper right-hand corner of the display. Three flow stability readings are possible:

<table>
<thead>
<tr>
<th>Status</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stable</td>
<td>0-25</td>
</tr>
<tr>
<td>Acceptable</td>
<td>25-90</td>
</tr>
<tr>
<td>Unstable</td>
<td>&gt;90</td>
</tr>
</tbody>
</table>

Unless a very volatile or compressible solvent is being pumped, for example hexane, a number near the higher end of the range (60-90) probably indicates that the system is not ideal, and the results of further troubleshooting might improve the flow stability.

NOTE: The Flow Stability Test might show unstable flow during column equilibration.
If the results of the flow stability test are abnormal for your LC application, follow these steps to locate the problem:

1. Test the integrity of the inlet and transducer check valves by running a Check Valve test. (See page 52.)
2. Verify that the mobile phase solvents are adequately degassed.
3. Refer to the recommendations of General LC System Troubleshooting Techniques in Appendix A, page 97.

The flow stability assessment will remain displayed until you stop the test by pressing any one of the following keys: [ENTER], [∧], [MENU], or [STATUS].

**Measured Parameters**
Measured Parameters (a passive test) shows the measured flow rate (Figure 4.10). The number in parentheses indicates the flow rate setting in the run file. The calculated flow is based on the flow calculated during the last 360° of motor rotation.

```
Calc Flow   (2.00)  1.95
```

*Figure 4.10  An example of the Measured Parameters Menu*

The measured parameters will remain on the display until the test is stopped by pressing any one of the following keys: [ENTER], [∧], [MENU], or [STATUS].

**Check Valve Test**
The Check Valve test (an active test) can help you further diagnose the source of flow stability problems. If the results indicate a defective check valve, the test should be repeated to ensure the results were not due to an isolated transient condition, such as a single air bubble.

This test affects flow accuracy while the test is running. Do not run the test during an analysis. The pump can be in EQUIL, or READY and the flow rate must be 2.5 mL/min or less (for standard liquid ends). If the test is activated and the current flow rate is greater than 2.5 mL/min, a message will be displayed, prompting you to reset the flow rate. In general, the flow rate must be set to one-quarter or less of the maximum flow rate of the liquid ends.

**HINT:** Defective check valves tend to perform better at higher column pressures. Lowering the column pressure by decreasing the flow rate increases the test's sensitivity of marginally operating check valves.

**NOTE:** The inlet check valve is located at the base of the inlet liquid end. The transducer check valve is located at the base of the pressure transducer.

To activate the test select /Check Valve Test/. Follow the displayed instructions. A message will inform you of the 8 - 10 pump cycle delay before test completion. During this time, the condition of the
Thermo Scientific 53

inlet and transducer check valves of the pump are monitored. When the monitoring period is complete, pumping returns to normal constant flow control and a message is displayed, showing the results. Messages are listed in Table 4.1.

NOTE: Changing mobile phase concentration might cause the test to report a good check valve as defective. Stabilize composition before running the test.

Pressing [RUN] after the results are displayed will rerun the test. Stop the test by pressing [ENTER] or [∧].

Table 4.1 Check Valve Test Results

<table>
<thead>
<tr>
<th>Message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both check valves good</td>
<td>Both check valves are performing well.</td>
</tr>
<tr>
<td>Transducer check valve is defective</td>
<td>The transducer check valve should be replaced. See Chapter 5, Required Maintenance for instructions.</td>
</tr>
<tr>
<td>Inlet check valve might be defective</td>
<td>The inlet check valve might be defective. An air bubble lodged in the check valve or piston seal or a slight leak in an inlet fitting might cause this message to be displayed. Verify that solvents are adequately degassed and that fittings are tight. Purge the pump and rerun the test to verify the message. If this same message is displayed, replace the inlet check valve. See Chapter 5, Required Maintenance for instructions.</td>
</tr>
<tr>
<td>Bubbles or leaks likely. Check degas</td>
<td>The check valves are not the cause of flow problems. Verify that solvents are adequately degassed and that fittings are tight. Observe the inlet tubing while purging the pump. If air bubbles are seen, increase the helium flow rate (if helium degassing), or tighten the leaking fitting. Tighten bottle caps. Ensure solvent supply is vented.</td>
</tr>
<tr>
<td>Test aborted, Pump not referenced in 10 Cycles</td>
<td>The pump is not able to establish a reference column pressure within 10 pump cycles. The pump has serious flow problems. Verify that the solvents used are miscible in all concentrations encountered. If possible for your column, increase the column pressure by raising the flow rate. The check valves require more than 100 psi column pressure to operate properly. Defective check valves will usually operate well enough at higher pressures to allow the test to run.</td>
</tr>
<tr>
<td>Test aborted By Operator</td>
<td>The test was stopped before the pump could count 8 cycles.</td>
</tr>
</tbody>
</table>
**Zero Pressure**
The pump allows the pressure transducer's output to be zeroed automatically without the need for adjustment of potentiometers. The pump should be stopped before selecting /Zero Pressure/. The display will show:

```
Release system pressure,
then press ENTER key.
```

*Figure 4.11  Release system pressure prior to zeroing the pressure transducer's output*

Release the system pressure by opening the bypass valve or removing the column from the system to ensure that the transducer is actually sensing zero system pressure. Otherwise, a message showing "Unable to Zero" will appear. Follow the instructions to complete zeroing the pressure. To abort the test, press [ENTER], or [∧], or [STOP]. This will return the zero setting to its previous value.

**THE MAINTENANCE LOG**

The Maintenance Log is fully described in Chapter 5, *Required Maintenance*.

**THE CALIBRATION MENU**

The Calibration Menu (Figure 4.12) contains a Flow Calibration "test". The flow Calibration can be run in one of three modes.

```
Flow Calibration
```

*Figure 4.12  The Calibration Menu*

**Flow Calibration**
The Flow Calibration Menu performs some internal calculations based on user-measured values. This is a passive test but it uses the [RUN] key. Unless run incorrectly, this test will not interfere with pump operation. Select /Flow Calibration/ to access the flow calibration menus.

The test is run in one of three modes. Select either Meter, Fixed Volume or Fixed Time from the Flow Calibration Menu (Figure 4.13). Depending on your selection, the display will allow you to enter values that enable the test to be completed. These are described in Figure 4.13.
Table 4.2 Flow Calibration Modes

<table>
<thead>
<tr>
<th>Calibration Mode</th>
<th>Value to Enter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Time</td>
<td>Measured Volume (mL)</td>
</tr>
<tr>
<td>Fixed Volume</td>
<td>Measured Time (min)</td>
</tr>
<tr>
<td>Meter</td>
<td>Measured Flow</td>
</tr>
</tbody>
</table>

**Fixed Time: Measured Vol (mL)**

This calibration mode assumes that you have collected and measured a specific volume pumped during a fixed time period. Selecting Fixed Time displays the Fixed Time Menu (Figure 4.14).

1. Enter the theoretical volume for the fixed time period in the Calculated Vol. field.
2. Enter the measured volume for the fixed time period in the Measured Vol. field.
3. Press [RUN] to initiate the test. During the test, the pump determines a new flow correction factor to compensate for the inaccuracy in the flow rate. The Flow Correction Menu displays the results of the test. Figure 4.15 shows example results.

<table>
<thead>
<tr>
<th>OLD</th>
<th>Flow Correction</th>
<th>NEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.00%</td>
<td>Use</td>
<td>101.00%</td>
</tr>
</tbody>
</table>

**Figure 4.15 The Flow Correction Menu with example fixed time calibration results**

*OLD*: The previous flow rate correction factor default or from a previous flow calibration test.

*NEW*: The new flow rate correction factor based on the Measured Vol. value.

*Flow Correction*: Use the [+]/- keys and press [ENTER] to select one of three choices:
Use: Use NEW flow correction factor. The factor remains in effect until you turn off the pump or initiated the NOVRAM.

Save: Save NEW flow correction factor to NOVRAM. This factor remains in effect until you save a different value over it, or until you reinitialize the NOVRAM (TESTS/SERVICE/Test 271). Test 271 replaces this value with the default flow correction factor.

Scrap: Discard the NEW (previous) flow calibration factor and keep the current value.

Press [RUN] to complete the test.

**Fixed Volume: Measured Time (min).**
This calibration mode assumes that you have externally timed the period in which a specific volume has been pumped.

Selecting Fixed Volume displays the Fixed Volume Menu (Figure 4.16).

<table>
<thead>
<tr>
<th>Calculated Time</th>
<th>10.00 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured Time</td>
<td>9.50 min</td>
</tr>
</tbody>
</table>

*Figure 4.16 The Fixed Volume Menu*
*(NOTE: The Measured Time value was artificially input to demonstrate the menu function.)*

1. Enter the theoretical time period for the fixed volume in the Calculated time field.
2. Enter the measured time for the fixed volume in the Measured Time field.
3. Press [RUN] to initiate the test. During the test the pump determines a new flow correction factor to compensate for the flow rate inaccuracy.

<table>
<thead>
<tr>
<th>OLD Flow Correction</th>
<th>NEW Flow Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.00% Use</td>
<td>101.00% Use</td>
</tr>
</tbody>
</table>

*Figure 4.17 The Flow Correction Menu with example fixed volume calibration results*

**OLD:** The previous flow rate correction factor default or from a previous flow calibration test.

**NEW:** The new flow rate correction factor based on the Measured Vol. value.

**Flow Correction:** Use the [+]/-keys and press [ENTER] to select Use, Save, or Scrap as described above.

4. Use the [+]/-keys to choose Use, Save, or Scrap.
5. Press [RUN] to complete the test.

**Meter: Measured Flow (mL/min)**

This calibration mode assumes that you have externally measured the precise flow rate that the pump is operating at while set at a specific flow rate.

