

2424 Evaporative Light Scattering Detector

Operator's Guide

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Waters

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Waters contact information

Contacting medium	Information
Internet	The Waters Web site includes contact information for Waters locations worldwide. Visit www.waters.com .
Telephone and fax	From the USA or Canada, phone 800 252-HPLC, or fax 508 872 1990. For other locations worldwide, phone and fax numbers appear in the Waters Web site.
Conventional mail	Waters Corporation 34 Maple Street Milford, MA 01757 USA

Safety considerations

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

When you develop methods, follow the "Protocol for the Adoption of Analytical Methods in the Clinical Chemistry Laboratory," *American Journal of Medical Technology*, 44, 1, pages 30–37 (1978). This protocol addresses good operating procedures and the techniques necessary to validate system and method performance.

Safety advisories

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

Operating this instrument

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

Applicable symbols

Symbol	Definition
	Confirms that a manufactured product complies with all applicable European Community directives
 ABN 49 065 444 751	Australia C-Tick EMC Compliant
	Confirms that a manufactured product complies with all applicable United States and Canadian safety requirements
	This product has been tested to the requirements of CAN/CSA-C22.2 No. 61010-1, second edition, including Amendment 1, or a later version of the same standard incorporating the same level of testing requirements

Audience and purpose

This guide is intended for personnel who install, operate, and maintain 2424 Evaporative Light Scattering (ELS) detectors.

Intended use of the 2424 ELS detector

Waters designed the 2424 ELS detector to analyze and monitor many compounds.

Calibrating

To calibrate LC systems, follow acceptable calibration methods using at least five standards to generate a standard curve. The concentration range for standards should include the entire range of QC samples, typical specimens, and atypical specimens.

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

Quality-control

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

ISM classification

ISM Classification: ISM Group 1 Class B

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

EC Authorized Representative



Waters Corporation (Micromass UK Ltd.)
Floats Road
Wythenshawe
Manchester M23 9LZ
United Kingdom

Telephone: +44-161-946-2400
Fax: +44-161-946-2480
Contact: Quality manager

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1

2424 ELS Detector Optics Principles

To use the 2424 ELS detector effectively, you must understand the principles that underlie operation of the detector's optics and electronics.

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Principles of evaporative light scattering detection

Overview

Evaporative light scattering (ELS) detection works by nebulizing the solvent flow from a liquid chromatography (LC) system and entraining the resultant droplets in a gas stream. Mobile phase is then evaporated from the droplets. When an analyte is less volatile than the mobile phase, it remains in the gas stream as a “dry” solute particle and flows to the ELS detector. Once there, the particles scatter the light beam. The amount of scattered light is measured and bears a relationship to the concentration of material eluting.

Capabilities

The 2424 ELS detector is compatible with virtually all modes of chromatography including flow injection analysis. The detector responds to all compounds that are, relative to their mobile phase, sufficiently nonvolatile at the conditions of analysis. Applications for ELS detection include combinatorial libraries of small molecules, natural product extracts and libraries, food products, and related materials. For detecting compounds that exhibit little to no UV/Vis response and do not ionize well for mass spectrometry, the ELS detector complements HPLC for analyzing sugars, antibiotics, antivirals, lipids, phospholipids, biomolecules, and natural products. You can use ELS detection in a system that includes a mass spectrometer and absorbance detector, applying it as a qualitative tool to demonstrate the purity or complexity of a sample. Quantitation can be achieved by carrying out a calibration plot, as explained later in this guide. Note, however, that the curve will not be linear because ELS detectors give a non-linear response.

ELS detection performs well in isocratic or gradient elution with a wide variety of mobile phases and additives. Waters recommends using mass spectrometry-compatible volatile mobile-phase modifiers.

ELS detection process

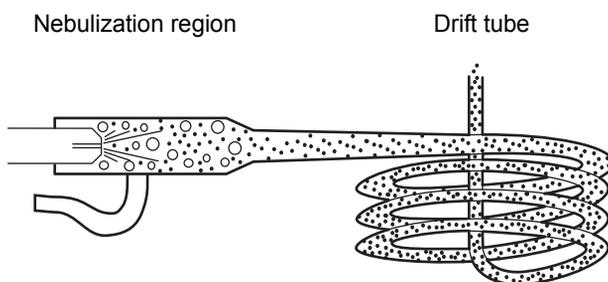
The three separate regions of an ELS detector are nebulization, desolvation, and detection. In all ELS detectors, these three regions are positioned so that the chromatographic effluent is nebulized and mobile phase is evaporated so

that dry solute particles, consisting only of analytes, reach the light source for scattering.

Low temperature nebulization

In the detector's nebulization region, the chromatographic effluent is transformed into a fine aerosol. A concentric tube, or flow-type nebulizer, mixes chromatographic effluent with a carrier gas (usually nitrogen) developing a series of droplets that forms the aerosol that enters a narrow-orifice drift tube.

Nebulization region and drift tube (representative)



The concentric flow nebulizer allows you to control the carrier gas flow versus the chromatographic effluent flow rate. High gas flow produces small droplets, requiring less heat to evaporate the solvent. Conversely, low gas flow produces large droplets, requiring more heat to evaporate the solvent.

Desolvation

In the desolvation region, the mobile phase evaporates, leaving dried solute particles in the drift tube.

As the aerosol drops exiting the nebulizer pass through the drift tube, they become smaller. The carrier gas sweeps the dried, aerosolized solute particles along to the instrument's detection region.

Evaporation occurs as a function of time, temperature, and pressure of the carrier gas. It is therefore important to use HPLC mobile phases that easily and quickly evaporate and desolvate. Solvents of fairly low boiling point and low viscosity are best. They include the more commonly used HPLC mobile phases: water, acetonitrile, methanol, ethanol, and THF. Viscous and high-boiling solvents might fail to fully separate from the analyte molecules or

species before the detection step. This adds to the background noise and decreases the analyte signal response, which causes low sensitivity (slope of the calibration plot) and high limits of detection (LOD). The evaporated HPLC solvents are condensed and captured in the recommended solvent trap and exhaust routing. Nevertheless, small amounts of residual can persist, and these should be exhausted into a fume hood to prevent their escape into the laboratory.

Detection

The analyte particles enter the detection region where a light source impinges on the particles. The light is thus scattered and focused onto a photomultiplier tube (PMT) where its intensity is measured.

The size (diameter) of the analyte particles determines how the light is scattered. The detector measures the intensity of the scattered light at 60° relative to the excitation beam to minimize polarization effects and stray light. Particles of different sizes exhibit different angular distributions of the scattered light, and particles whose sizes and shapes vary have different light-scattering cross sections. In general, larger particles scatter more light, yielding more intense signals and peak responses.

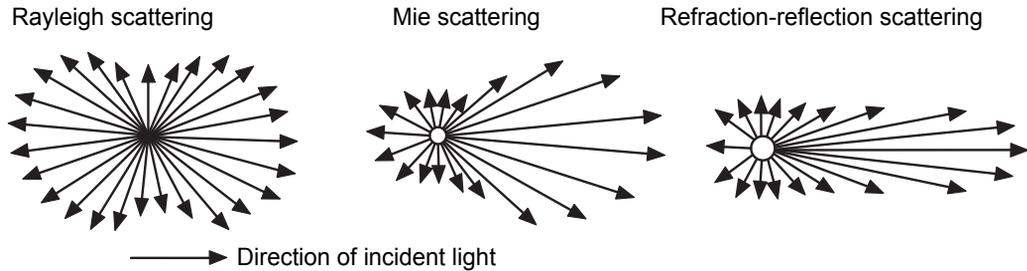
A photomultiplier tube (PMT) converts the scattered light signal to a voltage that can be recorded and analyzed. The stronger the scattering, the more intense the final signal on the ELS detection chromatogram. The scattered light is a rough measure of the mass of material represented by a chromatographic peak. To some degree, this “mass” response can be compound-independent. However, many factors can also affect the mass response, particularly the density of the analyte in a small dried particle. For example, a popped kernel of corn has a lower density than the unpopped kernel from which it originated. Yet, because it is larger, in most cases it would scatter more light. You should also remember that the output of an ELS detector has no direct relation to the molecular weight of an analyte.

Types of light scattering

The three possible regimes of light scattering are

- Rayleigh
- Mie
- refraction-reflection

Light scattering direction



For a nebulizer that produces an average droplet diameter of D_0 , the diameter of an average, resulting dry analyte particle is

$$D = D_0(c/p)^{1/3} \quad \text{where}$$

D_0 = Average liquid droplet diameter

c = Concentration of the analyte

p = Density of the dry analyte

For any given analyte peak, the response of an ELS detector can be that of all three light scattering regimes. The light-scattering type depends on the size of the particles going through the light beam. The ratio of particle diameter, D , to the incident wavelength, λ , or $\frac{D}{\lambda}$, defines the type of scattering that results.

- Rayleigh scattering occurs for the smallest particles where $\frac{D}{\lambda} < 0.1$. The scattered light from a particle is proportional to D^6 , and consequently the scattered signal is proportional to c^2 .
- Mie scattering occurs for particles where $\frac{D}{\lambda} > 0.1$, but < 1.0 . The scattered light is proportional to D^4 , and the scattered signal is proportional to $c^{4/3}$.

- Refraction-reflection scattering occurs for particles where $\frac{D}{\lambda} > 1.0$. The scattered light is proportional to D^2 , and the scattered signal is proportional to $c^{2/3}$.
- As a chromatographic peak elutes from a column, the concentration of the analyte it represents changes. Concentration goes from near-zero at the baseline to a maximum that corresponds to column efficiency, injection volume, retention time, and concentration of the sample when injected. From the maximum level, the concentration then returns to near-zero. If the concentration is high enough, the diameter of a dry analyte particle can vary through all three scattering regimes—Rayleigh, Mie, and refraction-reflection scattering. It is this variance that prevents linearity in ELS detection calibration plots over more than one order of magnitude.

ELS detection limitations

Consider these limitations when implementing global ELS detection separation methods:

- ELS detection lacks linearity over wide concentration ranges. When you use the detector for assays, you may need to experiment with a variety of “best fits” using linear, quadratic, and log-log responses for the compounds of interest. You might also need to establish groupings for expected concentration ranges.
- ELS detection is a destructive technique; the analyte is sacrificed to generate the scattering particles. Ideally, therefore, the ELS detector should be the final detector in a series. Alternatively, you can place the ELS detector upstream of others, provided you split the column effluent so that the ELS detector receives its own stream from the LC.
- Any particle can interfere with the sample signal, including particulates in poor-grade chromatographic solvents because the detector responds equally to all particulates. This lack of selectivity can cause problematic background noise.
- The detector’s sensitivity to the particulates increases noise and, consequently, signal-to-noise variation for a given method arising from differences in the quality of mobile phases. Moreover, stationary phase components can leach from the column and contribute particulates to the sample flow.

- You can reduce the load of unwanted particulates by filtering LC effluent and the instrument's carrier gas.
- ELS detection cannot detect compounds whose volatility resembles that of the mobile phase. When the analyte and mobile phase have similar volatility, it is impossible to evaporate the mobile phase from droplets without also evaporating the analyte.
- In many cases the detector is minimally sensitive to baseline drift caused by gradient changes in an LC separation. However, its performance is not completely independent of the effects of changing solvent composition, which affects the nebulizer's ability to form droplets and influence their size.

Detector description

The detection of a sample peak occurs as follows:

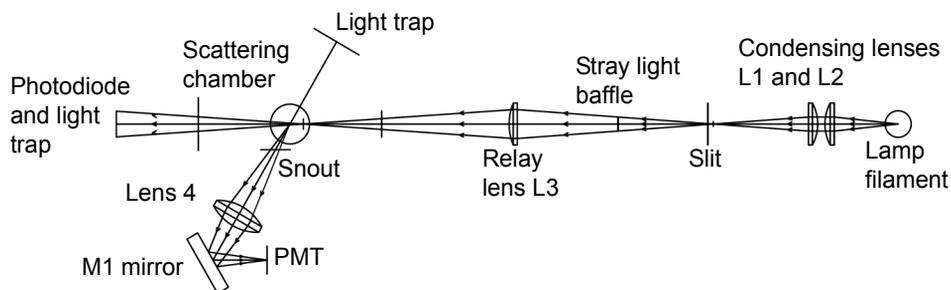
1. Eluent from the column flows into the nebulizer where a steady supply of gas converts it into a fine aerosol. Carefully controlled gas flow and flow rates determine the size of eluent droplets found in the aerosol.



