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Vanquish

Pump H

VH-P10-A-02

Operating Manual

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ThermoFisher SCIENTIFIC

Original Operating Manual

The hardware descriptions in this manual revision refer to devices: VH-P10-A-02.

Trademarks

Disclaimer

Printed manual version only

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Contacting Us

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Ordering Information

For ordering information or sales support for HPLC products, contact your local Thermo Fisher Scientific sales organization. For contact information, go to Contact Us on http://www.thermofisher.com.

Technical Assistance

For technical support for HPLC products, contact your local Thermo Fisher Scientific support organization. For contact information, go to Contact Us on http://www.thermofisher.com.

Contents

1 Using this Manual

This chapter provides information about this manual, the conventions used throughout the manual, and the reference documentation that is available in addition to this manual.

1.1 About this Manual

This manual describes the functional features and operating principle of your Vanquish™ device and provides instructions for installation, set up, start up, shut down, operation, maintenance and troubleshooting.

This manual also contains safety messages, precautionary statements, and special notices. Follow these properly to prevent personal injury, damage to the device, or loss of data.

Note the following:

- The device configuration may vary; therefore, not all descriptions necessarily apply to your particular device.
- If some detail applies to only one model or variant, the model or variant is identified by name.
- Illustrations in this manual are provided for basic understanding. They can vary from the actual model of the device or component. However, this does not influence the descriptions. No claims can be derived from the illustrations in this manual.
- The pump is also referred to as *module* or *device* in this manual.

The descriptions in this manual assume that the device is installed in the Vanquish system stack. If this is not the case, additional hardware is required and must be ordered separately. The information in this manual applies correspondingly.

1.2 Conventions

This section describes the conventions that are used throughout this manual.

1.2.1 Conventions for Safety Messages

The safety messages and precautionary statements in this manual appear as follows:

- Safety messages or precautionary statements that apply to the entire manual and all procedures in this manual are grouped in the Safety chapter.
- Safety messages or precautionary statements that apply to an entire section or to multiple procedures in a section appear at the beginning of the section to which they apply.
- Safety messages that apply to only a particular section or procedure appear in the section or procedure to which they apply. They appear different from the main flow of text.

Safety messages are often preceded by an alert symbol and/or alert word. The alert word appears in uppercase letters and in bold type.

Make sure that you understand and follow all safety messages presented in this manual.

1.2.2 Special Notices

Special notices and informational notes in this manual appear different from the main flow of text. They appear in boxes and a note label identifies them. The label text appears in uppercase letters and in bold type.

NOTICE

Highlights information necessary to prevent damage to the device or invalid test results.

TIP Highlights information of general interest or helpful information that can make a task easier or optimize the performance of the device.

1.2.3 Typographical Conventions

These typographical conventions apply to the descriptions in this manual:

Data Input and Output

The following appears in **bold** type:

- Input that you enter by the keyboard or that you select with the mouse
- Buttons that you click on the screen
- Commands that you enter by the keyboard
- Names of, for example, dialog boxes, properties, and parameters

For brevity, long expressions and paths appear in the condensed form, for example: Click **File > Save as**.

References and Messages

- References to additional documentation appear *italicized*.
- Messages that appear on the screen are identified by quotation marks.

Viewpoint

If not otherwise stated, the expressions *left* and *right* in this manual always refer to the viewpoint of a person that is facing the device from the front.

Particularly Important Words

Particularly important words in the main flow of text appear *italicized*.

Electronic Manual Version (PDF)

The electronic version (PDF) of the manual contains numerous links that you can click to go to other locations within the manual. These include:

- Table of contents entries
- Index entries
- Cross-references (in blue text)

1.3 Reference Documentation

In addition to this operating manual, other documentation is available for reference.

Hardware Documentation

Additional hardware documentation includes the following:

- *Operating manuals* for the other modules of the Vanquish system
- *Vanquish System Operating Manual*
- *Instrument Installation Qualification Operating Instructions*

Thermo Fisher Scientific provides up-to-date operating manuals as PDF (Portable Document Format) files that you can access from our customer manuals web site. To open and read the PDF files, Adobe™ Reader™ or Adobe™ Acrobat™ is required.

Go to the following web site: www.thermofisher.com/HPLCmanuals

Software Documentation

Additional software documentation includes the following:

- *Chromeleon™ Help and documents*
  The *Chromeleon Help* provides extensive information and comprehensive reference material for all aspects of the software.

In addition, the following documentation is available (availability depends on the software version):

- *Installation Guide*
  For basic information about device installation and configuration, refer to the *Installation Guide*.
- *Instrument Configuration Manager Help*
  For specific information about a certain device, refer to the *Instrument Configuration Manager Help.* In Chromeleon 7, devices are called modules.
- *Quick Start Guide*
  For information about the main elements of the user interface and step-by-step guidance through the most important workflows, refer to the *Quick Start Guide*.
- *Reference Card*
  For a concise overview of the most important workflows, refer to the *Reference Card*.

TIP The *Chromeleon Help* and documents are included in the software shipment.

Third-Party Documentation

Refer also to the user documentation provided by the manufacturers of third-party components and materials, for example, Safety Data Sheets (SDSs).

2 Safety

This chapter provides general and specific safety information and informs about the intended use of the device.

2.1 Safety Symbols and Signal Words

2.1.1 Safety Symbols and Signal Words in this Manual

This manual contains safety messages to prevent injury of the persons using the device.

The safety symbols and signal words in this manual include the following:

Always be aware of the safety information. Do not proceed until you have fully understood the information and consider the consequences of what you are doing.

CAUTION

Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury.

WARNING

Indicates a hazardous situation that, if not avoided, could result in serious injury.

2.1.2 Observing this Manual

Observe the following:

- Before installing or operating the device, read this manual carefully to be familiar with the device and this manual. The manual contains important information with regard to user safety as well as use and care of the device.
- Always keep the manual near the device for quick reference.
- Save this manual and pass it on to any subsequent user.

Read, understand, and comply with all safety messages and precautionary statements presented in this manual.

2.1.3 Safety Symbols on the Device

The table lists the safety symbols that appear on the device or on labels affixed to the device. Follow the safety notices in this manual to prevent the risk of operator injury or damage to the device.

Symbol	Description
	Indicates a potential hazard. Refer to this manual to avoid the risk of personal injury and/or to prevent damage to the device.
— O	Power supply is on Power supply is off
	Indicates alternating current.

2.1.4 Rating Plate

The rating plate is present on the device near the electrical connections. The rating plate indicates the serial number, part number, module name, revision number (if any), and the line and fuse rating.

TIP An additional type label on the leak tray of the device indicates the module name, serial number, part number, and revision number (if any). To facilitate device identification, have the information from this label available when communicating with Thermo Fisher Scientific.

2.2 Intended Use

The device is intended to be part of the Vanquish system.

The intended use of the Vanquish system is to analyze mixtures of compounds in sample solutions.

The device is for use by qualified personnel and in laboratory environment only.

The device and Vanquish system are intended to be used as General Laboratory Equipment (GLE).

They are not intended for use in diagnostic procedures.

Laboratory Practice

Thermo Fisher Scientific recommends that the laboratory in which the Vanquish system is used follow best practices for LC analyses. This includes among others:

- Using appropriate standards
- Regularly running calibration
- Establishing shelf life limits and following them for all consumables used with the system
- Running the system according to the laboratory's verified and validated 'lab developed test' protocol

2.3 Safety Precautions

2.3.1 General Safety Information

All users must observe the general safety information presented in this section and all specific safety messages and precautionary statements elsewhere in this manual during all phases of installation, operation, troubleshooting, maintenance, shutdown, and transport of the device.

If the device is used in a manner not specified by Thermo Fisher Scientific, the protection provided by the device could be impaired. Observe the following:

- Operate the device only within its technical specifications.
- Use only the replacement parts and additional components, options, and peripherals specifically authorized and qualified for the device by Thermo Fisher Scientific.
- Perform only the procedures that are described in this operating manual and in supporting documents for the device. Follow all instructions step by step and use the tools recommended for the procedure.
- Open the enclosure of the device and other components only if specifically instructed to do so in this manual.
- Thermo Fisher Scientific cannot be held liable for any damage, material or otherwise, resulting from inappropriate or improper use of the device. If there is any question regarding appropriate usage, contact Thermo Fisher Scientific before proceeding.

Safety Standard

This device is a Safety Class I instrument (provided with terminal for protective grounding). The device has been manufactured and tested according to international safety standards.

2.3.2 Qualification of the Personnel

Observe the information below on the proper qualification of the personnel installing and/or operating the device.

Installation

Only skilled personnel are permitted to install the device and to establish the electrical connections according to the appropriate regulations.

- Thermo Fisher Scientific recommends always having service personnel certified by Thermo Fisher Scientific perform the installation (for brevity, referred to as Thermo Fisher Scientific service engineer).
- If a person other than a Thermo Fisher Scientific service engineer installs and sets up the module, the installer is responsible for ensuring the safety of the module and system.

General Operation

The device is designed to be operated only by trained and qualified personnel in a laboratory environment.

All users must know the hazards presented by the device and the substances they are using. All users should observe the related Safety Data Sheets (SDSs).

2.3.3 Personal Protective Equipment

Wear personal protective equipment and follow good laboratory practice to protect you from hazardous substances. The appropriate equipment depends on the hazard. For advice on the hazards and the equipment required for the substances you are using, refer to the material handling and safety data sheet provided by the vendor.

An eyewash facility and a sink should be available nearby. If any substance contacts your skin or eyes, wash the affected area and seek medical attention.

Protective Clothing

To protect you from chemical splashes, harmful liquids, or other contamination, put on appropriate protective clothing, such as a lab coat.

Protective Eyewear

To prevent liquids from striking your eyes, put on appropriate protective eyewear, such as safety glasses with side shields. If there is a risk of splashing liquids, put on goggles.

Gloves

To protect you from harmful liquids and avoid personal injury during maintenance or service, put on appropriate protective gloves.

2.3.4 Electrical Safety Precautions

WARNING—Electric Shock or Damage to the Device

High voltages are present inside the device that could cause an electric shock or damage to the device.

- Do not make any changes to the electrical or grounding connections.
- If you suspect any kind of electrical damage, disconnect the power cord and contact Thermo Fisher Scientific Technical Support for assistance.
- Do not open the housing or remove protective panels unless specifically instructed to do so in this manual.
- Do not place liquid reservoirs directly upon the device. Liquid might leak into the device and get into contact with electronic components causing a short circuit. Instead, place liquid reservoirs in the solvent rack that is available for the Vanquish system.

2.3.5 General Residual Hazards

Pay attention to the following general residual hazards when working with the device:

WARNING—Hazardous Substances

Solvents, mobile phases, samples, and reagents might contain toxic, carcinogenic, mutagenic, infectious, or otherwise harmful substances. The handling of these substances can pose health and safety risks.

- Be sure that you know the properties of all substances that you are using. Avoid exposure to harmful substances. If you have any doubt about a substance, handle the substance as if it is potentially harmful.
- Wear personal protective equipment as required by the hazard and follow good laboratory practice.
- Reduce the volume of substances to the minimum volume required for sample analysis.
- Avoid handling of solvent reservoirs above head height.
- Do not operate the device in a potentially flammable environment.
- Avoid accumulation of harmful substances. Make sure that the installation site is well ventilated.
- Dispose of hazardous waste in an environmentally safe manner that is consistent with local regulations. Follow a regulated, approved waste disposal program.

WARNING—Biohazard

Biohazardous material, for example microorganisms, cell cultures, tissues, body fluids, and other biological agents can transmit infectious diseases. To avoid infections with these agents:

- Assume that all biological substances are at least potentially infectious.
- Wear personal protective equipment as required by the hazard and follow good laboratory practice.
- Dispose of biohazardous waste in an environmentally safe manner that is consistent with local regulations. Follow a regulated, approved waste disposal program.

WARNING—Self-Ignition of Solvents

Solvents with a self-ignition temperature below 150 °C might ignite when in contact with a hot surface (for example, due to leakage in the chromatography system).

Avoid the use of these solvents.

WARNING—Hazardous Vapors

Mobile phases and samples might contain volatile or flammable solvents. The handling of these substances can pose health and safety risks.

- Avoid accumulation of these substances. Make sure that the installation site is well ventilated.
- Avoid open flames and sparks.
- Do not operate the device in the presence of flammable gases or fumes.

CAUTION—Allergic Reaction

Some capillaries in the system are made of MP35N™, a nickel/cobalt-based alloy. Individuals with sensitivity to nickel/cobalt may show an allergic reaction from skin contact.

CAUTION—Sparking due to Electrostatic Discharge

Liquid flowing through capillaries can generate static electricity. This effect is particularly present with insulating capillaries and non-conductive solvents (for example, pure acetonitrile). Discharge of electrostatic energy might lead to sparking, which could constitute a fire hazard.

Prevent the generation of static electricity near the chromatography system.

2.3.6 In Case of Emergency

WARNING—Safety Hazard

In case of emergency, disconnect the device from the power line.

2.4 Solvent and Additive Information

2.4.1 General Compatibility

To protect optimal functionality of the Vanquish system, observe these recommendations on the use of solvents and additives:

- The system must be used with reversed-phase (RP) compatible solvents and additives only.
- Use only solvents and additives that are compatible with all parts in the flow path.
- Anhydrous methanol may lead to stress failures in titanium surfaces, especially when formic acid or TFA is added to the mixture. Thermo Fisher Scientific recommends adding 3% of water to prevent this.

Piston Seal Compatibility

- The pump is shipped with UHMW-PE piston seals. Using tetrahydrofuran, ketones, or ammonium hydroxide as solvents can damage the seals.
- In rare cases, a shortened lifetime of reversed-phase (UHMW-PE) piston seals has been observed with high pH, ammonium hydroxide containing mobile phases and prolonged exposure.

2.4.2 Allowed pH Ranges

Allowed pH ranges (standard system configuration):

System (Standard Configuration)	Allowed pH ranges	Remarks
Vanquish Core	1-13	• *pH value of 2 (Vanquish Horizon/Flex)*: Short-term use only. The application time should be as short as possible. Flush the system thoroughly after these applications. • *pH value of 1-2 (Vanquish Core)*: The application time should be as short as possible. Flush the system thoroughly after these applications. • *pH values higher than 9.5 with optical detectors*: Avoid using mobile phases with a pH value higher than 9.5 together with optical detectors. This can impair the functionality and optical performance of the detector flow cell.
Vanquish Horizon Vanquish Flex	2-12	

2.4.3 Allowed Concentrations

Allowed concentrations (standard system configuration):

System (Standard Configuration)	Chloride	Buffer	Remarks
Vanquish Core	0.1 mol/L or less	1 mol/L or less	*High chloride concentration*: The application time should be as short as possible. Flush the system thoroughly after these applications.
Vanquish Horizon Vanquish Flex	1 mol/L or less	-	

2.4.4 Further Information

- For details about the materials that are used in the analytical flow path of the device, see the *Specifications* chapter in this manual. For information about the materials that are used in the flow path of the other modules in the Vanquish system, refer to the *Specifications* chapter in the *Operating Manual* for the modules.
- Observe the general guidelines and recommendations on the use of solvents and additives in the chromatography system (see Use of Solvents and Additives (▶ page 82)).
- Refer also to the *Operating Manuals* for all modules in the Vanquish system. They may provide additional guidelines and information.

NOTICE

If the system configuration includes a non-standard detector, for example, a charged aerosol detector or refractive index detector, refer to the *Operating Manual* for the detector for specific recommendations regarding solvents and additives.

2.5 Compliance Information

Thermo Fisher Scientific performs complete testing and evaluation of its products to ensure full compliance with applicable domestic and international regulations. When the device is delivered to you, it meets all pertinent electromagnetic compatibility (EMC) and safety standards as described in this manual.

Changes that you make to the device may void compliance with one or more of these EMC and safety standards. Changes to the device include replacing a part or adding components, options, or peripherals not specifically authorized and qualified for the product by Thermo Fisher Scientific. To ensure continued compliance with EMC and safety standards, replacement parts and additional components, options, and peripherals must be ordered from Thermo Fisher Scientific or one of its authorized representatives.

The device has been shipped from the manufacturing site in a safe condition.

See also

Compliance Information (▷ page 220)

3 Device Overview

This chapter introduces you to the device and the main components.

3.1 Pump Features

The pump comprises the following main features:

- Two-channel pump with each channel based on a dual-piston in-parallel design
- Independent drive for each piston for high accuracy and increased flexibility
- Advanced Thermal Effect Compensation (ATEC) and electronic compressibility compensation (SmartFlow™) for precise and virtually pulse-free flow
- Active piston seal wash system for high lifetime of pistons and piston seals
  The piston seal wash system keeps the pistons wet and rinses the piston seals automatically. This prevents crystallization and particle deposits on the piston surfaces and seals, which may damage the components.
- Solvent selector "2 from 6" for increased flexibility
- Purge unit for easy and automatic purging
- Built-in vacuum degasser for enhanced flow stability and best detector sensitivity
- Easy access to the user-serviceable components and tool-free maintenance procedures for fast and reliable maintenance
- Easy maintenance because the pump remains in the Vanquish system stack

For specifications, see Performance Specifications (page 208).

3.2 Operating Principle

The pump can generate pressures up to 151 MPa with ultra-low pulsation. The pump is based on a two-channel, dual-piston design with electronic compressibility compensation.

The picture illustrates how the pump operates:

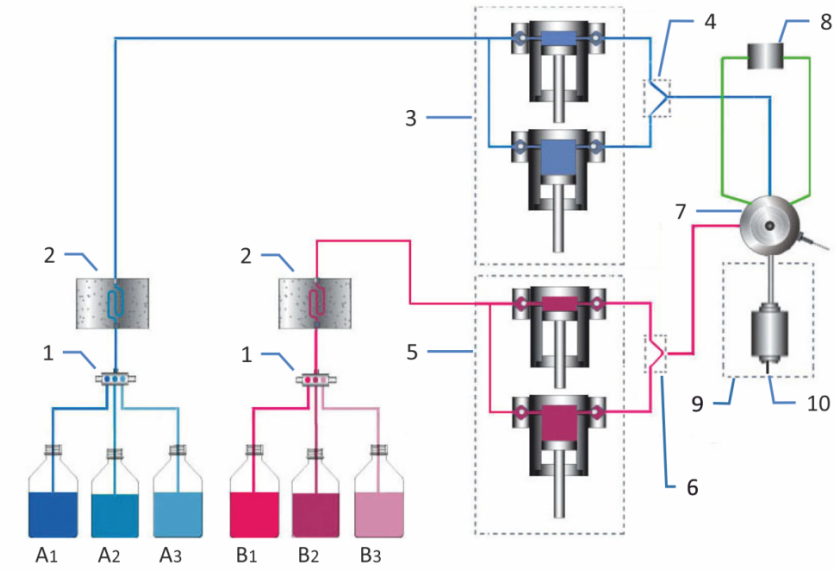

Figure 1: Operating principle

No.	Description
1	Solvent selector (pump inlet)
2	Solvent degasser (vacuum degasser)
3	Pump head, left (two pistons, parallel)
4	Y-connector, left
5	Pump head, right (two pistons, parallel)
6	Y-connector, right
7	Purge unit
8	System pressure sensor
9	Inline filter (static filter)
10	Pump outlet (outlet of the inline filter)

Each pump head comprises two cylinders that are connected in parallel. Thus, the solvent passes only one cylinder when the pump is delivering. To achieve continuous delivery, one cylinder is refilled while the other cylinder is delivering at the selected flow rate.

The pump uses independent piston drives and highly precise position and pressure sensors. This leads to high accuracy, increased reliability, and ultra-low pulsation when delivering compressible liquids. Independent of the operating pressure, the flow rate of the solvent (after expansion to atmospheric pressure) is always kept constant.

Two 3-port solvent selectors allow forming binary gradients from three solvents per channel. The solvent to be used for each channel is selected in the user interface.

The vacuum degasser enhances the flow stability and allows best detector sensitivity by continuously removing air that may be trapped in the solvents.

The solvent flow is through the pump head, from the inlet assembly to the pump cylinders, and on to a Y-connector. The Y-connector combines the solvent flows from the pump head cylinders.

From each Y-connector, the solvent stream is directed to the purge unit, which combines the two solvent streams, and on to the inline filter.

3.3 Interior Components

The user-accessible components of the device are located directly behind the front doors:

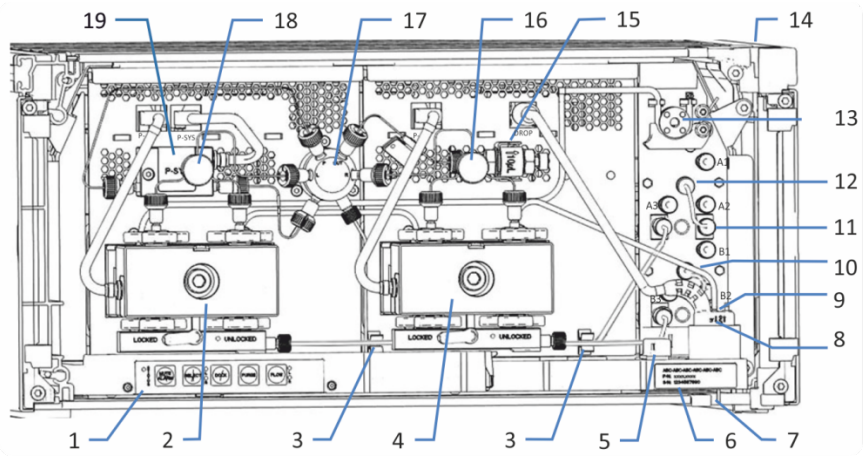

Figure 2: Interior view

No.	Description
1	Keypad with buttons for pump control
2	Pump head, left
3	Tubing clips for routing solvent lines to the pump heads
4	Pump head, right
5	Leak sensor
6	Type label, indicating the module name, serial number, part number, and revision number (if any)
7	Drain port
8	Seal wash detector (drop detector)
9	Vacuum degasser (solvent B) (partly hidden by seal wash detector)
10	Solvent selector (solvent B)
11	Vacuum degasser (solvent A)
12	Solvent selector (solvent A)
13	Seal wash pump
14	Tubing chase with tubing guides
15	Inline filter (static filter)
16	Y-connector, right
17	Purge unit
18	Y-connector, left
19	System pressure sensor

3.4 Piston Seal Wash System

To keep the pistons wet and rinse the piston seals, the pump has an active piston seal wash system (seal wash system). Piston seal washing prolongs the lifetime of the pistons and seals by preventing crystallization and particle deposits on the piston surfaces and seals, which may otherwise damage the pistons and seals.

The picture shows the flow path through the seal wash system.

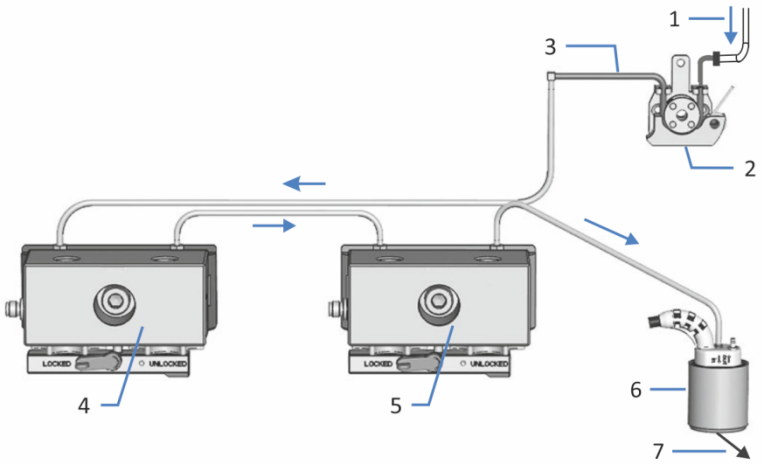

Figure 3: Flow path through the seal wash system

No.	Description
1	Seal wash line from autosampler
2	Seal wash pump (peristaltic pump)
3	Peristaltic tubing (PharMed™ tubing)
4+5	Pump heads
6	Seal wash detector (drop detector)
7	To waste

3.5 Purge Unit

The purge unit combines the solvent streams from the pump heads, connects the system pressure sensor to the flow system, and allows easy and automatic purging. The pump is shipped from the manufacturing site with the capillaries and tubing installed to the purge unit.

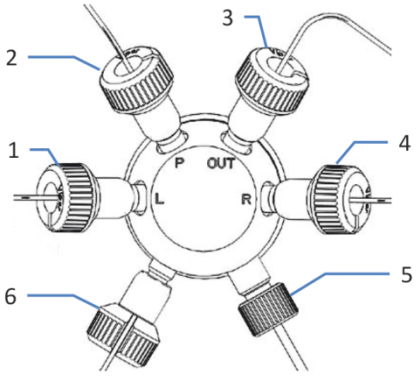

Figure 4: Connections on purge unit

No.	Description
1	Capillary from left Y-connector
2	Capillary to system pressure sensor (long capillary)
3	Capillary to inline filter
4	Capillary from right Y-connector
5	Waste tubing (from purge unit to drain port)
6	Capillary from system pressure sensor (short capillary)

3.6 Leak Detection

Leaks are a potential safety issue.

The leak sensor inside the device monitors the device for liquid leaks from the flow connections. The liquid is collected in the leak tray and guided to the drain port. From the drain port, the liquid is discharged to waste through the drain system of the Vanquish system.

When the leak sensor detects leakage, the status indicators change to red and beeping starts to alert you. Follow the instructions in this manual to find and eliminate the source for the leakage.

If leakage is not resolved after 3 minutes, the pump stops the flow.

3.7 Operation

The device is designed to be operated from a computer configured with the Chromeleon Chromatography Data System (CDS). The Chromeleon software provides complete instrument control, data acquisition, and data management.

For a basic description of instrument control and automated sample analysis with the Chromeleon software, refer to the *Vanquish System Operating Manual*. Details on control and operation of the device are available in the *Chromeleon Help*.

TIP The device can be operated also with other data systems, such as Thermo Scientific™ Xcalibur™. In this case, installation of additional software is required in addition to the data system software. For details, contact the Thermo Fisher Scientific sales organization.

A keypad is available inside the device, allowing you to perform certain basic functions directly from the device.

4 Unpacking

This chapter provides information for unpacking the device and informs you about the scope of delivery.

4.1 Unpacking

Damaged Packaging, Defective on Arrival

Inspect the shipping container for signs of external damage and, after unpacking, inspect the device for any signs of mechanical damage that might have occurred during shipment.

If you suspect that the device may have been damaged during shipment, immediately notify the incoming carrier and Thermo Fisher Scientific about the damage. Shipping insurance will compensate for the damage only if reported immediately.

Unpacking the Device

CAUTION—Heavy Load, Bulky Device

The device is too heavy or bulky for one person alone to handle safely. To avoid personal injury or damage to the device, observe the following guidelines:

- Physical handling of the device, including lifting or moving, requires a team effort of two persons.
- A team effort is in particular required when lifting the device into the system stack or when removing it.
- Use the carrying handles that were shipped with the device to move or transport the device. Never move or lift the device by the front doors. This will damage the doors or the device.

Tools required

Screwdriver, Torx™ T20

Follow these steps

1. Place the shipping container on the floor and open it.
2. Remove the ship kit from the shipping container.
3. Remove the device from the shipping container: Grasp the device by the carrying handles. Slowly and carefully, lift the device out of the shipping container.

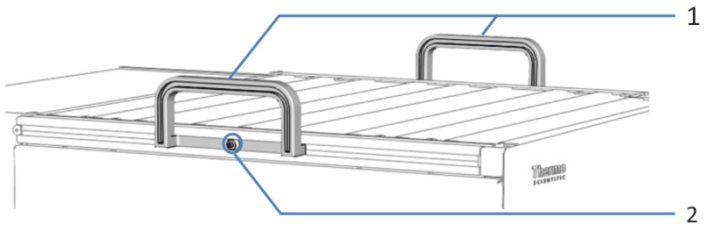

Figure 5: Carrying handles on the device

No.	Component
1	Carrying handles
2	Attachment screw (one on each carrying handle)

4. Place the device on a stable surface.

5. *If applicable:*
   Remove any additional packing material. Leave any protective films attached to the surfaces of the device until it is properly positioned in the system stack.

6. Transport the device by the carrying handles to the installation site, if it is not already there, and place it in the system stack (see System Arrangement (▸ page 50)).

7. On each carrying handle, loosen the attachment screw until the carrying handle is moveable in the rail. Do not remove the screws from the carrying handles completely.

8. Slide off the carrying handles from the rails towards the rear of the device.

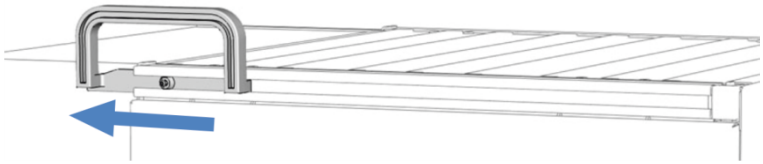

Figure 6: Sliding off the carrying handle from the left rail

TIP Keep the shipping container, the carrying handles with the attachment screws, and all packing material. These items will be needed if the device is transported to a new location or shipped.

9. Some surfaces including the doors of the device are covered by a protective film during shipment. Remove the protective film from all surfaces as applicable.

4.2 Scope of Delivery

The following items are included in the delivery:

- Pump
- Ship Kit
- Operating manual (downloadable from customer manual web site)
- Power cord

For information on contents of the ship kit or reordering parts, see Accessories, Consumables and Replacement Parts (page 211).

5 Installation

This chapter specifies the requirements for the installation site and describes how to set up, install, and configure the device in the Vanquish system and in the chromatography software.

5.1 Safety Guidelines for Installation

Pay attention to the following safety guidelines:

Observe all warning messages and precautionary statements presented in Safety Precautions (page 21).

CAUTION—Heavy Load, Bulky Device

The device is too heavy or bulky for one person alone to handle safely. To avoid personal injury or damage to the device, observe the following guidelines:

- Physical handling of the device, including lifting or moving, requires a team effort of two persons.
- A team effort is in particular required when lifting the device into the system stack or when removing it.
- Use the carrying handles that were shipped with the device to move or transport the device. Never move or lift the device by the front doors. This will damage the doors or the device.

CAUTION—Electric Shock or Damage to the Device

After the power to the device is turned off, the device is still energized as long as the power cord is connected. Repair work on the device while the device is connected to power could lead to personal injury.

- Always unplug the power cord before starting repair work inside the device.
- If you were instructed to remove any housing covers or panels, do not connect the power cord to the device while the cover or panels are removed.

5.2 Installing the Device

A Thermo Fisher Scientific service engineer installs and sets up the Vanquish system, including all modules and options or parts shipped with them. The service engineer checks that the installation is correct and that the Vanquish system and modules operate as specified. The engineer also demonstrates the basic operation and main features.

If personnel other than a Thermo Fisher Scientific service engineer installs the device, follow the steps below.

NOTICE

The device is part of the Vanquish system. Therefore, follow the order for installing the system modules as described in the *Vanquish System Operating Manual*.

1. Pay attention to the safety guidelines and observe all site requirements. See Safety Guidelines for Installation (▸ page 44) and Site Requirements (▸ page 47).
2. Set up the device hardware. See Setting Up the Hardware (▸ page 50).
3. Set up the flow connections. See Setting Up the Flow Connections (▸ page 53).
4. Turn on the device. See Turning On the Device (▸ page 73).

TIP

Before turning on the power to a Vanquish system module for the first time, verify that the chromatography software is installed on the data system computer. When the power is turned on, the required USB drivers are automatically found and the Windows™ operating system can detect the device.

5. Set up the device in the software. See Setting Up the Device in the Software (▸ page 74).
6. *Recommended*:
   Perform Instrument Installation Qualification.

   In the Chromeleon software, a wizard is available to guide you through the qualification process. On the **Chromeleon 7 Console**: Click **Tools > Instrument Qualification > Installation Qualification**.

   Follow the instructions in the *Instruments Installation Qualification Operating Instructions*. The manual provides information about the required materials and detailed instructions.

NOTICE

If the device is operated with another data system, refer to the documentation for the software that you are using and/or perform the qualification manually. The *Instruments Installation Qualification Operating Instructions* provide information about the parameters to be adapted and the required settings.

7. *Recommended*: Perform Operational Qualification.
   The qualification kit includes all materials required for the qualification and detailed instructions.

Moving the Device after Installation

If you have to move the device after it has been set up and installed in the Vanquish system, prepare the device for transport and move it to the new location. Follow the instructions in Transporting or Shipping the Device (▸ page 178).