Selecting /Meter/ displays the Meter Menu (Figure 4.18).

```
·Selected Flow.  1.00 Mn
·Measured Flow  1.00 Mn
```

*Figure 4.18 The /Meter/ Menu
(NOTE: The Measured Time value was artificially input to demonstrate the menu function.)*

1. Enter the set flow in the Selected Flow field.
2. Enter the measured flow in the Measured Flow field.
3. Press [RUN] to initiate the test. During the test the pump determines a new flow correction factor to compensate for the inaccuracy in the flow. The Flow Correction Menu displays the results of the test. Figure 4.19 shows example results.

```
OLD Flow Correction NEW
100.00% Use 101.00%
```

*Figure 4.19 The Flow Correction Menu with example fixed volume calibration results*

4. Use the [+]/[-] keys to choose Use, Save or Scrap as described for the Fixed Time Menu.
5. Press [RUN] to complete the test.

To exit the flow calibration menus without entering any values, press [\^] until you return to the Calibration Menu.

*NOTE: Do not press [STOP] unless you have already entered a new value in one of the flow calibration menus. If the pump is in RUN, doing so will interfere with your analysis. Use [\^] to exit the flow calibration menus instead.*
THE SERVICE MENU

The Service Menu (Figure 4.20) contains several service-related tests, including the Hardware Series test.

<table>
<thead>
<tr>
<th>Test</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM Test</td>
<td>200</td>
</tr>
<tr>
<td>RAM Test</td>
<td>201</td>
</tr>
<tr>
<td>Cycle Step Count</td>
<td>205</td>
</tr>
<tr>
<td>External Inputs</td>
<td>206</td>
</tr>
<tr>
<td>Display Test</td>
<td>208</td>
</tr>
<tr>
<td>Transducer Range</td>
<td>209</td>
</tr>
<tr>
<td>Motor Step/Valve</td>
<td>211</td>
</tr>
<tr>
<td>Hardware Series</td>
<td>220</td>
</tr>
<tr>
<td>Initialize NOVRAM</td>
<td>271</td>
</tr>
</tbody>
</table>

Figure 4.20 The Service Menu

The numbers in parentheses refer to a similar test found in earlier SpectraSYSTEM pumps. They are included for the convenience of users and service personnel familiar with this previously-used numbering scheme.

Current History

By selecting /Current History/ you access a chronological list of operating state changes. The negative number on the far left indicates the time (in minutes) between the time the Current History Menu was accessed and the state change occurred. More specific information about reading the Current History Menu is found in the SpectraSYSTEM Pumps Field Repair Manual.

To exit the Current History, press [ENTER].

Lifetime History

By selecting /Lifetime History/ you access a log of five measured items relating to the entire time the pump has been in operation. An example Lifetime History Menu is shown in Figure 4.21.

The top line shows 1) the total time that the pump's motor has been running in hours (Hr) and 2) the total number of strokes in thousands (kSt) taken by the cam; the bottom line shows 3) the number of times the pump has been powered-on (on), 4) the number of times the pump has been powered-down (off), and 5) the number of times an error occurred when NOVRAM was written to upon power-down (bad).
Press any one of the following keys to exit the Lifetime History screen: [ENTER], [∧], [MENU], or [STATUS].

<table>
<thead>
<tr>
<th>1.2 Hr</th>
<th>2.3kSt</th>
</tr>
</thead>
<tbody>
<tr>
<td>24on</td>
<td>23off</td>
</tr>
</tbody>
</table>

*Figure 4.21  The Lifetime History Menu*

**ROM Test (Passive)**

The ROM test (200) verifies the integrity of the ROM (Read Only Memory) in your pump. The ROM is where all of the built-in programs for the pump operation are stored. If faults are found in any part of ROM, a message indicating that the test has failed will be displayed. Press [STOP] to stop this test. Do not to press [STOP] more than once or else pump operation will be interfered with.

If a failure is indicated, contact Thermo Fisher Scientific.

**RAM Test (Active)**

The RAM test (201) verifies the integrity of the RAM (Random Access Memory) in your pump. The RAM is where your pump files are stored and where temporary calculations are performed. The pump must be stopped (STOP) for this test to be implemented. If any faults are found with RAM, the message shown in Figure 4.22 is displayed.

*Figure 4.22  RAM Test failure message*

Contact Thermo Fisher Scientific if this test indicates a failure.

**Cycle Step Count (Passive)**

Normally, 12,800 motor drive pulses are required for one revolution of the pump motor, as detected by the cam sensor. The Cycle Step Count test (205) displays a count of the number of pulses required for the last complete motor revolution.

The Cycle Step Count test is a dynamic measurement of the number of steps counted, the lag amount (the number of steps the count has shifted since the last revolution), and the number of seconds required for the last revolution.
Generally, the number of steps should be 12,800 ± 64. The lag value varies due to the load on the pump. This number should be steady, or fluctuate no more than ±120 steps.

Start the test by selecting /Cycle Step Count/. To stop the test, press any one of the following keys: [ENTER], [∧], [MENU], or [STATUS].

NOTE: The Cycle Step Count test requires that a full cam revolution has occurred.

External Inputs (Passive)

The External Inputs test (206) allows you to conveniently monitor the status of two of the external input lines, STOP and RUN. The STOP line causes the pump to stop pumping when momentarily grounded. A momentary ground at the RUN input line causes the run time clock to begin. Use this test if you are having difficulty interfacing your pump to a controlling device, such as a SpectraSYSTEM autosampler.

To run the test, select /External Inputs/. The display continuously shows the current state of the STOP and RUN inputs (updates every 0.5 second). "Lo" means the input is grounded (active) and "Hi" means the input is "high" (inactive).

To stop the test, press either [ENTER], [∧], [MENU], or [STATUS].

Display Test (Passive)

The Display test (208) exercises the pump's display. When initiated, the display shows staggered alphanumeric characters that scroll from left to right. Pressing [STOP] freezes the display; pressing [RUN] resumes movement.

This test is also a keyboard test. Pressing the cursor keys will cause the alphanumeric display to scroll in that direction.

Other keys can be tested by first pressing [ENTER] to access the key test. The display will verify other keys such as [STATUS] or [MENU], as soon as each is pressed.

To return to the scrolling alphanumeric characters, press [RUN], [RUN]. To stop the test, and return to the Service Test Menu, press [STOP], [STOP].

Contact your representative if the display appears unusual.
Transducer Range
(Active)

Transducer Range is not truly a test. It contains a field where you must enter the calibration value (in mV) for a replaced pressure transducer. The range is located on the replacement transducer wire. Your pump features advanced circuit designs which allow the pressure transducer range adjustment to be set by entering a value from the keyboard. No adjustment of potentiometers is necessary. Your pump comes from the factory preset to the proper range. The value is stored in a NOVRAM. Do not change the transducer calibration setting unless the pressure transducer or System PCB are replaced. The calibration number is recorded on a tag attached to the transducer cable. The System PCB and pressure transducer are not user-serviceable parts. A qualified service representative must perform any repair or replacement.

Motor Step
(Active)

The Motor Step/Valve test (211) exercises the pump motor. When activated, the pump motor is continuously stepped and each switching valve is sequentially opened and closed at a rate of 1 valve per 0.512 seconds. This test is useful for detecting an intermittently failing switching valve or pump motor.

Select /Motor Step Valve/ to initiate the test. Follow the instructions. Each open valve is shown dynamically on the display. The test will continue until one of the following keys is pressed: [ENTER], [∧], [STOP], [MENU], or [STATUS].

Hardware Series
(Active)

The Hardware Series test (220) is an extensive evaluation of the System Printed Circuit Board (PCB), switching valve, pump motor, and pressure transducer. The System PCB contains all of the circuitry for the operation of the pump, except for the display functions. Once activated, the test exercises and diagnoses the condition of various circuits. The pump must be idle (not pumping) before activating the test. This test will not affect pump files.

NOTE: The external events connector (if present) must be removed from the rear of the pump before initiating the Hardware Series test. Otherwise, "Board Failure: Code 8" might occur.

To activate the test, select /Hardware Series/. Follow the instructions given on the display. Typically, the display will show:
Release system pressure
Then press ENTER.

Figure 4.23 Initial Hardware Series test message

Open the column bypass valve or otherwise remove column pressure from the transducer since the pump will operate during the test and an excessively high column pressure might be generated if not bypassed. Press [ENTER] to continue the test.

Once the test is activated the display will appear as in Figure 4.24.

Test in Progress

Figure 4.24 Hardware Series test message, after pressing [ENTER]

The pump's components are tested in the following order.

1. Pressure transducer and circuitry
2. Input/output ports
3. Motor drive circuitry
4. Cam marker and circuitry
5. Motor revolution and sine/cosine circuitry

As each portion of the test is completed a message is displayed. If all components and circuitry are within specifications, the messages shown in Figure 4.25 are displayed during the test.

If a failure is detected during the test, the failure message is displayed. It remains displayed until [ENTER] is pressed (the test resumes).

To stop the test, press [STOP], or press [∧] to return to the Service Menu.