Warning: Fire and explosion hazard. Do not use air as the carrier gas when the mobile phase contains flammable components.

2. Droplets are vaporized in the evaporation drift tube, leaving a rising column of particles, suspended in gas and vaporized solvent, to pass into the center of the light scattering chamber.
3. Two condensing lenses, L1 and L2, focus light from the lamp through a slit.

2424 ELS detection process (representative)



4. Lens L3 relays the light from the slit to the center of the scattering chamber. A baffle between the slit and relay lens minimizes stray light reaching the scattering chamber.
5. Only light scattered at a 60° angle relative to the incident light is channeled through the snout and collector lens, L4. The positioning and design of the snout, together with the aid of two light traps, minimize stray light that can be detected. The first light trap houses a photodiode to intercept a portion of the stray incident light by monitoring lamp intensity variations. The second light trap minimizes stray light opposite the collection optics.
6. The collector lens focuses light onto the M1 mirror to change the direction of light before reflecting it onto the photomultiplier tube.
7. The PMT converts the light to an electrical signal.
8. Remaining gaseous effluent is vented.

Signal processing and noise calculations

Power source fluctuations can introduce noise in the detector output and be a major source of noise at high signal levels. To offset their effect, a reference signal tracks lamp fluctuations and corrects the sample (PMT) signal accordingly.

Calibrating the photomultiplier tube (PMT)

The full scale sensitivity of the instrument is controlled by the gain setting, which increases the voltage to the PMT to amplify response. The instrument gain is achieved by controlling the high voltage supply to the PMT. However, the PMT response is not linear, so each unit must be individually calibrated to determine the required voltage settings for each gain value. PMT calibration is performed by Waters after the assembly and alignment of the detector and whenever the PMT or any PC boards are replaced.

Filtering noise

In the General tab of the ELS Instrument Method Editor (for details, refer to the Empower or MassLynx online Help), you can apply an optional noise filter (the Time Constant parameter) to the data acquired.

Electronics and data acquisition

The detector's electronics consist of the following components:

- DC power supply – Provides all DC voltages required for the analog and digital circuitries.
- Preamplifier board – Collects and processes the analog input signals from the PMT and photodiode to the microprocessor for further signal conditioning. Sample and reference signals are integrated and A/D conversion is performed simultaneously. This ensures the best rejection of common mode noise in the two beams, leading to a very quiet baseline.
- Controller board – Provides the drive circuitry for all modules in the system such as the lamp, heaters, cooler, keypad, display, PMT, fans, external column heater, etc. It provides power to the CPU board and the preamplifier board. It also interfaces between the Preamplifier board and the CPU board.
- CPU board – Contains the microprocessor, serial RS232 and Ethernet communications, battery backed nonvolatile RAM (in which the user parameters and calibration values are saved), and Flash RAM (in which the firmware resides).
- Display and Keypad – Provides the user with direct control of the system when it is used in standalone mode. The keypad allows the user to access the control system, program methods, calibrate, and troubleshoot the detector, while the display shows the status of many functions.

Nebulizer

Both high-flow and low-flow nebulizers are available. The high-flow nebulizer is standard in the 2424 ELS detector and is designed for flow rates ranging from 300 to 3000 $\mu\text{L}/\text{min}$. The low-flow nebulizer is designed for 50 to 500 $\mu\text{L}/\text{min}$ and gives the highest sensitivity performance.

Optics bench

The detector's optics bench consists of three major systems:

- Illumination
- Light scattering chamber
- Collections

Illumination system

The illumination system uses these components to direct broadband light from the lamp into the light scattering chamber:

- Tungsten halogen lamp
- Entrance mask
- Two convex lenses, L1 and L2, acting as a condenser
- Slit
- Baffle
- Convex relay lens L3

Light scattering chamber

The light scattering chamber is the equivalent of a flow cell in other detectors. It provides an environment where the sample in the gas stream and the incident light beam can interact. The chamber contains these components:

- Two light traps
- Reference photodiode

To prevent the solvent and analyte from condensing on the chamber walls or optical surfaces, the chamber is heated to 50 °C (122 °F) and cannot be varied. A thermistor for temperature regulation and an over-temperature switch are included in its heating circuit.

Collections system

The collections system collects scattered light from the scattering chamber and directs it to the PMT for conversion to an electrical signal. It consists of these components:

- Snout
- Biconvex collector lens, L4
- Mirror M1
- PMT

Temperature control

To vaporize and evaporate the solvent, the nebulizer and drift tube have temperature control.

Nebulizer

The nebulizer can be heated using a variable control heater. This heater, represented as a power function, can heat the sample solution to improve mass flow into the drift tube. The power function indicates the power available to the nebulizer heater circuit. In certain cases, the nebulization process of the mobile phase can be endothermic, as with 100% organic solvents such as methanol and acetonitrile. These require more power than other eluents.

The nebulizer can also be cooled when faster equilibration times are required. This reduces the amount of solvent that is sprayed into the drift tube in the vaporization process and allows the drift tube temperature to run lower, therefore increasing the sensitivity of semi-volatile samples.

Drift Tube

You can set the drift tube heater up to 100° C to evaporate any residual solvent. RTD (resistance temperature detector) sensors provide temperature feedback to the heater control to ensure the desired temperature is maintained. The RTD is placed at the end of the drift tube, where the temperature is hottest, so it can give accurate feedback of the most extreme temperature the particles will be exposed to. This is particularly important for semivolatile substances.

Startup diagnostics

On starting the detector, the presence of many electronic devices and components is verified. Some can self calibrate, a process that takes place at this time. The startup diagnostics include these tests:

- Central processing unit (CPU) test
- Serial communication interface (SCI) test
- Electrically erasable programmable read-only memory (EEPROM) test
- RAM test
- Display test pattern
- Application program checksum verification (firmware)
- Lamp test
- Photodiode test
- PMT test

The signal of the lamp is measured, and the normalization constant is adjusted accordingly to compensate for lamp intensity variations. This minimizes the influence of lamp intensity changes on detected signal levels. All settings are restored to the values present when the unit was shut down, except for the heater setpoints and gas flow, which must be specified.

Recommendation: Turn the power off and on once a week to compensate for lamp aging.

Lamp energy and performance

In conventional designs of ELS detectors, the signal-to-noise performance of the instrument is directly proportional to the lamp energy input to the instrument. Lamp energy input to the detector can be affected by these factors:

- Age and efficiency of the lamp
- Improperly maintained optics
- Normal degradation of optical components (including the photomultiplier tube)

Optical components degrade slowly. In conventional ELS detectors, response increases by incrementally increasing the gain. However, a sample's response varies with energy throughput. If the lamp energy is degraded, peak response degrades accordingly. If lamp intensity diminishes, peak response decreases and noise increases. During normal operation, lamps are usually replaced when the reference energy falls below a user-set threshold. The useful lamp life depends on the method's specific requirements for noise performance. Eventually, the detector's performance becomes unacceptable and the lamp replacement is necessary.

Tip: It is good practice to inspect the detector's general condition when lamps are replaced.

Predicting when the detector's performance degrades to an unacceptable level based solely on reference energy is unsatisfactory. Each user's analyses require different levels of sensitivity. Determining reference energy alone to evaluate performance assumes that lamps exhibit the same longevity and degradation patterns. Waters therefore designed the detector to operate as independently of lamp output as possible. Ultimately, the detector's performance is a function of unique application requirements.

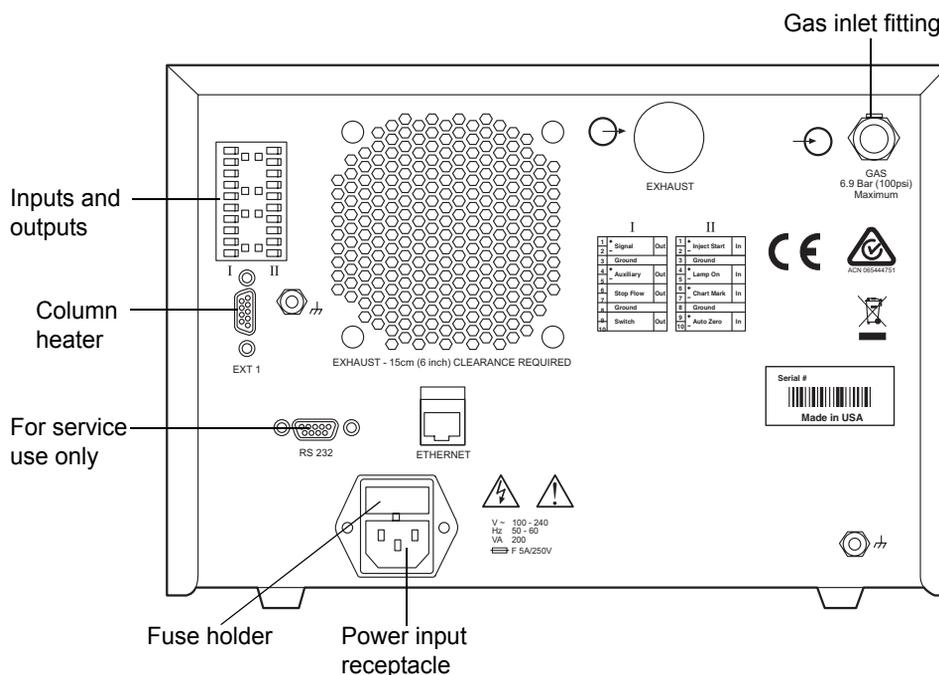
Signal-to-noise measurements are the best way to evaluate performance and set boundaries for acceptable operational sensitivity limits. Waters

guarantees 2000 hours of lamp life, or one year since date of purchase, whichever comes first.

Rear panel

The following figure shows the rear panel locations of the connectors used to operate the detector with external devices.

2424 ELS detector rear panel



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2 Setting up the Detector

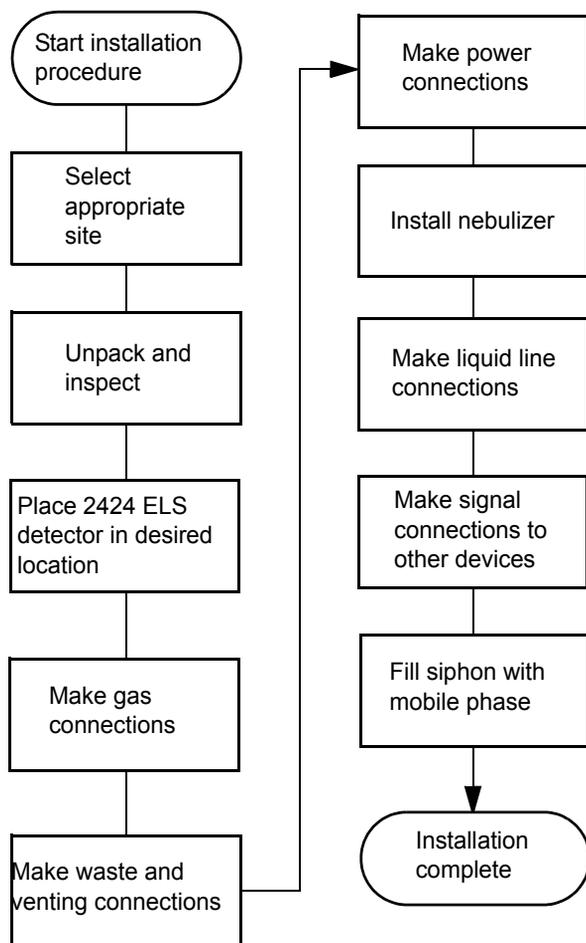
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Introduction

The following figure shows the major steps in installing the detector.

Major steps in installing the detector



Before you begin

Requirement: To install the detector, you should know how, in general, to set up and operate laboratory instruments and computer-controlled devices and also how to handle solvents.