5.3 Site Requirements

The operating environment is important to ensure optimal performance of the device.

This section provides important requirements for the installation site. Note the following:

- Operate the device only under appropriate laboratory conditions.
- The device is intended to be part of the Vanquish system. Observe the site requirements for the Vanquish system as stated in the *Vanquish System Operating Manual*.
- For specifications, see Specifications (▶ page 207) and the *Specifications* sections in the *Operating Manuals* for the other modules in the Vanquish system.
- For general residual hazards, see General Residual Hazards (▶ page 24).

5.3.1 Power Considerations

The power supply of the device has wide-ranging capability, accepting any line voltage in the range specified for the device.

CAUTION—Electric Shock or Damage to the Device

Connecting the device to a line voltage higher or lower than specified could result in personal injury or damage to the device.

Connect the device to the specified line voltage only.

5.3.2 Power Cord

The power cords are designed to match the wall socket requirements of the country in which they are used. The end of the power cords that plugs into the power socket on the device is identical for all power cords. The end of the power cords that plugs into the wall socket is different.

WARNING—Electric Shock or Damage to the Device

- Never use a power cord other than the power cords provided by Thermo Fisher Scientific for the device.
- Only use a power cord that is designed for the country in which you use the device.
- Do not use extension cords.
- Never plug the power cord to a power socket that is shared with other equipment (for example, multiple sockets).
- Operate the device only from a power outlet that has a protective ground connection.
- In case of emergency, it must be possible to reach the power cord easily at any time to disconnect the device from the power line.

WARNING—Electric Shock or Damage to a Product

Misuse of the power cords could cause personal injury or damage the instrument. Use the power cords provided by Thermo Fisher Scientific only for the purpose for which they are intended. Do not use them for any other purpose, for example, for connecting other instruments.

5.3.3 Condensation

NOTICE—Condensation in the device can damage the electronics.

- When using, shipping, or storing the device, avoid or minimize conditions that can lead to a build-up of condensation in the device. For example, avoid significant or fast changes in environmental conditions.
- If you suspect that condensation is present, allow the device to warm up to room temperature. This may take several hours. Wait until the condensation is gone completely before connecting the device to the power line.

5.4 Accessing the Interior Components

To access the interior components in the device, open the front doors. To allow easy access from the front, the user-accessible components and flow connections in the device are located directly behind the doors.

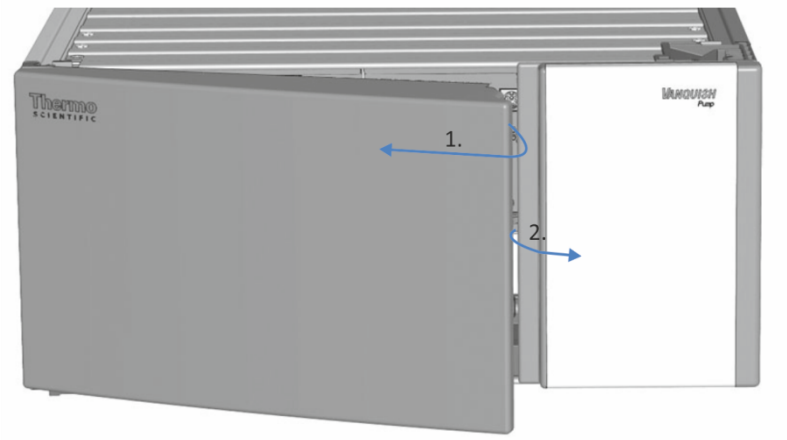

Figure 7: Opening the front doors

5.5 Setting Up the Hardware

This section describes how to set up the hardware and provides information about the device connectors and cables.

5.5.1 System Arrangement

The device is part of the Vanquish system. The system modules are typically arranged in a system stack, with the arrangement depending on the system configuration.

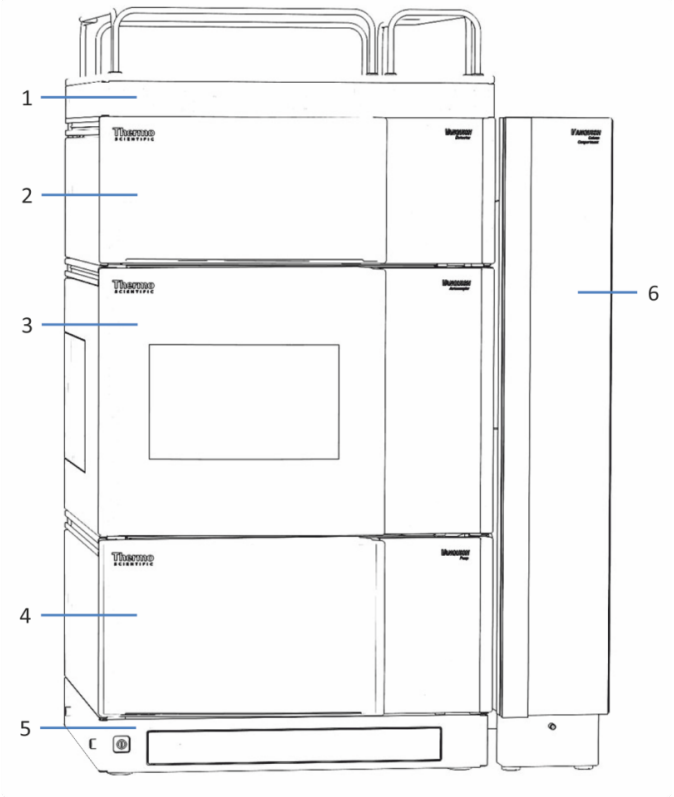

Figure 8: Vanquish system, standard configuration (example)

No.	Description
1	Solvent Rack
2	Detector
3	Autosampler
4	Pump
5	System Base
6	Column Compartment

For instructions on how to set up the system stack, refer to the *Vanquish System Operating Manual*.

5.5.2 Connecting the Device

Device Connectors

The following connectors are provided on the device:

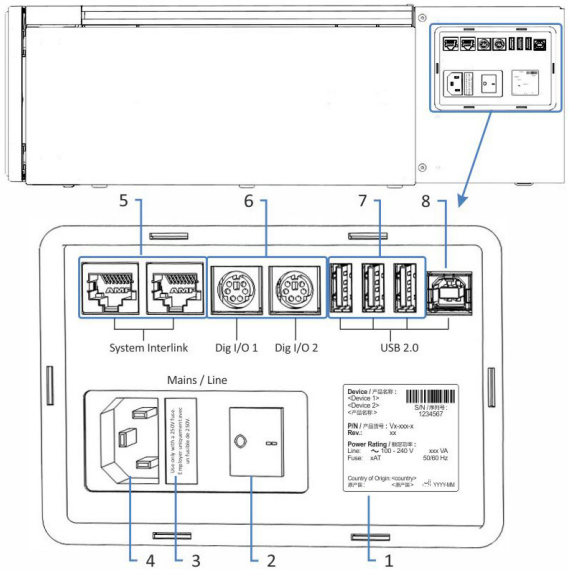

Figure 9: Electrical connectors and device connectors on the pump

No.	Description
1	Rating plate (example), indicating the serial number, part number, module name, revision number (if any), and the line and fuse rating
2	Main power switch (on/off control)
3	Fuse holder
4	Power-inlet connector
5	System Interlink port Allows power on/off control for the device from the Vanquish system base and device communication
6	Digital I/O ports (Dig I/O) Allow exchange of digital signals with external instruments Each digital I/O port provides one input, one relay output, and one bidirectional input/output. For connection and pin assignment information, see Digital I/O (▶ page 222).
7	USB hub ("A" type connector) Allows connection to other modules in the Vanquish system
8	USB (Universal Serial Bus) port ("B" type connector) Allows connection to other modules in the Vanquish system or the computer on which the data management system is installed, such as the Chromeleon software

TIP Thermo Fisher Scientific recommends using the USB ports only as described above. If the USB ports are used for any other purpose, Thermo Fisher Scientific cannot ensure proper functionality.

Follow these steps

NOTICE

- Never use defective communication cables. If you suspect that a cable is defective, replace the cable.
- To ensure trouble-free operation, use only the cables provided by Thermo Fisher Scientific for connecting the device.

1. Place the device in the system as required by the system configuration. For details, refer to the *Vanquish System Operating Manual*.
2. Connect the required interface cables to the device. For information about how to connect the device to other modules in the Vanquish system or to the chromatography data system computer, refer to the *Vanquish System Operating Manual*.
3. Connect the power cord (see Connecting the Power Cord (▸ page 52)).

5.5.3 Connecting the Power Cord

NOTICE

Condensation in a device can damage the electronics.

- Before connecting the devices to the power line, be sure that no condensation is present in the devices.
- If you suspect that condensation is present, allow the device to warm up to room temperature slowly. Wait until the condensation is completely gone before proceeding.

1. Verify that the power switch on the device is set to OFF.
2. Connect the power cord to the power inlet connector on the device.
3. Connect the free end of the power cord to an appropriate power source.

5.6 Setting Up the Flow Connections

This section describes how to set up the flow connections to and from the device and additional flow connections, if required.

5.6.1 General Information and Guidelines

The pump is shipped from the manufacturing site with the flow connections installed between the interior components.

When setting up flow connections, follow these rules and recommendations:

Flow connections can be filled with hazardous substances. Observe the warning messages and precautionary statements presented in Safety Precautions (▸ page 21).

- Dirty components can contaminate the chromatography system. Contamination leads to poor performance of the modules and entire system or can even cause damage to the modules and system. Therefore:
  - Always wear appropriate gloves.
  - Place the components only on a clean, lint-free surface.
  - Keep your tools clean.
  - Use only lint-free cloth for cleaning.
- For installation instructions and guidelines and for handling recommendations, see Connecting Fittings, Capillaries, and Tubing (▸ page 55).

NOTICE

When you install devices or components to the system, always flush them to waste before connecting them in the system flow path. To flush the Vanquish modules, follow the instructions in the *Vanquish System Operating Manual*.

TIP Components or connections in the flow path to other system modules may be closed with plugs to protect the component or connection during transport.

When you remove the plugs to connect the device in the system, keep the plugs. You may need them to close the connections again, for example, for future transport.

Follow these steps

To set up the additional flow connections and complete the installation, follow these steps:

1. Connect the pump to the drain system (see Guiding Liquids to Waste (▸ page 57)).
2. Connect the solvent lines (see Connecting the Solvent Lines (▸ page 58)).
3. Set up the seal wash system (see Seal Wash System (▸ page 64)).
4. Connect the pump to the autosampler (see Connecting the Pump and Autosampler (▸ page 72)).

5.6.2 Guiding Capillaries and Tubing Through the System

Flow connections between the modules of the Vanquish system are guided through either the tubing chase in the devices or the guide holes or capillary clips of the devices.

Tubing Chase with Tubing Guides

To guide certain tubes and lines from the top module to the bottom module in the Vanquish system stack, the stackable modules have a tubing chase on the inside right. The tubing chase provides four tubing guides.

Each guide can hold up to three tubes or lines. In each module, push the tube (or line) into the appropriate guide.

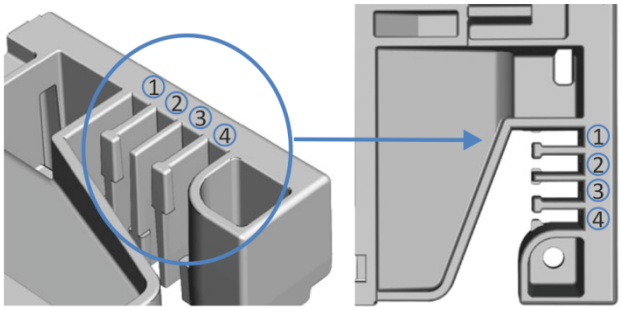

Figure 10: Tubing chase with tubing guides (left: view from inside, right: view from top)

No.	Use for
1	Solvent tubing (up to three solvent lines)
2	Solvent tubing (up to three solvent lines)
3	Wash liquid tubing (seal wash, autosampler needle wash)
4	Detector waste line

Tubing Brackets

Tubing brackets are available for holding the tubing in place. Slip the bracket side onto the drain pipe.

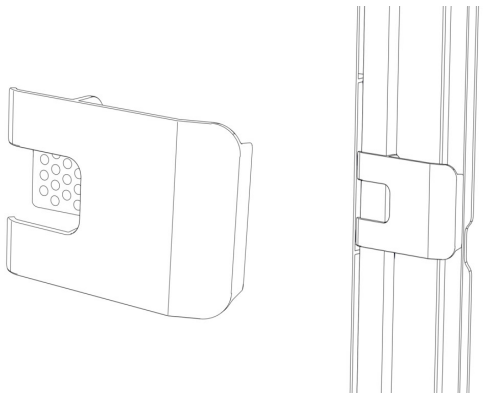

Figure 11: Tubing bracket (left), tubing bracket installed (right)

Dual System Arrangements

The number of tubes may exceed the capacity that the tubing guides can hold. In this case, it is recommended to place the solvent lines in the tubing guides and route any additional tubes freely in the tubing chase.

Guide Holes and Capillary Clips

Guide holes and capillary clips are provided at specific positions on the system modules. Route flow connections from one module to the next module in the Vanquish system through the appropriate guide hole or capillary clip when instructed to do so in the manual.

5.6.3 Connecting Fittings, Capillaries, and Tubing

This section provides information about how to connect and handle capillaries, fittings, and tubing.

5.6.3.1 General Guidelines

When connecting capillaries and tubing, follow these general recommendations:

- Use only the capillaries and tubing (for example, solvent lines or waste tubing) that are shipped with the product or additional or spare capillaries and tubing as recommended by Thermo Fisher Scientific.
- The connectors must be free from contaminants. Even minute particles may cause damage to the system or lead to invalid test results.

- Do not install capillaries or tubes that are stressed, nicked, kinked, or otherwise damaged.
- Install capillaries and fittings only at the positions for which they are intended.

5.6.3.2 Connecting Viper Capillaries

This section describes how to connect Viper™ capillaries. All Viper flow connections in the Vanquish system are designed to be finger-tight.

To connect Viper capillaries with knurls, follow these steps:

NOTICE

- Tighten or loosen Viper capillaries *only* with your fingers. Do not use tools other than the knurl that comes with the capillary.
- To avoid damage to the capillary or connection, tighten and loosen the Viper capillaries *only* when the system pressure is down to zero.

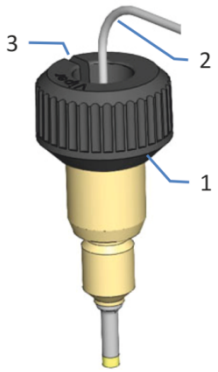

Figure 12: Viper fitting with knurl

No.	Description
1	Knurl
2	Capillary
3	Slot

1. Insert the Viper capillary into the connection port.
2. Tighten the connection by the knurl.

TIP Note the slot in the knurl. You can easily remove the knurl from the capillaries through this slot if space is limited.

3. Check whether the connection leaks. If leakage exists, follow the steps further down.

Resolving Leakage of Viper Fittings with Knurls

1. Tighten the connection a little more.
2. If leakage continues, remove the capillary.
3. Clean the capillary ends carefully by using a lint-free tissue wetted with isopropanol.
4. Reinstall the capillary.
5. If the connection continues to leak, install a new Viper capillary.

5.6.4 Guiding Liquids to Waste

The following liquids collect in the leak tray and flow off through the drain port at the bottom right of the leak tray into the drain system of the Vanquish system:

- Leaking liquid from the leak tray
  Leaking liquid collects in the leak tray and flows off through the drain port outlet into the drain system of the Vanquish system.
- Waste liquid from the purge unit
  Waste liquid from the purge unit flows off through the waste outlet port into the drain system of the Vanquish system. To avoid false leak alarms, verify that the waste line sits properly in the waste outlet port. If it does not, liquid from the purge unit may accumulate in the drain port and activate the leak sensor.

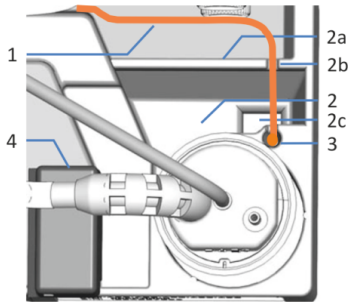

Figure 13: Outlets for guiding liquids to waste

No.	Description
1	Waste line from purge unit: routing path to outlet
2	Drain port, with
2a	Drain port wall
2b	Groove in drain port wall for routing the waste line to the waste outlet port
2c	Drain port outlet (to Vanquish drain system)
3	Waste outlet port (to Vanquish drain system)
4	Leak sensor

For information about how the liquid is discharged to waste through the Vanquish drain system, refer to the *Vanquish System Operating Manual*.

5.6.5 Connecting the Solvent Lines

The pump is shipped from the manufacturing site with the solvent lines installed between the components in the pump. To complete the setup, install the solvent lines between the pump inlet ports and the solvent reservoirs.

TIP The flow path determines the pump inlet (component at which the solvent enters the pump) and the solvent flow through the pump. With the binary pump, the pump inlets are the solvent selectors. The operating principle illustrates the solvent flow through the pump (see Operating Principle (page 31)).

Parts and tools required

- Solvent reservoir assemblies, including reservoir, reservoir cap, cap plugs, and retaining guide for the solvent line
- Solvent lines
- Solvent line filters

Optional to shut off the solvent flow through the system at the solvent reservoir

- Shut-off valve, kit containing one shut-off valve and fitting connections
- Tubing cutter

Preparations

1. Assemble the solvent line filter.
2. Rinse the solvent reservoirs thoroughly. Use a high-purity solvent for rinsing.
3. On the pump inlet, remove the plug that protects the inlet during shipment, if applicable.
4. For easier access to the lower degas chambers, remove the seal wash detector assembly (funnel and detector).

Assembling the Solvent Line Filter

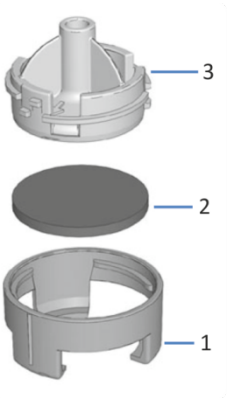

Figure 14: Solvent line filter

No.	Description
1	Solvent line filter, filter holder bottom part
2	Filter frit
3	Solvent line filter, filter holder top part

1. Assemble the solvent line filter, wearing appropriate clean gloves:
   a) Place the frit in a level position in the filter holder (bottom part).
   b) Screw the filter top to the filter bottom.

Removing the Seal Wash Detector Assembly

Grasp and pull the seal wash detector assembly (funnel and detector) upward by the funnel. The detector including the tubing and cable can remain connected to the funnel.

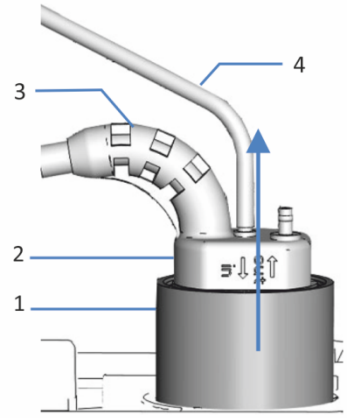

Figure 15: Removing the seal wash detector assembly

No.	Description
1	Funnel, seal wash detector
2	Seal wash detector
3	Detector cable
4	Seal wash line

Connecting the Solvent Lines

Connecting the solvent lines comprises the following steps:

1. Routing the solvent lines to the solvent rack
2. Connecting the solvent lines to the solvent reservoirs
3. *Optional:* Installing shut-off valves in the solvent lines

TIP To avoid the formation of air bubbles in liquid lines, always place reservoirs in the solvent rack on top of the system stack.

Routing the Solvent Lines to the Solvent Rack

1. Connect each solvent line to the pump inlet port for which it is intended (see the labeling on the solvent lines and in the pump).
2. Route the solvent lines from the pump to the solvent rack, through the tubing guides in the pump and all modules above the pump in the system stack. Observe the routing guidelines in Guiding Capillaries and Tubing Through the System (▸ page 54).
3. Route the solvent lines through the guide hole in the solvent rack and fix them in the appropriate tubing guides.

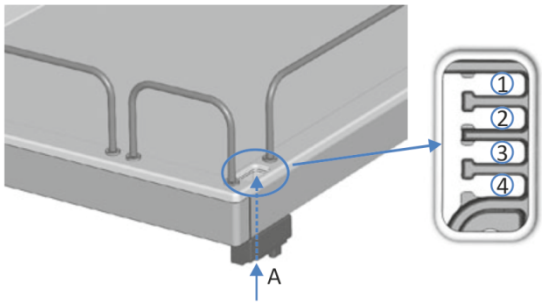

Figure 16: Guide hole and tubing guides in the solvent rack

No.	Description
A	Guide hole (solvent rack)
1	Solvent lines (up to three solvent lines)
2	Solvent lines (up to three solvent lines)
3+4	Not to be used for solvent lines; reserved for other tubing

Connecting the Solvent Line to the Solvent Reservoir

Observe the guidelines and recommendations in Use of Solvents and Additives (▶ page 82).

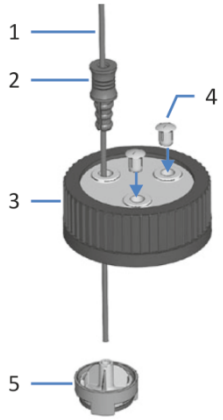

Figure 17: Preparing the solvent line and reservoir cap

No.	Description
1	Solvent line
2	Retaining guide
3	Reservoir cap
4	Cap plugs
5	Solvent line filter

1. Feed each solvent line through a retaining guide.
2. Feed the solvent line through an open hole in a cap for a solvent reservoir. The retaining guide keeps the solvent line in place in the reservoir.
3. Close any open holes in the reservoir caps with the cap plugs.
4. Slide a solvent line filter holder onto each solvent line.
5. Fill the solvent reservoirs with solvent.
6. Tighten the reservoir cap hand-tight. Press the retaining guide into the hole in the reservoir cap so that the tubing is kept in place in the cap.
7. Place the solvent reservoirs in the solvent rack.
8. Position the solvent lines straight in the tubing guides.
9. *Optional:* Install shut-off valves in the solvent lines (see Installing Solvent Shut-Off Valves (▶ page 62)).
10. Check the solvent lines across the entire flow path. Make sure that the lines are not bent, pinched, or squeezed at any point in the flow path.
11. Reinstall the seal wash detector assembly.

5.6.6 Installing Solvent Shut-Off Valves

These steps apply only when installing a shut-off valve *during* initial setup of the pump. To install a shut-off valve *after* initial operation of the pump, follow the steps in Installing Solvent Shut-Off Valves (▷ page 101).

When

To shut off the solvent flow through the system at the solvent reservoir, for example, to prevent solvent from flowing through the system when you open a flow connection on the low-pressure side

Parts and additional items required

- Shut-off valve, kit containing one shut-off valve and fitting connections
- Tubing cutter

Preparations

Prepare the pump and follow the steps in Connecting the Solvent Lines (▷ page 58).

Follow these steps

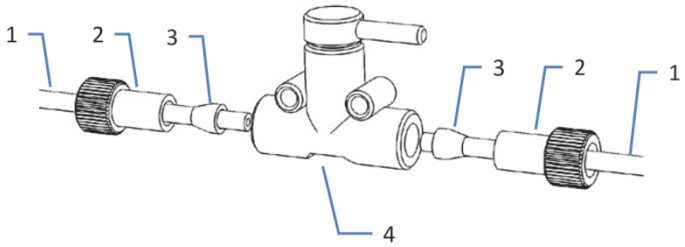

Figure 18: Installing a shut-off valve in the solvent line

No.	Description
1	Solvent line
2	Fitting
3	Ferrule
4	Shut-off valve

1. Cut the solvent line about 10 cm from the reservoir cap with a tubing cutter. Make sure that the cut is at a right angle to the length of the line.
2. Onto the free end of each solvent line, slide a fitting and a ferrule. Mind the correct orientation of the fitting and ferrule (see picture).

3. Tighten the solvent lines to the shut-off valve.

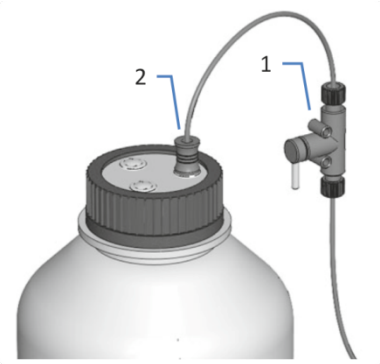

Figure 19: Solvent line with shut-off valve installed

No.	Description
1	Shut-off valve
2	Retaining guide

4. Check the solvent lines across the entire flow path. Make sure that the lines are not bent, pinched, or squeezed at any point in the flow path.

5.7 Seal Wash System

The flow path of the seal wash system passes through the metering device head in the autosampler and the pump heads in the pump. The seal wash system comprises the following parts:

- In the pump: Seal wash pump (peristaltic pump), seal wash lines, and seal wash detector (drop detector)
- In the autosampler: Seal wash lines
- Reservoir for the seal wash liquid

Both, the autosampler and pump are shipped with the seal wash components installed and the lines connected within each of the two modules.

To complete the setup, interconnect the seal wash paths of the modules, connect and fill the seal wash reservoir, and flush the seal wash system (see Setting Up the Seal Wash System (▶ page 64)).

5.7.1 Choosing the Seal Wash Liquid

Use 75% isopropanol in water and 0.1% formic acid (HPLC-grade; preparation by volume, for example, *75 mL isopropanol + 25 mL water + 0.1 mL formic acid*).

5.7.2 Setting Up the Seal Wash System

Parts and tools required

- Seal wash reservoir assembly, including reservoir, reservoir cap, cap plugs, and retaining guide for the seal wash line
- Seal wash line (silicone tubing) for connection to the seal wash pump; the line is pre-installed to the seal wash outlet of the metering device head
- Seal wash line (silicone tubing) for connection to the seal wash reservoir

TIP To avoid the formation of air bubbles in liquid lines, always place reservoirs in the solvent rack on top of the system stack.

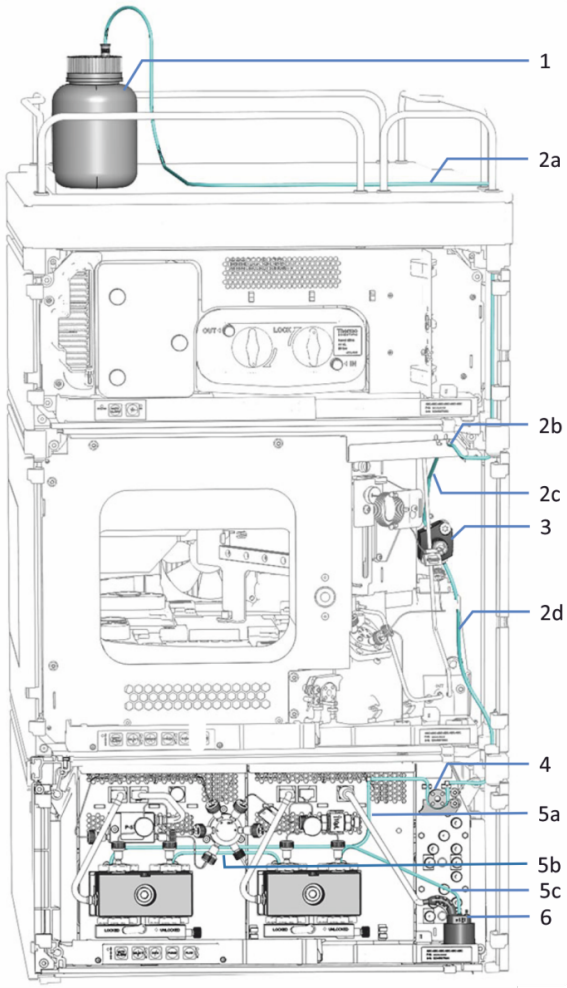

Figure 20: Seal wash system in the Vanquish system (example with a single-split sampler)

No.	Description
1	Seal wash reservoir
2	Seal wash lines in the autosampler (thick tubing), with:
2a	Wash line from reservoir to inlet port
2b	Seal wash inlet port (right tubing connector)
2c	Wash line from inlet port to metering device head
2d	Wash line to seal wash pump
3	Metering device head
4	Seal wash pump (peristaltic pump)
5	Seal wash lines in the pump (thin tubing), with:
5a	Wash lines from seal wash pump to left pump head
5b	Wash line from left pump head to right pump head
5c	Wash line from right pump head to seal wash detector
6	Seal wash detector (drop detector)

Preparations

Rinse the seal wash reservoir thoroughly. Use a high-purity solvent for rinsing.

Follow these steps

Setting up the seal wash system comprises the following steps:

1. Engaging the peristaltic tubing
2. Connecting the seal wash line between autosampler and pump
3. Routing the seal wash line to the solvent rack
4. Connecting the seal wash line to the seal wash reservoir
5. Flushing the seal wash system

Follow the steps in the respective sections.

Engaging the Peristaltic Tubing

In the pump, engage the peristaltic tubing (PharMed™ tubing) in the seal wash pump:

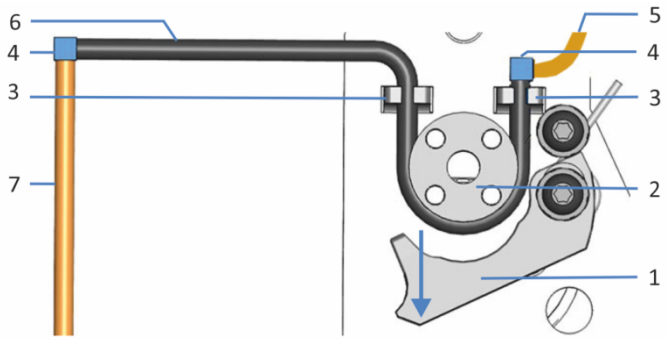

Figure 21: Seal wash pump

No.	Description
1	Pump lever
2	Pump rotor
3	Tubing holder (peristaltic tubing)
4	Tubing connector
5	Seal wash line from autosampler (silicone tubing)
6	Peristaltic tubing
7	Seal wash tubing to pump head (silicone tubing)

1. Press down the lever on the seal wash pump and hold it in that position with one hand.
2. With your other hand, insert the tubing between the lever and the rotor and wind it around the rotor.
3. Release the lever.

4. Check that the peristaltic tubing is inserted properly in the tubing holders. If it is not, push the tubing into the holders. Make sure that the tubing is not pinched or squeezed in the holders.
5. Check that the right tubing connector rests on the tubing holder. If it does not, push the tubing connector onto the holder.

Connecting the Seal Wash Line between Autosampler and Pump

1. In the autosampler, locate the seal wash line (clear silicone tubing) to the pump:
   - *Single split sampler:* The seal wash inlet port is located on the top enclosure frame (right tubing connector). The seal wash line to the pump is interconnected to the seal wash inlet port.
   - *Dual split sampler:* The seal wash inlet port is located on the right enclosure frame (top tubing connector). The seal wash line to the pump interconnects seal wash inlet and outlet port.
2. Disconnect the seal wash line from the seal wash inlet port.
3. Route the seal wash line from the seal wash outlet in the autosampler through the tubing guides to the peristaltic tubing in the pump.
   - *Single split sampler:* The seal wash outlet is located on the bottom end of the metering device.
   - *Dual split sampler:* The seal wash outlet is located on the right enclosure frame (bottom tubing connector).