---

Figure 4.25 No problems found during the Hardware Series test.
If problems are found during the test, a message suggesting the most likely failure is displayed, although in some cases other failures are possible. The messages shown in Table 4.3 indicate a possible System PCB failure.
### Table 4.3 Errors indicating possible System PCBA failure

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOARD FAILURE: CODE XXX</td>
<td>If the failure is identified as a component on the system printed circuit board or if the test cannot determine the failed component, a message is reported where XXX is a 1-, 2- or 3- digit number. 8</td>
</tr>
<tr>
<td>TRANSUDER UNPLUGGED</td>
<td>The pressure transducer was not detected. The connector going to the pressure transducer should be checked. Access to this connector requires the removal of the pump's outer protective cover. Because there are safety issues involved in its removal, this should only be performed by a qualified service technician. The location of this connector as well as the proper procedure for removing the outer cover are outlined in the Field Repair Manual.</td>
</tr>
<tr>
<td>CANNOT ZERO TRANSUDER</td>
<td>The transducer circuitry is not able to compensate for the zero offset of the transducer. Make sure that the system is at zero column pressure (column bypassed) before starting the test. If so, replace the transducer. Contact your local sales/service representative for assistance.</td>
</tr>
<tr>
<td>CAM MARKER NOT FOUND</td>
<td>This message indicates that the sensor that detects cam revolutions is not operational. Either the motor coupling is loose or the cam sensor is defective. This requires tightening of the motor-to cam coupler if loose, or replacement of the cam sensor. Both of these actions require the removal of the top cover. Because of safety issues involved in the removal of this cover a trained service technician should perform this evaluation.</td>
</tr>
</tbody>
</table>
### Table 4.3 Errors indicating possible System PCBA failure, continued

<table>
<thead>
<tr>
<th>Error Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAM SENSOR FAILURE</td>
<td>The cam sensor cable is disconnected or defective and needs to be replaced. Correction of this problem requires the removal of the top cover. Because of safety issues involved in the removal of this cover a trained service technician should perform corrective action. Contact your local sales/service representative for service information.</td>
</tr>
<tr>
<td>NO CURRENT TO MOTOR</td>
<td>The test has detected no current flow through the pump motor. Either the motor cable is unplugged on the System PCB or the entire drive circuitry is defective. Correction of this problem requires the removal of the top cover. Because of safety issues involved in the removal of this cover a trained service technician should perform corrective action. Contact your local sales/service representative for information on obtaining a replacement.</td>
</tr>
</tbody>
</table>
Initialize NOVRAM
(Active)

The pump must be stopped for /Initialize NOVRAM/ to be completed.

**NOTE:** Initialize NOVRAM (271) has a profound effect upon the pump's non-volatile RAM. Do not initialize the NOVRAM unless you fully understand all consequences associated with this action.

By initializing the NOVRAM all files are reset to their default values, with the exception of the run file. All user-preferences set in /OPTIONS/ are also returned to their default values. In addition, any changes that had been made to the Liquid End Type and Flow Calibration parameters are erased, and these selections are returned to their default values.

In general, any field value or selection that is normally retained when the pump is turned off and then on will be reset to its default value when the NOVRAM is initialized.

**NOTE:** The pressure transducer's range value is not reset when the NOVRAM is initialized.

**HINT:** To retain a single file while initializing the NOVRAM: load it (so that it becomes the run file), stop the pump, initialize NOVRAM, make a change to a value within the run file from Status, then select /Save File/ at the bottom of the Status Menu.
Required Maintenance

Introduction

When properly maintained, your Thermo Scientific pump will provide years of trouble-free operation. It is important that your pump receive routine preventive maintenance to ensure reliability and optimum performance. Properly performed routine, preventive maintenance also helps keep your warranty valid. Your pump is designed to encourage proper maintenance by making maintenance parts easy to access, replace and record.

This chapter describes the Maintenance Log Menu and how to use it. Some hints to help you extend the maintenance period of your pump are also included. Easy-to-follow, step-by-step required maintenance procedures are also contained in this chapter so that you can keep your pump in optimum working condition. A few maintenance tips for parts of the pump not directly involved with solvent flow follow the maintenance procedures. The last section contains replacement procedures for two user-serviceable parts: fuses and the solvent switching valve.

NOTE: Maintenance of the pump is the responsibility of the user. Routine maintenance is not provided under warranty. However, planned maintenance contracts are generally available. Please contact your local representative if you are interested in purchasing a planned maintenance contract.

THE BENEFITS OF PROPER MAINTENANCE

As with most things, there is tremendous benefit in doing things right the first time. For example, an unusually fast seal failure might indicate either incorrect installation or a scratched piston. A scratched piston might be caused by improper installation of the seal or piston, by allowing the pump to sit idle with a buffered eluant in it, or by failing to filter your eluants.
Maintenance Schedule

Table 5.1 Gradient Pump Preventative Maintenance Schedule

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Procedure</th>
<th>Performed By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily</td>
<td>Check waste reservoir. Empty as required.</td>
<td>User</td>
</tr>
<tr>
<td></td>
<td>Check solvent reservoir. Replenish as required.</td>
<td>User</td>
</tr>
<tr>
<td>Annually</td>
<td>Replace piston seals.</td>
<td>User</td>
</tr>
<tr>
<td></td>
<td>Replace backflush seal.</td>
<td>User</td>
</tr>
<tr>
<td></td>
<td>Check pistons and Kel-F seals. Sonicate any parts as required.</td>
<td>User</td>
</tr>
</tbody>
</table>

Maintenance Log

The Maintenance Log provides a convenient way for you to record maintenance performed on the liquid ends and set intervals for periodic maintenance. When a maintenance interval has been exceeded the pump will automatically display a message indicating that maintenance might need to be performed.

MAINTENANCE LOG MENU

The Maintenance Log is accessed by selecting /TESTS/ from the Main Menu, then selecting /Maintenance Log/ (Figure 5.1 and Figure 5.2).

Figure 5.1 Main Menu with TESTS selected

Figure 5.2 Tests Menu with Maintenance Log selected

The Maintenance Log Menu (See Figure 5.3) consists of a table, used to record dates and volumes, followed by one field used to enter a value relating to flow, and two additional menu items. All of these are described in this section.
The Maintenance Table

The top half of the Maintenance Log Menu is a table. (Figure 5.3)

**ITEM, DATE, DUE, and VOL**

The ITEM field remains fixed. "Seal 1" and "Seal 2" should be paired with "Piston 1" and "Piston 2", respectively, to identify the inlet and outlet liquid ends. "Inlet" refers to the inlet check valve, while "X-ducer" refers to the transducer check valve.

Enter the date (day/month/year) in the DATE field for the last time maintenance was performed on each item.

The pump keeps "liters pumped" counters, in the VOL (volume) field, for each major maintenance item (the pump seals, pistons, and check valves). You might set a DUE volume in liters for each item. When the DUE volume is exceeded by the volume of liters pumped (VOL), the reminder "MAINTENANCE DUE - SEE PUMP LOG" is displayed. This message will appear each time a file is initialized. You might choose to use this feature to set regular intervals for maintenance, such as seal changes, pump/column cleaning, or simply to serve as a reminder to verify that the system is operating properly. The interval remains set until either the date has been updated or the DUE value has been increased.

In the example shown in Figure 5.3, a fairly complete maintenance was done on 8 Aug 95, when both seals and check valves were replaced.

**Setting Intervals**

The volume of mobile phase that you can expect to pump before the pump requires maintenance is very dependent upon the eluant being pumped and your adherence to good chromatographic practices. To obtain the maximum lifetime and best performance from your pump, read *Extending the Maintenance Period* on page 72. Pump pistons and check valves have been known to last for years. Even the seals themselves can last more than a year for some applications.
An initial guideline for setting up your Maintenance Log for the first time is to set both seal DUE counters to 200 liters, and the check valve and piston DUE counters to 600 liters. Setting a value of zero (0) for any DUE interval inactivates the Maintenance Log for that specific item. To inactivate the entire Log, a zero (0) must be entered for all DUE intervals. Your specific maintenance interval can be determined by observing pump performance over time.

**When a Maintenance Message is Displayed**
Whenever the interval has been exceeded, and the message "MAINTENANCE DUE - SEE PUMP LOG" is displayed, you should either verify that the pump needs maintenance or that the pump is operating properly. If a maintenance interval is exceeded and you find that the pump does not require maintenance, increase the DUE interval by another 50 liters from the previous setting. Once you have established an expected interval for your system, use that interval for routine preventive care.

If you find that the interval before component failure is either unacceptable or variable, then the source of the problem must be identified. Read this chapter and Appendix A. Poor chromatographic practices are by far the most common source of problems. Specific procedures for inspecting and changing parts begin on page 73.

### Maintenance Position

Selecting /Maintenance Position/ prepares the pump for liquid end removal or replacement. The display shown in Figure 5.4 appears:

```
To install or remove liquid ends press ENTER
```

*Figure 5.4 Maintenance position message*

The maintenance position puts the pump's cam into a position to facilitate liquid end removal.

### Liquid End Type

The Liquid End Type Menu allows you to select the proper liquid end for a specific application. Do not change the flow range unless you are installing liquid ends with capacities different from those purchased with the pump.

```
Liquid End Type   Normal
Flow Range       0 - 10 mL/Min
```

*Figure 5.5 Liquid End Type Menu*
**Selecting Normal, Bio, or SemiPrp**

If you select Normal, Bio, or SemiPrp (semi prep) in the Liquid End Type field, the Flow Range field changes automatically to corresponds to the preset ranges for these liquid ends. (Normal = 0 - 10 mL/min, SemiPrp = 0 - 30 mL/min, Bio = 0 - 10 mL/min, and Other.

**Selecting Other**

If you select Other in the Liquid End Type field, the Flow Range field becomes active, allowing you to enter your own flow range.

After changing the liquid end type on the display, press [ENTER]. A message (Figure 5.6) will prompt you to write down the old values in the Maintenance Log which correspond to the liquid ends you presumably just removed. It is important to keep records for each set of liquid ends you use. If you reinstall the "old" liquid ends, you will need to reenter the dates and statistics for the "old" ends into the Maintenance Log table. You are also reminded to enter new values into the log's VOL field, which correspond to the newly installed liquid ends. Normally the VOL field is not edited, but when new liquid ends are installed, ensure that the VOL fields for the appropriate maintenance items are reset to 0.

| Write down old values |
| ENTER new values in log |

*Figure 5.6 Reminder to keep proper records when liquid ends are changed*

**Flow Correction**

An additional menu appears whenever you press an arrow key, [ENTER], or [+] [-] from the display shown in Figure 5.7. This menu allows you to set a Flow Correction, if desired. OLD and NEW values are displayed. For no Flow Correction, enter 100.00%.