Before installing the detector, ensure that

- it is not situated under a heating or cooling vent
- the required components are present
- none of the shipping containers or unpacked items are damaged

Unpacking and inspecting

The shipping carton contains these items:

- 2424 ELS detector
- *Waters 2424 Evaporative Light Scattering Detector Operator's Guide*
- Startup kit
- Release notes

To unpack the detector and nebulizer:

1. Check the contents of the shipping cartons against the packing lists to ensure that you received all items.
2. Save the shipping cartons for future transport or shipment.

If you discover any damage or discrepancy when you inspect the contents of the cartons, immediately contact the shipping agent and your local Waters representative.

Customers in the USA and Canada should report damage and discrepancies to Waters Technical Service (800 252-4752). Others should phone their local Waters subsidiary or Waters corporate headquarters in Milford, Massachusetts (USA), or they may visit <http://www.waters.com>.

For complete information on reporting shipping damages and submitting claims, see *Waters Licenses, Warranties, and Support Services*.

Selecting a site within a laboratory

The reliable operation of your detector depends on a proper installation site and suitable power supply.

Site selection requirements

Install the detector in an area that meets the requirements in the table at the end of this section.

The detector is a stackable unit and does not require bench space beyond the dimensions shown in the figure on [page 2-5](#).



Caution: To avoid damaging the detector, the amount of weight stacked on top of it should not exceed 18 kg (40 pounds).

Place the detector close to the column outlet to minimize band broadening, which reduces the resolution of a chromatogram.

Tip: If your system includes more than one detector, connect the ELS detector so that it is the final detector in the series because it nebulizes column effluent and exhausts it as gas vapor.

Installation site requirements

Parameter	Requirement
Operating temperature range	4 to 30 °C (39.2 to 86 °F); avoid direct exposure to sunlight and heating and cooling vents
Storage temperature range	-30 to 60 °C (-22 to 140 °F))
Relative humidity	20 to 95%, noncondensing
Storage humidity range	0 to 95%, noncondensing
Bench space	At least 33.53 cm (13.2 inches) wide × 66.04 cm (26 inches) deep × 20.8 cm (8.2 inches) high (includes 15.0 cm [6 inches] clearance at the rear and 5 cm [2 inches] clearance on the left for ventilation) At least 5 cm (2 inches) clearance is needed on the left side of the detector to allow venting for nebulizer cooling. Blocking this vent could adversely affect nebulizer cooling.
Power	Grounded AC, 100 to 240 VAC, 50 to 60 Hz nominal 200 VA

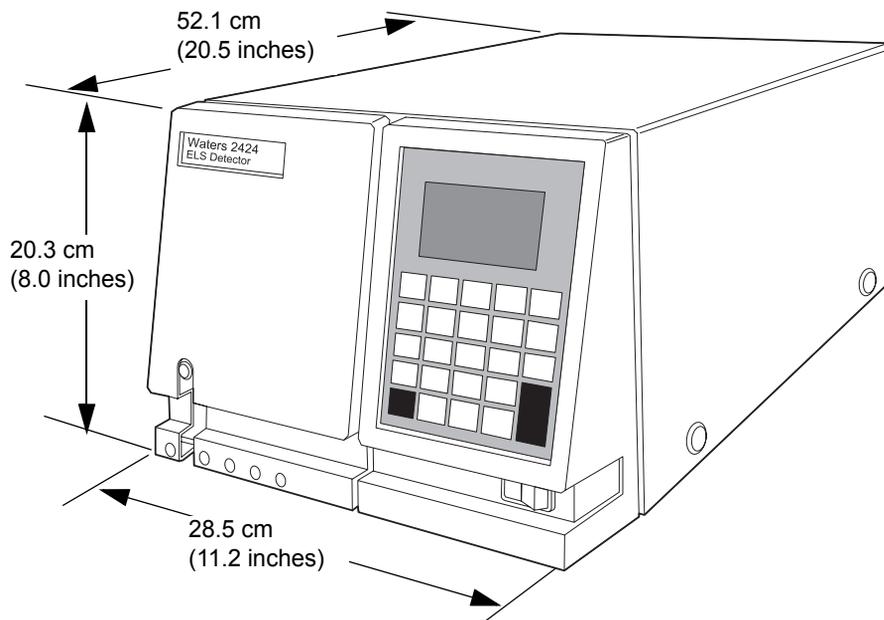
Installation site requirements (Continued)

Parameter	Requirement
Gas supply	450 to 690 kPa (4.5 to 6.9 bar, 65 to 100 psi), at the regulator, of dry, oil-free, filtered nitrogen or zero grade oil-free, filtered air
Ventilation	Locate near fume hood or exhaust system for proper venting of detector exhaust
Surface orientation	Level (ensures proper nebulizer drip tray function)
Altitude limitations	None

Detector dimensions

The following figure shows the dimensions of the detector.

Detector dimensions



Tip: Access to the instrument inside the top cover is not required. All required access is through the left-front panel where the liquid line connections are located.

Power requirements

The detector, which operates over the range 100 to 240 VAC, is shipped from the factory with two 5.00 A, 250 V fuses.



Warning: To avoid electrical shock, observe these precautions:

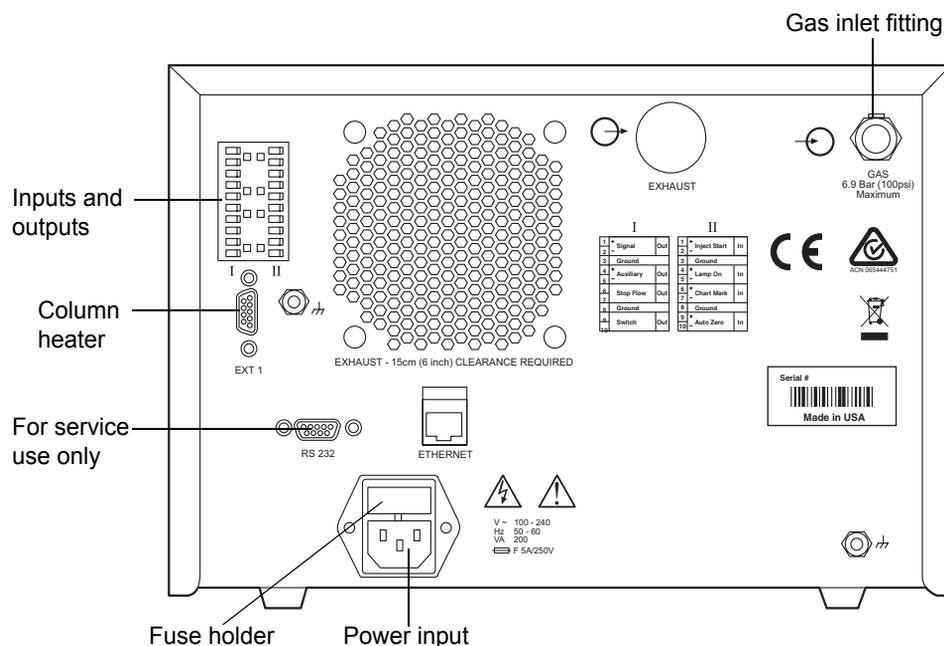
- Use power cord SVT-type in the United States and HAR-type (or better) in Europe. For other countries, contact your local Waters distributor.
- Power-off and unplug the detector before performing any maintenance on the instrument.
- Connect all components of the HPLC system to a common ground.



Warning: For continued protection against fire, replace fuses only with those of the same type and rating.

The detector's two fuses are located above the power input receptacle on its rear panel.

2424 ELS detector rear panel



To replace a fuse in the detector, see [page 4-14](#).

Gas requirements

Use a constant supply of dry, oil-free, filtered nitrogen (or zero-grade, oil-free, filtered air) to operate the detector. Other inert gases can also be used. Use an operating pressure, at the regulator, of between 450 to 690 kPa (4.5 to 6.9 bar, 65 to 100 psi).



Warning: Do not use gases that are not inert. In particular, avoid those that would allow the combustion of combustible solvents and/or the oxidation of samples.



Caution:

- A pressure relief valve vents gas to protect the detector when the input pressure is too high. If you can hear gas leaking from the relief valve, lower the input pressure to avoid wasting gas.
- Gas cylinders are not recommended for extended operation of the detector due to the rapid consumption of gas. For example, a standard tank of nitrogen running a standard flow nebulizer at 170 kPa (1.7 bar, 25 psi) would last approximately 40 hours.

Making the gas supply connection

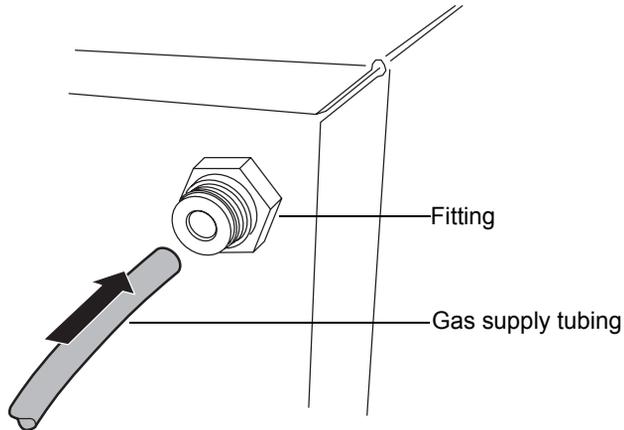
The detector is connected to the gas supply via 6-mm plastic tubing (supplied in startup kit). The tubing attaches to the detector via a fitting on the back of the unit.

To make the gas supply connection

1. Cut the 6-mm tubing squarely (that is, perpendicular to the tubing's horizontal axis).

2. Insert the tubing into the fitting until it bottoms.

Inserting the gas supply tube

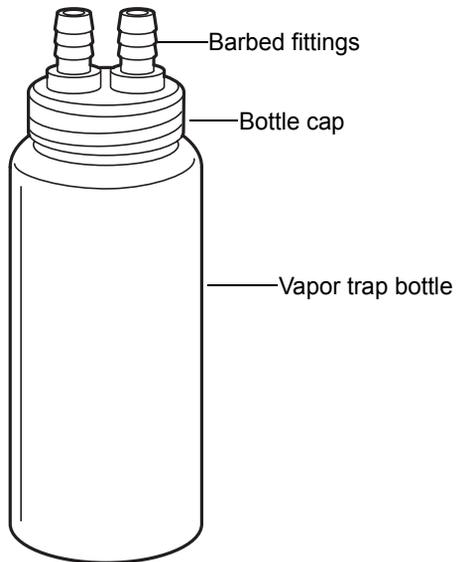


3. Pull the tubing to check engagement of the grab ring.
4. Two pieces of tubing are provided in the startup kit. If you are using the system with an external filter, first connect the gas source to the filter, and then connect the filter to the back of the unit.

Venting the exhaust hose

To properly vent the exhaust vapor to waste, a vapor trap exhaust bottle is provided (startup kit). The vessel traps condensates that form from vented vapor exiting the detector.

Vapor trap bottle



Caution:

- Failure to use the vapor trap could result in too strong a vacuum, which could adversely affect the vapor flow through the drift tube. This could cause loss of sensitivity and excessive high-frequency noise in the baseline.
- To avoid condensate flowing backward into the detector and thus damaging it, run at least 61 cm (24 inches) of the instrument's exhaust hose vertically toward the bench top.

Exhaust Venting Requirements

Requirement: Ensure the instrument's exhaust hose runs straight down, toward the bench top, a minimum of 61 cm (24 inches).

- Attach the vapor trap bottle to the end of the exhaust hose.
- Place the vapor trap bottle's exit hose close to an evacuation source, but do not apply a vacuum.

- Direct the exhaust from the detector into a fume hood or exhaust vent.
- Ensure both hoses are free of restrictions.