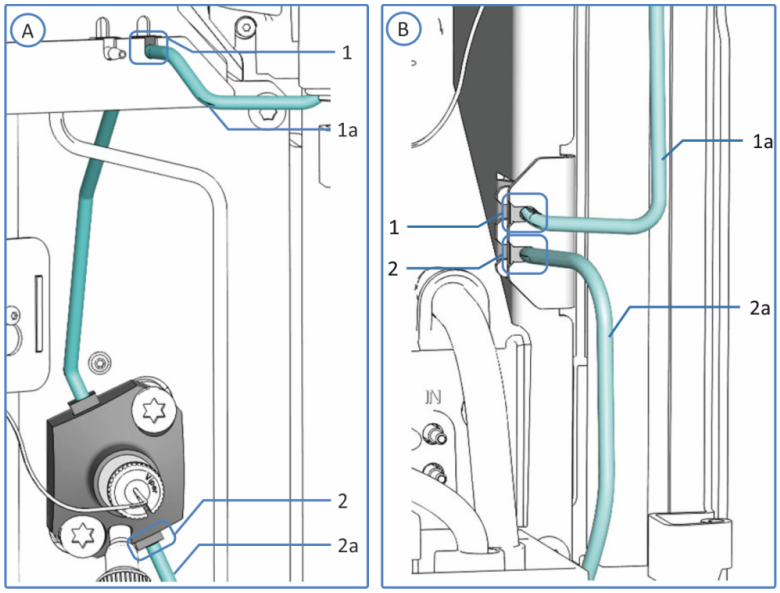

Figure 22: Seal wash connections

No.	Description
A	*Single split sampler:* Seal wash connections on the top enclosure frame
B	*Dual split sampler:* Seal wash connections on the right enclosure frame

No.	Description
1	Seal wash inlet port
1a	Seal wash line to reservoir
2	Seal wash outlet
2a	Seal wash line to pump

4. In the pump, connect the seal wash line to the tubing connector on the free end of the peristaltic tubing.

Routing the Seal Wash Line to the Solvent Rack

1. Locate the seal wash line for connection from the autosampler to the seal wash reservoir.
2. Connect the seal wash line on the autosampler:
   - *Single split sampler:* Connect the line to the seal wash inlet port on the top enclosure frame (right tubing connector).
   - *Dual split sampler:* Connect the line to the seal wash inlet port on the right enclosure frame (top tubing connector).
3. Route the seal wash line from the autosampler to the solvent rack through the tubing guides in the autosampler and all modules above the autosampler in the system stack.
4. Route the seal wash line through the guide hole in the solvent rack and fix it in the appropriate tubing guide.

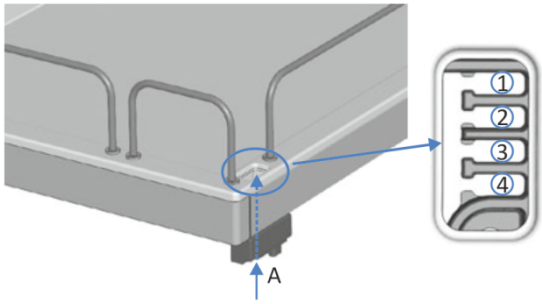

Figure 23: Guide hole and tubing guides in the solvent rack

No.	Description
A	Guide hole (solvent rack)
1+2	Not to be used for seal wash line; reserved for other tubing
3	Tubing guide for seal wash line
4	Not to be used for seal wash line; reserved for other tubing

Connecting the Seal Wash Line to the Seal Wash Reservoir

Mind the requirements outlined in Choosing the Seal Wash Liquid (▷ page 64).

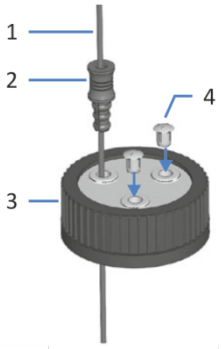

Figure 24: Wash line and reservoir cap

No.	Description
1	Wash line
2	Retaining guide
3	Reservoir cap
4	Cap plugs

1. Feed the wash line through the retaining guide.
2. Feed the wash line through an open hole in the cap of the wash reservoir. The retaining guide keeps the tubing in place in the reservoir.
3. Close any open holes in the reservoir cap with cap plugs.
4. Fill the wash reservoir with wash liquid.
5. Tighten the reservoir cap hand-tight. Press the retaining guide into the hole in the reservoir cap so that the tubing is kept in place in the cap.
6. Place the wash reservoir in the solvent rack.
7. Position the wash lines straight in the tubing guides.
8. Check the wash lines over the entire flow path:
   a) Make sure that no bending (kink), pinching or squeezing of the wash lines is present at any point in the flow path.
   b) If you have to cut tubing to length, use a tubing cutter. Make sure that the cut is at right angle to the length of the line.

Flushing the Seal Wash System

To flush the seal wash system, follow the procedure in Flushing the Seal Wash System (▷ page 70).

5.7.3 Flushing the Seal Wash System

To flush the seal wash system, select one of the following alternatives:

- Turn on the pump.
  Whenever the pump is turned on, the pump starts operation with a seal wash cycle.
- Flush the seal wash system from the Chromeleon software.
- Flush the seal wash system from hand.
  Select this alternative to flush the seal wash system when the pump is powered off.

Flushing the Seal Wash System from the Chromeleon software

To flush the seal wash system from the Chromeleon software, start a seal wash cycle by setting the seal wash pump to **Active** mode (**SealWashPump = Active**).

During the seal wash cycle, the seal wash system is automatically filled with the seal wash liquid. It will take 5 minutes for the liquid to travel through the entire flow path.

Flushing the Seal Wash System from Hand

To flush the seal wash system from hand, follow these steps:

1. Disconnect the tubing from the seal wash detector.

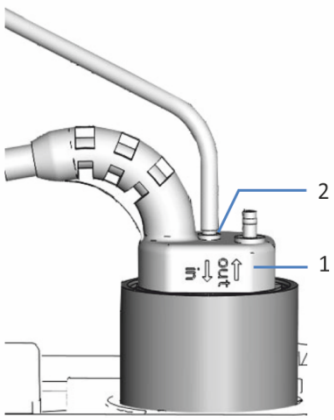

Figure 25: Seal wash detector

No.	Description
1	Seal wash detector
2	Tubing connection port (port labeled **in**)

2. Insert a syringe into the open end of the tubing.
3. To allow the liquid to travel easily through the seal wash system, press down the lever of the seal wash pump and hold it in that position with one hand.
4. Pull out the syringe plunger to draw seal wash liquid into the tubing.
5. Release the lever of the seal wash pump when the liquid reaches the syringe.
6. Remove the syringe and reconnect the tubing to the connection port on the seal wash detector.
   Mind the port labeling. To ensure correct functioning of the seal wash detector, the tubing needs to be connected to the port labeled **in**.

5.8 Connecting the Pump and Autosampler

Parts required

Capillary to connect the pump to the autosampler

Follow these steps

1. On the connecting capillary, remove the knurls.
2. Guide the connecting capillary through the guide holes in the housings of both, the pump and autosampler.

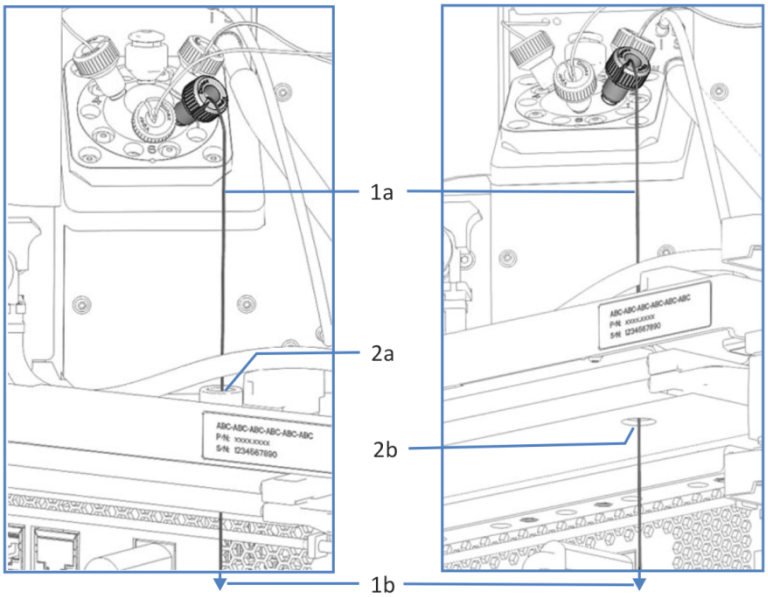

Figure 26: Guide holes in the autosampler and pump (left: view from VF-/VH-autosampler (example); right: view from pump)

No.	Description
1	Capillary connecting the pump and autosampler:
1a	Capillary end connected to the autosampler injection valve
1b	Capillary end to be connected to pump outlet
2	Guide holes in autosampler housing and pump housing:
2a	Guide hole in autosampler housing (view from above)
2b	Guide hole in pump housing (view from below)

3. Reattach the knurls to the connection capillary.
4. In the pump, connect the capillary to the pump outlet.
5. In the autosampler, connect the capillary to the injection valve.

5.9 Turning On the Device

TIP

Before turning on the power to a Vanquish system module for the first time, verify that the chromatography software is installed on the data system computer. When the power is turned on, the required USB drivers are automatically found and the Windows™ operating system can detect the device.

To turn on the power to the device, follow these steps:

1. Check that the power button on the front left of the Vanquish system base (system power button) is pressed in. If the power button stands out, press the power button to turn on the power on the system base.
2. Turn on the device with its main power switch.

Turn off the device with the main power switch, when instructed to do so, for example, during maintenance. Pressing the system power button will not be sufficient to turn off the power to the device completely.

When Powering Up the Pump

Whenever the power to the pump is turned on, the following sequence of events occurs:

- The pump performs a self-test.
  If the self-test is not successful, the status indicators are red, and the pump is not ready for analysis. Check the Instrument Audit Trail for the related message and take appropriate remedial action.
- The pump starts operation with a seal wash cycle. Before turning on the pump, check the liquid level in the seal wash reservoir. Consider checking also the liquid level in the waste container.

See also

Power On/Off Control (▶ page 81)

5.10 Setting Up the Device in the Software

This manual assumes that the chromatography software is already installed on the data system computer and a valid license is available.

For more information about setting up the Vanquish system in the software, refer to the *Vanquish System Operating Manual*.

The Help for the software that you are using provides detailed information about the settings on each property page.

6 Operation

This chapter describes the elements for device control, provides information for routine operation and for shutdown.

6.1 Introduction to this Chapter

The information in this chapter assumes that the initial setup of the device has already been completed. If this is not the case, see the instructions in Installation (page 43).

For a basic description of instrument control and automated sample analysis with the Chromeleon software, refer to the *Vanquish System Operating Manual*. Details on control and operation of the device are available in the *Chromeleon Help*.

Software descriptions in this manual refer to Chromeleon 7. Terminology may be different to that of other software versions.

6.2 Safety Guidelines for Operation

When operating the device, pay attention to the following safety guidelines:

Observe all warning messages and precautionary statements presented in Safety Precautions (page 21).

CAUTION—High Luminosity of LED

The high luminosity produced by the LED illuminating the inside of the device can be harmful to the eyes.

- Do not look directly into the light produced by the LED.
- Do not use light-focusing instruments for viewing the light beam.

NOTICE

Pay attention also to the following guidelines:

- To prevent damage resulting from leakage or from running the pump dry, always set the lower pressure limit for the pump.
- If there is evidence of leakage in the device, turn off the pump flow and remedy the situation immediately.
- If the pump flow is interrupted, act appropriately to protect the components in the detector. For details, refer to the *Operating Manual* for the detector.
- Always verify that the autosampler is turned on before the pump flow is on and pressure builds up. If the autosampler is turned off, for example, after a power failure, stop the pump flow and wait until the pressure is down to zero before turning on the autosampler or other modules again.

6.3 Control Elements

The device is designed to be operated mainly from a computer running with the chromatography software.

In addition, the following elements are available on the device:

- Keypad
  The keypad buttons allow you to perform certain functions directly from the device.
- Status indicators
  The LEDs (Light Emitting Diodes) on the status indicator LED bar on the front side of the device and the **STATUS** LED on the keypad provide a quick visual check of the operational status of the device.

6.3.1 Keypad

The keypad inside the device allows you to perform certain functions directly from the device. When you press a button, a short beep confirms that the function is performed.

When the device is connected in the Chromeleon software, some functions may not be available from the keypad (see further down in this section).

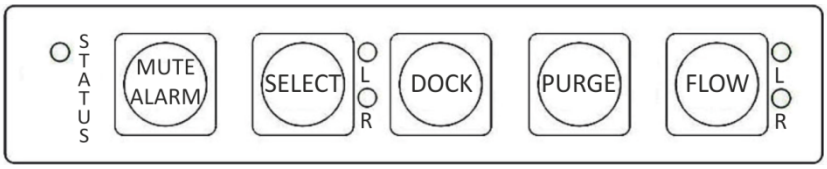

Figure 27: Keypad

STATUS

The **STATUS** LED provides a quick visual check of the operational status of the device.

When the doors are closed, the LED bar on the front side indicates the operational status.

For status details, see Status Indicators (▷ page 80).

MUTE ALARM

Beeping alerts you when the device detects a problem, for example, leakage. To turn off the beep for the current alarm, press this button. Eliminate the source for the alarm within 10 minutes. Otherwise, beeping starts again. If the device detects a different problem, beeping alerts you again immediately.

SELECT

Pressing the button selects the pump head for you which you can perform a **DOCK** or **PURGE** function from the keypad. The LEDs next to the button indicate the selection:

LED	Description
LED **L** = green	Left pump head selected
LED **R** = green	Right pump head selected

Before performing a **DOCK** or **PURGE** function from the keypad, select the pump head for which you want to perform the action.

DOCK

Pressing the button moves the pistons of the selected pump head to the appropriate position for maintenance procedures, such as pump head or piston replacement, and undocks the pistons.

When undocking is complete, the LED next to the **FLOW** button starts flashing green for the selected pump head. The LED continues flashing while no pistons are docked. Pressing the button again docks the pistons.

To avoid damage to the pump, remove or install the pump heads only while the pistons are undocked (LED is flashing).

PURGE

Pressing the button starts a purge cycle. Pressing the button while a purge cycle is running stops the cycle. See Purging the Pump (▶ page 91).

FLOW

Pressing the button starts or stops the flow, considering the selected flow rate, solvent composition, and flow acceleration/deceleration.

The LEDs next to the button indicate the following:

LED	Description
Off (dark)	The pump flow is off or zero.
Green	The pump head is delivering.
Green, flashing	The pistons are undocked.

When the Device is Connected in the Chromeleon Software

The button functionality is as follows when the device is connected in the Chromeleon software:

- No injection or sequence is running:
  All functions are available from the keypad.
- An injection or sequence is running:
  The **MUTE ALARM** function remains available from the keypad, allowing you to turn off the beep for the current alarm.

6.3.2 Status Indicators

The status LED bar on the front side of the device and the **STATUS** LED on the inside keypad provide information about the device status.

LED Bar

The LED bar colors provide the following information:

LED Bar	Description
Off (dark)	The power to the device is turned off.
Dimmed	The doors of the device are open.
Yellow, flashing slowly	The power to the device is turned on, but the device is not connected in the chromatography data system.
Yellow	The device is connected in the Chromeleon software, but the device is not equilibrated. The pump flow is off.
Green, flashing	A purge cycle is running.
Green	The device is equilibrated, but no data acquisition is running. The pump flow is on.
Blue	An injection or sequence is running, including data acquisition.
Red	A problem or error has occurred. For the related message, check the Instrument Audit Trail. For remedial action, see Troubleshooting (▶ page 187).

STATUS LED

The **STATUS** LED on the keypad inside the device provides the following information:

STATUS LED	Description
Off (dark)	The power to the device is turned off.
Green	The device is functioning properly.
Red	A problem or error has occurred. For the related message, check the Instrument Audit Trail. For remedial action, see Troubleshooting (▶ page 187).

For information about the LEDs that are present next to a button on the keypad, see Keypad (▶ page 78).

6.4 Power On/Off Control

The power switch on the device is the main switch for power on/off control. The main power switch is turned on during initial installation of the device.

For easier handling, you can use the power button on the front left of the Vanquish system base (system power button) for power on/off.

Observe the following:

- *All* modules in the Vanquish system that are connected to the system base via system interlink cables are turned on or off simultaneously when the system power button is pressed.
- When the power is on, the system power button is pressed in. When the power is off, the system power button stands out.
- If the main power switch on a device is off, you cannot turn on the device with the system power button.
- To turn off a device completely, you *have to* turn it off with the main power switch on the device. Pressing the system power button will not be sufficient to turn off the power to the device completely.

When Powering Up the Pump

Whenever the power to the pump is turned on, the following sequence of events occurs:

- The pump performs a self-test.
  If the self-test is not successful, the status indicators are red, and the pump is not ready for analysis. Check the Instrument Audit Trail for the related message and take appropriate remedial action.
- The pump starts operation with a seal wash cycle. Before turning on the pump, check the liquid level in the seal wash reservoir. Consider checking also the liquid level in the waste container.

6.5 Use of Solvents and Additives

Particles entering the chromatography system can block capillaries and valves, increase wear, and damage the column or system. Especially with aqueous solvents, algae and other microorganisms can grow and deposit in the system and block the solvent line filters. Blocked capillaries or filters can cause increased or unstable system pressure.

For optimum performance of the chromatography system, observe the following guidelines:

Solvent Quality and Filtration

- Use high-quality high-purity solvents (filtered) and additives as required by the application, for example, UHPLC-grade or LC/MS-grade. If a fluorescence detector is used in the system, consider using fluorescence-grade solvents.
  Filtered high-purity solvents are usually labeled accordingly by the vendor.
- Use high-quality water for example, UHPLC-grade or LC/MS-grade (0.2 µm filtered).
- When you use water from water purification systems, polymeric contamination may occur if the purification system is not maintained properly.
- When preparing salt solutions or buffers and preparation is complete, use membrane filtration (0.2 µm) to remove any particulate matter and to reduce microbial growth.
- Use fresh solvents at regular intervals. Avoid adding up (refreshing) solvents. With premixed solvents, be especially sure that they are properly prepared and fresh.
- Always use the appropriate solvent line filters as recommended by Thermo Fisher Scientific. Check the filter frits for permeability at regular intervals and replace them as necessary.
- For best seal performance, do not recycle or recirculate solvents.
- Note the special properties of the solvents, such as viscosity, boiling point, or UV absorption.

Solvent Reservoirs

- Before filling a solvent reservoir, rinse the reservoir thoroughly with a high-purity solvent.
- To reduce the growth of algae, consider using amber glassware or using appropriate additives, for example, formic acid.
- Avoid using methanol from aluminum reservoirs.

Flushing after Operation

- Flush out buffers and solutions that form peroxides.
- Never leave buffers, salt solutions, or aggressive solvents in the system for a longer period without flow.
- Before you change from a buffer or salt solution to organic solution, flush the system thoroughly with de-ionized water.
- Before you change solvents, make sure that the new solvent is miscible with the previous solvent. If the solvents are not miscible, flocculation may occur.
  Mix immiscible solvents with an intermediate solvent to replace them step by step. For example, use isopropanol.

6.6 Preparing the Device for Operation

This section gives information on any additional steps that are required to prepare the device for operation and sample analysis.

Before Operating the Device for the First Time

Prepare the device for the first-time operation, observing the following:

NOTICE

Flush the system flow path thoroughly before operating the device for the first time:

- When you install devices or components to the system, always flush them to waste before connecting them in the system flow path. To flush the Vanquish modules, follow the instructions in the *Vanquish System Operating Manual*.
- Some components of the device are filled with isopropanol when the device is shipped from the manufacturing site. When operating the device for the first time, use solvents that are miscible with isopropanol. If they are not, use an appropriate intermediate solvent.

- To remove the isopropanol from the device components:
  - Verify that the flow cell and the column are not connected in the flow path.
  - Purge the pump and then have the pump deliver flow for a short time.
- Verify that any air bubbles are completely flushed out of the system flow path.

Before Starting Sample Analysis

Before starting an analysis:

- Check the liquid level in the solvent reservoirs. Verify that the amount of solvent is sufficient for the analysis.
- Close the doors of all modules in the Vanquish system, if not already done.
- Make sure that the chromatography system is properly equilibrated (see further down).

System Equilibration

System equilibration should include the following operations:

- Purging the pump (*all* channels, including those not used for the application)
- Flushing the entire chromatography system with the starting solvent to rinse out any solvent from a previous analysis run
- Warming up (or cooling down) all temperature-controlled devices in the system to the starting temperature. Temperature-controlled devices can be, for example
  - Column compartment and post-column cooler
  - Sample compartment thermostatting in the autosampler
  - Flow cell in a fluorescence detector
  - Evaporation tube in a charged aerosol detector
- Turning on the lamp (or lamps) in the UV/VIS detector
- Monitoring the pump pressure and pressure ripple and checking that the pressure is stable and the ripple within reasonable limits for the application
- Monitoring the detector signal and checking whether the detector signal is stable so that the drift and signal noise are within reasonable limits for the application
- Performing an autozero of the detector baseline

TIP The Chromeleon software supports procedures for automatically starting a chromatography system in the software (**Smart Startup**). The startup procedure includes the operations for system equilibration. For details, refer to the *Chromeleon Help*.

6.7 Important Operating Parameters

The parameters described in this section should be considered for routine operation of the device. You can usually access these parameters from the Chromeleon user interface.

If a parameter listed below is not available in the Chromeleon software, consider updating the firmware and Chromeleon version.

For more information, refer to *Chromeleon Help and documents*.

Flow Parameters

Parameter	Description
Flow	The allowed flow range is indicated in the dialog box for the pump in the Instrument Configuration Manager. You can change the upper and lower limit for the flow rate within the allowed range.
Flow ramps	Set the flow acceleration and flow deceleration. *Recommendation*: Set the parameters to a value between 1/3 and factor 3 of the (column) flow rate.
Flow acceleration	The flow acceleration (**Maximum Flow Ramp Up**) determines how fast the pump starts delivering with the selected flow rate. If the value is too low, it will take correspondingly long for the pump to build up the necessary pressure and start delivering the required flow. If the value is too high, this may impair the column lifetime.
Flow deceleration	The flow deceleration (**Maximum Flow Ramp Down**) determines how fast the pump reduces the flow. If the value is too low, it will take correspondingly long for the pump to reduce the flow and thus the pressure. If the value is too high, this may impair the column lifetime.

Pressure Parameters

Parameter	Description
Pressure limits	The allowed pressure range is indicated in the dialog box for the pump in the Instrument Configuration Manager. You can adapt the upper and lower pressure limits within the allowed range. • The lower pressure limit helps to prevent the pump (and column) from running dry. A typical setting is 1 MPa. • The upper pressure limit helps to protect the column from too high pressure. The column and the application determine the appropriate setting. When the pump pressure is outside the specified limits, the Chromeleon software stops the pump flow and aborts a running Queue.

Parameter	Description
Pump pressure	In the dialog box for the pump in the Instrument Configuration Manager, the **Pump_Pressure** check box is selected as a standard when the pump is set up in the Chromeleon software. The Chromeleon software uses this setting to generate the channel for recording the pump pressure (which corresponds to the column pressure). Always record the pump pressure. If a problem occurs, the information from the pump pressure channel can provide helpful information to identify and eliminate the source for the problem.

Solvent and Waste Liquid Parameters

Parameter	Description
Solvent composition	In the dialog box for the pump in the Instrument Configuration Manager, set the number of the solvents to be used with the pump. You can change the standard solvent names as required. The solvent names appear in the Chromeleon user interface. In the Chromeleon Client, set the solvent composition (see Setting the Solvent Composition (▶ page 90)).
Solvent consumption	You can monitor the solvent consumption when you have entered the required information for the related solvent. Based on this information, the Chromeleon software *calculates* the liquid level, but you must update the volume information in the solvent reservoir manually with every new reservoir/fresh solvent. To monitor the liquid level in real time, based on real *physical* measurement (no manual information update required), install the Vanquish Solvent Monitor. The solvent monitor is available as an option (see Optional Accessories (▶ page 214)). For monitoring from the Chromeleon software, enter the following information: • Volume of solvent in the reservoir (at the beginning of a sequence) • Lower limit for the solvent in the reservoir, which is the minimum volume of liquid that must be available in the reservoir The **Remain Time** property for the solvent reports the time left until the liquid level is expected to reach the lower limit. The Chromeleon software calculates the time from the current flow rate and volume entered. • Warning limit when you want to be informed about the liquid level in the reservoir When the liquid in the reservoir reaches the lower limit, the Chromeleon software stops the pump as specified in the **Emergency Instrument Method** if available or aborts the Queue and stops the pump flow.

Parameter	Description
Waste level	You can monitor the liquid level in the waste container when you have entered the required information. Based on this information, the Chromeleon software *calculates* the liquid level, but you must update the remaining volume information manually with every new waste container. To monitor the liquid level in real time, based on real *physical* measurement (no manual information update required), install the Vanquish Solvent Monitor. The solvent monitor is available as an option (see Optional Accessories (▸ page 214)). For monitoring from the Chromeleon software, enter the following information: • Volume of liquid in the waste container at the beginning of a sequence • Upper limit for the liquid level in the waste container The **Remain Time** property for the waste reports the time left until the liquid level is expected to reach the upper limit. The Chromeleon software calculates the time from the current flow rate and calculated current liquid level. • Warning limit when you want to be informed about the liquid level in the waste container

Other Parameters

Parameter	Description
Compression	The compression values of the pump head can provide valuable information for troubleshooting. For details, see Resolving Pressure Pulsation or Shifts In Retention Time (▸ page 203).
Curve	You can specify linear or non-linear (curved) gradient profiles. • Curve 5 (default setting) is linear. Changes in the composition of the delivered solvent over time are constant. • Curves 1 through 4 are convex upward. Convex curves cause rapid changes in solvent composition at the beginning of the gradient and slower changes at the end. Slope changes over time become extreme as curves go from 4 (least convex) to 1 (most convex). • Curves 6 through 9 are concave upward. Concave curves cause slower changes in solvent composition at the beginning of the gradient and rapid changes at the end. Slope changes over time become extreme as curves go from 6 (least concave) to 9 (most concave). In addition, you can define step gradients directly in the gradient table (for example, step A and step B). Thus, more than 11 different options are available to change the gradient.

Parameter	Description
Degasser	The degasser is enabled as a standard when the pump is shipped (**Degasser = On**). This setting is the preferred setting.
Leak detection	Leak detection is enabled as a standard when the device is shipped (**Leak Sensor Mode = Enabled**). This is the preferred setting.
Piston calibration value	The **Piston Calibration Value** property must match the 3-digit calibration value that is imprinted on the rear of the piston. You have to update the value in the Chromeleon software, for example, when you install new pistons.
Purge	Purge the pump in the following situations: • To remove air bubbles that might be trapped in the system • When changing to a different type of solvent See Purging the Pump (▷ page 91).
Seal washing	The seal wash system is enabled and cannot be disabled. As a standard, the pump performs a seal wash in the following situations: • Once per hour • Each time the pump is turned on If required, you can start an additional seal wash cycle or stop a running cycle: • If the seal wash pump is in **Idle** mode, select **Active** to start a wash cycle. • If the seal wash pump is in **Active** mode, select **Idle** to stop a running wash cycle. You can disable the drop counter functionality by setting **Rear Seal Wash Monitoring** to **Disabled**. Note that disabling drop detection will not disable the seal wash system. However, messages relating to the seal wash system (for example, when the system has run out of wash liquid) or piston seal leakage will no longer alert you in the user interface.
Synchronization of the injection time with the pump strokes	Synchronizing the injection time with the pump strokes enhances the retention time precision. For details, see Synchronizing the Injection Time with the Pump Strokes (▷ page 103).

6.8 Setting the Solvent Composition

For increased flexibility, the pump is shipped with two 3-port solvent selectors. They allow forming binary gradients from three solvents per channel. The solvent to be used for each channel is selected in the user interface.

Follow these steps

1. In the Instrument Configuration Manager, in the dialog box for the pump, check and the change the following if required:
   - Number of the solvents to be used with the pump
   - Standard solvent names
     These solvent names appear in the Chromeleon user interface.
2. In the Chromeleon Client, set the solvent composition. For each of the two channels, select the solvent and set the percentage of solvent that you want to deliver.

Selecting the Solvent

1. For channel A, set **%A_Selector** to **%A1** or **%A2** or **%A3**.
2. For channel B, set **%B_Selector** to **%B1** or **%B2** or **%B3**.

Determining the Percentage of Solvent to Deliver

Set the percentage for solvent B (**%B**). Solvent A automatically delivers the remaining volume.

Examples

- To deliver 100% of solvent B2:
  Set **%B_Selector** to **%B2** and set **%B** to 100%.
- To deliver 100% of solvent A3:
  Set **%A_Selector** to **%A3** and set **%B** to 0%.
- To deliver 30% of solvent A1 and 70% of solvent B3:
  Set **%A_Selector** to **%A1**, set **%B_Selector** to **%B3**, and set **%B** to 70%.

6.9 Purging the Pump

Purging the pump means rinsing the pump for a short time at a higher flow rate, using the selected solvents. From the purge unit, the solvent flows off through the waste outlet port into the drain system of the Vanquish system.

When

- The pump is operated for the first time
  To flush out the isopropanol that is present in some components of the pump when the pump is shipped from the manufacturing site
- One or more solvent lines have been empty
- To remove air bubbles that might be trapped in the system (pump head, solvent lines) because air bubbles in the system may lead to the following problems:
  - Pressure pulsation
  - High noise level or pulsation during pump operation
  - Non-reproducible analysis
- When changing to a different type of solvent, for example, when changing to a different analytical method

Settings

The following settings are considered for the purge cycle:

Setting	Description
Purge flow	The standard setting is 5 mL/min. You can adapt the setting in the Chromeleon software if required. The setting is considered also when purging the pump from the keypad.
Purge time	The standard purge time is 5 minutes. You can adapt the setting in the Chromeleon software if required. The setting is considered also when purging the pump from the keypad.
Channel to be purged and solvent to be used	The purge cycle is performed with the most recently selected channel and eluent composition. You can adapt the settings in the Chromeleon software if required. The settings are considered also when purging the pump from the keypad.

To purge the pump

The following alternatives are available:

- Purge the pump from the Chromeleon software. See Purging the Pump from the Chromeleon Software (▷ page 92).
- Purge the pump from the keypad. See Purging the Pump from the Keypad (▷ page 93).

6.9.1 Purging the Pump from the Chromeleon Software

Items required

Solvents suitable for purging

To flush out the isopropanol when operating the pump for the first time, use solvents that are miscible with isopropanol. If they are not, use an appropriate intermediate solvent.

Follow these steps

1. For each channel, select the solvent that you want to use for purging. The solvent names below refer to the standard solvent names.
   For channel A, select the solvent by setting **%A_Selector** to **%A1** or **%A2** or **%A3**. For channel B, set **%B_Selector** to **%B1** or **%B2** or **%B3**.
2. Determine the percentage of solvent that you want to deliver by setting the percentage for solvent B (**%B**). Solvent A automatically delivers the remaining volume. Examples see at the end of this list.
   Recommended: The channel to be purged should deliver 100% of the volume.
3. *Optional:* Adapt the settings for the purge flow or purge time if required. For the settings considered for the purge cycle, see Purging the Pump (▶ page 91).
4. Start the purge cycle.
   The purge cycle ends automatically when the specified purge time ends. If you want to stop purging before the purge time ends, turn off the purge from the Chromeleon software.
5. Perform a purge cycle for all channels that you want to purge.

Examples

- To purge channel B with solvent B1 delivering 100%, select **%B1** and set **%B** to 100%.
- To purge channel A with solvent A3 delivering 100%, select **%A3** and set **%B** to 0%.

6.9.2 Purging the Pump from the Keypad

Items required

Solvents suitable for purging

To flush out the isopropanol when operating the pump for the first time, use solvents that are miscible with isopropanol. If they are not, use an appropriate intermediate solvent.

Follow these steps

1. Select the channels that you want to purge.
   On the keypad, check the LEDs next to the SELECT button. A green LED (L or R or both) indicates that the pump head (channel) is selected. Note the following:
   - The purge cycle will be performed for the selected pump head with the most recently used solvent.
   - When both pump heads are selected, each channel is purged with the most recently used solvent delivering 50 % of the volume.
   - When the pump is operated for the first time, the purge cycle will be performed for solvent 1 of the selected pump head (A1 or B1, respectively).

   Recommended: The channel to be purged should deliver 100% of the volume. Check and adapt the setting in the Chromeleon software if considered necessary.
2. *Optional (in the Chromeleon software):* Adapt the settings for the purge flow or purge time if required. For the settings considered for the purge cycle, see Purging the Pump (▷ page 91).
3. To start the purge cycle, press the PURGE button.

Note the following

- The purge cycle ends automatically when the specified purge time ends.
- Pressing the button while a purge cycle is running stops the cycle.

6.10 Optimizing the Performance of the Device

This section provides information for best performance of the device and gives hints on what you can do to optimize the performance further.