**NOTE:** The Flow Correction menu is the same as the menu displayed when a flow calibration (/TESTS/, /Calibration/, /Flow Calibration/) has been initiated, except that it does not include the Use, Save, or Scrap option.

<table>
<thead>
<tr>
<th>OLD Flow Correction</th>
<th>NEW Flow Correction</th>
</tr>
</thead>
<tbody>
<tr>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

*Figure 5.7 Flow Correction Menu*

Flow correction is a value, in percent, which adjusts the actual volume that the pump delivers. As you use the pump, you might feel that although the pump is set at a specific flow rate, for example 2 mL/min, the pump actually delivers slightly more or less than this volume per minute. This can be due to a variety of maintenance- or LC-related reasons (seals, valves, and so on).
If desired, manually enter a flow correction value. This value can be entered automatically, based on the result of the flow calibration test, initiated from /TESTS/, /Calibration/, /Flow Calibration/. This test [which requires you to enter an accurately measured operation value (time, volume or flow rate)] is fully explained in Chapter 4.

If no correction to the flow is desired, enter a value of 100% in this field. Values from 90% to 110% are valid. For example, if you pump for one minute at 1 mL/min and collect 0.95 mL, then the pump is actually delivering 5% less solvent than expected. To compensate, enter 105.26% in the Flow Correction field. The pump's Status Screen will still display a flow rate of 1.0 mL/min, but the pump will actually deliver 105.26% of what it normally delivers at 1.0 mL/min.

Press [ENTER] to save the value, or simply leave the menu by pressing an arrow key.

## Extending the Maintenance Period

As mentioned earlier, the volume of mobile phase you can expect to pump before maintenance is due is very much dependent on the way that the pump is being used. Following these guidelines helps you extend the life and improve the performance of your pump.

- Use high quality, spectro-grade or HPLC-grade solvents. These solvents do not usually need to be filtered before use.
- Filter water and prepared solvents through at least a 0.45-micron filter before placing them in the solvent reservoirs to remove particulate matter and organic contamination.
- Avoid pH extremes. Thermo Fisher Scientific offers an inert/biocompatible pump for mobile phases that are outside the pH range of 2.2 to 8.0.
- Verify that the solvents used are miscible in all proportions. This is very important for a buffered mobile phase. Precipitation of salts quickly damages maintenance parts.
- Never leave the pump filled with buffered solvent when not pumping. Either lower the flow to 0.1 mL/min. or thoroughly flush the pump. Flush with at least 25 mL of pure filtered water.
- The pump should be filled with methanol if it is to be left idle for more than two days. This avoids the possible growth of organisms in aqueous solvent systems.
- Never use hydrochloric acids solutions.
- Avoid metal ions that can cause corrosion due to electrochemical processes. Typical metal ions to avoid: manganese, chromium, nickel, copper, iron, molybdenum.
Maintenance Procedures

SAFETY PRECAUTIONS

Observe the following safety precautions whenever performing periodic maintenance.

**Caution!**
A caution alerts you to situations that could result in personal injury. It also tells you how to avoid them.

**High Voltage!**
This icon alerts you to the presence of high voltage and to the potential injury that could occur from electrical shock were you to come in contact with a specific instrument area or component. It also tells you how to avoid contact with the high-voltage areas in your instrument.

**Hot Surface!**
This icon alerts you to potential injury that could occur from coming in contact with a heated surface or area on or in an instrument. It also tells you how to avoid contact with the heated surfaces in your instrument.

This section includes procedures for:

- Complete liquid end maintenance (includes disassembly and assembly)
- Check valve replacement
- Passivating stainless steel parts

Also included are maintenance tips for pump parts that are not involved with pump flow.

TOOLS

The following tools are useful to have on-hand as you perform maintenance procedures.

- Tweezers
- Open-end wrenches (1/4-inch, 5/16-inch, 1/2-inch)
- Loupe or magnifying glass
- Allen wrench (Hex head) 9/64-inch
PREPARATION

Prepare the pump for maintenance before performing any maintenance procedure.

To prepare the pump for maintenance, flush the pump with 25 mL of methanol. If an incompatible solvent is resident in the pump, flush with appropriate intermediate solvents before flushing with methanol. For example, if chloroform is being used as the mobile phase solvent, an intermediate flush of 25 mL methylene chloride would be appropriate before flushing with methanol.

LIQUID END MAINTENANCE

Complete liquid end maintenance includes procedures for seal and piston maintenance:

- Removal
- Disassembly
  - inspection for contamination
  - cleaning
  - piston inspection
  - cleaning/replacing parts if necessary
- Assembly
- Installation

For thorough cleaning, piston replacement, or total liquid end reconditioning, the liquid ends must be removed.

Having a second set of reconditioned liquid ends on hand for quick replacement will save additional time and allow maintenance to be performed at your convenience. Contact your local Thermo Fisher Scientific representative if you are interested in obtaining spare components. Part numbers are included in Appendix C.

NOTE: Keep the liquid end components as clean as possible. Contamination decreases seal life significantly.

Preparation

1. Flush your pump with 25 mL prior to disassembling your liquid ends. If methanol is not compatible with the mobile phase in your pump, flush the system with 25 mL of an intermediate solvent before flushing with methanol.
2. Remove the front cover, exposing the liquid ends (Figure 5.8).
Figure 5.8 Pump with front cover removed
Liquid End Removal

To remove the liquid ends from the pump:

1. Remove all tubing attached to the pump heads. Turn the nuts counter-clockwise to remove (Figure 5.9).

2. Position the pump cam to enable the liquid ends to be removed. To do this, press [MENU], and select /TESTS/, /Maintenance Log/. Then move the cursor to /Maintenance Position/ and press [ENTER]. The display shown in Figure 5.10 appears.

Press [ENTER] to continue. The pump motor rotates for a few seconds and then is electrically locked into position. While the motor rotates the display appears as in Figure 5.11. When the cam is in the maintenance position, the display in Figure 5.12 appears.
Install or remove liquid ends when motor stops

Figure 5.11 The display when the motor moves cam to maintenance position

<table>
<thead>
<tr>
<th>X-ducer</th>
<th>(date)</th>
<th>(due)</th>
<th>(vol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Maintenance Position</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.12 The display after the motor moves the cam to the maintenance position

The pump is now in its maintenance position. It will hold this position (if power is maintained) until a file is initialized or a purge is started.

3. Remove the inlet check valve (Figure 5.13) from the inlet pump head.

NOTE: It is not necessary to remove the check valve to replace a piston, however, it is easier to remove at this time if total liquid end reconditioning is to be performed.

Figure 5.13 Inlet check valve
4. Push in the outlet (upper) liquid end and rotate it (90 degrees counter clockwise) until it releases from the pump module. Remove the liquid end and set it aside.

5. Push in the inlet (lower) liquid end and rotate it (90 degrees clockwise) until it releases from the pump module. Remove it and set it aside.

Liquid End Disassembly

To disassemble the liquid ends:

1. Separate the pump head from the piston holder housing by removing the two 9/64-inch hex cap screws. Turn the screws counter-clockwise.

2. Examine the Kel-F® seal in the cylinder bore. If the seal is damaged (scratched, warped or torn) it must be removed. Use tweezers to remove it by pulling gently on the seal's inner circumference. (Be careful not to scratch the cylinder surface!)

3. Examine the pump head for contamination. Flush the pump head with methanol or place it into an ultrasonic bath.

4. Remove the seal holder from the piston holder housing by grasping both ends of the exposed tube, and pulling gently (Figure 5.14).

Figure 5.14 Removing the seal holder from the piston holder housing
5. Carefully remove the piston seals from the seal holders using the seal removal tool supplied in the accessory kit. Insert the tool and wiggle it in a circular manner to remove the seal. (See Figure 5.15). Flush the holders with methanol if contamination is present.

![Figure 5.15 Using the seal removal tool](image)

6. While retaining the piston holder, remove the 9/64-inch retaining cap screw (Figure 5.15). This allows the piston holder to be removed from the piston holder housing. Separate the holder, piston, spring and housing.

NOTE: The piston components are spring loaded and might shoot out! (Figure 5.17)
7. Examine all parts for wear, corrosion or contamination. Clean all deposits. Look for wear marks on the stainless steel shaft of the piston and corresponding wear marks on the inner aspects of the spring which indicate bending or bowing. If these wear marks are present, replace the spring (Figure 5.17).

**NOTE:** It is normal for the piston holder to produce a small amount of wear particles.

8. Examine the piston carefully under a low-power microscope or magnifying glass for fine scratches, ridges, or scoring which can reduce seal life (Figure 5.18). Some apparent scratches are actually cleanable deposits. The piston can be cleaned by wiping it gently with a laboratory towlette or cotton swab that has been immersed in methanol. Replace the piston if scratched or pitted. The new piston should also be cleaned prior to installation.
Figure 5.17 Liquid end components
9. Thoroughly flush all components with methanol.

Liquid End Assembly

To replace the piston seal and reassemble the liquid end:

1. Place the seal holder on end on a clean, flat surface. Place the seal holder into the pump head with the seal down (spring should face the inside of the pump head.) Install new piston seals by setting them in position on the seal holder (spring side up) and gently pressing them into place with the pump head (Figure 5.19).

NOTE: It is possible to install the seal in the wrong end of the seal holder. If installed in the wrong end, the seal will not be flush with the top of the holder. The opposite end of the seal holder is deeper, to accommodate the piston flush seal. Install the piston seal only in the end closest to the tubes.
2. A piston flush seal (part of a Piston Flush Seal Kit and normally used with buffers), might be located at the opposite end of the seal holder. If you use a piston flush seal it should be replaced once a year. The piston flush seal is not subject to the higher pressures seen by the piston seal, so maintenance of this part is only occasionally necessary.