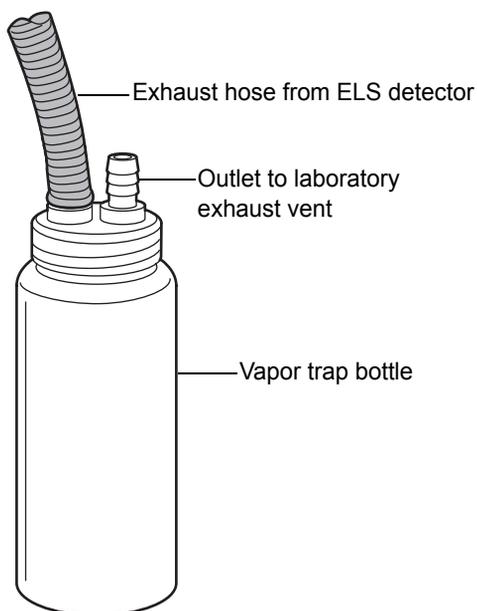


Warning: Inhalation risk. Do not allow detector exhaust to enter the laboratory atmosphere.

To vent the exhaust hose

1. Connect one end of the exhaust hose exiting from the rear of the detector directly onto one of the barbed fittings on the vapor trap bottle.

Vapor trap bottle and exhaust hose



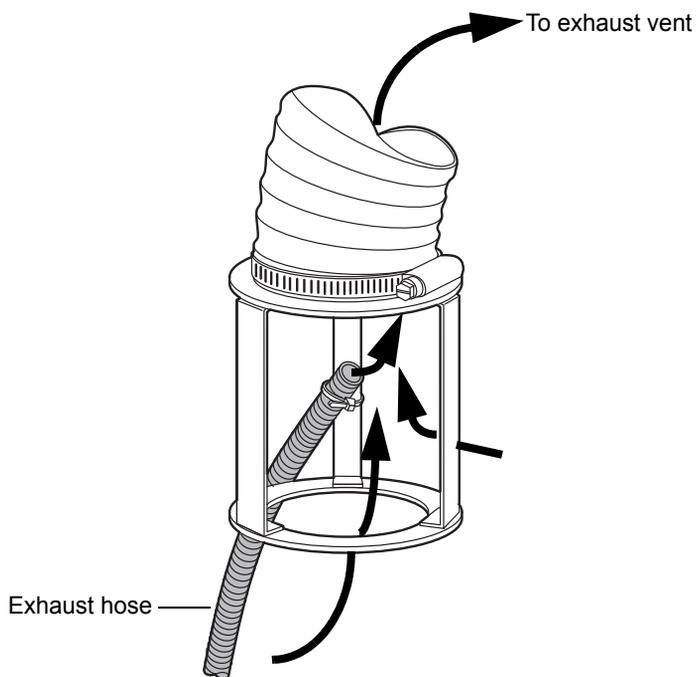
Caution:

- To avoid excessive electronic noise, do not kink the exhaust hose, which creates an unintended trap. The hose must slope downward, without sharply bending, when exiting the detector.
- To avoid operational problems, do not cut the exhaust hose.

2. Using the 1.5 meter (5-foot) hose, attach one end of the tubing to the remaining fitting on the bottle cap.
3. Position the other end of the tubing at a perpendicular angle to a laboratory exhaust system that applies gentle vacuum. There should be a minimum negative pressure of -0.2 kPa (0 bar, -0.03 psi) between the detector and the laboratory exhaust system.

 **Caution:** Avoid placing the tubing end inside the exhaust vent. Doing so will create a stronger vacuum on the gas exiting the detector and likely carry away valuable sample.

Exhaust system flow example



Connecting to the electricity source

The 2424 ELS detector requires a separate, grounded electricity source. The ground connection in the electrical outlet must be common and connected near the chromatographic system.

To connect to the electricity source

Recommendation: Use a line conditioner or an uninterruptible power supply (UPS) for optimum long-term input voltage stability.

1. Place the On/Off switch in the Off position.
2. Connect the female end of the power cord to the receptacle on the rear panel of the detector.
3. Connect the male end of the power cord to a suitable wall outlet.
4. Do not turn the detector on at this time.

Installing the nebulizer assembly

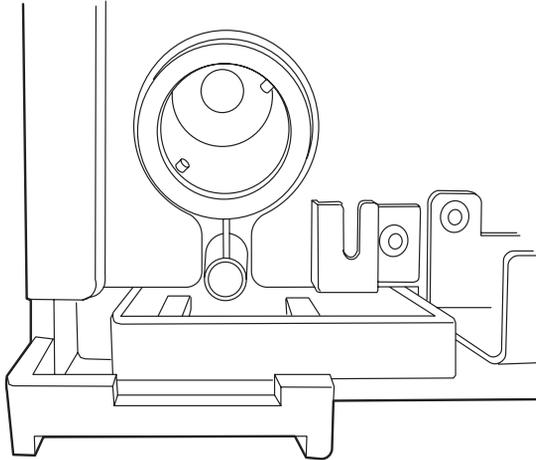
Waters offers two nebulizers for the 2424 ELS detector: a low-flow (for flow rates from 50 to 500 $\mu\text{L}/\text{min}$) and a high-flow (for flow rates from 300 to 3000 $\mu\text{L}/\text{min}$). The high-flow nebulizer is provided as standard equipment.

To install the nebulizer assembly

1. Remove the nebulizer assembly from the shipping container.
2. Slide the packing ring onto the assembly.
3. Remove the protective cap from the assembly.
4. Remove the protective cap from the end of the nebulizer tube.

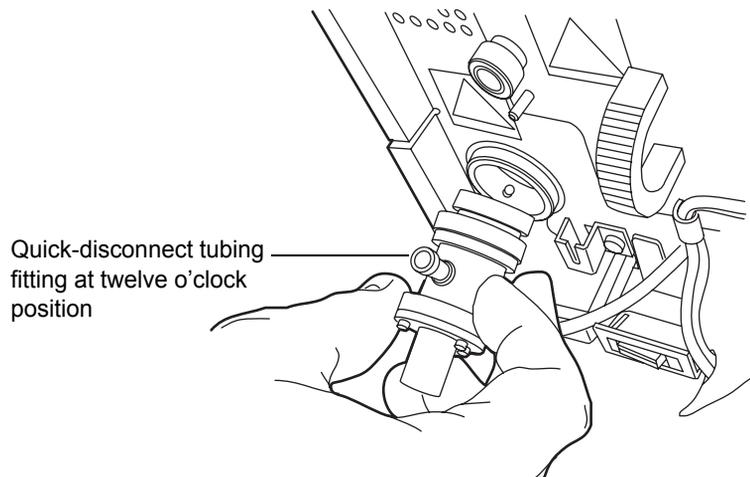
5. Align the two pins inside the nebulization chamber with the grooves in the nebulizer.

Pins inside the nebulization chamber



The quick-disconnect tubing fitting will be at the twelve o'clock position.

Installing the nebulizer



6. Push the nebulizer into the nebulization chamber, and turn it clockwise until it snaps into place.

See also: [“Selecting the type of nebulizer” on page 3-29.](#)

Connecting the siphon drain tubing

Siphon waste is routed down the front or to the rear of the detector via one of two different siphon drain tubes supplied in the startup kit.

Tip: At initial setup, Waters recommends that you fill the siphon with water or mobile phase. Omitting this step delays satisfactory detector performance.

Routing the siphon drain tubing down the front of the detector

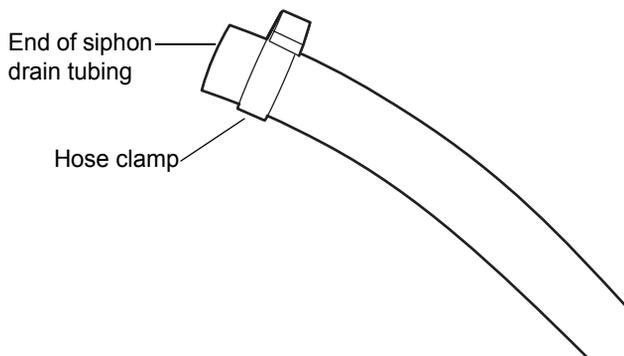
Required materials

- Front siphon drain tubing (in startup kit)
- Hose clamp, to secure front siphon drain tubing to siphon (in startup kit)

To route the siphon drain tubing down the front of the detector

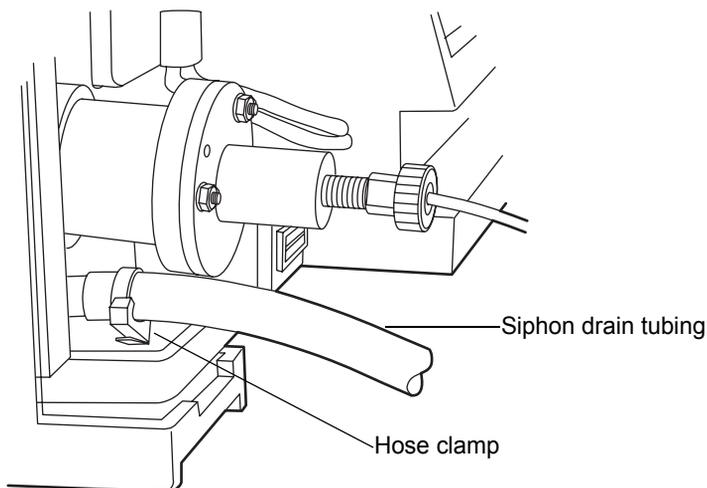
1. Slide the 0.68×0.74 cm ($.269 \times .291$ inches) hose clamp onto the end of the siphon drain tubing.

Hose clamp on end of siphon drain tubing



2. Attach the front siphon drain tubing to the stainless steel siphon drain on the front of the detector and pinch the clamp so that it is snug.

Front siphon drain tubing installation



3. Ensure that the siphon drain tubing is routed to a collection bottle in such a way that condensed solvent can flow freely from the condenser and the end of the tubing is not immersed in the collected liquid.



Warning: To avoid flooding the detector, ensure the siphon drain tubing is not kinked or submerged in the collection bottle.

Routing the siphon drain tubing to the rear of the detector

Tip: The rear siphon drain tubing is intended for use with the optional Waters Alliance bottle tray kit.

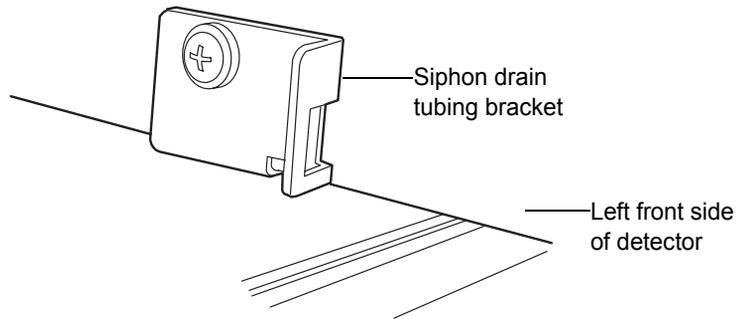
Required material

- Rear siphon drain tubing (in startup kit)
- Convulated tubing (in startup kit)
- Plastic hose clamp (in startup kit)
- Siphon drain tubing bracket (in startup kit)
- Phillips[®] screwdriver

To route the siphon drain tubing to the rear of the detector

1. Using a Phillips screwdriver, remove the front left-hand screw that secures the detector cover.
2. Insert the screw through the hole in the siphon drain tubing bracket, and align the screw and bracket with the hole that you removed the cover screw from.
3. Using a Phillips screwdriver, secure the bracket to the front, left side of the detector.

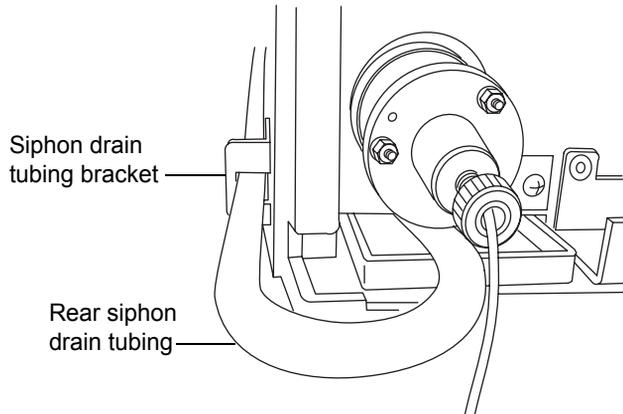
Siphon drain tubing bracket installation



4. Route the rear siphon drain tubing through the siphon drain tubing bracket to the rear of the unit.

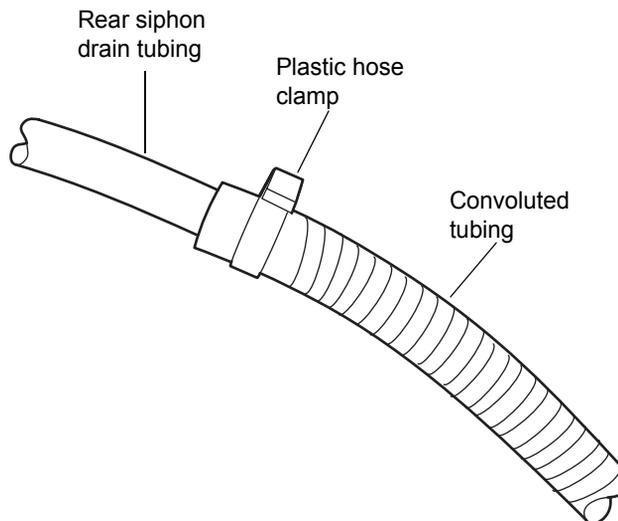
5. Attach the rear siphon drain tubing to the stainless steel siphon drain on the front of the detector.