6.10.1 General Guidelines

To optimize the performance of the device, consider the following general guidelines:

- Monitor the usage of specific device components that are subject to wear and stress and schedule appropriate maintenance intervals (see Predictive Performance (▷ page 119)).
- Observe the general guidelines and recommendations on the use of solvents and additives in the chromatography system (see Use of Solvents and Additives (▷ page 82)).
- Always use the built-in vacuum degasser.
- Purge the pump when changing to a different type of solvent or when restarting the pump after periods of inactivity.
- In the following situations, consider replacing the inline filter (plus capillary mixer) with which the pump is shipped with a mixing system:
  - To reduce the mixing ripple when you use UV absorbing solvents or solvent additives
  - For TFA (trifluoroacetic acid) applications

  Installing a mixing system affects the gradient delay volume, dwell volume, and ripple (see Gradient Delay Volume, Dwell Volume and Ripple (▷ page 95)).

TIP Shut-off valves for solvent lines are available as an option (see Installing Solvent Shut-Off Valves (▷ page 101)). These valves allow you to shut off the solvent flow through the system at the solvent reservoir, for example, to prevent solvent from flowing through the system when the pump flow is zero for a longer period.

6.10.2 Gradient Delay Volume, Dwell Volume and Ripple

The gradient delay volume of an HPLC system is defined as the volume of the entire flow path between the point where the gradient is formed and the point where the mobile phase enters the column. Thus, the gradient delay volume of an HPLC system is the volume that the pump must deliver until a change in solvent composition reaches the column inlet.

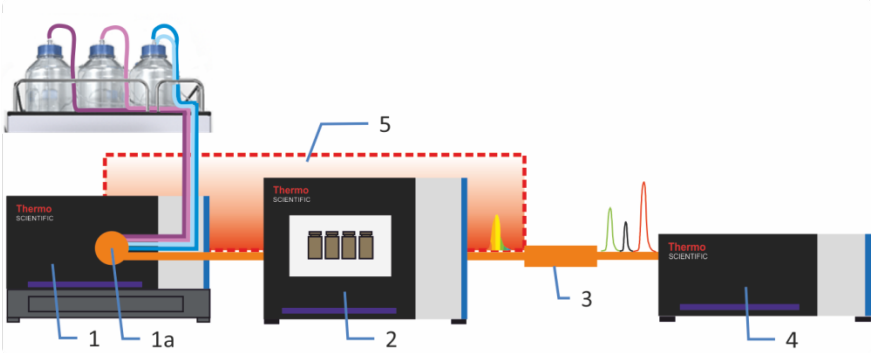

Figure 28: Gradient delay volume of an HPLC system

No.	Description
1	Pump with
1a	Point where the gradient is formed (purge unit)
2	Autosampler
3	Column
4	Detector
5	Gradient delay volume of the system

The pump contributes to the system gradient delay volume by the dwell volume. For the dwell volume of the pump, see Performance Specifications (▷ page 208).

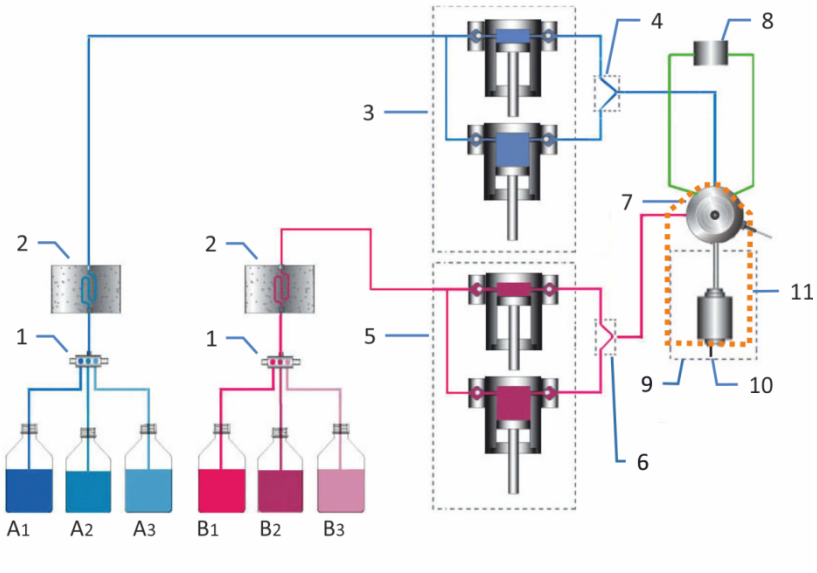

Figure 29: Dwell volume of the pump

No.	Description
1	Solvent selector
2	Solvent degasser
3	Pump head, left (two pistons, parallel)
4	Y-connector, left
5	Pump head, right (two pistons, parallel)
6	Y-connector, right
7	Purge unit
8	System pressure sensor
9	Inline filter (static filter)
10	Pump outlet (outlet of the inline filter)
11	Dwell volume of the pump

In the standard configuration, the pump has been optimized for the dwell volume and ripple. You can adapt the dwell volume or ripple to your requirements by replacing the inline filter and capillary mixer with which the pump is shipped with a mixing system.

Operating the pump with a mixing system reduces the ripple but increases the dwell volume of the pump and thus, the gradient delay volume of the system.

For information about the available mixing systems, see Available Mixing Systems (▷ page 97).

6.10.2.1 Available Mixing Systems

Each mixing system comprises a static mixer and a capillary mixer. The volumes of both mixers determine the entire volume of the mixing system.

The table lists the available mixing systems:

Description
Mixing system, volume: 200 µL, comprising: • Static mixer, volume: 150 µL • Capillary mixer, volume: 50 µL
Mixing system, volume: 400 µL, comprising: • Static mixer, volume: 350 µL • Capillary mixer, volume: 50 µL

For ordering information, see Optional Accessories (▷ page 214).

To install the mixing system, see Installing the Mixing System (▷ page 97).

6.10.2.2 Installing the Mixing System

Installing a mixing system affects the gradient delay volume, dwell volume, and ripple (see Gradient Delay Volume, Dwell Volume and Ripple (▷ page 95)).

When

- For highest sensitivity when mixing ripples interfere with the detection, for example, when you use UV absorbing solvents or solvent additives that amplify mixing ripples by interaction with the stationary phase
- For TFA applications

Parts required

Optional mixer kit, comprising the mixing system and required installation material (mounting bracket and screws)

Tools and additional items required

- Screwdriver, Torx 10
- Solvent suitable for purging

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. To remove harmful substances from the components in the flow path after the purge unit, have the pump deliver for a short time with the solvent that was used for purging.
3. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. Unplug the cable of the seal wash detector from the DROP DET port.
2. Unplug the cable of the right pump head from the P-WORK port if necessary.
3. Remove the right Y-connector.
4. Remove the capillary mixer (volume: 25 µL) that connects the purge unit and the inline filter when the pump is shipped from the manufacturing site.
5. On the filter outlet, disconnect the capillary that connects the inline filter to the autosampler injection valve.
6. Pull the inline filter out of the mounting bracket.
   You can remove the mounting bracket or leave it in the pump.
7. Attach the mounting bracket for the mixing system inside the pump.

Attaching the Mounting Bracket

1. Remove the push rivets that cover the mounting holes while no mounting bracket is installed.

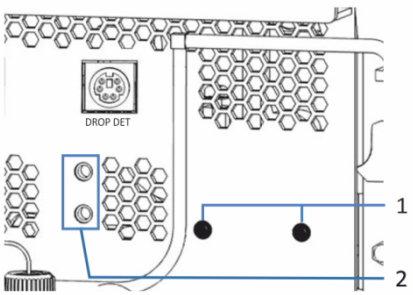

Figure 30: Installation position for mixing system

No.	Description
1	Push rivets covering the mounting holes for the mixing system
2	Mounting position (inline filter)

2. Using the screws shipped with the mixing system, attach the mounting bracket for the mixing system inside the pump.

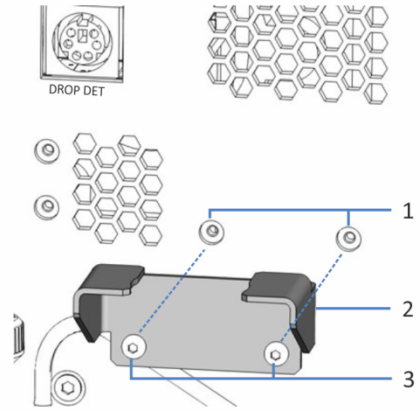

Figure 31: Mounting bracket for mixing system

No.	Description
1	Mounting holes for mounting bracket
2	Mounting bracket
3	Mounting screws (Torx)

3. Continue with the remaining steps.

Remaining steps

1. Insert the static mixer into the mounting bracket. Mind the direction of flow through the mixer (indicated by the arrow on the static mixer).

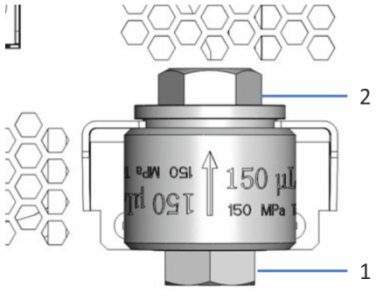

Figure 32: Static mixer

No.	Description
1	Static mixer inlet
2	Static mixer outlet

2. Connect the capillary mixer from the mixer kit to the port labeled OUT on the purge unit and to the static mixer inlet.

3. On the static mixer outlet, reconnect the capillary to the autosampler injection valve.

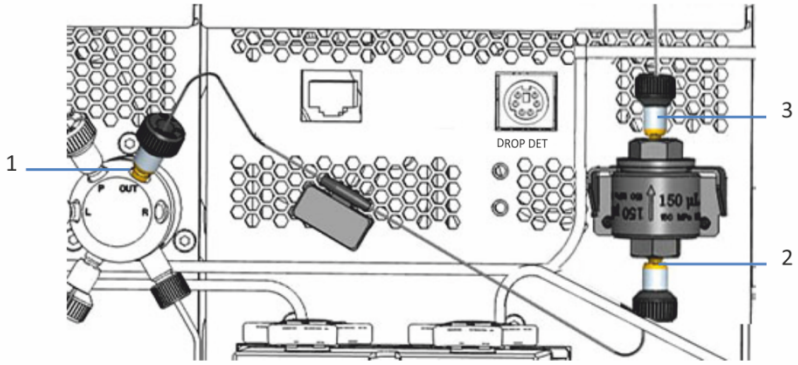

Figure 33: Mixing system installed and connected

No.	Description
1	Capillary mixer on purge unit (**OUT** port)
2	Capillary mixer on static mixer inlet
3	Capillary to autosampler injection valve

4. Reinstall the Y-connector.
5. Reconnect the cable of seal wash detector to the DROP DET port.
6. Reconnect the pump head cable to the P-WORK port if applicable.
7. Apply the flow rate of your application and have the pump deliver for a short time.
8. In the Chromeleon software:
   a) Set the **StaticMixer** property to the value indicated on the static mixer.
   b) *With Chromeleon 7.2.8 and later:* Set the **CapillaryMixer** property to the value indicated on the capillary mixer.
   c) Consider updating the Predictive Performance information (**InlineFilterChanged** command, see Predictive Performance (▷ page 119)).
9. Inspect the flow connections on the mixing system for indications of leakage before resuming operation.

6.10.3 Improving the Baseline Ripple

When

To reduce baseline ripples with special applications, for example, applications with mobile phases containing TFA (trifluoroacetic acid), you can use the **SmartStroke**™ function in the Chromeleon software. The **SmartStroke** function optimizes the piston stroke behavior, leading to a smoother baseline.

With **SmartStroke**, the pump performs more piston strokes. To extend the pump lifetime, use the function only when required by the application.

Prerequisites

The inline filter has been replaced with a mixing system. See Available Mixing Systems (▷ page 97) and Installing the Mixing System (▷ page 97).

How to use the SmartStroke function

Note the following:

- The **SmartStroke** function can be used for an instrument method as well as for the intervals between **Queue** runs.
- The **SmartStroke** function is disabled by default. Enable the function in the Chromeleon software. For details, refer to the *Chromeleon Help*.

6.10.4 Installing Solvent Shut-Off Valves

When

To shut off the solvent flow through the system at the solvent reservoir, for example, to prevent solvent from flowing through the system when you open a flow connection on the low-pressure side

The steps in this section apply only when installing a shut-off valve *after* initial operation of the pump. To install a shut-off valve *during* initial setup of the flow connections, follow the steps in Connecting the Solvent Lines (▷ page 58).

Parts and additional items required

- Shut-off valve, kit containing one shut-off valve and fitting connections
- Tubing cutter
- Solvent suitable for purging the pump

Preparations

1. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

Follow the steps for each solvent line in which you want to install a shut-off valve.

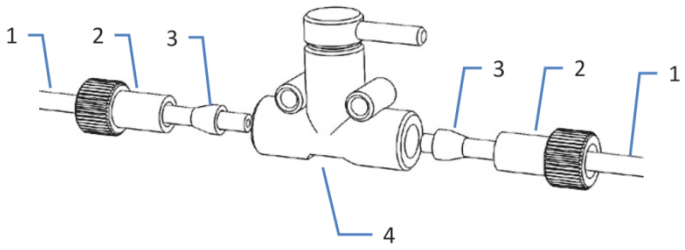

Figure 34: Installing a shut-off valve in the solvent line

No.	Description
1	Solvent line
2	Fitting
3	Ferrule
4	Shut-off valve

1. Unscrew the cap of the solvent reservoir and remove the cap together with the solvent line from the reservoir.
2. Start a purge cycle as appropriate.
3. Stop purging as soon as the solvent line is empty.
4. Retighten the reservoir cap hand-tight. The retaining guide must remain in the hole in the reservoir cap. If it does not, press the retaining guide into the hole so that the tubing is kept in place in the cap.
5. Cut the solvent line about 10 cm from the reservoir cap with a tubing cutter. Make sure that the cut is at a right angle to the length of the line.
6. Onto the free end of each solvent line, slide a fitting and a ferrule. Mind the correct orientation of the fitting and ferrule (see picture).
7. Tighten the solvent lines to the shut-off valve.
8. Check the solvent lines across the entire flow path. Make sure that the lines are not bent, pinched, or squeezed at any point in the flow path.

9. To remove any air from the solvent lines, purge the pump using the solvent of your application.

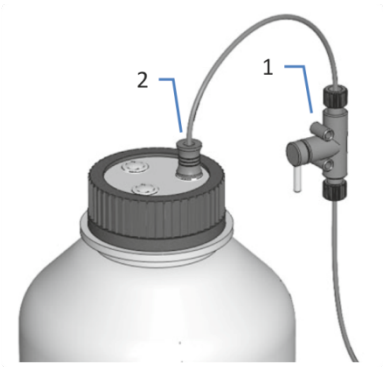

Figure 35: Solvent line with shut-off valve installed

No.	Description
1	Shut-off valve
2	Retaining guide

6.10.5 Synchronizing the Injection Time with the Pump Strokes

To enhance the retention time precision with gradient applications, you can synchronize the injection time of the Vanquish autosampler with the strokes of the Vanquish pump. The synchronization ensures that all injections are performed at the same phase of the pump cycle.

Synchronization is possible only when configured in the Chromeleon software (refer to the *Chromeleon Help*).

Then, the following properties are available in the Chromeleon software:

- **SyncWithPump**
  To enable synchronization, set the property to **On**. To disable synchronization, for example, for a specific application, set **SyncWithPump** to **Off**.
- **Pump**
  Shows the name of the pump to which the autosampler is linked.

6.11 Shutting Down the Device

If the device will not be operated for some time, follow the instructions in this section to shut down the device.

TIP The Chromeleon software provides procedures for automatically preparing the chromatography system for shutdown. The procedures include, for example, operations for reducing the flow rate, reducing the temperature in temperature-controlled devices, and turning off the detector lamps. For information about **Smart Shutdown** and **Smart Standby**, refer to the *Chromeleon Help*.

6.11.1 Short-Term Shutdown (Interruption of Operation)

To interrupt operation of the device for a short period (short-term shutdown), for example, overnight, observe these guidelines for the Vanquish system modules, as required by your system arrangement:

- For your Vanquish detector, note the following:

Detector Type	Description
Charged aerosol detector	Check that sufficient gas is available to continue gas flowing through the detector. This is to prevent any build-up of residue from solvents or analytes. Gas must be flowing when pump flow is delivered to the detector.
UV/VIS detectors	The lamp(s) in the detector can remain turned on. *Variable wavelength detector and VH-D10 diode array detector only:* The shutter can be moved to a closed position for protection of the flow cell.
Fluorescence detector	Turn off temperature control for the flow cell.

- Apply a flow of 0.05 mL/min and have the pump deliver an appropriate solvent.
  Check the lower pressure limit for the pump and adapt the value if necessary. If the pressure falls below the lower limit, the pump stops the flow.
- Set the injection valve in the autosampler to the Inject position.
- Make sure that the temperature of the column does not exceed 40 °C.
- When resuming operation, let the flow equilibrate and verify that the operating parameters for the other system modules are set as required before proceeding.

6.11.2 Long-Term Shutdown

To interrupt operation for a longer period, follow the instructions in this section.

TIP Shutting down the device affects the operation of the system. When shutting down the device, also observe the shutting down instructions for the other Vanquish system modules and take appropriate action (refer to the *Operating Manuals* for the modules).

1. Remove the column.
2. Flush the system with an appropriate solvent (minimum HPLC-grade). Observe the following:

Situation after Shutdown	If no additive is used	If an additive is used
Device remains in the laboratory after shutdown	Flush the system, for example with methanol. 100% acetonitrile should not be used.	Flush the system with several volumes of methanol and water (50:50) (for example, 1.0 mL/min for 10 minutes with the standard system) to prevent salt buildup in the fluidics. If the solvents in the device are not miscible with water, use an appropriate intermediate solvent.
Device shall be transported or shipped after shutdown	Flush the system with isopropanol.	Flush the system first with several volumes of methanol and water (50:50) (for example, 1.0 mL/min for 10 minutes with the standard system) to prevent salt buildup in the fluidics. If the solvents in the device are not miscible with water, use an appropriate intermediate solvent. Afterward, flush the system with isopropanol.

3. Turn off the pump flow and wait until the system pressure is down to zero.
4. Disconnect the solvent lines. See Disconnecting the Solvent Lines (▸ page 106).

TIP Removing the solvent lines from the tubing guides is usually not required (not even for replacing the slide-in module). However, when you remove the solvent lines from the tubing guides in the pump and all modules above the pump in the system stack, be careful not to pull on other tubing in the guides.

5. Empty the seal wash system. See Emptying the Seal Wash System (▷ page 106).

6. The step depends as follows:

Situation	Steps
Device and all other system modules remain in the system stack and are to be turned off	Turn off the system with the system power button on the system base.
Device shall be transported or shipped after shutdown	If one of the modules shall be removed from the system stack, turn off *all* system modules with their main power switch. Pressing the system power button will not be sufficient to turn off the power to the devices completely. Follow the instructions in Transporting or Shipping the Device (▷ page 178).

Disconnecting the Solvent Lines

1. Unscrew the caps of the solvent reservoirs.
2. Together with the caps, remove the solvent lines from the reservoirs.
3. Protect the solvent line filters from contamination as appropriate.
4. Purge the pump until the solvent lines are empty.
5. Disconnect the solvent lines on the pump inlets.
6. Close the pump inlets with appropriate plugs.

Emptying the Seal Wash System

1. Unscrew the cap of the seal wash reservoir.
2. Together with the cap, remove the seal wash line from the seal wash reservoir.
3. Remove the peristaltic tubing from the seal wash pump. When the tubing is removed, any liquid that may be present in the seal wash line, flows off to waste.

6.11.3 Restart after Long-Term Shutdown

To restart the device after a long-term shutdown, follow these steps:

1. Engage the peristaltic tubing in the seal wash pump.
2. Reconnect the seal wash line and the solvent lines to the appropriate reservoirs.
3. Retighten the reservoir cap hand-tight. The retaining guide must remain in the hole in the reservoir cap. If it does not, press the retaining guide into the hole so that the tubing is kept in place in the cap.
4. Turn on the device. Observe the following:

Situation	Action
If the device remained in the system stack and all system modules were turned off.	Turn on the system with the system power button on the system base.
If the device is restarted after transport.	Turn on the device with the main power switch.

5. Prepare and restart the other modules in the Vanquish system, following the instructions in the *Operating Manuals* for the modules. Pay special attention to the *Preparing the Module for Operation* section.
6. Purge the pump and then have the pump deliver for a short time.
7. Before starting an analysis, let the device equilibrate and be sure that it is ready for operation. See Preparing the Device for Operation (▶ page 84).

7 Maintenance and Service

This chapter describes the routine maintenance and the service procedures that the user may perform.

7.1 Introduction to Maintenance and Service

This chapter describes the routine maintenance and service and repair procedures that the user may perform.

Additional maintenance or service procedures must be performed only by service personnel certified by Thermo Fisher Scientific (for brevity, referred to as Thermo Fisher Scientific service personnel).

The device is designed for easy maintenance and service. The user-serviceable parts of the device can be accessed from the front. If not stated otherwise, the maintenance procedures do not require that you remove the device from the system.

The maintenance procedures do not require that you remove the doors. However, it is possible to remove a door if this should ever be required for a specific reason or procedure. If you need to remove a door, follow the related steps in Replacing the Doors (▷ page 176).

7.2 Safety Guidelines for Maintenance and Service

When performing maintenance or service procedures, pay attention to the following safety guidelines:

Observe all warning messages and precautionary statements presented in Safety Precautions (page 21).

WARNING—High Voltage

High voltages are present inside the device that could cause an electric shock.

Do not open the housing or remove protective panels unless specifically instructed to do so in this manual.

WARNING—Escape of Hazardous Substances from Flow Connections

Flow and capillary connections can be filled with substances that can pose health risks. Solvent can spray when capillaries burst, slip out of their fittings, or are not properly tightened or when capillary connections are otherwise open.

- Wear appropriate protective equipment and follow good laboratory practice.
- Before starting maintenance or repair procedures, flush out harmful substances with an appropriate solvent.

WARNING—Tilting Liquid Reservoirs

Liquids in the reservoirs on the solvent rack might contain harmful substances. Spilling of these substances can pose health and safety risks.

To prevent the reservoirs from tilting, be careful not to pull on the liquid lines when performing maintenance.

CAUTION—Spraying Solvent

Solvents can spray when under high pressure.

- Stop the pump flow prior to opening the flow path.
- Wait until the system pressure is down to zero.
- When opening the flow path, wear appropriate protective equipment.

CAUTION—Hydrostatic Pressure

Solvent may spill when you open the flow path. This is due to hydrostatic pressure in the system when the solvent reservoirs are located above the pump outlet. Before you loosen a connection in the flow path:

- Turn off the pump flow and wait until the system pressure is down to zero.
- Unscrew the caps of the solvent reservoirs and remove the solvent lines together with the caps from the reservoirs.
- Empty the solvent lines. See Emptying the Solvent Lines (▷ page 165).
- Retighten the reservoir caps.

CAUTION—Electric Shock or Damage to the Device

After the power to the device is turned off, the device is still energized as long as the power cord is connected. Repair work on the device while the device is connected to power could lead to personal injury.

- Always unplug the power cord before starting repair work inside the device.
- If you were instructed to remove any housing covers or panels, do not connect the power cord to the device while the cover or panels are removed.

7.3 General Rules for Maintenance and Service

For successful maintenance and service procedures, follow the rules and recommendations below.

General Rules

- Before starting maintenance or service procedures, shut down the device when instructed to do so.
- Use only the replacement parts specifically authorized and qualified for the device by Thermo Fisher Scientific.
- Follow all instructions step by step and use the tools recommended for the procedure.

Opening Flow Path Connections

- Before opening the flow path to replace capillaries in the system, turn off the pump flow and wait until the system pressure is down to zero.
- Dirty components can contaminate the chromatography system. Contamination leads to poor performance of the modules and entire system or can even cause damage to the modules and system. Therefore:
  - Always wear appropriate gloves.
  - Place the components only on a clean, lint-free surface.
  - Keep your tools clean.
  - Use only lint-free cloth for cleaning.
- After you have performed maintenance or service on the flow connections in the pump, test the pump for leakage before you resume operation.

Depot Repair

- If you need to return the device for depot repair, follow the instructions in Transporting or Shipping the Device (▷ page 178).

7.4 Routine and Preventive Maintenance

Optimum device performance, maximum uptime of the device, and accurate results can be obtained only if the device is in good condition and properly maintained.

7.4.1 Maintenance Plan

Perform the maintenance procedures in the table on a regular basis. The frequency given in the table is a suggestion. The optimum frequency for maintenance depends on several factors, such as the types and amounts of samples and solvents used with the device.

Frequency	What you should do...
Daily	• Inspect the flow connections for signs of leakage or blockage. • Inspect the flow connections for indications of salt deposits. • Inspect the flow connections for indications of air bubbles. Degas the solvents and purge the pump if necessary. • If the solvent is pure water or an aqueous buffer, replace the solvent in the reservoir daily. • Check the liquid level in the seal wash reservoir. Fill the seal wash reservoir with fresh seal wash liquid if required. • When you use buffers or salt solutions, flush the device thoroughly after use with an appropriate solvent that does not contain buffers or salts.

Frequency	What you should do...
Regularly	• Clean the check valves in an ultrasonic bath once a month (see Cleaning the Check Valves (▸ page 157)). • Check the liquid level in the solvent reservoirs to prevent the pump from running dry. Especially with phosphate buffer applications: The solvent reservoirs must not run empty while the pump is running. If they do, problems with the check valves and/or solvent selectors might occur. When the system is not operated for more than 1 day, flush the system and solvent lines, including those that are not used for the application, with buffer-free solvent. • Replace the wash liquid in the seal wash reservoir with fresh liquid. Rinse the reservoir thoroughly before filling it. Use a high-purity solvent for rinsing. • Test the seal wash system for leakage (see Testing the Seal Wash System for Leakage (▸ page 122)). • Replace the peristaltic tubing in the seal wash pump every 6 months (see Replacing the Seal Wash Lines (▸ page 123)). • Inspect the flow connections for damage, such as cracks, nicks, cuts, or blockage. • When you use additives, inspect the pump for leakage once a month. • Test the permeability of the inline filter or static mixer, depending on which component is installed. • To avoid contamination of the degasser, prepare fresh solvents, clean the solvent lines, and flush the degasser. • Check that all warning labels are still present on the device and clearly legible. If they are not, contact Thermo Fisher Scientific for replacement.
Annually	• Replace the solvent line filters (see Replacing the Solvent Line Filter (▸ page 168)). • Replace the piston seals (see Replacing the Piston Seals or Support Ring (▸ page 138)). • Replace the seal wash seals (see Replacing the Seal Wash Seals (▸ page 144)). • Inspect the pistons for particle deposits or indications of damage, for example, scratches or scores (see Cleaning the Piston (▸ page 137)). • Replace the seal wash lines (see Replacing the Seal Wash Lines (▸ page 123)). • Have Thermo Fisher Scientific service personnel perform preventive maintenance once a year.

A maintenance kit is available for the pump, which includes all parts that are required for routine maintenance (see Consumables and Replacement Parts (▸ page 215)).

TIP The Chromeleon software supports functions for estimating the lifetime of consumables (see Predictive Performance (▸ page 119)).

7.4.2 Flushing the Pump to Avoid Contamination

Items required

Fresh solvent

Observe the following guidelines

The following guidelines refer to conventional use of the Vanquish system as recommended in this manual, such as using fresh high-quality solvents (minimum UHPLC-grade or LC/MS-grade) that are replaced frequently:

- Regularly flushing the pump with fresh solvent is usually sufficient.
- If you use water, acetonitrile, or methanol for your chromatography, flushing the pump once a week is an appropriate interval.
- Mobile phases containing salts, buffering agents and/or other additives are inherently prone to organic contamination and/or biodegradation. When using non-volatile buffers, observe the following:
  - Mobile phases must be filtered before use.
  - For continuous trouble-free operation, the system must be flushed with, for example, > 60 % isopropanol or ethanol as a weekly procedure.
- Adapt the interval to the solvents in use.

TIP With persistent contamination, for example, if ghost peaks appear reproducibly in your blank chromatogram without injecting a sample, see Flushing the Pump with Persistent Contamination Only (▶ page 117).

7.4.3 Flushing the Pump with Persistent Contamination Only

When

TIP With conventional use of the Vanquish system as recommended in this manual, regularly flushing the pump is usually sufficient (see Flushing the Pump to Avoid Contamination (▷ page 116)).

For example, if ghost peaks appear reproducibly in your blank chromatogram without injecting a sample, consider a harsher cleaning procedure. Follow the instructions below.

Parts and additional items required

- Backpressure capillary (from Diagnostics tool kit)
- 6 molar (6 M) nitric acid (HPLC-grade)
- Waste container (for collecting the nitric acid)
- Fresh water (HPLC-grade)
- Fresh acetonitrile (HPLC-grade)
- New solvent reservoirs with fresh solvent
- New frits for solvent line filters

Follow these steps

1. Turn off the pump flow and wait until the system pressure is down to zero.
2. Install the backpressure capillary on the pump outlet. Guide the free end of the capillary to the waste container.
3. Replace the frits in the solvent line filters with new frits.
4. Replace the installed waste container with the new waste container to prevent any chemical reaction between the nitric acid and the solvent in the waste container.
5. For 1 hour, apply the flow rate of your application and flush the pump with 6 M nitric acid.
6. Flush the pump with fresh HPLC-grade water until the pH value is neutral.
7. Remove the waste container with the nitric acid and re-install the waste container that was installed previously.
8. For 2 hours, apply the flow rate of your application and flush the pump with fresh acetonitrile.

9. Connect the new solvent reservoirs, which contain fresh solvent.
10. Turn off the pump flow and wait until the system pressure is down to zero.
11. Uninstall the backpressure capillary and reconnect the system as required by your application.
12. Purge the pump.
13. Equilibrate the system.

7.4.4 Cleaning or Decontaminating the Device

Cleaning and decontamination must be performed by qualified personnel wearing suitable personal protective equipment. Always observe national and local regulations.

NOTICE

Wipe up all liquids spilled onto the system immediately. If surfaces are exposed for longer periods, these liquids can cause damage.

Decontamination

Decontamination is required, for example, when leakage or spillage has occurred, or before service or transport of the device. Use a suitable cleaning detergent or disinfectant to ensure that the treatment renders the device safe to handle.

Parts required

- Suitable cleaning detergent (or disinfectant)
- Purified water
- Lint-free cloths or wipes

CAUTION—Explosive Gas Mixtures from Alcoholic Cleaning Detergents

Alcohol-containing cleaning detergents may form flammable and explosive gas mixtures when exposed to air.

- Use such cleaning detergents only when required and only in adequately ventilated rooms.
- Avoid open flames or exposure to excessive heat during the cleaning process.
- Wipe the cleaned components thoroughly dry after cleaning. Do not operate the device before it is completely dry.

NOTICE

Observe the following:

- Only use cleaning detergents that will not damage the surfaces of the system.
- Never use sharp tools or brushes for cleaning any surfaces.
- Do not use sprays for cleaning.
- Prevent cleaning detergent from entering the flow path.
- Do not use excessively wetted cloth or wipes for cleaning. Prevent any liquids from entering the functional components of the device. Liquids can cause a short circuit when getting in contact with the electronic components.

Preparations

1. Turn off the power to the device and disconnect the power cord from the power source.

Follow these steps

1. Wipe the surfaces clean with a clean, dry, soft, lint-free cloth or wipe. If necessary, slightly dampen the cloth or wipe with a solution of lukewarm water and a suitable cleaning detergent.
2. Allow the cleaning detergent to react as recommended by the manufacturer.
3. Wipe the cleaned surfaces with purified water to ensure that all cleaning detergent residues have been removed.
4. Wipe the surfaces dry using a soft, lint-free cloth or wipe.

7.4.5 Predictive Performance

General Overview

The Chromeleon software supports functions for estimating the lifetime of consumables and for monitoring and recording service and qualification information about the device. These functions are called Predictive Performance. They allow you to schedule maintenance procedures based on the actual operating and usage conditions of the device.

On special wellness, service, and qualification panels, you can define intervals for replacing components that are subject to wear or stress and for service procedures or qualification procedures. In addition, you can set limits to alert you before and when the replacement, service, or qualification is due.

Color-coded bars on special panels provide visual feedback, allowing you to easily check and monitor the status. If a warning limit was set, a message in the Chromeleon Audit Trail alerts you when the action is due.

Some counters can be reset to zero after the required action was performed. To keep the Predictive Performance information up-to-date, consider resetting the counter when a maintenance, service, or qualification procedure has been performed.

For more information, refer to the *Chromeleon Help*.