*The piston guide bushings do not need replacement. Retain them for new seal replacement.*

To replace the piston flush seal:

- a. Use the seal removal tool to remove the piston flush seal.
- b. Insert a new piston flush seal into the seal holder (spring side down). The piston flush seal is thicker than a piston seal. The seal holder's cavity on the piston flush seal side is deeper to accommodate the larger size.
- c. Ensure that the piston flush seal is flush with the edge of the seal holder. Use the large end of the seal removal tool to push the seal into the holder.

3. Place the seal holder into the piston holder housing spring side up (Figure 5.20).
4. If the Kel-F seal is being replaced, put the new seal in the pump head cavity now.

5. Install the pump head onto the housing using the two 9/64-inch Allen head screws.
   a) For the inlet liquid end, the pump head must be connected to the piston holder housing as shown in Figure 5.21 (Inlet check valve down, retaining cap screw to the left).
   b) For the outlet liquid end, the pump head must be oriented as shown in Figure 5.22.

   Evenly tighten the screws to forty inch-pounds (tight).
Figure 5.21  Installing the retaining cap screw (inlet liquid end)

Figure 5.22  Installing the retaining cap screw (outlet liquid end)
6. Install the piston into the piston spring and then place them both into the piston holder housing (Figure 5.23). Do not press the piston through the seal at this time.

7. Compress the piston holder into the holder housing and install the retaining cap screw with its washer as shown in Figure 5.21 and Figure 5.22, so that the screw enters the slot in the piston holder. This action pushes the piston through the seal. Tighten the screw until snug.

NOTE: Make sure the retaining cap screw is oriented on the left-hand side of the piston holder housing for both the inlet and outlet liquid ends.

Figure 5.23 Piston installation

Liquid End Installation

To install the liquid end assemblies into the pump, the pump must be in the maintenance position. If the pump has not been switched off since the liquid ends were removed, the pump motor should still be in its maintenance position.
To place the liquid end assemblies in the maintenance position:

1. Press [MENU], /TESTS/, /Maintenance Log/ then move the cursor to /Maintenance Position/ and press [ENTER]. The display shows:

```
To install or remove liquid ends, press ENTER
```

*Figure 5.24 Maintenance position message*

2. Press [ENTER] to continue. The pump motor rotates for a few seconds and then is electrically locked into position. While the motor rotates the display shows:

```
Install or remove liquid ends when motor stops
```

*Figure 5.25 Pump rotating cam to maintenance position*

The pump is now in its maintenance position. The display will appear as shown in Figure 5.26. The liquid ends can be installed.

```
X-ducer  (date)  (due)  (vol)
· Maintenance Position
```

*Figure 5.26 The display after the motor moves cam to the maintenance position*

To install the liquid ends:

1. Replace the inlet liquid end first. This liquid end contains tapped holes for the inlet check valve and the transducer tube. Install it by pressing in and turning it approximately 90 degrees counter-clockwise, until it locks into position. Be sure that the check valve (or the check valve hole, if the valve is not installed) is pointed down, and the transducer tube hole is pointed to the upper left-hand side (10 o'clock) (Figure 5.27).
2. Replace the outlet (upper) liquid end. This liquid end contains tapped holes for the crossover tube and the bypass valve tube. This liquid end is installed by pressing in and turning it approximately 90 degrees clockwise, until it locks into position. Be sure that the crossover tube hole is pointed up, and the bypass valve tube is pointed to the lower right-hand side (4 o'clock).

3. Replace the check valve and tubing. (Do not over-tighten fittings.) Generally, a 1/16-turn beyond finger-tight is sufficient to make a leak-free connection.

HINT: If the transducer check valve has been removed you can distinguish the two check valves: the inlet check valve has a wider fitting opening than the transducer check valve (connected to the pressure transducer).

4. After replacing the liquid ends, reset the VOL values in the Maintenance Log for all replaced components to zero (0).
POST-INSTALLATION
SEAL CONDITIONING

Follow the procedure below each time you replace liquid end seals.

1. Open the column bypass valve and purge with methanol to clear air from the solvent lines and liquid ends.

2. Purge the pump through an old column or flow restrictor at 4000 psi for a minimum of 20 minutes. Reduce the flow to 1 mL/min and continue pumping for 15 minutes.

3. Check for solvent leaks. Do not return the pump to every-day service unless you are sure that no leaks are present.
CHECK VALVE MAINTENANCE

If the pump has notified you that it is time to replace check valves or if check valve replacement was recommended in Appendix A, Troubleshooting, then follow these steps. Check valve maintenance consists of:

- Inlet check valve removal and installation
- Transducer check valve removal and installation

**NOTE:** The factory-supplied replacement check valves are manufactured in a clean-room environment and capped to protect them from contamination. It is very important to maintain a clean environment when installing them.

**Inlet Check Valve (bottom position)**

To remove the existing inlet check valve and install a new one:

1. Remove the solvent inlet tube (Figure 5.27) from the check valve.
2. Remove the defective check valve by rotating the valve counter-clockwise with a 1/2-inch open-end wrench.
3. Install the new check valve by rotating clockwise until the valve is snug against the liquid end cylinder. Reconnect the inlet tubing. Tighten to finger-tight.

**Transducer Check Valve**

To remove the existing transducer check valve (connected to the Pressure Transducer) and install a new one:

1. Remove the transducer tubing from the transducer check valve and the inlet pump head (Figure 5.28).
2. Remove the defective check valve by rotating it counterclockwise with a 1/2-inch open-end wrench.

3. Install the new check valve by rotating it clockwise until snug, and tighten with a 1/2-inch open-end wrench. Replace the connecting tubing. Tighten fittings only enough to stop leaks. Generally, this is 1/16-turn beyond finger-tight.
Maintenance Tips

This section contains useful maintenance tips for pump parts not directly related to solvent flow.

**DRIP TRAY**

A removable, white plastic solvent drip tray is located underneath the inlet bracket of your pump.

To remove the tray squeeze the top, front-edge of both sides of the tray together and carefully pull the tray out. You might need to wiggle the tray as you pull. If you see solvents in the tray, be particularly careful not to spill them as the tray is removed.

*HINT: It might be easiest to use the index finger of each hand to push the sides together.*

![Drip Tray Diagram](image)

*Figure 5.29 Drip tray installed*

**PASSIVATION OF STAINLESS STEEL COMPONENTS**

All the major type 316 stainless steel components used in the SpectraSYSTEM pumps are passivated prior to assembly to ensure the removal of porous particles from the surface and to coat the surface with a layer of chromium oxide, which is highly resistant to...
corrosion. All stainless steel replacement parts purchased from Thermo Fisher Scientific are also passivated.

However, stainless steel components are subject to corrosion from strong acid solutions (in particular, materials containing halides), organic acids, and sometimes even water. Resistance to corrosion of the stainless steel components can be enhanced by using the following procedures.

**CAUTION—Chemical Hazard!** Take care when passivating with strong acids. Wear protective eye covering and protective clothing.

*NOTE:* Before installing any new parts not supplied from the Factory such as stainless steel tubing, the parts should first be passivated using the methods below.

*NOTE:* **DO NOT** expose a column to the passivation mixture. Remove the column before pumping if it is necessary to pump passivation solvents through the pump. It is preferable, however, to remove the components from the pump and then passivate them apart from the system.

1. When the surface area to be passivated is thoroughly clean, it is passivated by wetting the surface with a 20% nitric acid solution in deionized water for about 10 minutes at room temperature.

2. After passivation, thoroughly clean the parts to remove any residual nitric acid. Wash with deionized water until the system is neutral to pH paper. Follow up with another wash using 50-50 water/methanol followed by methanol. When thoroughly clean, blow dry using nitrogen. (Do not use the laboratory air system or air from a compressor that might contain an oily residue.)

If frequent passivation is required to protect your pump from aggressive solvent systems, you might want to consider using the inert version of SpectraSYSTEM pumps. The inert pump parts do not require passivation.
If troubleshooting has pointed to a blown fuse in the power entry module, use the procedures below to make repairs.

**POWER ENTRY MODULE**

**FUSE REPLACEMENT**

Instrument power is supplied by two 4.0-amp fuses housed in the fuse compartment of the power entry module, above the power cord receptacle.

To replace the fuses:

1. Ensure that the power cord is *not* connected to the pump.
2. Use a small, flat blade screwdriver to pry open the power selector/fuse cover. You will probably hear the top edge of the cover snap as it is pried open.
3. Pull out the fuse holder and discard the bad fuse. Place the new fuse into the holder with the metal end visible.
4. Snap the fuse holder back into place.

*NOTE:* If the power selector barrel accidentally comes out, be sure to replace it so that the correct voltage for your area shows through the voltage window.

5. Firmly snap the housing cover back in place. Be sure that the correct voltage is visible in the voltage window.

*HINT:* Use two thumbs to push up on the top half of the cover as you push in.
Troubleshooting

Introduction

Your SpectraSYSTEM pump is designed to operate trouble-free for many years when properly maintained. Most pump problems can be avoided by simple, periodic maintenance, as described in Chapter 5. However, in the event that an error message is displayed or if a mechanical or electrical failure is suspected, the problem can be easily diagnosed. Further, if the diagnosis indicates that a problem exists with non user-serviceable parts inside the pump, a qualified Thermo Fisher Scientific service representative can quickly and easily replace most malfunctioning parts.

This appendix contains information on:

- Theory of operation
- General LC system troubleshooting
- Pump-specific hardware troubleshooting
- Error Messages
- Display Messages

A quick-reference hardware troubleshooting guide is included at the end of this appendix that includes tips for diagnosing and remedying hardware problems. This guide can save you time in diagnosing problems when the symptoms are known.

Theory of Operation

An isocratic pump works by first pulling a solvent into a valve. Solvent travels to the pump head, where a piston regulates the flow of the mixture to an outlet tube. The solvent is routed through the pressure transducer, into a second pump head, then through a bypass valve (closed during normal operation), and finally out to the LC system. The pump's outlet tubing is then generally connected to an automatic injector, such as an autosampler.
Troubleshooting Your Pump

SAFETY PRECAUTIONS

Observe the following safety precautions whenever troubleshooting hardware difficulties.