Rear siphon drain tubing installation



6. Route the other end of the rear siphon drain tubing through the opening in the rear left corner of the detector tray.
7. Attach the convoluted tubing to the rear siphon drain tubing using the plastic hose clamp.

Convoluted tubing attached to rear siphon drain tubing



8. Ensure that the siphon waste tube is routed to a collection bottle in such a way that condensed solvent can flow freely from the condenser and the end of the tube is not immersed in the collected liquid.



Warning: To avoid flooding the detector, ensure the siphon drain tubing is not kinked or submerged in the collection bottle.

Connecting the drip tray

The detector uses a drip tray underneath the nebulizer on the front panel to direct solvent to the front of the unit in the event of a leak.

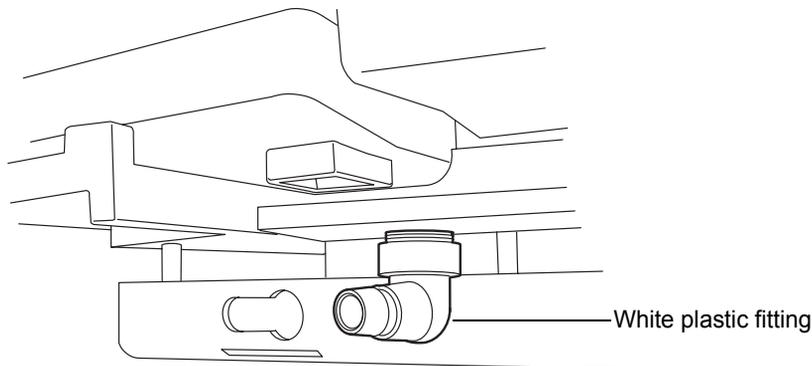
Required materials

- Tubing (not supplied)
- Sharp knife (not supplied)

To connect the drip tray

1. Cut a length of tubing sufficient to reach between the drip tray and the waste container.
2. Connect the tubing to the white plastic fitting located under the nebulizer on the front of the detector.

White plastic fitting under nebulizer



3. Insert the other end of the tubing into the waste container.

Connecting the nebulization gas to the nebulizer



Caution: To avoid contaminating the detector, connect the chromatography system during operation. Gas flow in the nebulizer creates a slight vacuum that can attract solvent or dust from the detector's inlet port.

Insert the gas inlet tubing into the quick-disconnect tubing fitting on the right-hand side of the nebulizer.

Connecting a column or second detector

Tips:

- If your system includes more than one detector, connect the ELS detector so that it is the final detector in the series because it nebulizes the column effluent and exhausts it as gas vapor.
- Do not allow solvent flow to continue if no gas flow is present.



Caution: In order to avoid particulate contamination, you should flush any columns you are connecting to the detector before connecting them.

Required materials

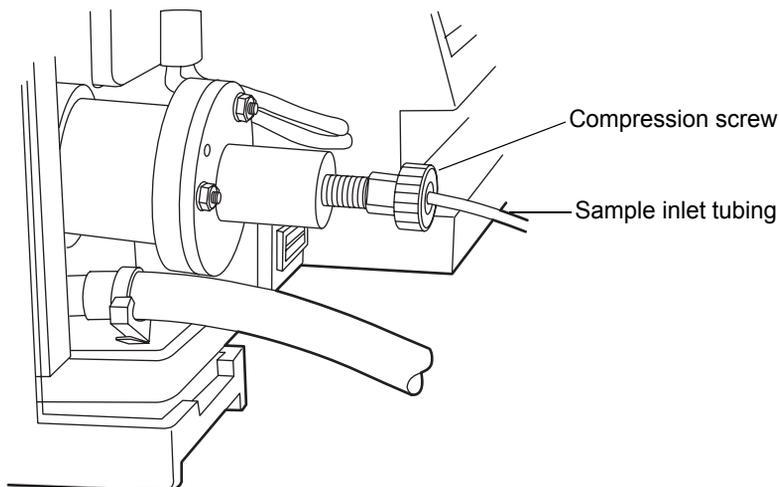
- Sample inlet tubing assembly
- 5/16-inch open-end wrench

To connect a column or second detector

1. Use the sample inlet tubing assembly supplied in the startup kit.

2. Insert one end of the inlet tubing assembly into the fluid fitting on the front of the nebulizer.

Sample inlet tubing connection



3. Tighten the compression screw 1/4-turn past finger tight.
4. Repeat step 2, inserting the other end of the inlet tubing assembly into the outlet fitting of the column or another detector.

Making signal connections

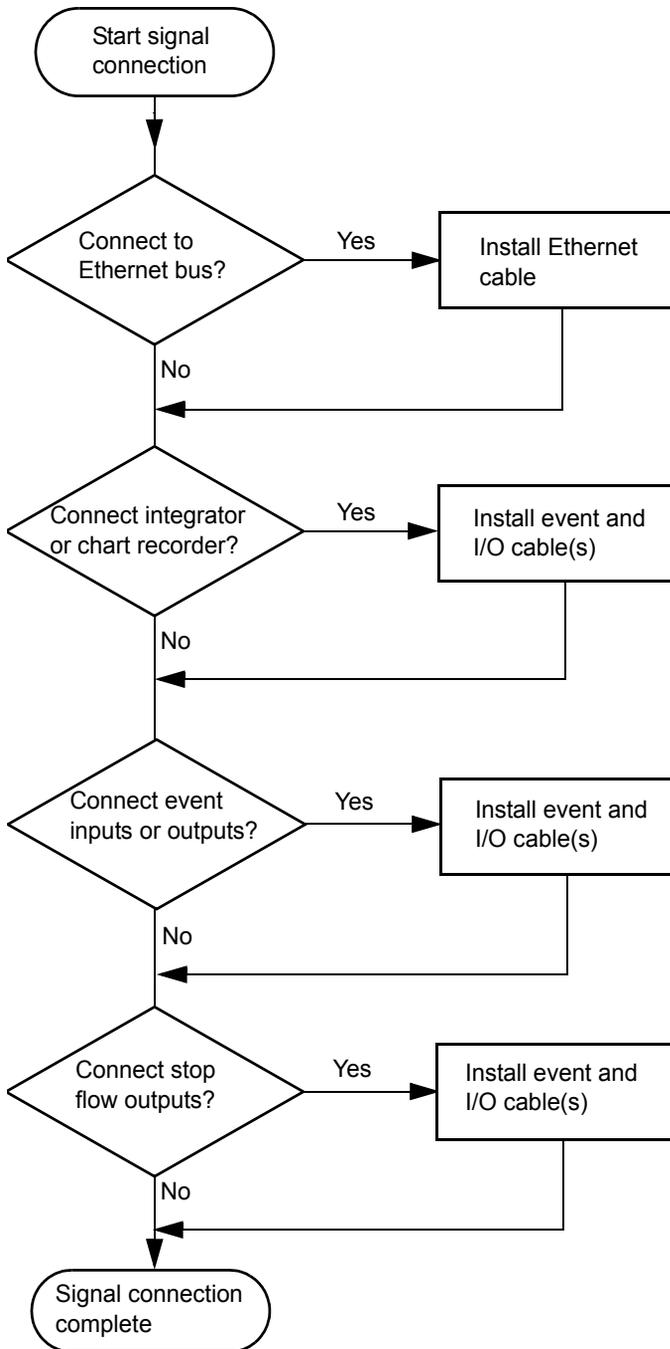
Tip: Connect the detector to other HPLC system components through an Ethernet connection.

The figure on [page 2-6](#) shows the rear panel locations of the connectors used to operate the detector with external devices.

The signal connections you need to make to your detector depend on the signal connections available on the other instruments in your HPLC system.

The following figure provides an overview of the steps to follow to connect the detector to other instruments in your HPLC system.

Connecting components to the detector overview



Connecting the Ethernet cable

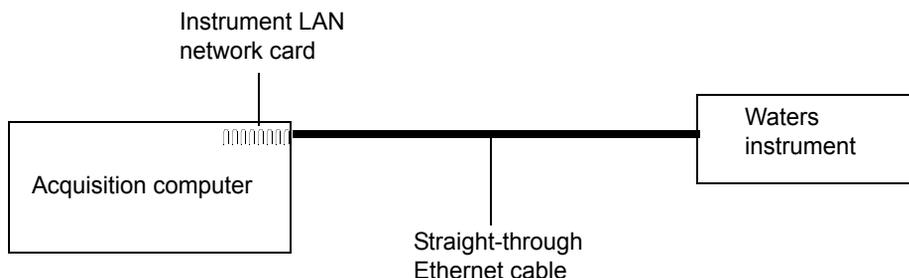
A Waters instrument communicates with the acquisition computer through the dedicated local area network (LAN). At the acquisition computer, the instrument network card provides the interface that makes communication possible.

You must install the Waters instrument software driver in the acquisition computer so that the computer can control the instrument. See the software installation instructions that accompany the instrument control software.

Single Waters instrument connection

In a single Waters instrument system configuration, the connection hardware requires only one standard, shielded Ethernet cable. This cable is contained in the startup kit.

Single Waters instrument connection



Multiple Waters instrument connections

In a system configuration with many Waters Ethernet instruments, an Ethernet switch is required to communicate multiple signals between Waters instruments and the acquisition computer.

Connection hardware requires one standard 100 base-T Ethernet cable per Waters instrument and a standard 100 base-T Ethernet cable to connect between the network switch and the acquisition computer.

You must install the Waters instrument control software in the acquisition computer so that the computer can control the Waters instrument. See the software installation instructions that accompany the software instrument driver disk.

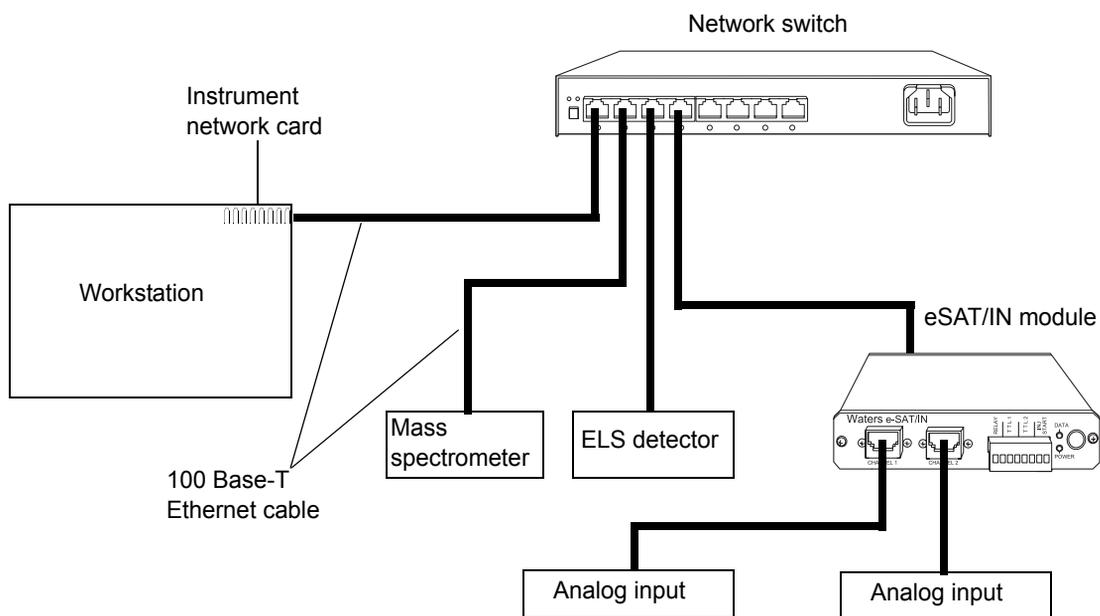
Network installation guidelines

Configurations for multiple Waters instruments use a dedicated LAN, which requires a design based on the following guidelines:

- 100 base-T, 100-Mbps shielded twisted-pair (STP) cable
- A maximum distance of 100 meters (328 feet)

Requirement: You must use a network switch for multiple Ethernet instruments. Use of a network hub in place of a network switch is not supported.