Available Parameters for the Pump

The list shows the most important Predictive Performance counters for the pump. Consider resetting these parameters after performing the related maintenance procedure:

Predictive Performance Command	To perform…
CheckValvesServiceDone	After replacement of the check valves. For each pump head, a common counter is available for all check valves (inlet check valves and outlet check valves).
PistonsChanged	After replacement of the pistons or pump head. For each pump head, a common counter is available for both pistons.
SealsChanged	After replacement of the piston seals or pump head. For each pump head, a common counter is available for all piston seals in the pump head.
InlineFilterChanged	If you have installed the static mixer instead of the inline filter: after installation of the static mixer or mixer replacement.
QualificationDone	After qualification procedures, for example, Instrument Qualification or Performance Qualification.
ServiceDone	After annual maintenance by service personnel.

7.5 Seal Wash System

Follow the sequence of steps for the maintenance procedure that you want to perform:

- To test the seal wash system for leakage, follow the steps in Testing the Seal Wash System for Leakage (▷ page 122).
- To replace the seal wash lines, follow the steps in Replacing the Seal Wash Lines (▷ page 123).
- To replace the seal wash detector (drop detector), follow the steps in Replacing the Seal Wash Detector (▷ page 126).

TIP To replace the seal wash seals, which are part of the pump head, see Replacing the Seal Wash Seals (▷ page 144).

7.5.1 Testing the Seal Wash System for Leakage

When

- At regular intervals
- When you installed the pump head during maintenance procedures

Items required

- Syringe (12 mL)
- Seal wash liquid

Follow these steps

1. Disconnect the tubing from the seal wash detector.

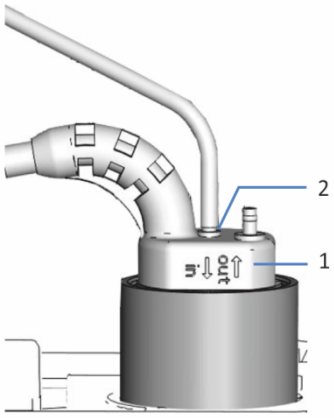

Figure 36: Seal wash detector

No.	Description
1	Seal wash detector
2	Tubing connection port (port labeled **in**)

2. Insert a syringe into the open end of the tubing.
3. To allow the liquid to travel easily through the seal wash system, press down the lever of the seal wash pump and hold it in that position with one hand.
4. Pull out the syringe plunger to draw seal wash liquid into the tubing.
5. When about 10 mL of liquid are present in the syringe, release the lever of the seal wash pump.
6. Press the lever firmly onto the tubing and press the liquid from the syringe into the seal wash system.

7. Check whether liquid escapes from the connections of the seal wash system or under the pump heads.

Observation	Remedial Action
Leakage is present	Tighten or replace leaky connections. Repeat the inspection.
No leakage is present	Remove the syringe and reconnect the tubing to the seal wash detector (port labeled **in**).

7.5.2 Replacing the Seal Wash Lines

When

- Damage or blockage of the seal wash lines
- Peristaltic tubing: Every 6 months as preventive maintenance for the seal wash pump
- Other seal wash lines: Once a year

Parts and additional items required

- Seal wash lines as required:
  - Seal wash lines that connect the seal wash reservoir to the peristaltic tubing in the pump

    For more information, refer to the *Operating Manual* for the Vanquish autosampler.
  - Seal wash lines that connect the components in the pump
  - Peristaltic tubing (PharMed tubing)
- Fresh seal wash liquid

For an overview of the seal wash system, see the picture in Setting Up the Seal Wash System (▶ page 64).

Tools required

Tubing cutter (optional)

Preparations

1. Unscrew the cap of the seal wash reservoir and remove the seal wash line together with the cap from the reservoir.
2. To empty the seal wash line, press down the lever of the seal wash pump. Release the lever when the line is empty.

Follow these steps

NOTICE

When you must remove a seal wash line from the tubing guides, be careful not to pull on other tubing in the guides.

Follow the sequence of steps for the seal wash line that you want to replace:

- For the seal wash lines that connect the seal wash reservoir to the peristaltic tubing in the pump, follow the steps in the *Operating Manual* for the Vanquish autosampler.
- For the peristaltic tubing, see Replacing the Peristaltic Tubing (▷ page 124).
- For the seal wash lines from peristaltic tubing to the pump heads and on to the seal wash detector, see Replacing the Seal Wash Lines between the Peristaltic Tubing and the Seal Wash Detector (▷ page 125).

Replacing the Peristaltic Tubing

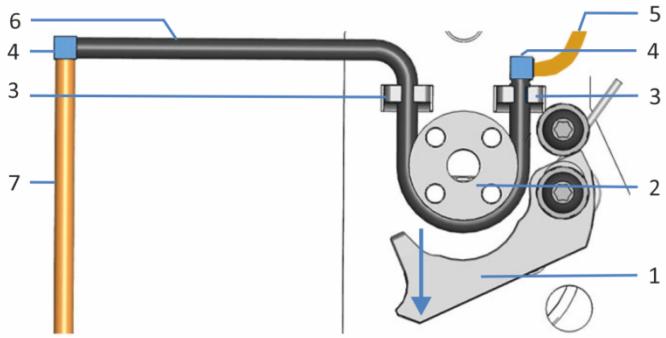

Figure 37: Seal wash pump

No.	Description
1	Pump lever
2	Pump rotor
3	Tubing holder (peristaltic tubing)
4	Tubing connector
5	Seal wash line from autosampler (silicone tubing)
6	Peristaltic tubing
7	Seal wash tubing to pump head (silicone tubing)

1. Disconnect the peristaltic tubing from the tubing connectors that connect it to the silicone tubing.
2. Press down the lever on the seal wash pump and remove the peristaltic tubing from the pump and from the tubing holders.
3. Connect the new peristaltic tubing to the silicone tubing using the tubing connectors. Cut tubing to required length, if applicable.
4. Insert the peristaltic tubing into the right tubing holder. Make sure that the tubing connector rests on the tubing holder. Push the tubing connector vertically down onto the holder if required.
5. Press down the lever on the seal wash pump and hold it in that position with one hand.
6. With your other hand, insert the tubing between the lever and the rotor and wind it around the rotor.
7. Release the lever.
8. Insert the peristaltic tubing into the left tubing holder.
9. Check that the peristaltic tubing is inserted properly in the tubing holders. If it is not, push the tubing into the holders. Make sure that the tubing is not pinched or squeezed in the holders.

Restarting the Seal Wash System

1. Retighten the reservoir cap hand-tight. The retaining guide must remain in the hole in the reservoir cap. If it does not, press the retaining guide into the hole so that the tubing is kept in place in the cap.
2. Check the wash lines over the entire flow path:
   a) Make sure that no bending (kink), pinching or squeezing of the wash lines is present at any point in the flow path.
   b) If you have to cut tubing to length, use a tubing cutter. Make sure that the cut is at right angle to the length of the line.
3. Flush the seal wash system, using fresh seal wash liquid (see Flushing the Seal Wash System (▶ page 70)).

Replacing the Seal Wash Lines between the Peristaltic Tubing and the Seal Wash Detector

1. Disconnect the seal wash tubing from the tubing connectors. Do not remove the tubing connectors.
2. Connect the new seal wash lines.

3. Retighten the reservoir cap hand-tight. The retaining guide must remain in the hole in the reservoir cap. If it does not, press the retaining guide into the hole so that the tubing is kept in place in the cap.
4. Check the wash lines over the entire flow path:
   a) Make sure that no bending (kink), pinching or squeezing of the wash lines is present at any point in the flow path.
   b) If you have to cut tubing to length, use a tubing cutter. Make sure that the cut is at right angle to the length of the line.
5. Flush the seal wash system, using fresh seal wash liquid (see Flushing the Seal Wash System (▶ page 70)).

7.5.3 Replacing the Seal Wash Detector

When

- Contamination of detector electrodes
- Impaired functionality of the seal wash system

Parts required

Seal wash detector assembly, consisting of the detector and funnel

Preparations

To prepare the new seal wash detector assembly push the seal wash detector into the funnel. Mind the orientation of the funnel.

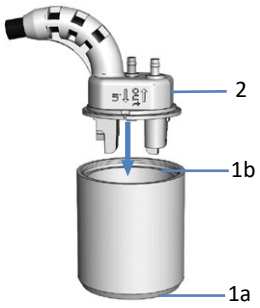

Figure 38: Assembling the seal wash detector parts

No.	Description
1a	Funnel (bottom side)
1b	Funnel (top side)
2	Seal wash detector

Follow these steps

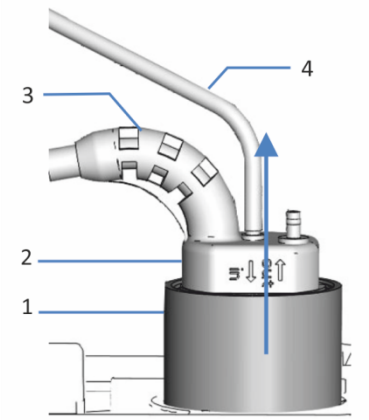

Figure 39: Removing the seal wash detector assembly

No.	Description
1	Funnel, seal wash detector
2	Seal wash detector
3	Detector cable
4	Seal wash line

1. Disconnect the seal wash line from the seal wash detector (port labeled **in**).
2. Unplug the detector cable from the **DROP DET** port.
3. Grasp and pull the seal wash detector assembly upward by the funnel.
4. Push the new seal wash detector assembly into the pump.

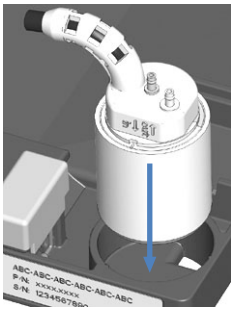

Figure 40: Installing the seal wash detector assembly

5. Reconnect the seal wash line to the seal wash detector (port labeled **in**).
6. Connect the detector cable to the **DROP DET** port.
7. Flush the seal wash system, using fresh seal wash liquid (see Flushing the Seal Wash System (▶ page 70)).

7.6 Y-Connector

When

Damage of Y-connector

Parts required

Y-connector

Tools and additional items required

- Solvent suitable for purging to flush out harmful substances
- Solvent suitable for your application

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

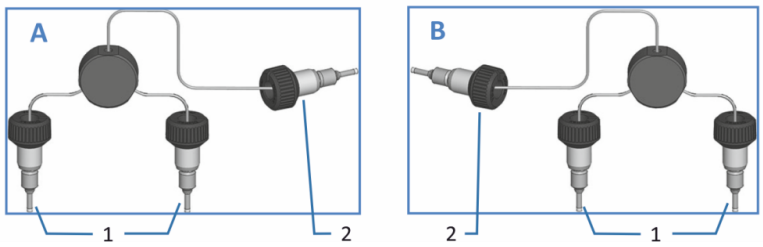

Figure 41: Y-Connector, used as left Y-connector (A) or right Y-connector (B)

No.	Description
1	Capillaries to outlet check valves on pump head
2	Capillary to purge unit (port marked **R** or **L**, depending on connector position)

1. Disconnect the Y-connector capillaries on the purge unit and on the outlet check valves of the pump head.
2. Install the new Y-connector:
   a) Connect the Y-connector capillaries to the outlet check valves.
   b) Connect the capillary to the purge unit.
3. Purge the pump using the solvent for your application.
4. Inspect the flow connections of the Y-connector for indications of leakage. Tighten leaky connections when the system pressure is down to zero.

7.7 Pump Head

Follow the sequence of steps for the maintenance procedure that you want to perform:

- To replace a pump head, see Replacing the Pump Head (▷ page 131).
- To replace a piston, see Replacing the Pistons (▷ page 134).
- To clean a piston, see Cleaning the Piston (▷ page 137).
- To replace the piston seals or support ring, see Replacing the Piston Seals or Support Ring (▷ page 138).
- To replace the seal wash seals, see Replacing the Seal Wash Seals (▷ page 144).
- To replace the pump head seals, see Replacing the Pump Head Seals (▷ page 149).
- To test the pump for piston seal leakage, see Testing the Piston Seals for Leakage (▷ page 152).

For an overview of the pump head parts, see Overview of Pump Head Parts (▷ page 130).

7.7.1 Overview of Pump Head Parts

The picture shows the main pump head parts.

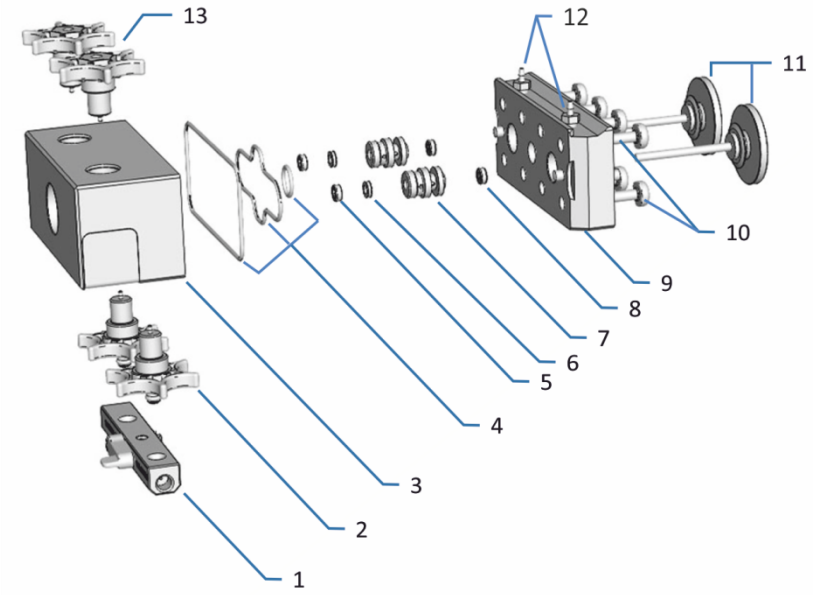

Figure 42: Overview of pump head parts

No.	Description
1	Inlet assembly
2	Inlet check valves
3	Pump head
4	Pump head seals (3 PTFE O-ring seals)
5	Piston seals
6	Support rings
7	Seal wash bodies (pump head bushing)
8	Seal wash seals
9	Seal wash plate
10	Screws, seal wash plate (8 screws)
11	Pistons
12	Connectors for seal wash tubing (screwable)
13	Outlet check valves

7.7.2 Replacing the Pump Head

When

Damage of pump head

Parts required

Pump head

Tools and additional items required

- Hexagon wrench, size 6
- Solvent suitable for purging to flush out harmful substances
- Solvent suitable for your application

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. Remove the pump head. See Removing the Pump Head (▸ page 131).
2. Install the pump head. See Installing the Pump Head (▸ page 132).

7.7.2.1 Removing the Pump Head

Preparations

Prepare the pump for removing the pump head. See Replacing the Pump Head (▸ page 131).

Follow these steps

1. Select the pump head for which you want to perform the procedure.
2. Undock the pistons either from the keypad or from the Chromeleon software. Wait until undocking is complete before proceeding with the next step.
3. On the inlet assembly of the pump head, disconnect the tubing from the degasser.
4. Unplug the cable of the pressure sensor from the **P-WORK** connector.

5. Remove the Y-connector (see Y-Connector (▷ page 128)).
6. Remove the seal wash lines from the tubing connectors on the pump head. Do not remove the tubing connectors.
7. Loosen the pump head screw with the hexagon wrench.
8. Hold the pump head with one hand, remove the pump head screw, and then remove the pump head by pulling it toward you.
   The pistons are usually removed from the pump together with the pump head.

TIP If a piston remained in the pump, write down the installation position in the pump head (right or left) and pull the piston out. If both pistons remained in the pump, be careful not to interchange them.

7.7.2.2 Installing the Pump Head

Preparations

1. Remove the pump head. See Removing the Pump Head (▷ page 131).
2. Before you begin, note the information for reinstalling pump heads and installing new pump heads (replacement pump heads).

Reinstallation of pump heads

- Be sure not to interchange the pump heads. To identify the correct installation position, note the labeling on the pressure sensor cable (**A** for the left pump head or **B** for the right pump head).
- *If the pistons remained in the pump head*: Consider verifying that the distance between the pistons and seal wash plate is correct (see the related steps in Replacing the Pistons (▷ page 134)).
- *If you have to reinstall the pistons*: Follow the steps in Replacing the Pistons (▷ page 134).

Installation of new pump heads (replacement pump heads)

- New pump heads can be installed in either position when installed for the first time. They have no label on the pressure sensor cable. For easier identification during future maintenance, consider labeling them according to the installation position (**A** for the left pump head or **B** for the right pump head).
- To protect the pistons during shipment, the spacing tool is installed between the seal wash plate and the pistons. Remove the spacing tool. Be careful not to pull out the pistons any further.

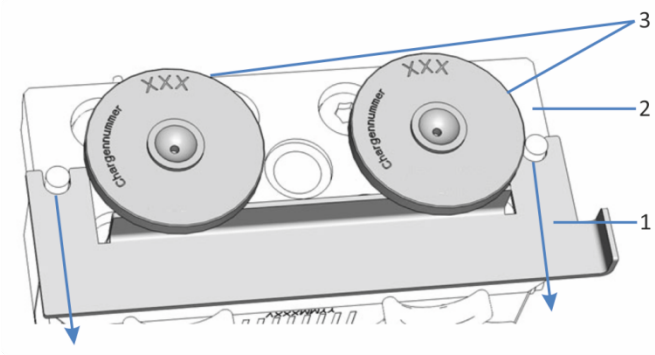

Figure 43: Removing the spacing tool

No.	Description
1	Spacing tool
2	Seal wash plate
3	Pistons

Follow these steps

1. Insert the pump head into the pump and tighten the pump head screw.
2. Connect the seal wash lines to the tubing connectors on the pump head.
3. Install the Y-connector (see Y-Connector (page 128)).
4. Connect the cable of the pressure sensor to the **P-WORK** connector.
5. On the inlet assembly of the pump head, connect the tubing from the degasser.
6. If the pump is connected in the Chromeleon software, disconnect the pump.
7. Turn off the pump with its main power switch and on again.
8. Dock the pistons either from the keypad or from the Chromeleon software. Wait until docking is complete before proceeding with the next step.
9. Purge the pump using the solvent of your application.
10. Inspect all flow connections on the pump head for indications of leakage. Tighten leaky connections when the system pressure is down to zero.
11. In the Chromeleon software, consider updating the Predictive Performance information for the pump head components.

12. Test the seal wash system and pump for leakage (see Testing the Seal Wash System for Leakage (▷ page 122) and Testing the Pump for Leakage (General Test) (▷ page 170)).

13. *Recommended:* From the Chromeleon software, perform performance qualification for the pump:

    - Run the pump-specific **Performance Qualification** tests (PQ tests) (= Flow Precision Test and Gradient Accuracy Test). For details, refer to the *Operational and Performance Qualifications manual*.
    - When the tests are completed, execute the **QualificationDone** command.

7.7.3 Replacing the Pistons

When

Damage of piston

Parts and additional items required

- Piston
- Isopropanol

Preparations

Remove the pump head (see Replacing the Pump Head (▷ page 131)).

Before you begin, observe the following:

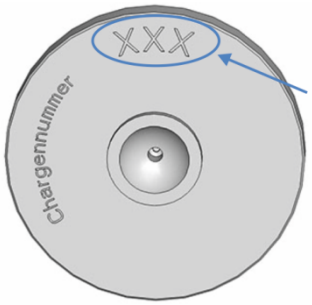

Figure 44: Piston calibration value

- Write down the 3-digit piston calibration value (which is imprinted on the piston base, see picture) and the installation position in the pump head (left or right). You might need this assignment in a later step.
- *For reinstallation of pistons:* Be sure not to interchange the pistons.
- *For Installation of new pistons (replacement pistons):* New pistons can be installed in either position.

Follow these steps

1. Remove the pistons from the pump head (or pump if necessary).
2. *When reinstalling a piston that you removed*
   Clean the piston. Follow the steps in Cleaning the Piston (▸ page 137).
3. To facilitate piston installation, inject a few drops of isopropanol into the piston cavity in which you want to install the piston.
4. Insert the pistons into the cavities.

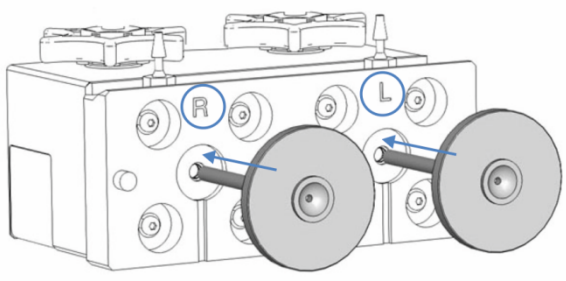

Figure 45: Installing the pistons

5. Place the spacing tool onto the pump head.

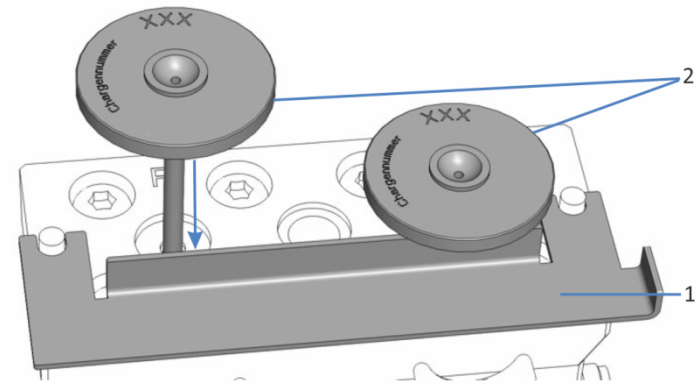

Figure 46: Installing the spacing tool and pistons

No.	Description
1	Spacing tool
2	Pistons (in the picture, the piston bases are marked)

6. Grasping the pistons by the piston base, push in the pistons until they contact the tool.
7. Remove the spacing tool. Be careful not to pull out the pistons any further.
8. Install the pump head (see Installing the Pump Head (▸ page 132)).

9. In the Chromeleon software, update or check the **Piston Calibration Value** property as applicable:

Pump Head	Property to be updated
For the left pump head	Under **Pump_Wellness_LeftBlock:**
Left piston	**PistonCalibrationValue_Drv1**
Right piston	**PistonCalibrationValue_Drv2**
For the right pump head	Under **Pump_Wellness_RightBlock:**
Left piston	**PistonCalibrationValue_Drv1**
Right piston	**PistonCalibrationValue_Drv2**
The property names in the table refer to the names in the **Command** window.	

   - *When installing a new piston:* Update the related **Piston Calibration Value** property with the value from the new piston. Run a self-test. Non-matching values may result in periodic baseline fluctuation or pulsation.
   - *When reinstalling a piston:* Verify that the **Piston Calibration Value** property for the related piston matches the value on the piston. Non-matching values may result in periodic baseline fluctuation or pulsation.

10. Inspect all flow connections on the pump head for indications of leakage. Tighten leaky connections when the system pressure is down to zero.

11. In the Chromeleon software, consider updating the Predictive Performance information for the pistons.

12. Test the seal wash system and pump for leakage (see Testing the Seal Wash System for Leakage (▷ page 122) and Testing the Pump for Leakage (General Test) (▷ page 170)).

13. *Recommended:* From the Chromeleon software, perform performance qualification for the pump:
   - Run the pump-specific **Performance Qualification** tests (PQ tests) (= Flow Precision Test and Gradient Accuracy Test). For details, refer to the *Operational and Performance Qualifications manual*.
   - When the tests are completed, execute the **QualificationDone** command.

7.7.4 Cleaning the Piston

When

Before reinstalling a piston that you removed

Items required

- Dry, lint-free tissue
- Isopropanol

Follow these steps

1. Inspect the piston for signs auf damage.
2. Carefully rinse the piston, using isopropanol.
3. With a dry, lint-free tissue, rub the piston several times.
4. Hold the piston and carefully move your fingernail over the piston surface. You should not feel inconsistent or rough areas.
5. Depends on the situation:

Situation	Action
No damage visible No inconsistent or rough areas	1. Carefully rinse the piston again, using isopropanol. 2. With a dry, lint-free tissue, rub the piston several times. 3. Reinstall the piston.
Piston is scratched or scored	Install a new piston.

7.7.5 Replacing the Piston Seals or Support Ring

When

- Damage to piston seals, leaky seals
- Unstable flow rates or baseline noise

Parts required

- Piston seals
- Support ring
  Note that the support ring is *not* a wear part. You need *not* replace the support ring when you replace a piston seal. Replace the support ring only when applicable.
- *Optional:* Seal wash seals (and seal-handling tool)
  Replacing the seal wash seal is recommended.

Tools and additional items required

- Screwdriver, Torx TX25
- Syringe filled with isopropanol
- Cleaning swab
- Lint-free tissue
- Seal-handling tool

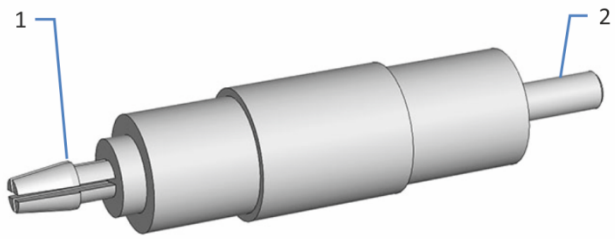

Figure 47: Seal-handling tool

No.	Description
1	Seal removal pin
2	Seal insertion pin

Preparations

1. Remove the pump head (see Replacing the Pump Head (▷ page 131)).
2. Remove the pistons (see Replacing the Pistons (▷ page 134)).

Follow these steps

1. Remove the screws on the rear of the pump head (on the seal wash plate).
2. Remove the seal wash plate from the pump head.

TIP Removing the seal wash plate may be easier with the spacing tool. Insert the spacing tool into the opening on one side of the seal wash plate and lever the plate away from the pump head. Repeat on the other side.

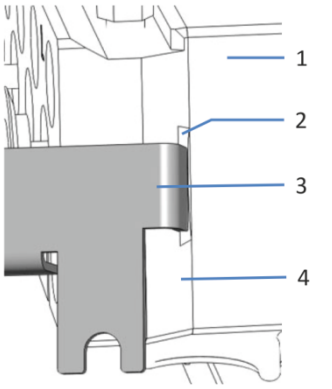

Figure 48: Removing the seal wash plate with the spacing tool

No.	Description
1	Pump head
2	Opening on seal wash plate
3	Spacing tool
4	Seal wash plate

3. Remove the seal wash bodies from the pump head if applicable.
4. Remove the support ring.
   Gently tap the pump head on a clean work surface to make the support ring drop out.

   If the support ring does not drop out, use the seal-handling tool. With the *insertion* pin, push the seal-handling tool at a slight angle into the pump head and remove the tool. The support ring is removed together with the tool.

NOTICE

Do *not* use the *seal removal pin* to remove the support ring. The support ring can be removed from the tool only with difficulties.

5. Remove the piston seal.
   With the *removal* pin, push the seal-handling tool into the pump head as far as it goes in and remove the tool. The piston seal is removed together with the tool. Once the seal has been removed, it cannot be reused.

6. *Required if you reinstall the support ring*
   Clean the support ring from the inside and outside, using isopropanol, a cleaning swab, and a lint-free tissue.

7. Pipette a few drops of isopropanol into cavity in the pump head, on the edge on which the piston seal will rest.

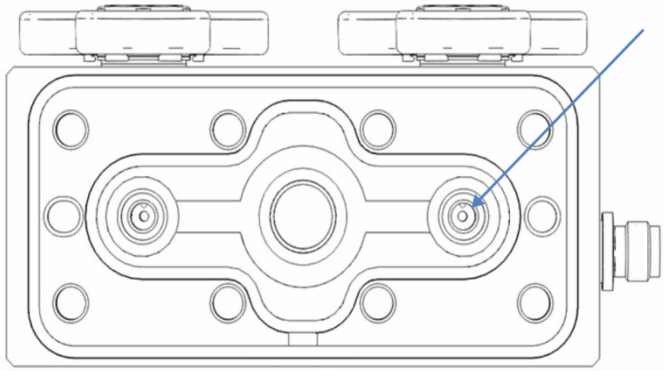

Figure 49: Edge on which the piston seal will rest

8. Slide the support ring onto the insertion pin of the seal-handling tool.

9. Slide the piston seal onto the insertion pin, with the open side of the seal facing away from the tool.

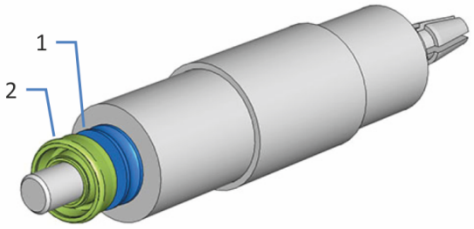

Figure 50: Support ring and piston seal on insertion pin

No.	Description
1	Support ring
2	Piston seal (open side facing away from the tool)

10. With the insertion pin, push the seal-handling tool into the pump head as far as it goes in.

11. Remove the tool from the pump head. The piston seal and support ring remain in the pump head.

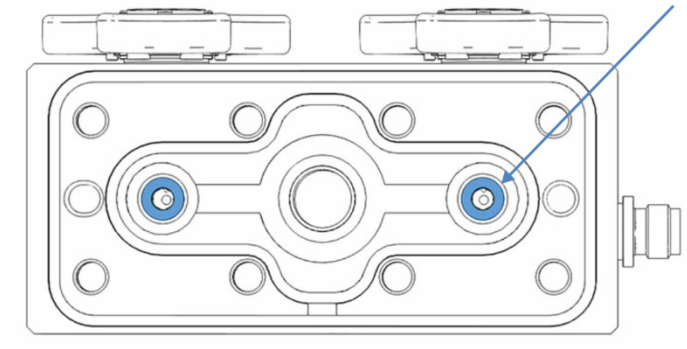

Figure 51: Pump head, piston seals, and support rings installed

12. Insert the seal wash bodies into the pump head if applicable. Mind the correct orientation. The even side faces the pump head.

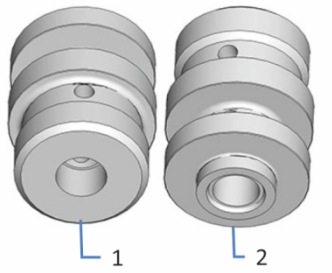

Figure 52: Orientation of the seal wash body

No.	Description
1	Side facing the pump head
2	Side facing the seal wash plate

13. *Recommended:* Replace the seal wash seals. Follow the appropriate steps in Replacing the Seal Wash Seals (page 144).

14. Place the seal wash plate onto the pump head and insert the screws.

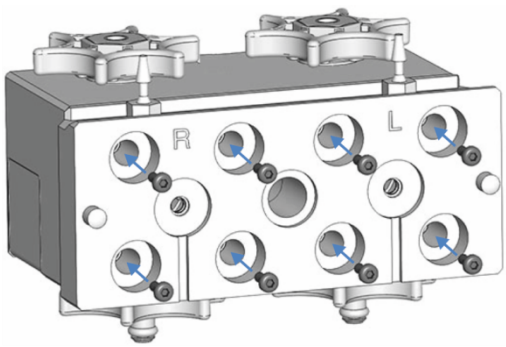

Figure 53: Pump head with seal wash plate and plate screws

15. With the screwdriver, hand-tighten the screws step by step in the order shown in the picture.

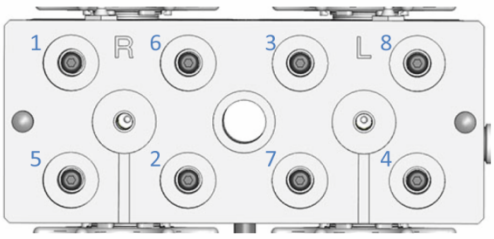

Figure 54: Tightening order for seal wash plate screws

16. Tighten the screws step by step in the given order once again.
17. Install the pistons. Follow the related steps in Replacing the Pistons (▷ page 134).
18. Install the pump head. See Installing the Pump Head (▷ page 132).
19. Observe the recommendations for new piston seals (see Recommendations for New Piston Seals (▷ page 143)).
20. Inspect all flow connections on the pump head for indications of leakage. Tighten leaky connections when the system pressure is down to zero.
21. In the Chromeleon software, consider updating the Predictive Performance information for the piston seals.
22. Test the seal wash system and pump for leakage (see Testing the Seal Wash System for Leakage (▷ page 122) and Testing the Pump for Leakage (General Test) (▷ page 170)).
23. *Recommended:* From the Chromeleon software, perform performance qualification for the pump:
    - Run the pump-specific **Performance Qualification** tests (PQ tests) (= Flow Precision Test and Gradient Accuracy Test). For details, refer to the *Operational and Performance Qualifications manual*.
    - When the tests are completed, execute the **QualificationDone** command.