**Caution!**
A caution alerts you to situations that could result in personal injury. It also tells you how to avoid them.

**High Voltage!**
This icon alerts you to the presence of high voltage and to the potential injury that could occur from electrical shock were you to come in contact with a specific instrument area or component. It also tells you how to avoid contact with the high-voltage areas in your instrument.

**Hot Surface!**
This icon alerts you to potential injury that could occur from coming in contact with a heated surface or area on or in an instrument. It also tells you how to avoid contact with the heated surfaces in your instrument.

TROUBLESHOOTING TIPS

**Eliminate all other possible sources of trouble**
Before you spend any time trying to diagnose a suspected pump problem you should verify that the pump is the only source of difficulty. Systematically eliminate all other instruments in your LC system as the source of trouble. If you are not sure which component of your chromatography system is responsible for poor system performance the General LC System Troubleshooting section beginning on page 97 of this appendix provides useful suggestions.

**When you're sure it's the pump**
Once you have isolated the pump as the only remaining source of difficulty, a variety of self-tests are built into the pump to help you determine if your pump is operating correctly.

The next section describes the tests found in the /TESTS/ menu item. Instructions for the built-in hardware and electronics diagnostics are contained within the description of the Test Menu.
<table>
<thead>
<tr>
<th>Symptom</th>
<th>Cause/Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No flow.</td>
<td>a) Check mobile phase connections,</td>
</tr>
<tr>
<td></td>
<td>b) Check for leaks,</td>
</tr>
<tr>
<td></td>
<td>c) Check pump troubleshooting guide.</td>
</tr>
<tr>
<td>2. High back pressure.</td>
<td>a) Check flow rate and system/column specifications,</td>
</tr>
<tr>
<td></td>
<td>b) Check for tubing or column blockage,</td>
</tr>
<tr>
<td></td>
<td>c) Check pump troubleshooting guide.</td>
</tr>
<tr>
<td>3. Unstable baseline or drift.</td>
<td>a) System/column not equilibrated; allow more time,</td>
</tr>
<tr>
<td></td>
<td>b) Check detector troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>c) Check pump troubleshooting guide.</td>
</tr>
<tr>
<td>4. Baseline noise.</td>
<td>a) Check for air bubbles in system, degas solvents,</td>
</tr>
<tr>
<td></td>
<td>b) Check for system/solvent contamination,</td>
</tr>
<tr>
<td></td>
<td>c) Check pump troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>d) Check PC1000 troubleshooting guides.</td>
</tr>
<tr>
<td>5. No peaks.</td>
<td>a) Check detector and data system connections,</td>
</tr>
<tr>
<td></td>
<td>b) Check autosampler troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>c) Check sample retention with chromatographic conditions.</td>
</tr>
<tr>
<td>6. Contaminating/ghost peaks.</td>
<td>a) Clean system and column,</td>
</tr>
<tr>
<td></td>
<td>b) Check autosampler troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>c) Check pump troubleshooting guide.</td>
</tr>
<tr>
<td>7. Poor peak shape.</td>
<td>a) Check system for leaks,</td>
</tr>
<tr>
<td></td>
<td>b) Check fittings and tubing lengths,</td>
</tr>
<tr>
<td></td>
<td>c) Check column performance,</td>
</tr>
<tr>
<td></td>
<td>d) Check autosampler troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>e) Check pump troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>f) Check detector troubleshooting guide.</td>
</tr>
<tr>
<td>Symptom</td>
<td>Cause/Remedy</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>8. Poor retention time reproducibility.</td>
<td>a) Check system for leaks and bubbles,</td>
</tr>
<tr>
<td></td>
<td>b) System/column not equilibrated, allow more time,</td>
</tr>
<tr>
<td></td>
<td>c) Check column performance,</td>
</tr>
<tr>
<td></td>
<td>d) Check pump troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>e) Check autosampler troubleshooting guide,</td>
</tr>
<tr>
<td></td>
<td>f) Check ISM or data system troubleshooting guide.</td>
</tr>
</tbody>
</table>

| 9. Poor peak area reproducibility.        | a) Check column performance,                                                |
|                                           | b) Check autosampler troubleshooting guide,                                  |
|                                           | c) Check data system troubleshooting guide.                                  |

| 10. Non-integrated or too many peaks.     | a) Check integrator or data system troubleshooting guide.                   |

| 11. No instrument of device control.     | a) Check cable connections,                                                |
|                                           | b) Check system configuration,                                              |
|                                           | c) Check individual instrument troubleshooting guide,                       |
|                                           | d) Check integrator or data system troubleshooting guide.                   |

For more detailed chromatographic troubleshooting, refer to any HPLC troubleshooting reference book or call your local sales or service representative.
## Table A.2  Pump-specific Hardware Problems

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible Cause</th>
<th>Diagnostic/Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. No response when power is switched on.</td>
<td>a) Power cord not firmly installed.</td>
<td>a) Re-seat cord.</td>
</tr>
<tr>
<td></td>
<td>b) Power cord defective.</td>
<td>b) None. Replace cord.</td>
</tr>
<tr>
<td></td>
<td>c) Power entry module fuse blown.</td>
<td>c) None. Refer to page 94 for fuse replacement.</td>
</tr>
<tr>
<td>2. No display. Fan and pump run OK.</td>
<td>a) Display contrast needs adjustment.</td>
<td>a) Press [STATUS]. Press and hold the right-arrow key. Press the [+] or [-] key to adjust the display contrast. Press [STATUS] again.</td>
</tr>
<tr>
<td></td>
<td>b) Internal fuse blown.</td>
<td>b) None. Contact Thermo Fisher Scientific representative for service.</td>
</tr>
<tr>
<td>3. No display.</td>
<td>a) System PCB defective.</td>
<td>a) None. Contact Thermo Fisher Scientific representative for service.</td>
</tr>
<tr>
<td>4. Only fan runs with power on.</td>
<td>a) Internal fuse blown.</td>
<td>a) None. Contact Thermo Fisher Scientific representative for service.</td>
</tr>
<tr>
<td></td>
<td>b) Display cable loose/unplugged.</td>
<td>b) None. Contact Thermo Fisher Scientific representative for service.</td>
</tr>
<tr>
<td>7. Pump motor will not run.</td>
<td>a) Max pressure set to zero.</td>
<td>a) Press [STATUS]. Set Maximum Pressure to a value &gt; 100 psi.</td>
</tr>
<tr>
<td>Symptom</td>
<td>Possible Cause</td>
<td>Diagnostic/Remedy</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>f) Target pressure low.</td>
<td>f) None. Press [PURGE] and then reinitialize file.</td>
<td></td>
</tr>
<tr>
<td>8. Oil found on inlet bracket.</td>
<td>a) Main bearing over-lubricated.</td>
<td>a) None. Small amount of oil is normal.</td>
</tr>
<tr>
<td></td>
<td>b) Switching valve defective.</td>
<td>b) Hardware Series Test page 61. Replace solvent switching valve.</td>
</tr>
<tr>
<td></td>
<td>c) Switching valve drive defective.</td>
<td>c) Hardware Series Test page 61. Contact Thermo Fisher Scientific representative for service.</td>
</tr>
<tr>
<td></td>
<td>c) Unstable load (column).</td>
<td>c) Flow Stability Test page 51. Check Valve Test page 52. Pump must see stable, non-compressible load.</td>
</tr>
<tr>
<td></td>
<td>d) Insufficient degas.</td>
<td>d) Flow Stability Test page 51. Check Valve Test page 52. Increase helium rate (if helium degas) or decrease flow rate (if vacuum degas). Use vent line and good bottle cap seal.</td>
</tr>
</tbody>
</table>
### Table A.2 Pump-specific Hardware Problems, *continued*

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Possible Cause</th>
<th>Diagnostic/Remedy</th>
</tr>
</thead>
<tbody>
<tr>
<td>f) Partially clogged frit or filter on high pressure side of pump.</td>
<td>f) Hardware Series Test page 61.</td>
<td>Replace filter or frit.</td>
</tr>
<tr>
<td>13. Pump goes from RUN immediately to READY (will not maintain RUN state).</td>
<td>a) Run file has only one time line.</td>
<td>a) View run file. Add time line and reload file.</td>
</tr>
<tr>
<td>14. Pump will not start or stop remotely.</td>
<td>a) Incorrect wiring.</td>
<td>a) External Inputs Test page 60. Correct wiring.</td>
</tr>
</tbody>
</table>
**Table A.3 Error Messages**