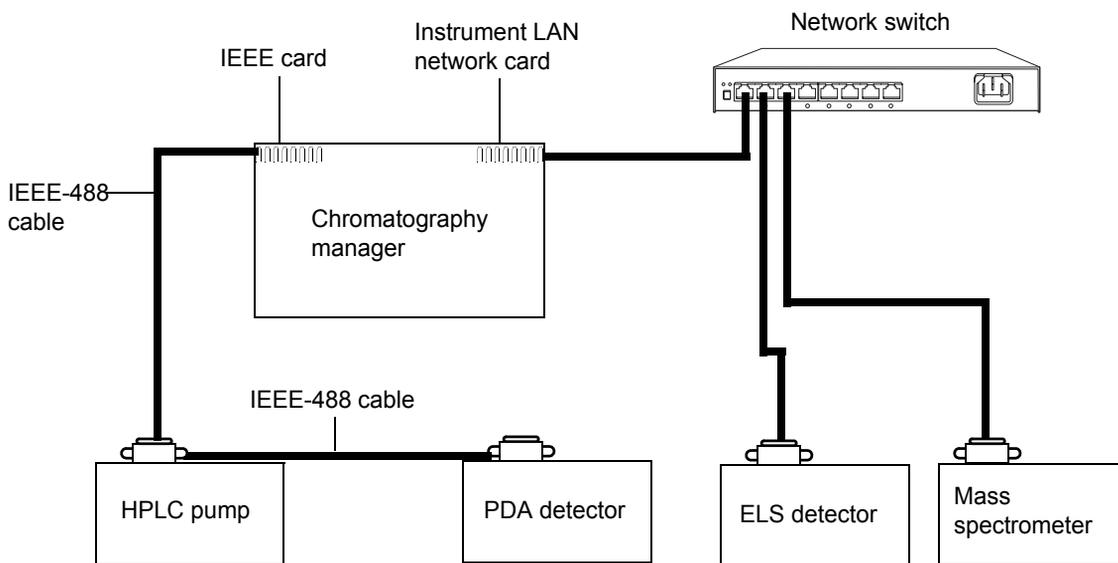
Multiple Waters Ethernet instrument connections



Connecting to a Waters MassLynx system using Ethernet

When connecting to a MassLynx system using Ethernet, the various components should be connected as shown in the figure below.

MassLynx system connections



Making inject start signal connections

When you are using an Ethernet data system with the detector, the data system or controller must receive an inject-start signal from the autosampler or manual injector to initiate the data collection and time-based programs.

The following table summarizes the inject start connections for different system configurations.

Detector inject start connections

Inject start output source	Inject start input connection (on the 2424 ELS detector, connector II)
Waters 700-series	Inject Start In + / -
Waters Alliance Separations Module	Inject Start In
Waters 712 Autosampler	Inject Start In + / -
Waters manual injector, or third-party manual injector or autosampler	Inject Start In + / -

Tip: For pinout connections to the detector, see [page 2-26](#).

Note: If the injector is an e2695 separations module running in Ethernet mode or a 2707 autosampler, then the inject start cable should not be connected. However, if the injector is an e2695 separations module running in IEEE mode, then the inject start cable should be connected.

Connecting to a manual injector

If you are using a manual injector with your system, connect the signal cables from the rear panel connector on the detector to the injector as shown in the following table.

Detector connections to a manual injector

2424 ELS detector (connector II)	Manual injector
Inject Start In + (red)	One set of spade lug Inject Start terminals
Inject Start In – (black)	

For information on injection trigger signals from a manual injector, see [page 2-31](#).

Connecting to other instruments

To connect the detector to other instruments, use the two analog-out/event-in (I/O) connectors and their corresponding pin-outs on the rear panel.

This section describes signal connections between the detector's rear panel and these items:

- Waters Alliance Separations Module
- Waters 1500-series pump
- Waters SAT/IN™ Module
- Waters, or other, manual injector
- Waters autopurification system
- Other manufacturer's integrator or A/D interface device



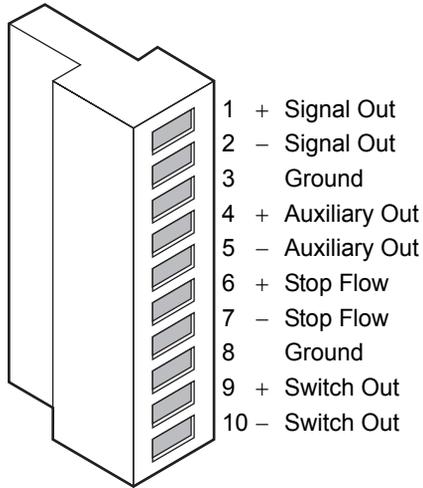
Warning: To avoid electrical shock, power-off the detector before making any electrical connections.

Requirement: To meet the regulatory requirements of immunity from external electrical disturbances that can affect the performance of this

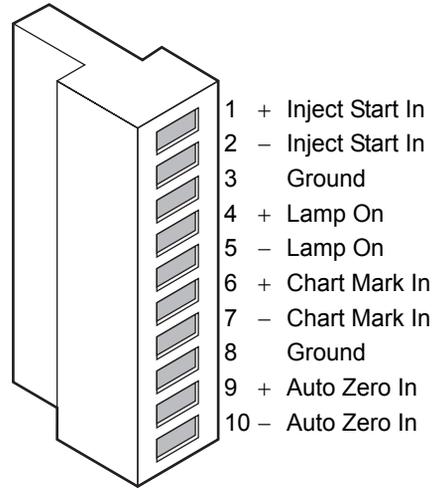
instrument, do not use cables longer than 3 meters (9.8 feet) when you make connections to the I/O connectors. In addition, ensure you connect the shield of the cable to ground at one instrument only.

2424 rear panel analog-out/event-in connectors

Connector I (outputs)



Connector II (inputs)



The following table describes the detector I/O connections.

Detector analog-out/event-in connections

Signal connections	Description
Inject start in	Activates timed events by triggering the run-time clock to start.
Lamp on	Enables and disables the lamp. When the input is active, the lamp is on.
Chart mark in	Adds a chart mark (at 10% of full scale) to either or both analog output channels (Signal Out 1 and Signal Out 2) and is configurable.
Auto zero in	Calculates an offset value that, when added to the sample signal, makes the resulting baseline signal zero.

Detector analog-out/event-in connections (Continued)

Signal connections	Description
Signal out	Provides a high resolution analog output for the sample signal. Output voltage range: –0.1 to 2.1 VDC (selectable maximum data rates are 10, 20, 40, or 80 Hz).
Auxiliary out	Monitors the nebulizer, drift tube, column heater temperature, or gas pressure and is programmable. Output voltage range: –0.1 to 2.1 VDC (fixed maximum data rate is 10 Hz).
Stop flow	Stops the flow to the chromatographic system when a low input gas pressure condition, temperature control error condition, or lamp failure occurs.
Switch out	Controls a timed event or threshold level and is a user-programmable auxiliary output.

Generating inject start

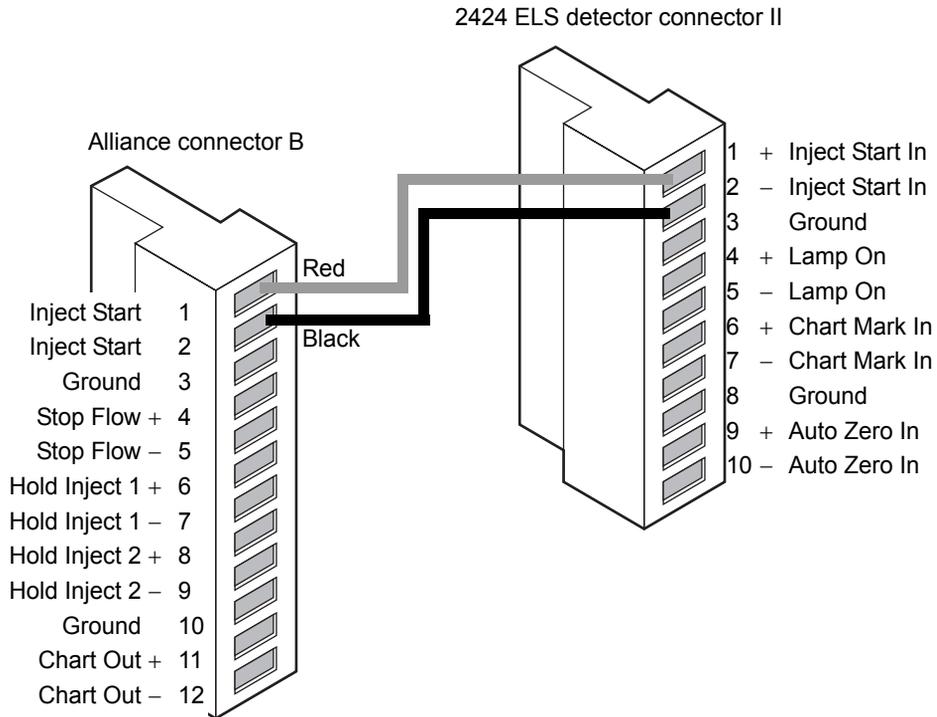
To generate the inject start function on the detector at the start of an injection from the Alliance Separations Module, make the connections shown in the following table and figure.

Tip: The firmware defaults to auto zero on inject.

Detector connections to an Alliance separations module

Alliance separations module (connector B)	2424 ELS detector (connector II)
Pin 1 inject start (red)	Pin 1 inject start in + (red)
Pin 2 inject start (black)	Pin 2 inject start in – (black)

Inject start connections between the Alliance separations module and the detector



Generating stop flow

The detector has a dedicated switch output, called “stop flow” that becomes active when a heater, gas flow, or lamp failure occurs.

To use the stop flow function, make the connections shown in the following table and figure.



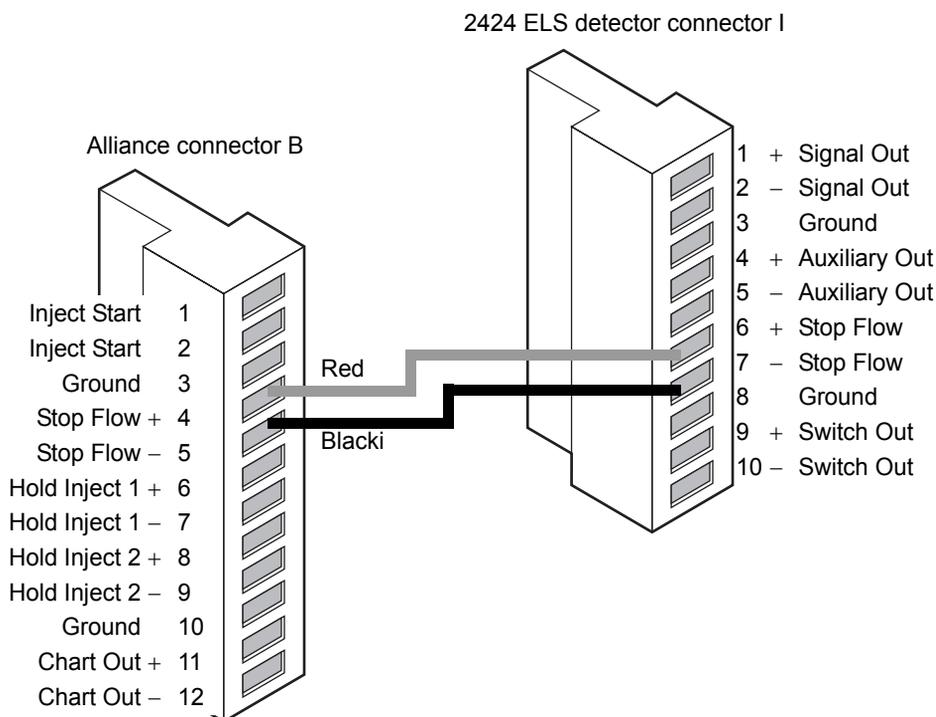
Warning: Fire and explosion hazard. Failure to connect the stop flow output could cause the detector to flood.