7.7.6 Recommendations for New Piston Seals

When

When new piston seals have been installed

TIP The actions recommended in this section directly influence pump performance and the piston seal life cycle.

Items required

- nanoViper™ capillary (length: 750 mm, inner diameter: 75 µm)
- Isopropanol
- Solvent suitable for your application

Recommendations

- Allow new piston seals to run in.
- Never run the pump dry.
  Running the pump dry can damage the pistons or piston seals.

Allowing New Piston Seals to Run In

1. Purge the pump. For 15 minutes, apply a purge flow of approximately 1.3 mL/min using isopropanol.
2. Install the nanoViper capillary on the pump outlet. Guide the free end of the capillary to the waste container.
3. For 30 minutes, apply a flow of approximately 2.0 mL/min using isopropanol to generate a backpressure of approximately 80 MPa.
4. Turn off the pump flow and wait until the system pressure is down to zero.
5. Remove the capillary from the pump outlet and reconnect the pump to the system.
6. Purge the pump using the solvent for your application.
7. If an increased leakage rate is observed with new piston seals after several hours of operation, operate the pump for at least 2 hours at 35 MPa.

TIP If the piston seals are not sufficiently tight yet, have the pump build up high pressure and hold the pressure for some minutes.

7.7.7 Replacing the Seal Wash Seals

When

- Damage to the seal wash seal, leaky seal
- Once a year

Parts required

Seal wash seals

Tools and additional items required

- Screwdriver, Torx TX25
- Syringe filled with isopropanol
- Seal-handling tool

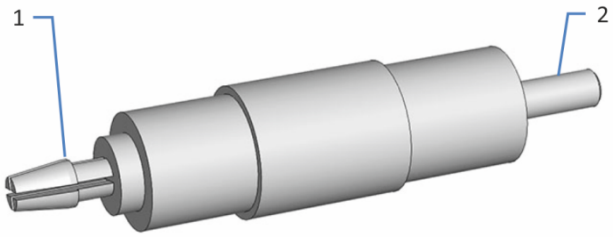

Figure 55: Seal-handling tool

No.	Description
1	Seal removal pin
2	Seal insertion pin

Preparations

1. Remove the pump head (see Replacing the Pump Head (▷ page 131)).
2. Remove the pistons (see Replacing the Pistons (▷ page 134)).

Follow these steps

1. Remove the screws on the rear of the pump head (on the seal wash plate).
2. Remove the seal wash plate from the pump head.

TIP Removing the seal wash plate may be easier with the spacing tool. Insert the spacing tool into the opening on one side of the seal wash plate and lever the plate away from the pump head. Repeat on the other side.

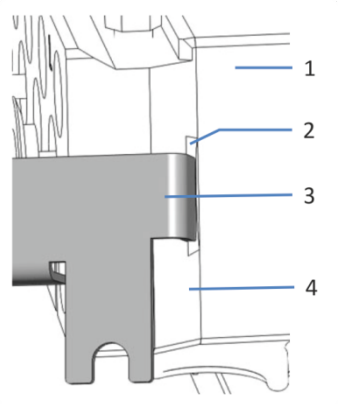

Figure 56: Removing the seal wash plate with the spacing tool

No.	Description
1	Pump head
2	Opening on seal wash plate
3	Spacing tool
4	Seal wash plate

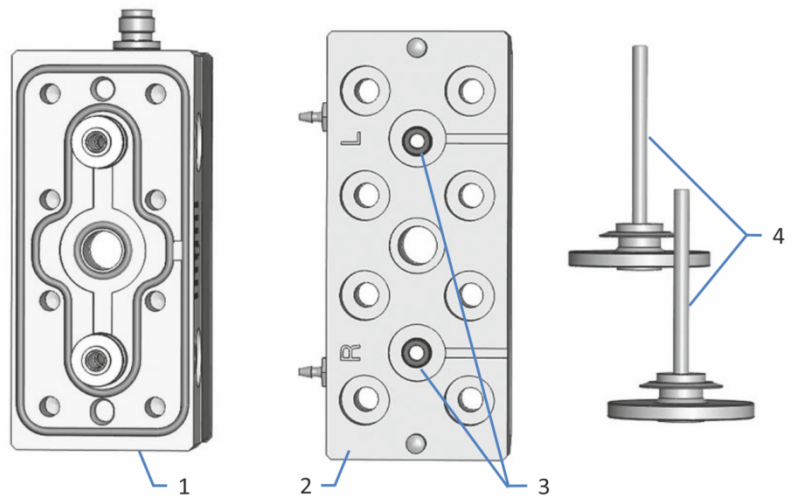

Figure 57: Pump head, seal wash plate and pistons removed

No.	Description
1	Pump head
2	Seal wash plate, channel side
3	Seal wash seals
4	Pistons

3. If the seal wash bodies are present in the seal wash plate, remove them from the plate.

4. Remove the seal wash seal.
   On the seal wash plate (channel side), set the *insertion* pin of the seal-handling tool at a slight angle to the seal. Push the seal out of the plate and remove the tool.

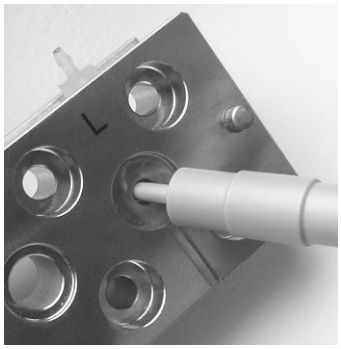

Figure 58: Removing the seal wash seal

5. Slide the new seal onto the insertion pin of the seal-handling tool.

6. To facilitate seal installation, inject a few drops of isopropanol into the seal cavities on the seal wash plate (no-channel side).

7. On the seal wash plate (no-channel side), set the insertion pin of the seal-handling tool at a 90° angle to the plate and push the insertion pin vertically into the plate as far as it goes in.

8. Remove the tool from the seal wash plate. The seal remains in the plate.

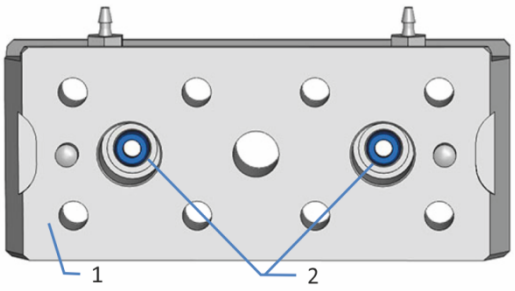

Figure 59: Seal wash plate (no-channel side)

No.	Description
1	Seal wash plate (no-channel side)
2	Seal wash seals

9. Insert the seal wash bodies into the pump head if applicable. Mind the correct orientation. The even side faces the pump head.

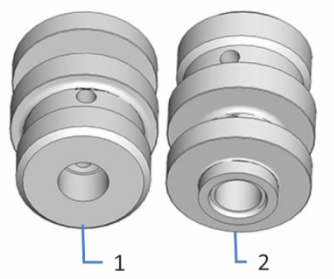

Figure 60: Orientation of the seal wash body

No.	Description
1	Side facing the pump head
2	Side facing the seal wash plate

10. Place the seal wash plate onto the pump head and insert the screws.

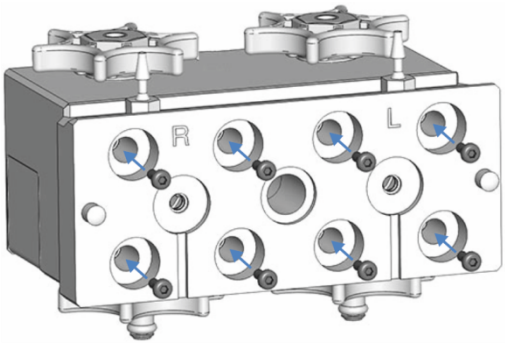

Figure 61: Pump head with seal wash plate and plate screws

11. With the screwdriver, hand-tighten the screws step by step in the order shown in the picture.

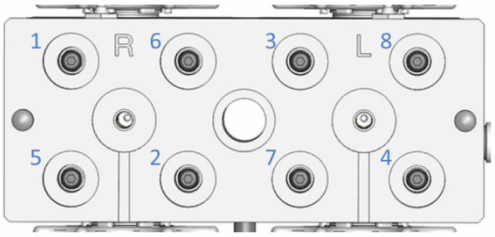

Figure 62: Tightening order for seal wash plate screws

12. Tighten the screws step by step in the given order once again.

13. Install the pistons. Follow the related steps in Replacing the Pistons (▶ page 134).

14. Install the pump head. See Installing the Pump Head (▷ page 132).
15. Inspect all flow connections on the pump head for indications of leakage. Tighten leaky connections when the system pressure is down to zero.
16. Test the seal wash system and pump for leakage (see Testing the Seal Wash System for Leakage (▷ page 122) and Testing the Pump for Leakage (General Test) (▷ page 170)).
17. If you also replaced the piston seals, proceed with the specific steps further down.

Specific Steps After Piston Seal Replacement

If you replaced the piston seals together with the seal wash seals, proceed with these steps:

1. Observe the recommendations for new piston seals (see Recommendations for New Piston Seals (▷ page 143)).
2. In the Chromeleon software, consider updating the Predictive Performance information for the piston seals.
3. *Recommended:* From the Chromeleon software, perform performance qualification for the pump:
   - Run the pump-specific **Performance Qualification** tests (PQ tests) (= Flow Precision Test and Gradient Accuracy Test). For details, refer to the *Operational and Performance Qualifications manual*.
   - When the tests are completed, execute the **QualificationDone** command.

7.7.8 Replacing the Pump Head Seals

When

Damage to pump head seals, leaky seals

Parts and tools required

- Pump head seals
- Tweezers

Preparations

1. Remove the pump head (see Replacing the Pump Head (▸ page 131)).
2. Remove the pistons (see Replacing the Pistons (▸ page 134)).

Follow these steps

1. Remove the screws on the rear of the pump head (on the seal wash plate).
2. Remove the seal wash plate from the pump head.

TIP Removing the seal wash plate may be easier with the spacing tool. Insert the spacing tool into the opening on one side of the seal wash plate and lever the plate away from the pump head. Repeat on the other side.

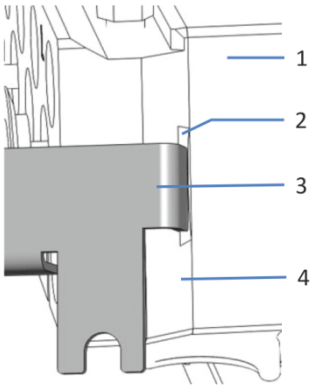

Figure 63: Removing the seal wash plate with the spacing tool

No.	Description
1	Pump head
2	Opening on seal wash plate
3	Spacing tool
4	Seal wash plate

3. Remove the seal wash bodies from the pump head if applicable.

4. Remove the pump head seals. Using tweezers facilitates the procedure for the seals labeled 1 and 3 in the picture.

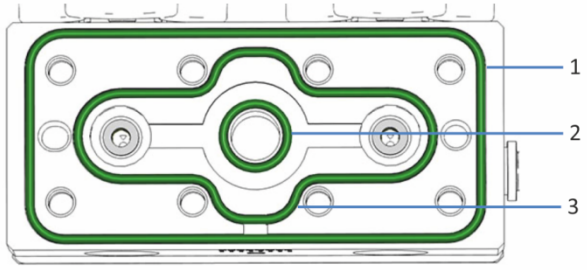

Figure 64: Pump head seals

No.	Description
1	Pump head seal, O-ring 65x1.5
2	Pump head seal, O-ring 9x1.5
3	Pump head seal, O-ring 45x1.5

5. Install the new seals.
   Place the seal onto the receiving groove. With your finger on the seal, follow the groove shape until the seal rests exactly in the groove.

6. Insert the seal wash bodies into the pump head if applicable. Mind the correct orientation. The even side faces the pump head.

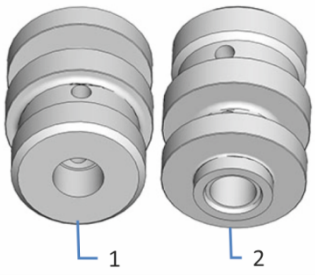

Figure 65: Orientation of the seal wash body

No.	Description
1	Side facing the pump head
2	Side facing the seal wash plate

7. Place the seal wash plate onto the pump head and insert the screws.

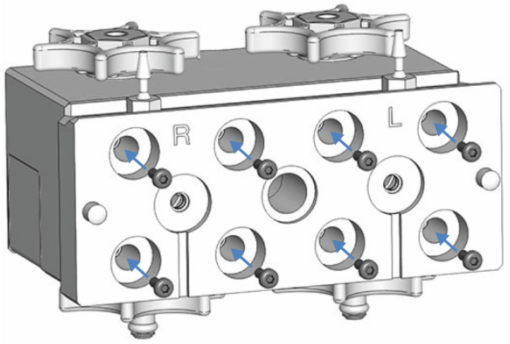

Figure 66: Pump head with seal wash plate and plate screws

8. With the screwdriver, hand-tighten the screws step by step in the order shown in the picture.

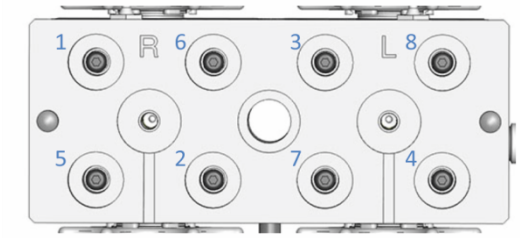

Figure 67: Tightening order for seal wash plate screws

9. Tighten the screws step by step in the given order once again.
10. Install the pistons. Follow the related steps in Replacing the Pistons (▸ page 134).
11. Install the pump head. See Installing the Pump Head (▸ page 132).
12. Inspect all flow connections on the pump head for indications of leakage. Tighten leaky connections when the system pressure is down to zero.
13. Test the seal wash system and pump for leakage (see Testing the Seal Wash System for Leakage (▸ page 122) and Testing the Pump for Leakage (General Test) (▸ page 170)).

7.7.9 Testing the Piston Seals for Leakage

When

- Pressure pulsation, shift in retention times, and/or poor reproducibility can indicate possible piston seal leakage.
- If messages regarding piston seal leakage appear in the chromatography software, for example, **"The piston seal leakage has exceeded the recommended limit (code 4121)"**.

With Chromeleon 7.2.6 and later

Run the **Advanced Leak Test** (see Testing from the Chromeleon Software (▶ page 199)).

With Chromeleon 7 earlier than Chromeleon 7.2.6

Parts and additional items required

- Backpressure capillary (from Diagnostics tool kit) (optional)
- Isopropanol

Follow these steps

1. From the Chromeleon software, start a seal wash cycle.
2. When the seal wash cycle is complete, disconnect the tubing from the seal wash detector (port labeled **in**).

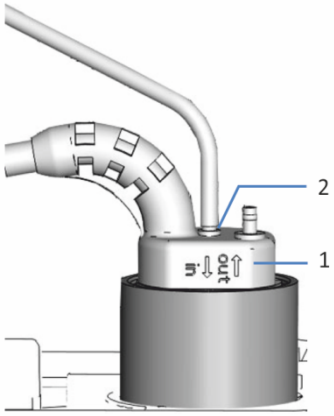

Figure 68: Seal wash detector

No.	Description
1	Seal wash detector
2	Tubing connection port (port labeled **in**)

3. Remove some liquid from the tubing, for example, by shaking the tubing.

4. Set up the system in such a way that approximately 120 MPa of backpressure is produced.
   For example, install an appropriate backpressure capillary on the pump outlet (outlet of the inline filter or static mixer).

5. Apply a flow rate of 3 mL/min using isopropanol.

6. To evaluate possible leakage, observe the liquid level in the tubing. Finish the observation before a new seal wash cycle starts (after one hour).

7. Depends on your observation:

Observation	Remedial Action
Liquid level in the tubing remains unchanged	The piston seals seal tightly. Reconnect the seal wash tubing to the seal wash detector (port labeled **in**). This completes the test.
Liquid level in the tubing is decreasing	The seal wash seals are leaky: 1. Replace the seal wash seals. 2. Reconnect the seal wash tubing to the seal wash detector (port labeled **in**). 3. Repeat the test starting with step 1.
Liquid level in the tubing is increasing	One or more piston seals are leaky. Continue with the next steps.

8. On the right pump head, remove the seal wash tubing that connects the left pump head to the right pump head.

9. Apply a flow rate of 3 mL/min for 100% solvent A using isopropanol.

10. For about 5 minutes, observe the liquid level in the tubing. Finish the observation before a new seal wash cycle starts.

11. Depends on your observation:

Observation	Remedial Action
Liquid level in the tubing is increasing again	1. Replace the piston seals in the *left* pump head. 2. Reconnect the seal wash tubing to the right pump head. 3. Reconnect the seal wash tubing to the seal wash detector (port labeled **in**). 4. Repeat the test starting with step 1.
Liquid level in the tubing does not increase again	1. Replace the piston seals in the *right* pump head. 2. Reconnect the seal wash tubing to the right pump head. 3. Reconnect the seal wash tubing to the seal wash detector (port labeled **in**). 4. Repeat the test starting with step 1.

7.8 Check Valves

Follow the sequence of steps for the maintenance procedure that you want to perform:

- To replace the inlet check valves, see the next section.
- To replace the outlet check valves, see Replacing the Outlet Check Valves (▷ page 156).
- To clean the check valves, see Cleaning the Check Valves (▷ page 157).

7.8.1 Replacing the Inlet Check Valves

The picture shows the parts that must be removed.

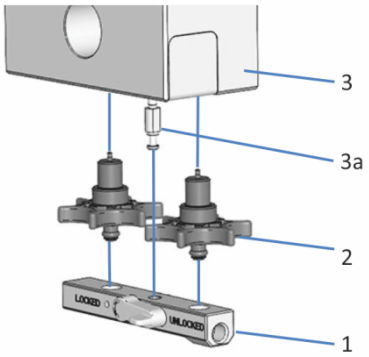

Figure 69: Replacing the inlet check valves

No.	Description
1	Inlet assembly, pump head
2	Inlet check valves
3	Pump head
3a	On pump head: Locating pin for inlet assembly

When

- Issue with the check valve that could not be solved by cleaning (for example, persistent leakage)
- Damage of inlet check valve

Parts required

Inlet check valve

Additional items required

- Solvent suitable for purging to flush out harmful substances
- Solvent suitable for your application

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. On the inlet assembly of the pump head, disconnect the tubing from the degasser.
2. Remove the inlet assembly:
   - Set the lever on the assembly into the **Unlock** position.
   - Pull the assembly downward.

TIP Pushing down the assembly on the left side facilitates removing the assembly.

3. Loosen and remove the inlet check valve.
4. Tighten the new inlet check valve finger-tight.
5. Install the inlet assembly:
   - Push the assembly onto the locating pin.
   - Set the lever on the assembly into the **Lock** position.
6. On the inlet assembly, reconnect the tubing from the degasser.
7. Purge the pump using the solvent for your application.
8. Inspect the inlet check valves and inlet assembly connections for indications of leakage. Tighten leaky connections when the system pressure is down to zero.
9. *Optional*: Test the pump for leakage (see Testing the Pump for Leakage (General Test) (▶ page 170)).

7.8.2 Replacing the Outlet Check Valves

The picture shows the parts that must be removed.

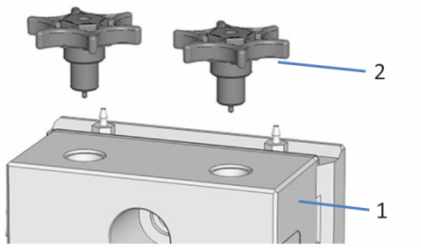

Figure 70: Replacing an outlet check valve

No.	Description
1	Pump head
2	Outlet check valves

When

- Issue with the check valve that could not be solved by cleaning (for example, persistent leakage)
- Damage of outlet check valve

Parts required

Outlet check valve

Additional items required

- Solvent suitable for purging to flush out harmful substances
- Solvent suitable for your application

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. Turn off the pump flow and wait until the system pressure is down to zero.
3. Remove the Y-connector (see Y-Connector (▶ page 128)).

Follow these steps

1. Loosen and remove the outlet check valve.
2. Tighten the new outlet check valve finger-tight.
3. Install the Y-connector (see Y-Connector (▶ page 128)).

4. Purge the pump using the solvent for your application.
5. Inspect all flow connections on the pump head for indications of leakage. Tighten leaky connections when the system pressure is down to zero.
6. *Optional*: Test the pump for leakage (see Testing the Pump for Leakage (General Test) (▶ page 170)).

7.8.3 Cleaning the Check Valves

The cleaning procedure includes the following:

- Ultrasonic cleaning with pure isopropanol
- Running-in the check valves in the pump at high backpressure

When

- Dirty or malfunctioning check valves
- Once a month

Parts and additional items required

- Syringe (12 mL), filled with isopropanol
- Small beaker filled with isopropanol
- Ultrasonic bath
- Solvents suitable for your application (for purging)
- Solvents suitable for the run-in procedure
  In most cases, you can use the solvents of your application. To avoid electrostatic discharge in the backpressure capillary, at least 20% water should be present in the 50/50 mixture of solvents A and B. If you are using water-free solvents like normal-phase solvents, use 80% isopropanol in water on both, channel A and channel B.
- Appropriate backpressure capillary, generating > 120 MPa at a flow rate of 1 mL/min (for example: nanoViper capillary, inner diameter: 50 µm, length: 950 mm, with water. You can use the backpressure capillary from the Diagnostics tool kit).

Preparations

Remove the check valves that you want to clean.

Recommended: Clean the inlet check valves and outlet check valves of all pump heads at the same time. To remove the check valves, follow the steps in Replacing the Inlet Check Valves (▶ page 154) and Replacing the Outlet Check Valves (▶ page 156).

Follow these steps

1. In the direction of flow, fill the check valves with isopropanol, using the syringe.
2. Place the check valves in the beaker. Clean them in the ultrasonic bath for 10 minutes.
3. In the direction of flow, flush the check valves with isopropanol, using the syringe.
4. Reinstall the check valves. Follow the steps in Replacing the Inlet Check Valves (▸ page 154) and Replacing the Outlet Check Valves (▸ page 156).
5. Install the backpressure capillary on the pump outlet. Guide the free end of the capillary to the waste container.
6. Have the pump deliver the solvents suitable for the run-in procedure: Start with 50% B and a flow rate of 1 mL/min. Increase the flow rate until the system pressure is well above 120 MPa and run the pump for 20 minutes.
7. Inspect the pump heads and check valves for indications for leakage. Tighten leaky connections only when the system pressure is down to zero.
8. Uninstall the backpressure capillary and reconnect the pump as required by your application.
9. Purge the pump, using the solvents of your application.
10. Test the pump for leakage (see Testing the Pump for Leakage (General Test) (▸ page 170)).
11. In the Chromeleon software, consider updating the Predictive Performance information for the check valves.

7.9 Inline Filter

Follow the sequence of steps for the maintenance procedure that you want to perform:

- To test the inline filter for permeability, see the next section.
- To replace the inline filter or the capillary mixer (volume: 25 µL) connecting the purge unit to the filter inlet, see Replacing the Inline Filter or Capillary Mixer (▷ page 160).

7.9.1 Testing the Inline Filter for Permeability

When

If you observe pressure pulsation, inconstant pressure, or high backpressure at the column and pump

Additional items required

- Water as solvent
- Tissue

Follow these steps

1. Disconnect the capillary on the outlet of the inline filter.
2. To absorb liquid leaving the filter, place the tissue under the filter outlet.
3. Apply a flow of 2 mL/min using water.
4. Observe the pump pressure.
5. Depends on the pressure reading:

Pressure Reading	Action
Pressure is less than 0.8 MPa	Continue with the next step.
Pressure is 0.8 MPa or higher	Replace the inline filter.

6. Reconnect the capillary to the outlet of the inline filter.
7. Test the pump for leakage. See Testing the Pump for Leakage (General Test) (▷ page 170).

7.9.2 Replacing the Inline Filter or Capillary Mixer

When

- Impaired filter permeability
- Damage of inline filter or capillary mixer, which connects the purge unit to the inline filter

Parts and additional items required

- As applicable
  - Inline filter (static filter)
  - Capillary mixer (volume: 25 µL), connecting the purge unit to filter inlet
- Solvent suitable for purging

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. To remove harmful substances from the components in the flow path after the purge unit, have the pump deliver for a short time with the solvent that was used for purging.
3. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. Unplug the cable of the seal wash detector from the **DROP DET** port.
2. Unplug the cable of the right pump head from the **P-WORK** port if applicable.
3. Remove the right Y-connector (see Y-Connector (▷ page 128)).
4. As applicable, disconnect the capillary mixer on the filter inlet or remove the capillary mixer on the filter inlet and on the purge unit.
5. On the filter outlet, disconnect the capillary that connects the inline filter to the autosampler injection valve.
6. Pull the inline filter out of the mounting bracket.
7. Insert the new inline filter into the mounting bracket. Mind the direction of flow through the filter (indicated by the arrow on the filter).

8. As applicable, reconnect the capillary mixer to the filter inlet or install a new capillary mixer.
   When installing a new capillary mixer, mind the direction of flow through the mixer (indicated by the arrow on the capillary mixer).
9. On the filter outlet, reconnect the capillary to the autosampler injection valve.
10. Reinstall the right Y-connector.
11. Reconnect the cable of seal wash detector to the **DROP DET** port.
12. Reconnect the pump head cable to the **P-WORK** port if applicable.
13. Apply the flow rate of your application and have the pump deliver for a short time.
14. Inspect the flow connections on the inline filter for indications of leakage before resuming operation.
15. In the Chromeleon software, consider updating the Predictive Performance information for the inline filter.
16. *Optional*: Test the pump for leakage (see Testing the Pump for Leakage (General Test) (▶ page 170)).

7.10 Mixing System

Follow the sequence of steps for the maintenance procedure that you want to perform:

- To test the static mixer for permeability, see Testing the Static Mixer for Permeability (▷ page 162).
- To replace the static mixer or capillary mixer, see Replacing the Static Mixer or Capillary Mixer (▷ page 163).

7.10.1 Testing the Static Mixer for Permeability

When

If you observe pressure pulsation, inconstant pressure, or high backpressure at the column and pump

Additional items required

- Water as solvent
- Tissue

Follow these steps

1. Disconnect the capillary on the outlet of the static mixer.
2. To absorb liquid leaving the static mixer, place the tissue on the mixer outlet.
3. Apply a flow of 2 mL/min using water.
4. Observe the pump pressure.
5. Depends on the pressure reading:

Pressure Reading	Action
Pressure is less than 0.8 MPa	Continue with the next step.
Pressure is 0.8 MPa or higher	Replace the static mixer.

6. Reconnect the capillary to the outlet of the static mixer.
7. Test the pump for leakage. See Testing the Pump for Leakage (General Test) (▷ page 170).

7.10.2 Replacing the Static Mixer or Capillary Mixer

When

- Impaired permeability of the static mixer
- Damage of static mixer
- Leaky capillary mixer

Parts and additional items required

- As applicable
  - Static mixer
  - Capillary mixer
- Solvent suitable for purging

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. To remove harmful substances from the components in the flow path after the purge unit, have the pump deliver for a short time with the solvent that was used for purging.
3. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. Unplug the cable of the seal wash detector from the **DROP DET** port.
2. Unplug the cable of the right pump head from the **P-WORK** port if applicable.
3. Remove the right Y-connector (see Y-Connector (page 128)).
4. As applicable, disconnect the capillary mixer on the static mixer inlet or remove the capillary mixer on the static mixer inlet and purge unit.
5. Pull the static mixer out of the mounting bracket.
6. Insert the new static mixer into the mounting bracket. Mind the direction of flow through the static mixer (indicated by the arrow on the static mixer).

7. As applicable, reconnect the capillary mixer to the static mixer inlet or install a new capillary mixer.
   When installing a new capillary mixer, mind the direction of flow through the capillary mixer (indicated by the arrow on the capillary mixer).
8. On the static mixer outlet, reconnect the capillary to the autosampler injection valve.
9. Reinstall the right Y-connector.
10. Reconnect the cable of seal wash detector to the **DROP DET** port.
11. Reconnect the pump head cable to the **P-WORK** port if applicable.
12. Apply the flow rate of your application and have the pump deliver for a short time.
13. Inspect the flow connections on the inline filter for indications of leakage before resuming operation.
14. In the Chromeleon software, consider updating the Predictive Performance information for the static mixer (**InlineFilterChanged** command).
15. *Optional*: Test the pump for leakage (see Testing the Pump for Leakage (General Test) (▷ page 170)).

7.11 Solvent Lines and Solvent Line Filters

Follow the sequence of steps for the maintenance procedure that you want to perform:

- To empty the solvent lines, see Emptying the Solvent Lines (▸ page 165).
- To replace solvent lines, see Replacing Solvent Lines (▸ page 165).
- To replace the solvent line filter, see Replacing the Solvent Line Filter (▸ page 168).

7.11.1 Emptying the Solvent Lines

When

To empty the solvent lines, for example, for maintenance or service procedures

Preparations

1. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. Unscrew the cap of the solvent reservoir and remove the cap together with the solvent line from the reservoir.
2. Start a purge cycle as appropriate.
3. Stop purging as soon as the solvent line is empty.

7.11.2 Replacing Solvent Lines

To replace solvent lines, follow the sequence of steps for the solvent line that you want to replace.

TIP The flow path determines the pump inlet (component at which the solvent enters the pump) and the solvent flow through the pump. With the binary pump, the pump inlets are the solvent selectors. The operating principle illustrates the solvent flow through the pump (see Operating Principle (▸ page 31)).

- Solvent line from the solvent reservoir to the pump inlet: Follow the steps in Solvent Lines From Reservoir To Pump Inlet (▸ page 166).
- Solvent line from the pump inlet to the degasser: Follow the steps in Solvent Lines From Pump Inlet to Degasser (▸ page 167).
- Solvent line from the degasser to the pump head: Follow the steps in Solvent Line From Degasser To Pump Head (▸ page 167).

7.11.2.1 Solvent Lines From Reservoir To Pump Inlet

When

Damage or blockage of the solvent line

Parts and additional items required

- Solvent line between solvent reservoir and pump inlet
- Solvent suitable for purging

Preparations

1. To flush out harmful substances, purge the pump with an appropriate solvent.
2. Empty the solvent lines (see Emptying the Solvent Lines (▷ page 165)).

Follow these steps

1. Remove the solvent line from the reservoir cap:
   a) Remove the filter from the solvent line.
   b) Remove the retaining guide.
   c) Pull the solvent line out of the reservoir cap.
2. Disconnect the solvent line on the pump inlet.
3. Remove the solvent line from the pump and all modules above the pump in the system stack. When removing the solvent line from the tubing guides, do not pull on other tubing in the guides.
4. To install the new solvent line, follow the related steps in Connecting the Solvent Lines (▷ page 58).
5. To remove any air from the solvent lines, purge the pump using the solvent of your application.

7.11.2.2 Solvent Lines From Pump Inlet to Degasser

When

Damage or blockage of the solvent line

Parts and additional items required

- Solvent line between pump inlet (solvent selector) and degasser
- Solvent suitable for purging

Preparations

- To flush out harmful substances, purge the pump with an appropriate solvent.

Follow these steps

1. Remove the solvent line on the pump inlet and on the degasser.
2. Install the new solvent line.
3. To remove any air from the solvent lines, purge the pump using the solvent of your application.

7.11.2.3 Solvent Line From Degasser To Pump Head

When

Damage or blockage of the solvent line

Parts and additional items required

- Solvent line between degasser and pump head inlet
- Solvent suitable for purging

Preparations

- To flush out harmful substances, purge the pump with an appropriate solvent.

Follow these steps

1. Remove the solvent line on the degasser and on the inlet assembly of the pump head.
2. Install the new solvent line.
3. To remove any air from the solvent lines, purge the pump using the solvent of your application.

7.11.3 Replacing the Solvent Line Filter

When

- Damage of solvent line filter
- Impaired permeability of filter frit

Parts and additional items required

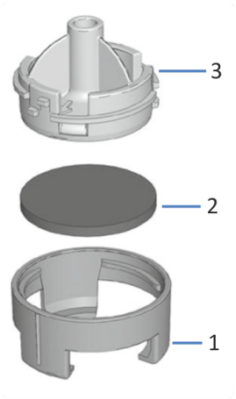

Figure 71: Solvent line filter

No.	Description
1	Solvent line filter, filter holder bottom part
2	Filter frit
3	Solvent line filter, filter holder top part

- As applicable:
  - Filter holder
  - Filter frit
- Solvent suitable for purging

Preparations

1. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. Unscrew the cap of the solvent reservoir and remove the cap together with the solvent line from the reservoir.
2. Remove the filter holder from the solvent line.
3. *As applicable*: Open the filter holder and remove the filter frit.