<table>
<thead>
<tr>
<th>Error Message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BELOW MINIMUM PRESSURE</strong>;</td>
<td>The column pressure has fallen below the file's Minimum Pressure setting. Check for mobile phase leaks.</td>
</tr>
<tr>
<td><strong>CHECKSUM ERROR BAD PROGRAM</strong>;</td>
<td>The program memory might have been corrupted. Make a note of the circumstances which preceded the message and contact Thermo Fisher Scientific.</td>
</tr>
<tr>
<td><strong>CODE ERROR PROGRAM LOST</strong>;</td>
<td>The program code has errors. Make a note of the software version and the circumstances which preceded the message. Contact Thermo Fisher Scientific.</td>
</tr>
<tr>
<td><strong>CODE ERROR STACK UNDERFLOW</strong>;</td>
<td>The program code has errors. Make a note of the circumstances which preceded the message. Contact Thermo Fisher Scientific.</td>
</tr>
<tr>
<td><strong>CODE ERROR STACK OVERFLOW</strong>;</td>
<td>The program code has errors. Make a note of the software version and the circumstances which preceded the message. Contact Thermo Fisher Scientific.</td>
</tr>
<tr>
<td><strong>CODE ERROR FALSE POWER FAIL</strong>;</td>
<td>You might have experienced low line voltage (&quot;brown-out&quot;) or there might be hardware problems. Note the circumstances which preceded the message and contact Thermo Fisher Scientific.</td>
</tr>
<tr>
<td><strong>EXCEEDS FLOW RANGE</strong></td>
<td>A flow rate was entered in the pump file which exceeded the flow rate capabilities of the pump. The maximum flow rate for standard SpectraSYSTEM pumps is 10 mL/min. If higher flow rates are needed, inert/biocompatible liquid ends are available to increase the flow rate to 30 mL/min. Contact your local sales representative for information.</td>
</tr>
<tr>
<td><strong>MAX PRESSURE EXCEEDED</strong>;</td>
<td>The column pressure of the system has exceeded the MaxP (maximum pressure) value entered into the pump file. The file's Maximum Pressure value might need to be increased. The default value is 3000 psi for 10 mL/min liquid ends (the maximum is 6000 psi). If your operating column pressure is increasing, check for column plugging.</td>
</tr>
<tr>
<td><strong>MOTOR STALLED</strong></td>
<td>The motor is unable to maintain the combination of requested flow rate and needed pressure for operation. Reduce flow rate or check for flow restriction or plugged column frit.</td>
</tr>
<tr>
<td><strong>OVER MAXIMUM TEMPERATURE</strong>;</td>
<td>The pump has overheated. This might be due to blocked ventilation slots or a hardware malfunction.</td>
</tr>
<tr>
<td><strong>POWER FAILURE CONTINUE</strong>;</td>
<td>A power failure has occurred or the pump was switched off with the motor running. The pump has automatically resumed operation. (&quot;Continue&quot; was selected in /OPTIONS/, /Error Recovery/, AC Power Fail.)</td>
</tr>
<tr>
<td><strong>POWER FAILURE STOP</strong>;</td>
<td>A power failure has occurred or the pump was switched off with the motor running. The pump has automatically stopped. (&quot;Stop&quot; was selected in /OPTIONS/, /Error Recovery/, AC Power Fail.)</td>
</tr>
<tr>
<td><strong>POWER FAILURE SHUTDOWN</strong>;</td>
<td>A power failure has occurred or the pump was switched off with the motor running. The pump has automatically loaded and run the shutdown file. (&quot;Shutdown&quot; was selected in /OPTIONS/, /Error Recovery/, AC Power Fail.)</td>
</tr>
<tr>
<td><strong>ZERO FLOW RATE</strong></td>
<td>A time line (other than Time = 0.0 min) with a zero flow rate was encountered. To remedy, enter a valid flow rate in the first line of the pump file. Rates between 0.01 and 10 mL/min are valid for standard SpectraSYSTEM Pumps. The optional inert/biocompatible liquid ends extend the maximum flow rate to 30 mL/min.</td>
</tr>
</tbody>
</table>
### Table A.4 Display Messages

<table>
<thead>
<tr>
<th>Message</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance Due</td>
<td>A volume milestone has been reached. Consult the Maintenance Log for component by pressing the [MENU] key and selecting /TESTS/, /Maintenance Log/. For more information, refer to Chapter 5.</td>
</tr>
<tr>
<td>See Log</td>
<td></td>
</tr>
<tr>
<td>Memory Nearly Full</td>
<td>There might not be enough memory available. Double-check the file to ensure that no parameters or settings were lost. Free memory by deleting an old or unused file, or by reducing the number of time lines in a file. Try to save the file again.</td>
</tr>
<tr>
<td>Data Might Not Be Saved</td>
<td></td>
</tr>
<tr>
<td>Not Enough Room</td>
<td>The run file changes cannot be saved to the file. Free memory by deleting an old or unused file, or by reducing the number of time lines in a file. Try to save the run file once more from the Status Menu.</td>
</tr>
<tr>
<td>File Not Saved</td>
<td></td>
</tr>
<tr>
<td>Run In Progress</td>
<td>The test cannot be initiated because the pump is in RUN or is in HOLD.</td>
</tr>
<tr>
<td>No Testing Allowed</td>
<td></td>
</tr>
<tr>
<td>Reagents</td>
<td>Acids</td>
</tr>
<tr>
<td>----------</td>
<td>-------</td>
</tr>
<tr>
<td>Acetic, 10%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Acetic, 50%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Hydrochloric, 50%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Nitric, 10%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Phosphoric, 50%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Sulfuric, 50%</td>
<td>Excellent</td>
</tr>
<tr>
<td>Water, 100%</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

Table A.5 Solvent Compatibility for Pump Wetted Surfaces

Stainless Steel (316) | Polyetheretherketone (PEEK) | PTFE | Piston Seal Gold | Piston Seal Black | Check Valve Ceramic
--- | --- | --- | --- | --- | ---
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |
Excellent | Excellent | Limited | Unsatisfactory | Excellent | Excellent |

Excellent = Standard or better lifetime with no appreciable chemical attack
Limited = Variable lifetime given actual mobile phase composition, pressure, and temperature
Unsatisfactory = Significant chemical attack and decrease in lifetime
Thermo Scientific 105

Glossary

**A**

**autosampler**

an instrument designed to automatically inject samples into the sample flow path with a high degree of precision and reproducibility; sometimes called an injector

**B**

**baseline**

the reference line at the bottom of a chromatogram from which measurements are made; a baseline represents the chromatogram that would be drawn if only the mobile phase (with no sample) were run through the column

**binary**

capable of mixing or switching between two solvents

**biocompatible**

describes components that are inert when used with biological samples; biocompatible components are usually made from titanium, Teflon®, PEEK, quartz, or sapphire

**buffer**

a medium the resists changes in acidity and alkalinity

**C**

**channel**

the path along which something (solvent or information) flows

**chromatogram**

a plot depicting the separated components in a sample (absorbance units versus time); each component is shown as a separate peak whose concentration can be determined by studying the area under the peak

**chromatograph**

the basic set of instruments needed to perform chromatography: a pump, injector (manual or automatic), a column, and a detector; various recording and data handling instruments are common additions

**chromatography**

a means of separating and analyzing mixtures of chemical substances

**column**

the packed tube through which a sample is passed for separation; the sample separates according to the way in which it adheres to the column's packing material

**component**

an "ingredient" in a chemical mixture, also the individual parts of a liquid end assembly

**conditioning**

the process of preparing the surface of the column wall and introducing the buffer pH conditions into the column before a run
| **configuration** | the way instruments are interconnected to form a system |
| **cursor** | a moving or blinking symbol on the display which indicates where information is entered |

**D**

| **default** | a value or choice built into a system; if no specific choice is made, instruments will run (or data analyzed) using the default settings |
| **degassing** | removal of dissolved gas \(i.e.,\) oxygen from the solvent to prevent bubbles from forming in the pump; degassing can be done by vacuum or by sparging |
| **detector** | the instrument used to detect the presence of a chemical compound |
| **diagnostics** | ways of detecting and isolating instrument or software problems |
| **digit** | an editable space within a field |
| **display** | the backlit LCD screen on all SpectraSYSTEM instruments |

**E**

| **elution time** | the length of time needed to pass a particular sample through a packed LC column |
| **equilibration** | the process used to bring a system (solvent, column, etc.) to a point of equilibrium, where all thermal and chemical reactions occur at equal rates; a stable baseline is a good sign of a well-equilibrated system |
| **error message** | a printed or displayed message that notifies the user of an error condition |
| **error recovery** | user-selectable responses to error conditions detected by the instrument, such as a power interruption or over-pressure |
| **external event** | an action performed by an external device that is under the control of the current instrument (see also timed event) |