Requirement: To automatically stop the chromatographic flow to the system in the event of an error condition or hardware failure, the Stop Flow signal must be connected to the chromatographic pump.

Detector connections to an Alliance separations module

Alliance separations module (connector B)	2424 ELS detector (connector I)
Pin 4 stop flow + (red)	Pin 6 stop flow + (red)
Pin 5 stop flow – (black)	Pin 7 stop flow – (black)

Stop flow connections between the Alliance separations module and the detector



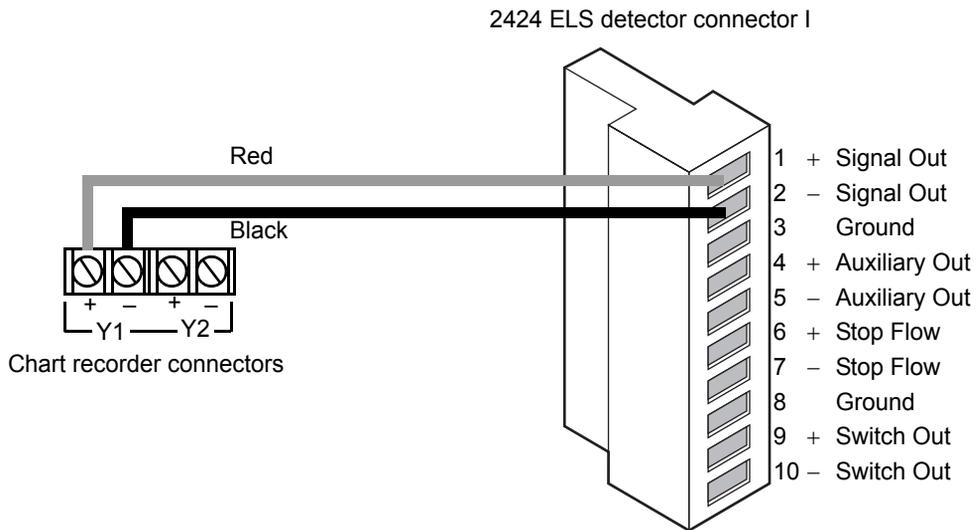
Connecting to a chart recorder or external analog data collection device

To send an analog output signal from the detector to a chart recorder, make the connections shown in the following table and figure.

Analog output connections to a chart recorder

Chart recorder connectors	2424 ELS detector (connector I)
Pen 1 +	Pin 1 signal out + (red)
Pen 1 -	Pin 2 signal out - (black)
Tip: For this connection, do not use the cable shield. Tape back the shield. Tape back the shield to prevent it from causing a short circuit.	

Analog output connections to a chart recorder



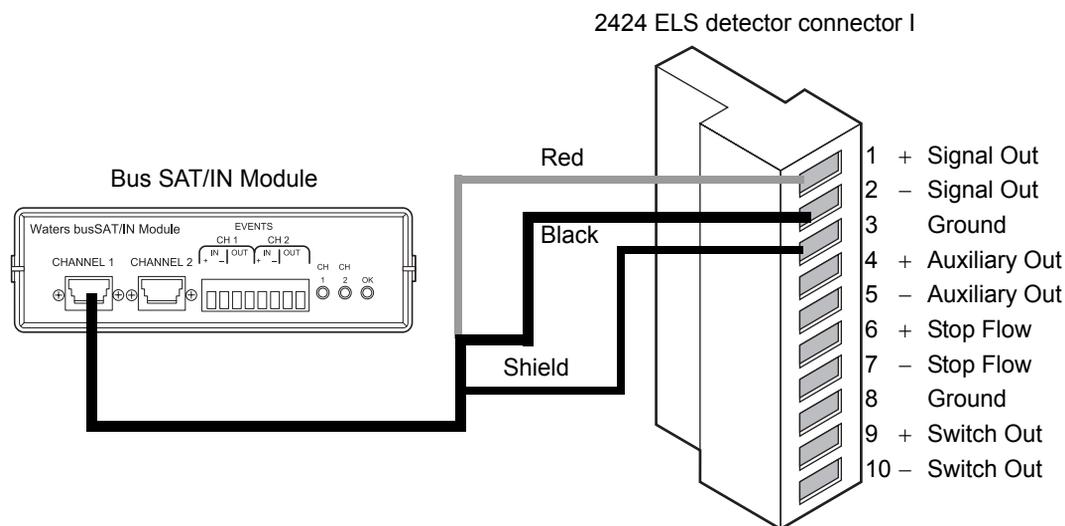
Connecting to a Millennium data system using a busSAT/IN module

To send an integrator analog output signal (–0.1 to +2.1 V) from the detector to a Millennium System (through a two-channel SAT/IN Module), make the connections shown in the following table and figure.

Detector connections to the busSAT/IN module

SAT/IN module connector	2424 ELS detector (connector I)
CHANNEL 1	Pin 1 signal out + (white)
	Pin 2 signal out – (black)

Analog output connections to the busSAT/IN module



Connecting injection trigger signals

The detector accepts the following injection trigger signals from a manual injector:

- Inject start signal from a contact closure signal with each injection
- Auto zero signal to adjust the zero offset of the detector each time the injector makes an injection

Each time the detector receives a signal from an injector, it performs the corresponding auto zero or Inject Start function.

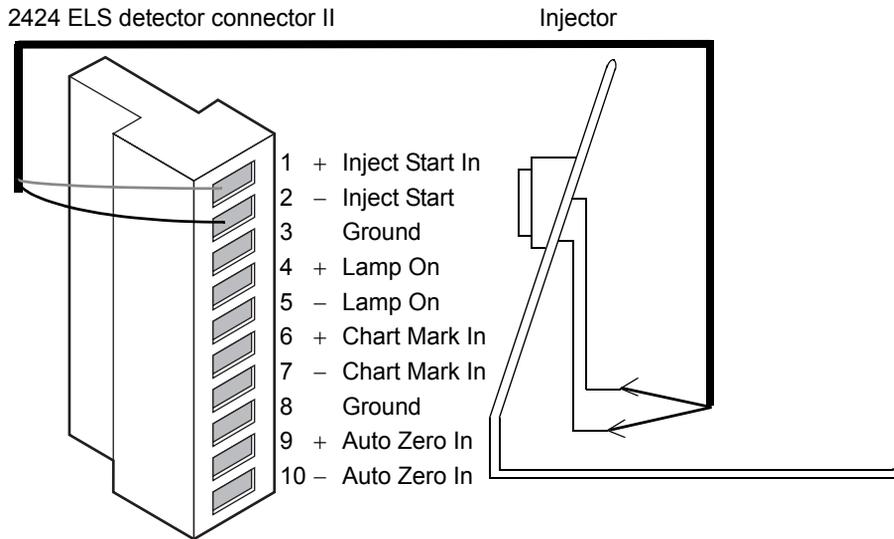
To send an auto zero or chart mark signal from an injector to the detector, make the connections shown in the following tables and figures.

Tip: The firmware defaults to auto zero on inject.

Inject start connections to an injector (pulse duration 0 to 10 seconds)

2424 ELS detector (connector II)	Injector connector
Pin 1, inject start in + (red)	Two spade lug terminal connectors (both cables may be functionally identical) or similar connectors.
Pin 2, inject start in – (black)	

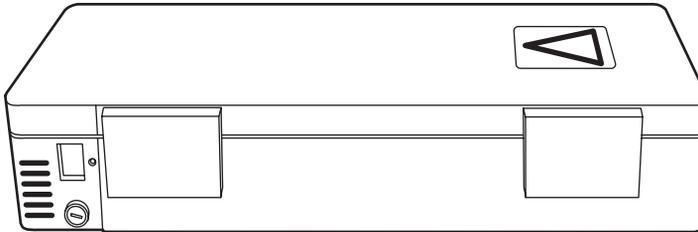
Inject start connections to an injector



Connecting the Waters column heater module

The detector can control one Waters column heater module through the EXT port on the rear panel of the detector. The port is a standard, 9-pin, D-type connector.

Waters column heater module



3

Operating the Detector

Contents:

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Starting up the detector	3-2
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Navigating the user interface	3-13
Preparing to start a run	3-15
Setting up a run	3-17
Configuring the detector	3-26
Operating the detector	3-30
Programming methods and events	3-34
Conserving lamp life	3-41
Changing chromatographic conditions	3-43
Shutting down the detector	3-44
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After you install the detector, you are ready to set it up and operate it either as a standalone instrument or as part of a data system.

- As a standalone instrument – Use the detector as a standalone detector within a system, such as the Waters Alliance system, or with any fluid-handling unit, injector, integrator, or data system. You can program the front panel of the detector for standalone operation (see [page 3-31](#)).
- As part of an Empower System – Use the detector configured with an Empower system to control and collect digital data. To configure the detector with this system, follow the instructions in the Empower online Help to specify parameters and control the detector.
- As part of a MassLynx System – Use the detector configured with a MassLynx system. To configure the detector with a MassLynx system, follow the instructions in the MassLynx documentation to set the parameters and control the detector.

Starting up the detector

Initializing the detector

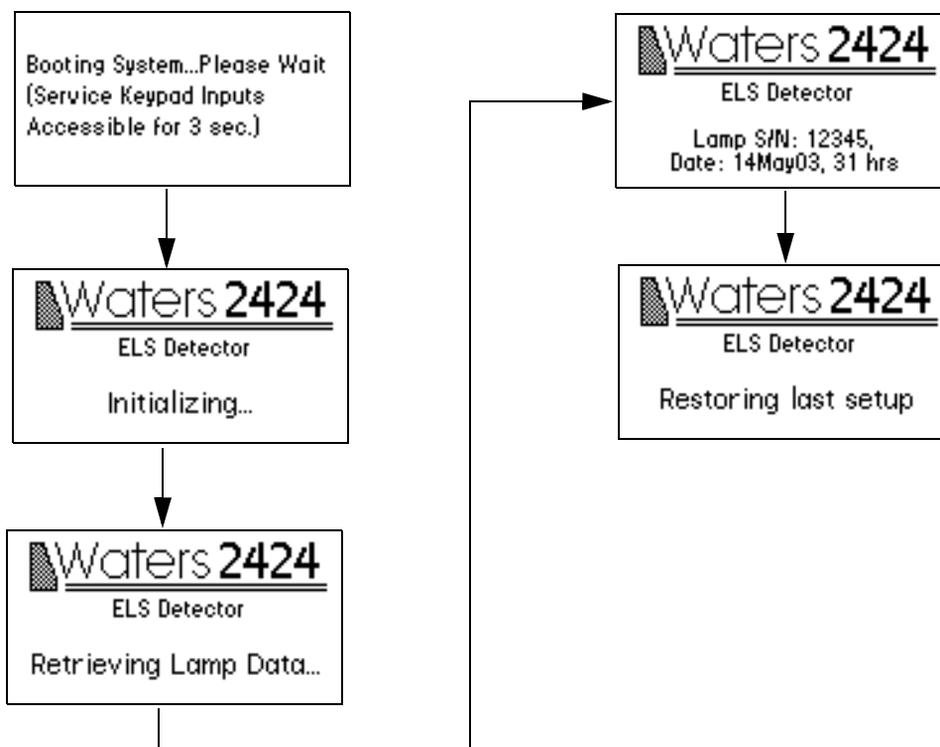
Before you power-on the detector, turn the gas supply on. Ensure the power cord connector that runs from the detector's rear panel to the power source is properly installed.