4. Assemble the solvent line filter, wearing appropriate clean gloves:
   a) Place the frit in a level position in the filter holder (bottom part).
   b) Screw the filter top to the filter bottom.
5. Slide the filter holder onto the solvent line.
6. Retighten the reservoir cap hand-tight. The retaining guide must remain in the hole in the reservoir cap. If it does not, press the retaining guide into the hole so that the tubing is kept in place in the cap.
7. To remove any air from the solvent lines, purge the pump using the solvent of your application.

7.12 Testing the Pump for Leakage (General Test)

When

Following maintenance on the fluidic system of the pump, such as the flow connections, pump heads, or check valves

With Chromeleon 7.2.6 and later

Run the **Advanced Leak Test** (see Testing from the Chromeleon Software (▶ page 199)).

With Chromeleon 7 earlier than Chromeleon 7.2.6

Parts and additional items required

- Fitting plug, Viper
- Solvent suitable for your application

Follow these steps

1. Disconnect the capillary on the outlet of the inline filter (or static mixer if installed).
2. Close the pump outlet with the fitting plug.
3. Set the upper pressure limit to 145 MPa.
4. Apply a flow of 50 µL/min and use the solvent for the application.
5. Observe the pressure. When the pressure reading is between 60 MPa and 100 MPa, change the flow rate to a lower value.
6. Have the pump deliver until a pressure of 140 MPa has built up.
7. When the pressure is 140 MPa, apply a flow of 1 µL/min.
8. Observe the pressure.
   The pressure should increase or remain constant for a minimum of 1 minute. A drop in pressure indicates possible leakage.
9. Find and eliminate the cause for the leak.
   Take remedial action only when the system pressure is down to zero.

Possible Source	Remedial Action
Capillary connections	Inspect the capillary connections for signs of leakage. Tighten or replace leaky connections when the system pressure is down to zero.

Possible Source	Remedial Action
Piston seals	• Test the piston seals for leakage. Replace leaky piston seals. • If leakage is observed with new piston seals, run in the seals. Using the solvent of your application or water, operate the pump for 2 hours or longer at 35 MPa.
Check valves	• If leakage is observed on the connection port, turn off the pump flow. When the system pressure is down to zero, tighten the check valve a little more. • Remove the valve cartridge. Clean the cartridge in an ultrasonic bath. If cleaning is not sufficient, replace the cartridge.
Purge unit	Pull the waste line out of the waste outlet port and repeat the test. If liquid leaves the waste line, the purge unit is leaky. Contact Technical Support. After the test, push the waste line back into the waste outlet port. To avoid false leak alarms, verify that the waste line sits properly in the waste outlet port. If it does not, liquid from the purge unit may accumulate in the drain port and activate the leak sensor.

7.13 Replacing the Main Power Fuses

When

Blown fuses

Parts required

Fuses (2 fuses, 5 AT, 230 V AC, slow-blow, 5 x 20 mm) from Fuses Kit

Tools required

Slotted screwdriver, any size between 3.3 mm and 5.5 mm is appropriate

Preparations

WARNING—Electric Shock

High voltages are present inside the device that could cause an electric shock or damage to the device.

- Turn off the device with its main power switch. Disconnect the power cord from both the power source and the device.
- Use only the fuses of the type and current rating specified for the device by Thermo Fisher Scientific.
- Do not use repaired fuses and do not short-circuit the fuse holders.

Follow these steps

The fuse holder is located next to the main power switch.

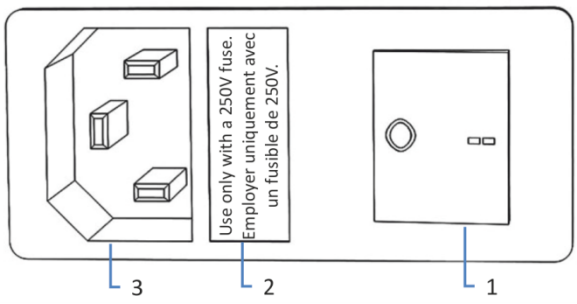

Figure 72: Fuse holder

No.	Description
1	Main power switch (on/off control)
2	Fuse holder
3	Power-inlet connector

1. Use the screwdriver to remove the fuse holder.
2. Replace the two fuses with new fuses of the specified type and current rating. Always replace *both* fuses.
3. Reinstall the fuse holder.
4. Reconnect the power cord to the power source and to the device.
5. Turn on the device with the main power switch.

7.14 Updating the Device Firmware

The description in this section refers to the Chromeleon 7 Chromatography Data System.

When

Updating the device firmware might be required, for example, when a new firmware version is released that adds functionality or solves problems of a previous version.

Items required

Firmware version/Chromeleon version as appropriate

TIP When a new firmware version is released, the new version will be included in the next available Chromeleon version. The new firmware will *not* be transferred automatically to the device when you install the Chromeleon version.

Preparations

1. Read the release notes provided with the firmware and/or Chromeleon version.
2. Connect the device in the Chromeleon software.
3. Stop all operations on the Instrument that includes the device.
4. Wait until the Instrument is idle.
5. Turn off the pump flow and wait until the system pressure is down to zero.

Follow these steps

1. Start the Instrument Configuration Manager program.
2. Perform a firmware update from the **General** tab page in the configuration dialog box for the device. For details, refer to the *Chromeleon Help*.
   The firmware update may take several minutes.

NOTICE

A firmware downgrade or incomplete firmware update may result in loss of functionality or malfunctioning of the device.

- Do not interrupt communication between the Chromeleon software and the device at any time during the procedure.
- At the beginning of the update process, a message appears showing the firmware version currently installed in the device and the version that will be transferred from the Chromeleon software. If the firmware installed in the device is a later version than the version in the Chromeleon software, cancel the download.

3. Monitor the Audit Trail of the Instrument Configuration Manager program to see whether the firmware update was successful or failed.

4. Depends on the situation:

Situation	Action
Firmware update successful	Requalification of the device may be required. Refer to the release notes.
Firmware update failed	Turn the device off and on again. Repeat the firmware update.
Firmware update fails repeatedly	Contact Thermo Fisher Scientific Technical Support.

7.15 Replacing the Doors

When

Damage of door

TIP The maintenance procedures do not require that you remove the doors. If this should ever be required for a specific reason or procedure, follow the steps in this section.

Parts required

Replacement door

Preparations

If the door to be replaced is located directly below the solvent rack, remove all reservoirs from the solvent rack.

Follow these steps

NOTICE

To avoid damage to the door hinges, be careful when performing the following sequence of steps and do not apply force.

1. If the door is located directly below the solvent rack, lift the solvent rack slightly on the front edge.
2. To remove a door, push the door upward while opening.
   Open the door to a position in which the two hinges on the housing are aligned in the grooves on the door. You can remove the door only when the hinges are in the grooves.

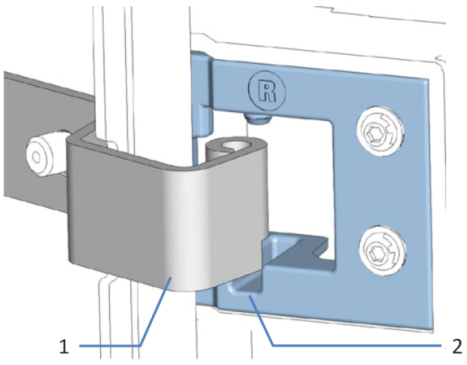

Figure 73: Unhinging a door

No.	Description
1	Hinge on the housing
2	Reception groove on the door

3. Slightly tilt the door to the outside, away from the housing, and remove the door.
4. To install the door, align the door with the hinges on the housing. Do not clamp tubing or capillaries between the door and the enclosure.
5. Insert the hinges in the groove, by pushing up and slightly turning the door.
6. Push the door downward to lock it in place.
   You can close the door only when it is properly installed.

7.16 Transporting or Shipping the Device

If you want to transport the device to a new location or if you need to ship the device, first prepare the device for transport, and then move or ship the device as required. Follow the instructions in this section.

Observe the following safety guidelines:

CAUTION—Heavy Load, Bulky Device

The device is too heavy or bulky for one person alone to handle safely. To avoid personal injury or damage to the device, observe the following guidelines:

- Physical handling of the device, including lifting or moving, requires a team effort of two persons.
- A team effort is in particular required when lifting the device into the system stack or when removing it.
- Use the carrying handles that were shipped with the device to move or transport the device. Never move or lift the device by the front doors. This will damage the doors or the device.

Follow these steps

1. Prepare the device for transport. See Preparing the Device for Transport (▸ page 178).
2. The step depends as follows:
   - ♦ To transport the device to a new location, follow the instructions in Transporting the Device to a New Location (▸ page 179).
   - ♦ To ship the device, follow the instructions in Shipping the Device (▸ page 180).

7.16.1 Preparing the Device for Transport

To prepare the device for transport, follow these steps:

1. Perform a long-term shut down of the device (see Long-Term Shutdown (▸ page 105)).
2. Turn off the device with its main power switch and disconnect the power cord.
3. Remove all cables and flow connections to other devices.
4. Close open flow connections with appropriate plugs, for example, the plugs you removed when setting up the pump.

5. Pull the waste line out of the waste outlet port.
6. Check the leak tray and drain port. If liquid is present, absorb the liquid with a tissue.
7. Remove the device or slide-in module from the system stack as required:
   Install the carrying handles and remove the device from the Vanquish system. Follow the instructions on dismounting the system stack in the *Transporting or Shipping the System* section of the *Vanquish System Operating Manual*.

   -or-

   Remove the slide-in module from the device enclosure in the system stack (see Removing the Slide-In Module (▸ page 181)).

7.16.2 Transporting the Device to a New Location

Preparations

Prepare the device for transport. See Preparing the Device for Transport (▸ page 178).

Follow these steps

1. Observe the notes for handling and lifting the device safely.
2. Transport the device to the new location.
3. Install and set up the device in the system stack. Follow the instructions on mounting the system stack in the *Vanquish System Operating Manual*.
4. Set up the device:
   a) Connect the device and set up flow connections (see Installation (▸ page 43)).
   b) Prepare the device for operation (see Preparing the Device for Operation (▸ page 84)).
5. Before starting an analysis, let the device equilibrate and be sure that it is ready for operation.

7.16.3 Shipping the Device

Preparations

Prepare the device for transport. See Preparing the Device for Transport (▸ page 178).

CAUTION—Possible Contamination

Hazardous substances may have contaminated the device during operation and may cause personal injury to service personnel.

- Decontaminate all parts of the device that you want to return for repair.
- Fill in and sign the Health and Safety Form. Thermo Fisher Scientific refuses to accept devices for repair if the Health and Safety Form is missing, incompletely filled in, or unsigned.

Follow these steps

1. Follow the unpacking instructions in this manual in the reverse order.
   Use only the original packing material and shipping container. If the original shipping container is not available, appropriate containers and packing material can be ordered from the Thermo Fisher Scientific sales organization.
2. If you need to return the device to Thermo Fisher Scientific for depot repair, contact your local Thermo Fisher Scientific support organization for the appropriate procedure.

Restarting the Device after Shipping

To install the device after shipping, follow the instructions on mounting the system stack in the *Vanquish System Operating Manual*.

7.17 Replacing the Slide-In Module

You can remove the slide-in module from the enclosure of a module for transporting or shipping purposes. The enclosure remains in the system stack. To return a defective module to the factory, install the slide-in module in the enclosure of the replacement module.

7.17.1 Removing the Slide-In Module

CAUTION—Heavy Load, Bulky Device

The device is too heavy or bulky for one person alone to handle safely. To avoid personal injury or damage to the device, observe the following guidelines:

- Physical handling of the device, including lifting or moving, requires a team effort of two persons.
- A team effort is in particular required when lifting the device into the system stack or when removing it.

Tools required

Screwdriver, Torx T20

Preparations

1. Prepare the device for transport. See Transporting or Shipping the Device (▷ page 178).

Follow these steps

1. Loosen the four captive screws on the front left and front right of the device.

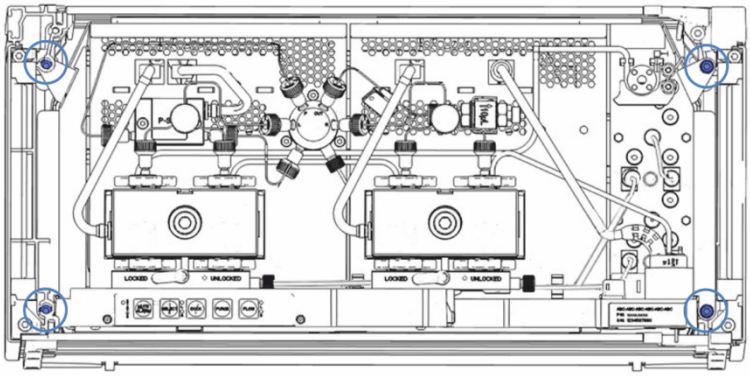

Figure 74: Captive screws on the slide-in module (doors not shown)

2. Push all tubing and capillaries, which are present in the tubing chase of the Vanquish system modules, into the tubing chase. Otherwise, you will not be able to remove the slide-in module properly from the enclosure in the next step.

3. Grasp the slide-in module by the leak tray and pull the module out of the enclosure by approximately 10 cm.

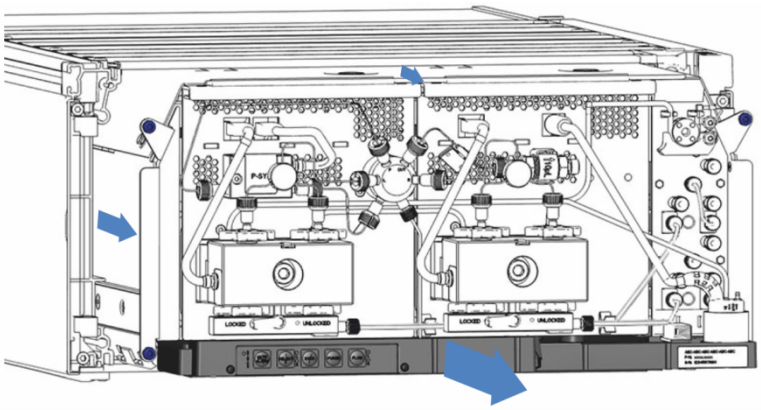

Figure 75: Pulling out the slide-in module (doors not shown)

NOTICE

The slide-in module can fall down when pulling it out of the enclosure too far.

Pull out the slide-in module just far enough so that you can grasp it on both sides from below.

4. Remove the slide-in module from the enclosure. The following steps require a team effort:

   a) Take the slide-in module on both sides from below.

   b) Pull the slide-in module from the rails towards the front.

   c) Place the slide-in module on a clean and stable surface.

7.17.2 Returning the Slide-In Module

CAUTION—Possible Contamination

Hazardous substances may have contaminated the device during operation and may cause personal injury to service personnel.

- Decontaminate all parts of the device that you want to return for repair.
- Fill in and sign the Health and Safety Form. Thermo Fisher Scientific refuses to accept devices for repair if the Health and Safety Form is missing, incompletely filled in, or unsigned.

Preparations

1. Remove the slide-in module from the enclosure. See Removing the Slide-In Module (▶ page 181).

Follow these steps

1. Install the slide-in module to the enclosure of the replacement device. Follow the steps for inserting the slide-in module in the enclosure and tightening the captive screws in Installing the Slide-In Module (▶ page 183).
2. Follow the instructions in Shipping the Device (▶ page 180).

NOTICE

Shipping the slide-in module improperly leads to damage to the device.

Always ship the slide-in module as described in this operating manual.

7.17.3 Installing the Slide-In Module

CAUTION—Heavy Load, Bulky Device

The device is too heavy or bulky for one person alone to handle safely. To avoid personal injury or damage to the device, observe the following guidelines:

- Physical handling of the device, including lifting or moving, requires a team effort of two persons.
- A team effort is in particular required when lifting the device into the system stack or when removing it.

Tools required

Screwdriver, Torx T20

Preparations

1. Unpack the replacement device. Remove the slide-in module from its enclosure as described in Removing the Slide-In Module (▷ page 181).
2. Verify that the device enclosure into which the slide-in module shall be installed is clean. If required, clean the inner and outer surfaces of the enclosure. See Cleaning or Decontaminating the Device (▷ page 118).
3. When installing the slide-in module to an enclosure in the system stack, check that the enclosure is placed correctly in the stack.

Follow these steps

1. Push all tubing and capillaries, which are present in the tubing chase of the Vanquish system modules, into the tubing chase. Otherwise, you will not be able to insert the slide-in module properly into the enclosure in the next step.
2. On the slide-in module, check that you can move the captive screws back and forth with your fingers. If you cannot, screw them in until you can.
3. Insert the slide-in module in the enclosure. The following steps require a team effort:
   a) Take the slide-in module on both sides from below.
   b) Lift the slide-in module to the height of the enclosure.
   c) Place the slide-in module in the enclosure so that the module sits in the enclosure by approximately 25 cm.
   d) Push the slide-in module onto the rails and into the enclosure until the slide-in module sits completely in the enclosure.

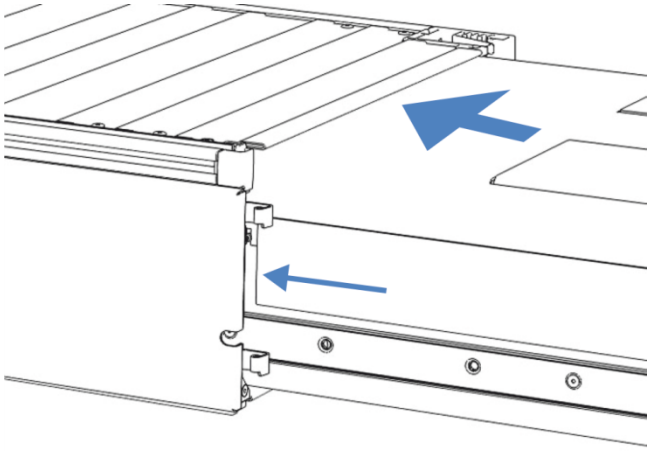

Figure 76: Inserting the slide-in module

4. To facilitate tightening the slide-in module in the enclosure, pull out the module a few millimeters (approximately 2 to 5 mm).

5. With the screwdriver, move each captive screw back and forth while pressing inward until the screw slips into the thread.
6. Push the slide-in module back into the enclosure as far as it goes in.
7. Gradually and evenly, tighten the four captive screws on the slide-in module hand-tight.

NOTICE

- Verify that the screws are tightened. Pull the slide-in module by the leak tray towards the front and check whether the screws move. If they do not move, the slide-in module is installed properly.
- If the screws move, tighten the screws further. With a torque wrench, the recommended torque is 1.2 Nm.

8. Set up and restart the device.

7.17.4 Setting Up the Slide-In Module

After you have installed the slide-in module in the enclosure, set up and restart the device.

Follow these steps

1. Set up the slide-in module:
   a) Connect the slide-in module and set up flow connections (see Installation (▷ page 43)).
   b) Prepare the slide-in module for first-time operation (see Preparing the Device for Operation (▷ page 84)).
   c) If you installed a replacement slide-in module, update the instrument configuration in the chromatography data system accordingly.
2. Prepare *all other* modules of the Vanquish system for operation and restart them. Refer to the *Operating Manuals* for the modules.
3. Before starting an analysis, let the chromatography system equilibrate and be sure that it is ready for operation.
4. From the Chromeleon software, perform performance qualification for the pump:
   - Run the pump-specific **Performance Qualification** tests (PQ tests) (= Flow Precision Test and Gradient Accuracy Test). For details, refer to the *Operational and Performance Qualifications manual*.
   - When the tests are completed, execute the **QualificationDone** command.

8 Troubleshooting

This chapter is a guide to troubleshooting issues that may arise during operation of the device.

8.1 General Information about Troubleshooting

The following features help you to identify and eliminate the source for problems that may arise during operation of the device.

NOTICE

When the Vanquish system includes a Vanquish charged aerosol detector, the detector may affect the operation and/or performance of the pump. For example, errors in the detector may affect the pump by automatically stopping the pump flow. For more information, refer to the *Operating Manual* for the detector.

TIP For information about operating issues that might occur during the operation of a Vanquish system, refer to the *Vanquish System Operating Manual*.

If you are unable to resolve a problem following the instructions given here or if you experience problems that are not covered in this section, contact Thermo Fisher Scientific Technical Support for assistance. See the contact information at the beginning of this manual.

To facilitate device identification, have the serial number and technical name available when communicating with Thermo Fisher Scientific.

Status Indicators

The status indicator LED bar on the front side of the device and the **STATUS** LED on the keypad inside provide quick visual feedback on the operational status of the device. If the device firmware detects a problem, the status indicators are red.

Alarms

Leaks are a potential safety issue. Therefore, if a leak sensor detects leakage, beeping starts to alert you in addition to the message in the Instrument Audit Trail and the status indicators changing to red. Follow the instructions in this manual to find and eliminate the source for the leakage.

Instrument Audit Trail Messages

If the device firmware detects a problem, the problem is reported to the chromatography data system.

The chromatography data system logs information about all events related to instrument operation for the current day in an Instrument Audit Trail. The Instrument Audit Trail is named with the current date, using the format yyyymmdd. For example, the Instrument Audit Trail for May 15, 2019, is named 20190515.

The Instrument Audit Trails can be found on the ePanel Set (Audit ePanel). In addition, Audit Trails for each instrument are available in the Chromeleon 7 Console Data view, in the folder of the instrument.

Messages in the Instrument Audit Trail are preceded by an icon. The icon identifies the seriousness of the problem. For possible causes and remedial actions, see Messages (▶ page 190).

Tests from the Chromeleon Software

With **Chromeleon 7.2.6** and later, tests are available to help you to identify and eliminate the source for a problem (see Testing from the Chromeleon Software (▶ page 199)).

Firmware Failure

If a firmware failure occurred during operation of the module, an exception log has been created about the processes during the firmware failure. The firmware sends the exception log to the Instrument Audit Trail when the module is connected in the chromatography data system.

In this case, observe the following:

- Send the Instrument Audit Trail as **.cmbx** file to the Technical Support before you clear the log.
- To clear the exception log and continue operation of the module, perform the command **ExceptionLogClear**.

For more information, refer to the *Chromeleon Help*.

8.2 Messages

This section provides information about the messages that may appear in the Instrument Audit Trail during operation of the pump. For easier identification of the source for a problem, note the **Device** information that may appear in front of the message:

Device Information	Description
[Main Device Name]	With messages relating to the entire pump, for example, to the leak detection, main board or with a communication error
[Pump Device Name]	With messages relating to the entire flow unit, for example, to the system pressure
[Pump Device Name]_ Wellness_RightBlock	With messages relating to the right pump block or components in the right pump head, for example, the pistons or check valves.
[Pump Device Name]_ Wellness_LeftBlock	With messages relating to the left pump block or components in the left pump head, for example, the pistons or check valves.
Whenever possible, the source of the problem is narrowed down further by the **Drive** information:	
Drive1	Indicates that components on the *left* side in the pump block/head cause the problem
Drive2	Indicates that components on the *right* side in the pump block/head cause the problem
Example: [Pump Device Name]_Wellness_LeftBlock (Drive 2) in front of a message indicates that the message refers to the components on the *right* side in the *left* pump block/ pump head.	

The **Device Names** are specified in the dialog box for the pump in the Instrument Configuration Manager. The default names are:

Device Name	Default Name
[Main Device Name]	PumpModule
[Pump Device Name]	Pump

The table lists the most frequently observed messages for the device and provides troubleshooting assistance.

Each message consists of a code number and a text. The code number is the unique identifier for the problem while the wording may change. Note the following:

- To facilitate finding a message, the table lists the messages sorted by code.

- If you cannot find the code you are looking for, check the message text. The two messages "Unexpected module behavior" and "Module malfunction detected" can be assigned to different codes. See the beginning of the table for more information.

TIP If you are unable to resolve the problem following the instructions in this manual, or if you encounter a message not listed in the table, write down the code and wording of the message and contact us. For details, see the *Contacting Us* section at the beginning of this manual.

Message and Code	Description and Remedial Action
Unexpected module behavior. Code xx	xx = Two-digit to four-digit code number. When the message appears, write down the message code and turn off the module. Wait for 5 seconds and turn on the module again. **TIP** If the message appears with *codes 74* or *103*, the firmware may be defective or incomplete. Update the firmware, see Updating the Device Firmware (▸ page 174). If the message appears again, contact Technical Support.
Module malfunction detected. Code xx	xx = two-digit to four-digit code number When the message appears, write down the message code. Turn off the module and contact Technical Support.
Code 33 Leak detected – eliminate within approx. 180 seconds.	Find and eliminate the source for the leakage (see Resolving Liquid Leaks (▸ page 201)). The pump flow stops if leakage is not resolved within 3 minutes.
Code 34 Leak detected.	The pump stopped because of leakage. The message appears because the leakage reported earlier with code 33 was not resolved within 3 minutes. Find and eliminate the source for the leakage (see Resolving Liquid Leaks (▸ page 201)).
Code 36 Download failed.	The firmware download has not been successful. Repeat the download.
Code 37 Download firmware mismatch.	You tried to download a firmware file that is invalid for the pump. Repeat the download with a firmware file that is valid for the pump.
Code 52 Module software incomplete. Download firmware (again).	The firmware is incomplete, for example, because the communication between the chromatography data system and the module was interrupted during the firmware download. Repeat the download.
Code 79 [Device] was not found	The message may appear for a pump head or the system pressure sensor. Verify that the pressure sensor cable of the device for which the message appears is properly plugged into the connection port.
Code 89 Liquid leak sensor missing or defective.	Contact Thermo Fisher Scientific Technical Support for assistance. To operate the device nevertheless, you can disable the leak sensor functionality in the chromatography data system by setting **Leak Sensor Mode** to **Disabled**.

Message and Code	Description and Remedial Action
Code 90 Download firmware mismatch – invalid version.	You tried to download an incompatible firmware with an earlier version number than the firmware that is currently installed in the module. Downgrading the firmware may result in loss of functionality or malfunctioning of the module. If required, repeat the download with a firmware version later than the version currently installed in the module.
Code 91 Data changed during read.	• This may be a temporary error. Turn off the module. Wait for 5 seconds and turn on the module again. • The firmware may be defective. Update the firmware. • If the message appears for the pressure sensor in a pump head or for the system pressure sensor: Verify that the cable of the pressure sensor for which the message appears is properly plugged into the connection port.
Code 92 Data verification failed.	• This may be a temporary error. Turn off the module. Wait for 5 seconds and turn on the module again. • The firmware may be defective. Update the firmware. • If the message appears for the pressure sensor in a pump head or for the system pressure sensor: Verify that the cable of the pressure sensor for which the message appears is properly plugged into the connection port.
Code 118 USB Buffer Overflow.	This is a software problem. The module produces data faster than the computer on which the chromatography data system is running can process the data. 1. In the chromatography data system, disconnect and reconnect the module. 2. If this does not solve the problem, update the firmware or the chromatography data system version. 3. If the problem persists: Also, third-party software on the computer, for example, virus scanners or poor computer performance can cause the problem. Contact the onsite IT department.
Code 120 System interlink request timed out.	Communication with the module failed. The module did not respond in time. For the module for which the message appears: 1. Turn on the module if it is not yet turned on. 2. Check the system interlink connections to the module. Verify that all system interlink cables are connected at both ends. 3. If the message persists, replace the system interlink cables.
Code 126 Device lost system interlink connection.	A system interlink cable may be disconnected from the module or defective. 1. Check the system interlink connections to the module. Verify that all system interlink cables are connected at both ends. 2. If the message persists, replace the system interlink cables.
Code 128 System interlink data errors.	A system interlink cable may be disconnected from the module or defective. 1. Check the system interlink connections to the module. Verify that all system interlink cables are connected at both ends. 2. If the message persists, replace the system interlink cables.

Message and Code	Description and Remedial Action
Code 129 Device X not found on system interlink.	X = serial number The module with the given serial number may be disconnected, turned off or a firmware update is running. 1. Check the system interlink connections to the module. 2. If the message persists, check the module operational status.
Code 131 System interlink bus not operable.	A system interlink cable may be disconnected from the module or defective. 1. Check the system interlink connections to the module. Verify that all system interlink cables are connected at both ends. 2. If the message persists, replace the system interlink cables.
Code 136 Lock request rejected – already locked by X.	X = lock holder ID, with keypad button ID, USB address referring to the chromatography data system or system interlink address referring to the system controller or a module The module is already locked by another software (system controller or chromatography data system) or a keypad button. Wait until the module is released from the locked state.
Code 137 Lock by X expired.	X = lock holder ID, with keypad button ID, USB address referring to the chromatography data system or system interlink address referring to the system controller or a module Inform Thermo Fisher Scientific about the occurrence. No further action required.
Code 145 Lock holder X lost.	X = lock holder ID, with keypad button ID, USB address referring to the chromatography data system or system interlink address referring to the system controller or a module The lock was released automatically since its holder disappeared from system interlink. 1. Check if the module holding the lock was turned off. 2. Check the system interlink connections to the module.
Code 152 Assignment or command rejected – device locked.	Module is not ready to accept command or property assignment since locked by another software (system controller or chromatography data system). Wait until module is released by the current software (system controller or chromatography data system).
Code 4098 Upper pressure limit exceeded	Check the flow path for blockage. *If the flow path is blocked:* • The column may be contaminated. Rinse or replace the column. If the problem occurs due to column ageing, it may be sufficient to increase the setting for the upper pressure limit. • The autosampler may be blocked. Check the autosampler components and eliminate the source for the blockage. *If the flow path is not blocked:* Depending on the pump configuration, test the inline filter or static mixer for permeability (depending on which component is installed). See Testing the Inline Filter for Permeability (▶ page 159) or Testing the Static Mixer for Permeability (▶ page 162).

Message and Code	Description and Remedial Action
Code 4099 Pressure fallen below lower limit.	Check the following causes: • One or more solvent reservoirs are empty. Fill the reservoirs and purge the pump. If you are monitoring the solvent consumption from the Chromeleon software, the message "**Code 4158 Out of eluent X**" alerts you when a reservoir is empty. • Air bubbles may be trapped in the solvent lines. Check the solvent line filters. Purge the pump. • Leakage may be present in the system. Resolve the leakage. For the pump, see Resolving Liquid Leaks (▷ page 201). For the other system modules, refer to the *Operating Manuals* for the modules. • A check valve may be contaminated or defective. Clean or replace the check valves as appropriate (see Check Valves (▷ page 154)). • With the applied flow, the pump cannot build up enough pressure to reach the lower pressure limit. Adapt the lower pressure limit or increase the flow.
Code 4100 Purge pressure limit exceeded	A pressure of more than 5 MPa built up after a purge cycle has started. Perform the following sequence of steps: 1. On the purge unit, remove the capillary from the system pressure sensor. 2. To absorb liquid leaving the capillary, place a tissue under the purge unit and capillary. 3. Mute the alarm by pressing the MUTE ALARM button on the pump keypad. 4. Start a purge cycle. *If the message does not appear again:* The purge unit is defective. Contact Technical Support. *If the message appears again:* 1. The capillaries that connect the system pressure sensor to the purge unit are blocked. Replace the capillaries. 2. If the message appears again afterward, run a self-test. 3. If the message persists, contact Technical Support.
Code 4101 Not ready. Please run self-test.	The pump is not ready because the self-test was not successful. Repeat the self-test.
Code 4112 Self-test failed because of fluctuating pressure.	Changes in pressure have occurred during the self-test. Wait until the system pressure is down or depressurize the system and repeat the self-test.
Code 4113 Self-test failed because pressure is out of range.	The pressure has not been down to zero during the self-test. Verify that the pressure sensor cables are properly connected. Wait until the system pressure is down or depressurize the system and repeat the self-test. If the message appears again, the system pressure sensor may be defective. Contact Technical Support.
Code 4114 The device is busy. Please retry after 1 minute.	The pump is not ready because, for example, a self-test or recalibration procedure is running. Retry after 1 minute. If the message appears again, wait until the system pressure is down or depressurize the system and turn the pump off and on again.