**F**

<p>| <strong>field</strong> | an area in a display, screen, or menu where an entry is required or a choice must be made |
| <strong>flow parameters</strong> | flow rate, solvent, and run time |</p>
<table>
<thead>
<tr>
<th><strong>flow rate</strong></th>
<th>the rate at which solvent flows through a system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>G</strong></td>
<td>Ground terminal</td>
</tr>
<tr>
<td><strong>H</strong></td>
<td>Helium manifold</td>
</tr>
<tr>
<td><strong>helium sparging</strong></td>
<td>see sparging</td>
</tr>
<tr>
<td><strong>I</strong></td>
<td>Inert</td>
</tr>
<tr>
<td><strong>injection</strong></td>
<td>the manual or automatic introduction of a sample into a chromatography system</td>
</tr>
<tr>
<td><strong>integator</strong></td>
<td>the instrument used to analyze data and produce a chromatogram</td>
</tr>
<tr>
<td><strong>isocratic</strong></td>
<td>constant solvent composition</td>
</tr>
<tr>
<td><strong>K</strong></td>
<td>Kel-F seal</td>
</tr>
<tr>
<td><strong>keypad</strong></td>
<td>all of the keys by which you can communicate with an instrument or computer</td>
</tr>
<tr>
<td><strong>L</strong></td>
<td>LC</td>
</tr>
<tr>
<td><strong>linear</strong></td>
<td>a gradient curve that follows a straight line</td>
</tr>
<tr>
<td><strong>liquid end</strong></td>
<td>the inlet or outlet assemblies of the pump consisting of the head, piston, seals, and sometimes a check valve</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td></td>
</tr>
<tr>
<td><strong>maintenance log</strong></td>
<td>a place to record dates, service, and cumulative solvent volume pumped</td>
</tr>
<tr>
<td><strong>menu</strong></td>
<td>a list of choices</td>
</tr>
<tr>
<td><strong>method</strong></td>
<td>the set of parameters that define how one or more analyses will be accomplished</td>
</tr>
<tr>
<td><strong>method development</strong></td>
<td>the process of specifying the parameters under which an instrument will perform a particular function</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td></td>
</tr>
<tr>
<td><strong>NOVRAM</strong></td>
<td>Non-volatile RAM (random access memory). Computer memory into which the user can enter information and instructions and from which the user can recall information. Data in NOVRAM are saved even when the instrument is switched off.</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td></td>
</tr>
<tr>
<td><strong>parameter</strong></td>
<td>a value or set of values used to define the characteristics or behavior of an instrument or system</td>
</tr>
<tr>
<td><strong>PEEK</strong></td>
<td>polyetheretherketone; a material frequently used in fabricating inert/biocompatible components</td>
</tr>
<tr>
<td><strong>piston</strong></td>
<td>the short cylinder piece that moves inside the sealed cylindrical opening and is used to pressurize fluid</td>
</tr>
<tr>
<td><strong>piston holder housing</strong></td>
<td>the shaft into which the piston and its holder are housed</td>
</tr>
<tr>
<td><strong>piston flush seal</strong></td>
<td>the low-pressure spring seal inside the liquid ends, facing the piston assembly</td>
</tr>
<tr>
<td><strong>piston seal</strong></td>
<td>also called pump seal, a high-pressure spring seal located inside the pump head</td>
</tr>
<tr>
<td><strong>plot</strong></td>
<td>the presentation of analytical data in a graphical manner; typical plots include chromatogram traces and calibration curves</td>
</tr>
<tr>
<td><strong>prime</strong></td>
<td>to flush the solvents contained in a new pump in order to prepare the pump for solvents chosen by the user</td>
</tr>
<tr>
<td><strong>pump</strong></td>
<td>the instrument used to push a liquid solvent through a chromatography system</td>
</tr>
<tr>
<td><strong>purge</strong></td>
<td>to flush the system with fresh, degassed solvent</td>
</tr>
<tr>
<td>Letter</td>
<td>Term</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Q</td>
<td>queue</td>
</tr>
<tr>
<td>R</td>
<td>RAM</td>
</tr>
<tr>
<td>R</td>
<td>real-time</td>
</tr>
<tr>
<td>R</td>
<td>reproducibility</td>
</tr>
<tr>
<td>R</td>
<td>retaining screw</td>
</tr>
<tr>
<td>R</td>
<td>run</td>
</tr>
<tr>
<td>R</td>
<td>run file</td>
</tr>
<tr>
<td>R</td>
<td>run time</td>
</tr>
<tr>
<td>S</td>
<td>sample</td>
</tr>
<tr>
<td>S</td>
<td>seal holder</td>
</tr>
<tr>
<td>S</td>
<td>shutdown file</td>
</tr>
<tr>
<td>S</td>
<td>solvent</td>
</tr>
<tr>
<td>S</td>
<td>solvent filter</td>
</tr>
<tr>
<td>S</td>
<td>solvent program</td>
</tr>
<tr>
<td>S</td>
<td>sparging</td>
</tr>
<tr>
<td>S</td>
<td>status</td>
</tr>
<tr>
<td>S</td>
<td>status lock</td>
</tr>
</tbody>
</table>
### Stroke
one complete revolution of the pump's cam which displaces both pistons

### System
a set of chromatography instruments that operate together in a concerted manner to produce an analytical result

### T

#### Timed Event
an instrument action triggered to occur at a specific, preset time during a run or analysis

#### Trace
a chromatogram

#### Transducer Check Valve
the valve which attached to the inlet of the pressure transducer

### V

#### Vacuum Degassing
the technique of removing dissolved gasses from solvents by passing the solvent through tubing made of gas-permeable membrane, and creating a vacuum around the tubing, thus allowing gasses to be evacuated out of the solvent and into the surrounding chamber

#### Viscosity
the degree to which a fluid resists flow
C

Kits and Parts Lists

Introduction

This chapter contains unpacking lists and information for several kits and accessories available from Thermo Fisher Scientific for use with your SpectraSYSTEM pump. Described in this chapter are:

- Accessory Kit    p/n A4070-010
- Standard Maintenance Kit  p/n A4050-010
- Standard LC Fittings Kit   p/n A4051-010
- Piston Flush Seal Kit (10 mL)  p/n A4114-010
- Piston Seal Kit (30 mL)   p/n A4084-010
- Solvent Inlet Tube Kit    p/n A4074-010
- Solvent Tube Extension Kit  p/n A4117-010
- Manual Injection Valve Bracket Kit  p/n A4054-010
- Narrow-bore Upgrade Kit   p/n A5190-060

Accessory Kit

Your kit consists of:

1. 4 amp, 250V fuse
2. 2 12-inch piece stainless steel tubing (0.06 OD x 0.02 ID) (27.5 cm length)
3. 2 nuts, 0.06 OD
4. 2 ferrules
5. 1 seal removal tool
6. 2 piston seals
7. 1 hex/ball wrench
8. 1 4-connection cable
9. 1 external function connector
10. 1 20 mL (cc) priming syringe with Luer LOK® tip
11. 1 Luer adapter
12. 1 waste tube kit:
   1. 1 48-inch Teflon tubing, 0.031 ID (123 cm)
   2. 1 washer and finger-tight fitting
   3. 1 solvent bottle label
13. 3 stainless steel tubing, 0.06 OD x 0.007 ID
Standard Maintenance Kit

The Standard Maintenance Kit contains the following:

4 inlet filter cartridges
1 inlet check valve
1 transducer check valve
2 sapphire pistons (0.125 inch-diameter)
1 barbed fitting (nylon)
1 piece piston flush tube (Tygon®), 0.0655 ID (approx. 76 cm long)
1 syringe (20 cc)
6 piston seals
2 piston flush seals
6 Kel-F seals
1 seal removal tool
1 seal insertion tool

Standard LC Fittings Kit

Your kit consists of:

1 storage/carrying case
1 120-inch piece Teflon tubing, 0.063-inch ID
2 adapter fittings (10-32M)
4 Rheodyne nuts/ferrules
4 Parker type nuts/ferrules
3 wrenches (sizes: 1/4" - 5/16", 3/8" - 7/16", 1/2" - 9/16")
1 1/8-inch tube adapter for gas regulator assorted tubing:
   stainless steel 0.020-inch ID
   stainless steel 0.010-inch ID

Fittings kits contain tubing and fittings commonly needed for LC systems. These fittings can be used for several different instruments. If you change your LC configuration or damage connections, the fittings provided in this kit should allow you to make changes or replacements quickly and easily. All fittings can be kept in the compartmentalized storage box.
Piston Flush Seal Kit (10 mL)

Your kit consists of:

1 piece tubing, 30-inch, Tygon (76 cm length)
1 barbed fitting (nylon)
2 piston flush seals
1 seal removal tool
1 seal insertion tool
1 syringe, 20 cc

Piston Seal Kit (30 mL)

Your kit consists of:

1 piston (with small O-ring, high pressure)
3 PEEK wash rings
1 large O-ring
1 Piston flush seal (low-pressure)

Solvent Inlet Tube Kit

Your kit consists of:

1 bottle cap
1 tubing, Teflon, 0.063 ID

Solvent Tube Extension Kit

Your kit consists of:

4 60-inch extension tubing, with washer and union
   (152 cm length)
1 tubing Teflon, 0.063 ID
Manual Injection Valve Bracket Kit

Your kit contains:

1. 11-3/16 inch steel mounting rod
2. Rod brackets
2. Short column brackets
2. Long column brackets
1. Manual injector valve mount
4. Short set screws (6-32 x 1/4-inch)
2. Flat-head screws (8-32 x 3/8-inch)
2. Screws (6-32 x 7/16-inch)
2. Long set screws (6-32 x 5/8-inch)
1. Allen wrench (1/16-inch)
1. 12 inches stainless steel tubing, 0.06 OD × 0.01 ID, 12 inches

If you purchased a Rheodyne valve (standard), you also received the valve, accompanied by Rheodyne's documentation.

Installing the Holder onto the Valve

To install the valve onto the bracket, do the following:

1. Move the injector valve handle to the "LOAD" position. Using the Allen wrench supplied with your Rheodyne valve, loosen the two set screws and remove the injection valve handle.

2. Hold the valve mounting bracket so that the two set screw holes are on the left. Place the injector valve into the bracket from the rear. If your injector valve has a remote start cable attached to it, place the cable into the cut-out on the left side of the bracket. When aligned correctly the "V" made by the two flats of the valve shaft will point to the upper left-hand mounting hole.

3. Fasten the valve securely with the two flat-head (Phillips) screws.

4. Attach the handle to the valve by tightening the two set screws, making sure that each screw is positioned over a flat edge of the valve shaft.

5. Install a long (5/8-inch) set screw into each of the valve bracket's mounting holes.

6. Install the rod through the valve bracket so that the notched portion of the rod faces you, as you look at the front of the injection valve.
7. Slide the valve bracket so that it is within the top quarter of the rod. Tighten the two set screws, securing the valve bracket to the rod.

8. Brackets for long (22 cm - 25 cm) and short (3 cm - 10 cm) columns are provided. Choose the bracket size that matches the type of column you use. Both brackets can be mounted, if desired.

9. Install a short (1/4-inch) set screw into each column bracket you want to use. Slide the brackets onto the rod for positioning. Temporarily tighten the set screws to hold the brackets in place (Figure C.1).

10. Remove the two top cover screws from the right side of your SpectraSYSTEM pump or detector. Install a rod bracket into the lower hole, using a 7/16-inch Phillips-head screw.

11. Rest the rod in the lower rod bracket (with the injector valve facing toward the front) and place the upper rod bracket on top of the rod. Attach the upper rod bracket to the pump or detector, using the other 7/16-inch screw.

12. Re-position the column brackets or manual injector valve as needed, and tighten the set screws.
Figure C.1 Manual Injection Valve/Column Bracket mounted to a SpectraSYSTEM instrument
Narrow-bore Upgrade Kit

Your kit consists of:

- 0.01” ID bypass, crossover, and transducer stainless steel tubes
- 0.03” ID Teflon solvent inlet tube
- Low-volume outlet liquid-end assembly
- 3 μL static mixer
- 0.007” stainless steel tubing
- Nuts and ferrules for all tubes
- Instruction sheet
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