Message and Code	Description and Remedial Action
Code 4119 Can't start pump while alarm is on.	An alarm is present, for example, because leakage has been detected. You can restart the pump flow only when the alarm is no longer present. Mute the alarm by pressing the **MUTE ALARM** button on the pump keypad. Find and eliminate the source for the alarm as suggested for the accompanying message.
Code 4120 The rear seal wash system has run out of wash solution.	This message alerts you only when the drop counter functionality of the seal wash detector is enabled (standard setting). • Verify that wash liquid is present in the seal wash reservoir. • Inspect the seal wash lines across the entire flow path for indications of blockage or leakage. Verify that all seal wash lines are properly connected and routed. Replace the seal wash lines as necessary (see Replacing the Seal Wash Lines (▸ page 123)). • Inspect the peristaltic tubing for indications of blockage or damage. Replace the tubing as necessary (see Replacing the Seal Wash Lines (▸ page 123)). • Verify that the peristaltic tubing is properly inserted in the seal wash pump and that the lever of the pump is not blocked. • Inspect the electrodes of the seal wash detector for contamination or damage. Replace the seal wash detector as necessary (see Replacing the Seal Wash Detector (▸ page 126)). • Start an additional seal wash cycle from the Chromeleon software. While the wash cycle is running, inspect the pump heads. If droplets leave the pump head at the rear, the seal wash seal is defective. Replace the seal wash seals (see Replacing the Seal Wash Seals (▸ page 144)).
Code 4121 Piston seal leakage has exceeded the recommended limit.	This message alerts you only when the drop counter functionality of the seal wash detector is enabled (standard setting). Test the pump for piston seal leakage and take the recommended action (see Testing the Piston Seals for Leakage (▸ page 152)).
Code 4122 The rear seal leak sensor detects drops constantly.	This message alerts you only when the drop counter functionality of the seal wash detector is enabled (standard setting). • Verify that the liquid flows off properly into the drain system, through the drain port at the bottom right of the leak tray. • Inspect the bottom side of the seal wash detector: Remove the seal wash detector assembly from the pump and disconnect the detector from the funnel. Dry the bottom side with a cloth or tissue. Inspect the detector electrodes. If they are clean and undamaged, reassemble the detector and the funnel and reinstall the assembly in the pump (see Replacing the Seal Wash Detector (▸ page 126)). • If the message appears again, the seal wash detector may be defective. Replace the seal wash detector (see Replacing the Seal Wash Detector (▸ page 126)).

Message and Code	Description and Remedial Action
Code 4125 Degasser malfunction	The vacuum level monitoring function detected insufficient degasser vacuum. Turn the pump off and on again. In the chromatography data system, check the degasser vacuum. After about 1 minute, the setting should change from **NotOk** to **Ok**. If the degasser vacuum is still insufficient, the degasser may be leaky. Locate the **DegasserPressure** property in the **Command** window, write down the pressure reading, which can provide helpful information to identify the source for the problem, and contact Technical Support.
Code 4127 The pump drive is still in undock position. Please execute a dock command.	This message alerts you during pump maintenance (for example, when replacing the piston seals or pistons) when you try to start the pump while the pistons are not yet in the correct position for normal operation. To return the pistons into the correct position, perform a **Dock** command.
Code 4148 Can't perform this command while the flow is on.	You tried to run a self-test while the flow rate was not yet down to zero. Turn off the flow and repeat the command.
Code 4152 Pressure sensor malfunction. Check cable connection and retry.	Verify that the cable of the pressure sensor for which the message appears is properly plugged into the connection port. Restart the flow. If the message appears again, the pressure sensor may be defective: • If the message appears for the pressure sensor of a pump head, replace the pump head. • If the message appears for the system pressure sensor, contact Technical Support.
Code 4156 Compression limit reached.	The compression value was 100% during the last stroke. If the compression value is lower than 100% for several strokes afterward, the message **"Compression back to normal" (code 4157)** appears. If this message does not appear, inspect the flow connections for indications of air bubbles. Purge the pump if necessary. If the message **"Compression limit reached"** persists, see Resolving Pressure Pulsation or Shifts In Retention Time (▶ page 203).
Code 4158 Out of eluent X	This message alerts you only if you are monitoring the solvent consumption from the Chromeleon software. The message indicates for which solvent the reservoir is empty.
Code 4159 The waste bottle is full.	This message alerts you only if you are monitoring the liquid level in the waste container. Empty the waste container when needed.
Code 4161 Pressure recalibration deviates by xx bar.	The pump pressure was not down to zero during the self-test. Verify that the pressure sensor cable is properly connected to the **P-SYS** connector. Wait until the pressure is down and repeat the test.

Message and Code	Description and Remedial Action
Code 4176 The pump pressure exceeded the absolute limit. Check pressure sensor cables for proper connection and flow path for clogging. Then, perform a self-test.	Follow these steps: 1. Verify that the pressure sensor cables are properly connected. Reconnect the cables if necessary. 2. Check the flow path for clogging and remedy the situation if necessary. 3. Perform a self-test. If the message appears again, follow these steps: 1. Purge the pump. 2. Perform pressure recalibration (see Performing Pressure Recalibration (▸ page 205)). 3. Start the pump flow. If the message persists, the system pressure sensor may be defective. Contact Technical Support.
Code 4182 Unexpected piston docking or linear encoder error.	The message appears if the pistons are not correctly docked for pump operation. Follow these steps: 1. With the **SELECT** button on the keypad, select both pump heads. 2. Undock the pistons by pressing the **DOCK** button. 3. Wait until undocking is complete (LEDs next to the **FLOW** button are flashing green). 4. Dock the pistons by pressing the **DOCK** button again. 5. If the message appears again, contact Technical Support.
Code 4208 System pressure too high. Please relieve pressure and retry.	Follow these steps: 1. Verify that the pressure sensor cables are properly connected. Reconnect the cables if necessary. 2. Check the flow path for clogging and remedy the situation if necessary. 3. Run a self-test. If the message persists, the system pressure sensor may be defective. Contact Technical Support.
Code 4209 Could not build up enough pressure. Please check the fitting plug.	The pump could not build up enough pressure during pressure sensor calibration. This may be caused by the following: • Air may be trapped in the system. Purge the pump. • Leakage at the pump outlet: Check that the plug at the pump outlet is properly seated. • Pump leakage: Test the pump for leakage (see Testing the Pump for Leakage (General Test) (▸ page 170)).
Code 4211 Invalid calibration. Please perform pressure recalibration.	This message may appear while pressure recalibration is running, indicating that the recalibration procedure cannot be performed correctly. Check the pressure reading. If the pressure does not reach 140 MPa, follow these steps: 1. Purge the pump. 2. Perform pressure recalibration (see Performing Pressure Recalibration (▸ page 205)). 3. If the message appears again, inspect the pump for indications of leakage and replace leaky components as necessary.

Message and Code	Description and Remedial Action
Code 4212 Nonlinear pressure sensor. Please perform pressure recalibration.	Start the pressure recalibration procedure (see Performing Pressure Recalibration (▷ page 205)).
Code 4213 Head pressure does not match system pressure signal. Execute self-test or perform pressure recalibration.	First, run the self-test. If the message appears again, perform pressure recalibration (see Performing Pressure Recalibration (▷ page 205)).
Code 4220 Pump head not recognized. Please plug in the sensor cable.	If the pump head cable is not yet connected to the **P-WORK** connector, connect the cable. If the cable is connected, verify that it is properly seated. If the problem persists, the pump head may be defective. Replace the pump head (see Replacing the Pump Head (▷ page 131)).
Code 4230 Wrong value entered. Please verify your input with the piston calibration data.	The piston calibration value you entered is incorrect. Be sure that your input corresponds to the 3-digit calibration value that is imprinted on the rear of the piston. Check your input for typing errors.
Code 4231 Pressure sensor not recognized. Please plug in the sensor cable.	Verify that the cable of the pressure sensor for which the message appears is properly plugged into the connection port. Restart the flow. If the message appears again, the pressure sensor may be defective: • If the message appears for the pressure sensor of a pump head, replace the pump head (see Replacing the Pump Head (▷ page 131)). • If the message appears for the system pressure sensor, the system pressure sensor may be defective. Contact Technical Support.
Code 4232 The identification number of the XX has changed.	XX is the left pump head or right pump head The message appears when a pump head has been replaced or when the left and right pump heads have been interchanged, for example, accidentally during maintenance/service. The message is for informational purposes only. No action is required.
Code 4233 The data of the XX is invalid. Did you plug it into the correct socket?	XX is the left pump head or right pump head or the system pressure sensor You may have connected the cable of the device indicated in the message to the wrong socket, for example, the cable of the system pressure sensor has been connected to the socket for the pump head cable. Verify that the cable is connected to the correct socket and that the cable is properly seated.
Code 4234 The flow was stopped due to a request from another module.	The pump flow was stopped because of a problem with another module. Check the messages from other modules.
Code 4237 Out of solvent.	The solvent reservoir is empty. Refill the solvent reservoir and purge the pump.
Code 4238 Mainboard initialization failed.	Main board initialization has not been successful. 1. This may be a temporary error. Turn off the module. Wait for 5 seconds and turn on the module again. 2. If the message appears again, update the firmware. 3. If the message persists, the main board may be defective. Contact Technical Support.

8.3 Testing from the Chromeleon Software

With Chromeleon 7.2.6 and later

The Chromeleon software supports functions for helping you identify and eliminate the source for a problem. A wizard guides you through the process and provides information on remedial actions.

When

- Suspected leakage
  The **Simple Leak Test** checks the capillary and fitting connections.
- Pressure pulsation, shifts in retention time
  The **Advanced Leak Test** checks the check valves, piston seals, and capillaries.

Parts required

- Fitting plug
- Solvent of your application

Follow these steps

1. In the Chromeleon software, on the **Wellness** sub-panel for the pump, start the test that you want to run.
2. A wizard guides you through the process. Follow the instructions on the screen.
3. **Simple Leak Test** only: Visually inspect the pump for liquid leaks from the flow connections.
4. Take appropriate remedial action as required.

8.4 Testing the Pump for Leakage

Tests

The following tests assist you in finding out whether leakage is present in the pump, and they help you to locate the source of a leak:

- Pump leak test (general test)
  See Testing the Pump for Leakage (General Test) (▷ page 170)
- Piston seal leak test
  See Testing the Piston Seals for Leakage (▷ page 152)
- Seal wash system leak test
  See Testing the Seal Wash System for Leakage (▷ page 122)

8.5 Resolving Liquid Leaks

TIP If you are using Chromeleon 7.2.6 or later and suspect that leakage may be present in the pump, run the **Simple Leak Test** (see Testing from the Chromeleon Software (▸ page 199)). When the leak sensor reports leakage, see further down.

When

The leak sensor is wet. The leak sensor reports leakage.

If leakage is not resolved after 3 minutes, the pump stops the flow.

Parts and additional items required

- Replacement part as required
- Cloth or tissue

Preparations

When resolving leakage, observe the safety guidelines and general rules for maintenance and service as presented in Maintenance and Service (▸ page 109).

Follow these steps

1. Locate the source of the leak.
   As leakage usually occurs at a connection, visually inspect all components and connections in the flow path.

   The following tests can help you to identify the source:

   - Leakage test for the seal wash system
     See Testing the Seal Wash System for Leakage (▸ page 122).
   - Leakage test for the piston seals
     See Testing the Piston Seals for Leakage (▸ page 152).
   - Leakage test for the entire pump
     See Testing the Pump for Leakage (General Test) (▸ page 170).

   After taking remedial action as required, proceed with the next steps.
2. With a cloth or tissue, thoroughly absorb all liquid that has collected in the leak tray and under the leak sensor. Be careful not to bend the sensor.
3. Allow the sensor to adjust to the ambient temperature for a few minutes.
4. If leakage is no longer reported, you can resume operation.

8.6 Pressure Issues or Shifts in Retention Time

When you observe pressure issues or shifts in retention time, the following sections help you to identify and eliminate the source for the problem:

- Pressure pulsation
  See Resolving Pressure Pulsation or Shifts In Retention Time (▷ page 203) and Testing the Inline Filter/Static Mixer for Permeability (▷ page 205).
- Shift in retention times
  See Resolving Pressure Pulsation or Shifts In Retention Time (▷ page 203).
- Messages regarding the pump head pressure or nonlinear pressure sensor appear in chromatography software
  See Performing Pressure Recalibration (▷ page 205).
- Inconstant pressure or high backpressure at the column and pump
  See Testing the Inline Filter/Static Mixer for Permeability (▷ page 205).

8.6.1 Resolving Pressure Pulsation or Shifts In Retention Time

When

You observe pressure pulsation or shifts in retention time.

With Chromeleon 7.2.6 and later

Run the **Advanced Leak Test** (see Testing from the Chromeleon Software (▷ page 199)).

With Chromeleon 7 earlier than Chromeleon 7.2.6

Check the compression values.
The compression values of the pump heads can provide valuable information for troubleshooting.

Follow these steps

1. In the Chromeleon software, check the **Compression** values for the pump heads (compression on the left side in the pump head = **CompressionDrv1**, compression on the right side in the pump head = **CompressionDrv2**).
   The values indicate the compression of the last stroke in percent.
   The compression value should be less than 100%.

   - With isocratic conditions, the compression value should remain stable.
   - When running a gradient, the compression value changes roughly proportional to the pressure curve.

     If the value is close to 100%, the required precompression may not be reached and pulsation may occur.

     The table shows guide values for some solvents (pure solvent, degassed) with the pump being purged and the pressure being stable for some time. The values are linear to the pressure.

Pressure (MPa)	Compression in % with		
	Water	Methanol	Acetonitrile
25	11% ± 7%	22% ± 7%	22%± 7%
50	21%± 7%	41%± 7%	38%± 7%
75	30%± 7%	57%± 7%	53%± 7%
100	39%± 7%	71%± 7%	66%± 7%
125	47%± 7%	82%± 7%	76%± 7%
150	55%± 7%	90%± 7%	85%± 7%

2. Take remedial action if required.

Compression	Remedial Action
Lower than indicated in the table	The outlet check valve may be defective. Replace the outlet check valve. See Replacing the Outlet Check Valves (▶ page 156).
Higher than indicated in the table	• The piston seal may be defective. Replace the piston seal. See Replacing the Piston Seals or Support Ring (▶ page 138). • The inlet check valve may be defective. Replace the inlet check valve. See Replacing the Inlet Check Valves (▶ page 154).
Very high (message "**Compression limit reached**" and low pressure)	• Air bubbles may be present in the pump. Make sure that no air bubbles are present in the solvent lines and then, purge the pump. • *If solvent shut-off valves are installed:* Verify that the valves are open. • Excessive leakage may be present on the inlet check valve. Remove the solvent line from the solvent reservoir and the solvent line filter from the solvent line. While the pump is running, observe the liquid in the solvent line. If the liquid moves also against the direction of flow during the stroke, the inlet check valve may be defective. Replace the inlet check valve. See Replacing the Inlet Check Valves (▶ page 154).

8.6.2 Performing Pressure Recalibration

When

Messages regarding the pump head pressure or nonlinear pressure sensor appear in chromatography software, for example:

- **Code 4212 Nonlinear pressure sensor. Please perform pressure recalibration.**
- **Code 4213 Head pressure does not match system pressure signal. Execute self-test or perform pressure recalibration.**

Follow these steps

1. *Before* you perform pressure recalibration, check the remedial actions for the message (see Messages (▸ page 190)).
   Before pressure recalibration should be performed, message-specific remedial actions might be required. Perform these actions as applicable and proceed with the next step.
2. On the purge unit, remove the capillary from the **OUT** port.
3. Close the port and the open end of the capillary with an appropriate plug or cap.
4. In the Chromeleon software, on the **Service** sub-panel for the pump, click **Calibrate** to start the pressure recalibration procedure. A wizard guides you through the procedure.

8.6.3 Testing the Inline Filter/Static Mixer for Permeability

When

If you observe pressure pulsation, inconstant pressure, or high backpressure at the column and pump

Additional items required

- Water as solvent
- Tissue

Follow these steps

- *The pump has an inline filter installed*
  Test the inline filter (see Testing the Inline Filter for Permeability (▸ page 159)).
- *The pump has the mixing system installed*
  Test the static mixer (see Testing the Static Mixer for Permeability (▸ page 162)).

9 Specifications

This chapter provides the physical and performance specifications, including information about the materials used in the flow path of the device.

9.1 Performance Specifications

The pump performance is specified as follows:

Type	Specification*
Operating principle	Parallel dual-piston pump with independent piston drives and variable stroke volume
Compressibility compensation	Fully automated, independent of the composition of the mobile phase
Flow range (settable)	0.001 – 5 mL/min in 1 µL/min increments
Flow accuracy	± 0.1%
Flow precision	< 0.05% RSD or < 0.01 min SD, whichever is greater
Pressure range	5 – 151 MPa (50 – 1517 bar, 700 – 22002 psi)
Pulsation	< 0.4% or < 0.2 MPa, whichever is greater
Gradient formation	High-pressure gradient proportioning
Proportioning accuracy	± 0.2% (of full-scale)
Proportioning precision	< 0.15%SD
Number of solvents	2 out of 6
Maximum stroke volume	120 µL
Mixer volume	Standard configuration: 25 µL capillary mixer (proprietary) Other mixing systems are available as an option.
Dwell volume (contribution of the pump to the system gradient delay volume)	35 µL (with standard pump configuration) (35 µL to 400 µL with optionally available mixing systems)
Solvent degassing	Built-in, number of channels: 2 out of 6
Biocompatible	Yes
Communication	*USB:* 1 USB port (USB 2.0, "B" type connector) 1 USB hub with 3 ports (USB 2.0, "A" type connectors) *I/O Interface:* 2 Dig I/O ports (mini-DIN), each providing one input, one relay output, and one bidirectional input/output *System Interlink*: 2 system interlink ports (RJ45-8 connectors)
Control	Chromeleon 7 The device can be operated also with other data systems. For details, contact the Thermo Fisher Scientific sales organization. Keypad with 5 buttons for performing certain functions directly from the device
Materials in the analytical flow path	MP35N, DLC (diamond like carbon), titanium, ceramics, PEEK, UHMW PE, fluoropolymers For information about the chemical resistance of materials refer to the technical literature.

Type	Specification*
Solvent and additive information	See Solvent and Additive Information (▷ page 26).
Safety features	Leak detection and safe leak handling, excess pressure monitoring
Good Laboratory Practice (GLP) features	Predictive Performance functions for scheduling maintenance procedures based on the actual operating and usage conditions of the device. All system parameters logged in the Chromeleon Audit Trail.
* Typical operating conditions for measurable specifications: Flow accuracy, flow precision, pulsation: 1 mL/min at 60 MPa, water Proportioning accuracy, proportioning precision: 0.2 to 4.0 mL/min, 0-100%, water/spiked water	

9.2 Physical Specifications

The physical conditions of the device are specified as follows:

Type	Specification
Range of use	Indoor use only
Ambient operating temperature	5 °C - 35 °C
Ambient storage temperature	-20 °C - 45 °C
Ambient operating humidity	20% - 80% relative humidity (non-condensing)
Ambient storage humidity	Maximum 60% relative humidity (non-condensing)
Operating altitude	Maximum 2000 m above sea level
Pollution degree	2
Power requirements	100 – 240 VAC, ± 10 %; 50/60 Hz, max. 525 W / 550 VA
Overvoltage category	II
Emission sound pressure level	< 70 dB(A), typically < 48 dB(A)
Dimensions (height x width x depth)	19.2 x 42 x 62 cm
Weight	32 kg

10 Accessories, Consumables and Replacement Parts

This chapter describes the standard accessories that are shipped with the device and the accessories that are available as an option. This chapter also provides information for reordering consumables and replacement parts.

10.1 General Information

The device must be operated only with the replacement parts and additional components, options, and peripherals specifically authorized and qualified by Thermo Fisher Scientific.

Accessories, consumables, and replacement parts are always maintained at the latest technical standard. Therefore, part numbers are subject to change. If not otherwise stated, updated parts will be compatible with the parts they replace.

10.2 Ship Kit

The ship kit includes the items listed in the table. The kit content is subject to change and may vary from the information in this manual. Refer to the content list included in the kit for the most recent information about the kit content at the time when the device is shipped.

Ship kit

Item	Quantity in shipment
Silicone tubing, 3 m	1
Solvent line filter, filter holder (no filter frit included)	6
Solvent line filter, filter frit, biocompatible, 10 µm	6
Plugs and retaining guides for reservoir caps, kit including • Cap plug to close open holes in the reservoir cap (pack of 5) • Retaining guide to keep the liquid line in place in the reservoir cap (pack of 2)	7
Fitting plug, Viper	1
Tool kit, including • Screwdriver, Torx TX25 • Hexagon wrench, size 6 • Seal-handling tool • Spacing tool, pump heads and pistons	1
Reservoir, 0.25 L, with reservoir cap	1
Tubing bracket	1
Solvent lines (pack of 6), from solvent reservoirs to pump inlet (solvent selector)	1
System interlink cable (RJ45), 0,5 m	1
USB cable, type A to type B, high-speed, USB 2.0, cable length: 5 m	1

For reordering information, see Consumables and Replacement Parts (▷ page 215).

10.3 Optional Accessories

The following accessories are available as an option:

Solvent shut-off valve

Description	Part No.
Solvent shut-off valve To prevent the solvent from flowing through the system, for example, when opening a flow connection on the low-pressure side.	6036.0010

Solvent monitor

Description	Part No.
Vanquish Solvent Monitor To actively monitor the liquid level in solvent reservoirs and waste containers in real time. Monitoring is based on real physical measurement (no data input required).	
Solvent monitor, 4-channel version	6230.1320-01
Solvent monitor, 8-channel version	6230.1310-01

Mixing systems

Description	Part No.
Mixing systems - For: • Highest sensitivity when mixing ripples interfere with the detection • TFA applications For the available mixer kits, see further down.	

Mixer kits

The mixer kits include the mixing system and required installation material. Each mixing system comprises a static mixer and a capillary mixer. The volumes of both mixers determine the entire volume of the mixing system.

Description	Part No.
Mixer kit for mixing system, volume: 200 µL, comprising: • Static mixer, volume: 150 µL • Capillary mixer, volume: 50 µL	6268.5120
Mixer kit for mixing system, volume: 400 µL, comprising: • Static mixer, volume: 350 µL • Capillary mixer, volume: 50 µL	6268.5310

10.4 Consumables and Replacement Parts

The following consumables and replacement parts are available for the pump:

10.4.1 Maintenance Kit

Description	Part No.
Maintenance kit, including: • Pump head seal (3 PTFE seals, different sized) • Silicone tubing (clear tubing) • Peristaltic tubing (white tubing) • Tubing connector (straight) • Tubing connector (90°-angled) • Tubing connector (ID 1/16") (pack of 4) • Seal wash seal (pack of 4) • Piston seal (pack of 4) • Solvent line filter (5 filter holders and 6 frits, biocompatible, 10 µm) • Cleaning swab (pack of 25) • Seal wash plate, screws (pack of 8) • Tubing clip (self-adhesive) (pack of 2)	6044.1956

10.4.2 Pump Head and Components

Description	Part No.
Pump head (complete assembly), including spacing tool	6044.1201
Piston seal (RP) and seal wash seal (pack of 2 each)	6266.0309
Support ring (pack of 2)	6040.0012
Piston, sapphire	6267.0050
Inlet assembly	6044.2330
Check valve, inlet check valve	6044.2300
Check valve, outlet check valve	6044.2310
Pump head seals (PTFE O-rings, sizes: 9x1.5, 45x1.5, 65x1.5; 5 each)	6044.1210
Screws for seal wash plate (pack of 8)	6000.0036
Seal-handling tool	6040.7158

10.4.3 Solvents and Wash Systems

Reservoirs for solvents and wash liquids

Description	Part No.
Reservoir, 1 L, including cap	2270.0012
Reservoir, 0.25 L, including cap	2270.0026
Cap for reservoirs, screw-cap (pack of 4)	6270.0013
Cap plug to close open holes in the reservoir cap (pack of 20)	6000.0047
Retaining guide to keep the liquid line in place in the reservoir cap (pack of 5)	6000.0042
Plugs and retaining guides for reservoir caps, kit including • Cap plug to close open holes in the reservoir cap (pack of 10) • Retaining guide to keep the liquid line in place in the reservoir cap (pack of 5)	6030.9101

Seal wash system

Description	Part No.
Peristaltic and wash tubing kit The kit includes peristaltic tubing (PharMed), silicone tubing, and tubing connectors for use in • Seal wash system in the pump and in the autosampler • Needle wash system in the autosampler • Drain pump in the autosampler **NOTICE**: Use the thick silicone tubing (and related tubing connectors) in the autosampler. Use the thin silicone tubing (and related tubing connectors) in the pump. Use the screwable connectors for the pump head.	6044.1150
Seal wash detector (drop detector) with funnel	6044.1898
Piston seal (RP) and seal wash seal (pack of 2 each)	6266.0309

Solvent line filters, solvent lines and tubing

Description	Part No.
Solvent line filter, filter holder (pack of 6) (no filter frits included)	6268.0115
Solvent line filter, filter frit, biocompatible, 10 µm (pack of 10)	6268.0111
Solvent lines to connect the solvent reservoirs to the pump inlet	6036.1701
Tubing kit, including: • Solvent lines from solvent selectors to degasser • Solvent lines from degasser to pump head • Waste tubing from purge unit to drain port	6044.2055

10.4.4 Inline Filter

Description	Part No.
Inline filter set, including: • Inline filter (static filter, volume: 10 µL) • Capillary mixer (volume: 25 µL) to connect the purge unit to the static inline filter • Fitting plugs (pack of 2)	6044.5018

10.4.5 Miscellaneous Parts

Description	Part No.
Capillary, nanoViper (length: 750 mm, inner diameter: 75 µm) To be used, for example, when running in new piston seals.	6041.5780
Capillary kit, system pressure sensor (P-Sys) The kit includes the capillaries from system pressure sensor to purge unit (short capillary) and from purge unit to system pressure sensor (long capillary).	6044.1933
Cleaning swabs (pack of 25)	6040.0007
Diagnostics tool kit The kit includes a fitting plug (Viper, biocompatible) and nanoViper backpressure capillary (length: 950 mm)	6044.0100
Fitting plug, Viper, biocompatible	6040.2303
Front door kit, including right door and left door	6044.1920
Fuses kit, Vanquish system The kit includes the appropriate fuses for the Vanquish system modules. For the pump, use only the 5 AT 230 V AC, slow-blow fuses.	6036.0002
Y-connector To be used as left Y-connector or right Y-connector.	6044.1245
Packaging material for pump	6084.7001
For system capillaries and tubing, refer to the *Vanquish System Operating Manual.*	

10.4.6 Interface Cables and Power Cords

Interface cables

Description	Part No.
Digital I/O signaling cable, 6-pin, cable length: 5 m	6036.0006
System interlink cable (RJ45), 0.5 m	6036.0004
USB cable, type A to type B, high-speed, USB 2.0 Cable length: 1 m	6035.9035A
USB cable, type A to type B, high-speed, USB 2.0 Cable length: 5 m	6911.0002A

Power cords

Description	Part No.
Power cord, Australia	6000.1060
Power cord, China	6000.1080
Power cord, Denmark	6000.1070
Power cord, EU	6000.1000
Power cord, India, SA	6000.1090
Power cord, Italy	6000.1040
Power cord, Japan	6000.1050
Power cord, UK	6000.1020
Power cord, USA	6000.1001
Power cord, Switzerland	6000.1030

11 Appendix

This chapter provides additional information about compliance and the use of the digital I/O ports.

11.1 Compliance Information

11.1.1 Declarations of Conformity

CE Declaration of Conformity

The device has satisfied the requirements for the CE mark and is compliant with the applicable requirements.

EAC Declaration of Conformity

The device has satisfied the requirements for the EAC mark and is compliant with the applicable requirements.

RoHS Compliance

This product complies with the RoHS (Restrictions of Hazardous Substances) directives:

- *European RoHS Directive*
  Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment

  The CE mark on the device indicates that the product is compliant with the directive.

- *China RoHS regulations*
  Measures for Administration of the Pollution Control of Electronic Information Products

  One of the following logos may be present on the device if applicable:

Logo	Description
	The green logo marks items that do not contain the hazardous substances identified by the regulations.
	The orange logo including a one-digit or two-digit number marks items that contain hazardous substances identified by the regulations. The number indicates the environment-friendly use period (EFUP) of the item. During this period, the item (when used as intended) will not cause serious damage to human health or environment. For more information, go to http://www.thermofisher.com/us/en/home/technical-resources/rohs-certificates.html

UKCA Declaration of Conformity

The device has satisfied the requirements for the UKCA mark and is compliant with the applicable requirements.

UL/CSA 61010-1 Compliance

The label of the NRTL Lab on the device (for example, cTUVus or CSA mark) indicates that the device has satisfied the requirements of the applicable standards.

11.1.2 WEEE Compliance

This product is required to comply with the European Union's Waste Electrical & Electronic Equipment (WEEE) Directive. It is marked with the following symbol:

Figure 77: WEEE symbol

Thermo Fisher Scientific has contracted with one or more recycling or disposal companies in each European Union (EU) Member State, and these companies should dispose of or recycle this product. For further information, contact Thermo Fisher Scientific.

11.1.3 FCC Compliance

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the U.S. FCC Rules.

These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his expense.

11.1.4 Manual Release History

Revision	Covering
1.0 and 2.0	VH-P10-A-02

The instructions were prepared in English (original instructions). Other language versions are translations based on the English original instructions.

11.2 Digital I/O

The digital I/O ports (Dig I/O) can be used to exchange digital signals with external devices. Each port provides:

- one digital input
- one relay output
- one bidirectional input/output

Pin Assignment

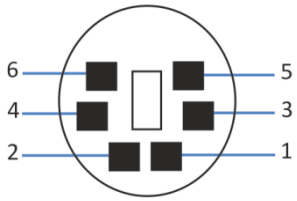

Figure 78: Digital I/O port

Pin	Description — Signal Name
1	Bidirectional input/output
2	Relay output — Relay_NC (Normally Closed contact)
3	Ground — GND
4	Digital input — Input
5	Relay output — Relay_COM COM is the common contact for NO and NC. If the relay is not activated or if the device is turned off, the connection is between COM and NC. If the relay is activated, the connection is between COM and NO.
6	Relay output — Relay_NO (Normally Open contact)

The next table lists the functions assigned to the connector pins and the color of the cable wire connected to each pin.

Pin	Wire Color	Signal Name	Signal Level	Remarks
1	Pink	Input/output	Input (low active): On: 0-0.4 V Off: 2.2-5 V Open Collector Output: 0-5 V, 0-2 mA Pull-up resistor: 47 kΩ to 5 V	Configure as either input or output. Reference potential is ground. Note the following: • The maximum input voltage at the input must not exceed +5 V with reference to ground. • The minimum input voltage must not be lower than the ground potential.
2	Gray	Relay output — Relay_NC	Potential free 0-24 V, 0-100 mA	Opening contact

Pin	Wire Color	Signal Name	Signal Level	Remarks
3	Green	Ground — GND	Ground	Reference potential
4	Yellow	Digital input — Input	Input (low active): On: 0-0.4 V Off: 2.2-5 V Pull-up resistor: 47 kΩ to 5 V	Digital input; reference potential is ground. Note the following: • The maximum input voltage at the input must not exceed +5 V with reference to ground. • The minimum input voltage must not be lower than the ground potential.
5	White	Relay output — Relay_COM	Potential free	Common contact for NO and NC
6	Brown	Relay output — Relay_NO	Potential free 0-24 V, 0-100 mA	Closing contact

Prerequisites

To use the digital I/O functionality, the following must be fulfilled:

- The digital I/O port is connected to the external device with the digital I/O signaling cable.
- The inputs and outputs that you want to use are selected in the Instrument Configuration Manager.

Connecting a Digital I/O Port

1. Plug the 6-pin connector of the cable into the digital I/O port that you want to use.
2. For each relay output or digital input to be used, connect the appropriate signal wire and ground wire to the corresponding connectors on the external device. For details, refer to the documentation provided with the external device.

Selecting the inputs and outputs in the chromatography data system

1. In the dialog box for the pump, on the **Inputs** and **Outputs** pages, select the inputs (**Pump_Input_X**) and outputs (**Pump_Relay_X**) that you want to use. The numbering in the dialog box corresponds to the port numbers on the pump.
2. To configure the bidirectional input/output (**Pump_IO_X**), select the related check box on either the **Inputs** or **Outputs** page, depending on the preferred usage.

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