Tip: If you do not turn the gas supply on before you turn the detector power on, the detector will display an error message.

To power-on the detector, press the On/Off switch located on the front lower-right corner of the detector.

At startup, the detector beeps three times, displays the message “Booting System... Please Wait,” and runs a series of startup confidence tests. The initialization screens appear in the order shown in the following figure.

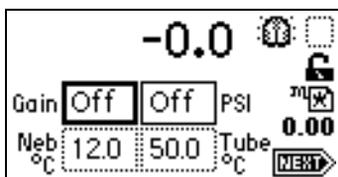
Detector startup screens



Tip: Service keypad inputs are coded for use only by Waters Service Engineers for troubleshooting.

When initialization is complete, the detector displays the Home screen (see [page 3-7](#) and [page 3-13](#)).

Detector Home screen



Tip: For normal use, allow the detector to warm up at least 60 minutes before operating.

If confidence tests fail

If one or more of the confidence tests fail during initial startup, the detector behaves as follows:

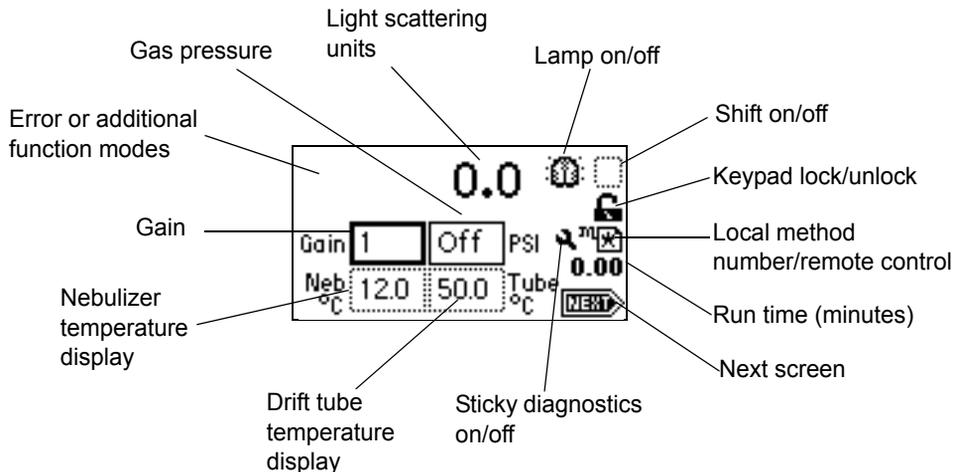
- Beeps
- Displays an error message
- For serious errors, displays the word “Error” in brackets (<Error>) in place of the runtime light scattering units on the Home screen.

See “Startup error messages” on page 5-2, for a list of startup confidence tests failures, error messages, and recommended recovery actions. Error messages that can appear as you operate the detector and suggested corrective actions are described in the table on page 5-17. See page 5-14 for hardware-related causes of confidence tests failure during startup and their corrective actions.

Using the display

The detector employs a 128 × 64 bitmap graphic display and a 24-key membrane keypad for the operator interface. After the startup confidence tests have run successfully, the detector displays the Home screen.

Detector Home screen



You can recall the Home screen at any time by pressing HOME. At the first use of the detector, the Home screen shows the default settings for the gain and pressure.

The detector monitors performance in units of light scattering in real time, allowing you to modify all the parameters discussed in the table in the next section.

Detector Home and Message screen icons

The detector Home and Message screens display the icons or fields shown in the previous figure. For a list of the ranges and defaults for these icons and fields, see the following table.

Detector Home and Message screen icons

Icon or field	Icon/field name	Function
	Gain	Selects the gain setting. Regular field.
PSI	Gas pressure	Displays the current gas pressure and allows you to enter a new gas pressure value.
Neb °C	Nebulizer temperature	Displays the current temperature of the nebulizer.
Tube °C	Drift tube temperature	Displays the current temperature of the drift tube.
0.0	LS units	Displays the current light scattering units.
	Lamp on	Indicates the lamp is on.
	Lamp off	Indicates the lamp is off.
	Shift off	Blank = Shift off
	Shift on	Indicates shift is on for one key press.

Detector Home and Message screen icons (Continued)

Icon or field	Icon/field name	Function
	Keypad unlock	Indicates unrestricted keypad entry.
	Keypad lock	Indicates parameter changes are not allowed; instrument is running a method.
	Sticky diagnostic on	Indicates a sticky diagnostic is active (see page 5-2).
	Local method number	Indicates that the detector is not controlled by a data system. It displays either a cursive “m” and the current method number or an asterisk (*), which indicates current conditions are not stored as a method.
	Remote control	Indicates that the detector is controlled by a data system, and displays a remote control icon.
0.00	Run time	Displays how many minutes elapsed since you pressed Run or since an inject start signal was received.
	Next	Indicates that pressing Next brings you to additional screens.
	Message screen icon	Indicates an error message.
	Message screen icon	Indicates a question.
	Message screen icon	Indicates a warning message.

Detector Home and Message screen icons (Continued)

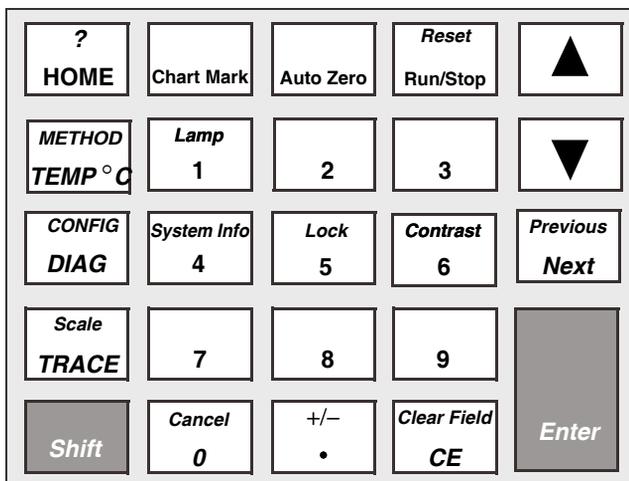
Icon or field	Icon/field name	Function
	Message screen icon	Indicates information is being displayed.
	Message screen icon	Indicates that you should standby.

Using the keypad

The detector's 24 keys carry out these functions:

- Full numeric entry – 10 digits plus a decimal point.
- Global functions – Enter, Shift, CE (Clear Entry), Next, and ? (Help).
- Navigation – ▲ and ▼ (used for navigation only; pressing ▲ may also move you to the left, ▼ to the right).
- Direct access to specific screens – HOME, TEMP ×C, METHOD, CONFIG (Configure), DIAG (Diagnostics), and TRACE.
- Primary function keys – Chart Mark, Auto Zero, Run/Stop, and Next. Primary function keys take effect immediately, with no further entry required.
- Secondary function keys – Reset, Lamp, Lock, System Information, Contrast, Previous, Cancel, +/-, and Clear Field. You must enter information into parameter fields and then press Enter.

Detector keypad



Keys labeled in an all-capital-letter style (HOME, METHOD, TEMP °C, CONFIG, DIAG, and TRACE) take you directly to a function from most screens.

Select a numeric entry on a choice list or menu as follows:

- For numeric entries from 1 to 9 (inclusive) on choice lists or menus, specify the number corresponding to the desired item, then press Enter.
- For the number 10, select 0, and then press Enter.
- To go to the end of a choice list, press •.
- For entries numbered 11 or 12, press the ▲ or ▼ key to scroll to the desired item on the choice list, and then press Enter.

Tip: The ▲ and ▼ keys do not increase or decrease the values in numeric fields. To change field entries, use the numeric keypad.

The following table explains the functions of the primary and secondary keys on the detector keypad.

Keypad description

Key	Description	
	Unshifted	Shifted
	HOME – Displays the Home screen containing icons and the gas pressure, Gain, Nebulizer, Drift Tube, and Light Scattering fields.	? – Displays context-sensitive Help when available.
	Chart Mark – Causes a momentary pulse to the analog output and digital data.	
	Auto Zero – Sets the light scattering offset so that the signal light scattering output reads 0 LSU.	
	Run/Stop – Starts or stops (pauses) the run clock. The elapsed time appears near the lower, right-hand corner of the Home screen.	Reset – Resets the detector run clock to zero minutes and returns the detector to initial conditions for the current method.
 	▲ and ▼ – Displays the active field, displaying a heavy border on screens with entry fields (edit, check box, or choice list). The arrow keys make a different field active. (▲ moves up or leftward; ▼ moves down or rightward.) On screens with a scrollable list, these keys move the highlight upward (toward the beginning of the list) or downward (toward the end). Other screens can have special instructions for using the ▲ and ▼ keys (for example, the Display Contrast screen).	

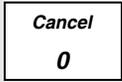
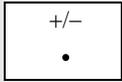
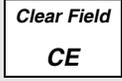
Keypad description (Continued)

Key	Description	
	Unshifted	Shifted
<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 0 auto;"> <i>Previous</i> Next </div>	Next – Displays a screen with additional options related to the current screen. Repeated pressing of this key returns you to where you started. On most screens where this key is active, the NEXT arrow appears in the lower, right-hand corner of the display.	Previous – Navigates through the screens in reverse order when the Next key is available.
<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 0 auto;"> METHOD TEMP °C </div>	TEMP °C – Displays the Temp °C screen, with which you set the nebulizer power factor for heating, turn cooling on, and specify the drift tube temperature.	METHOD – Displays the list of options for creating and clearing timed and threshold events and storing, retrieving, and resetting methods.
<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 0 auto;"> CONFIG DIAG </div>	DIAG – Displays the list of diagnostic routines.	CONFIG – Displays the first Configuration screen.
<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 0 auto;"> <i>Scale</i> TRACE </div>	TRACE – Displays the light scattering monitor trace for the channel.	Scale – Provides you with the means to modify the display range in the X (time) and Y (LSU) dimensions when the light scattering trace is visible.
<div style="border: 1px solid black; padding: 2px; width: fit-content; margin: 0 auto;"> Shift </div>	Shift – Enables the shifted functions (identified by the text at the top of most keys). The shifted state is temporary (for one keystroke only) and resets after the next keystroke.	

Keypad description (Continued)

Key	Description	
	Unshifted	Shifted
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> 0 - 9 </div>	0-9 – Enters the corresponding number into a current field. Also positions the cursor at the corresponding entry in a list (0 = tenth item). Selects the corresponding number from a choice list.	0-9 – See descriptions for specific, shifted numeric keys.
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> <i>Lamp</i> 1 </div>	1 – See 0-9 above.	Lamp – Displays the lamp use statistics for a currently installed lamp, and provides the means to turn the lamp on or off. The current state of the lamp is indicated by an icon on the Home screen.
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> <i>System Info</i> 4 </div>	4 – See 0-9 above.	System Info – Displays system information including software version, checksum, and instrument serial number.
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> <i>Lock</i> 5 </div>	5 – See 0-9 above.	Lock – Enables or disables the keypad lock feature when you are on the Home screen. Use the lock to prevent inadvertent changes to detector settings. The current lock state is indicated by an icon on the Home screen.
<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> <i>Contrast</i> 6 </div>	6 – See 0-9 above.	Contrast – Permits adjustment of contrast (viewing angle) of the liquid crystal display.

Keypad description (Continued)

Key	Description	
	Unshifted	Shifted
	0 – See 0-9 above.	Cancel – Backs out of a prompt without completing the task. The word “Cancel” appears as a cue in the lower, right-hand border of the message.
	<ul style="list-style-type: none"> • – Enters a decimal point. Also positions the cursor at the last entry in a list. 	+/- – Enters a positive/negative sign. Use this function to invert the sign of the number in the active field.
	CE – Clears an editing change and returns the contents of a field to its previous value. Sets the value to a unique word for some fields. For example, in the voltage offset diagnostic, you may either enter a numeric offset value or press CE to change it to Off.	Clear Field – Blanks the current entry field before you enter the desired values.
	Enter – Completes the entry in an edit field. Also advances the active field as if ▼ had been pressed (except after you edit the wavelength on the Home screen). Press Enter to acknowledge error messages and other prompts; the word “Enter” appears as a cue in the lower, right-hand border of the message.	

Tip: The detector does not have a polarity setting because the detector signal measures and outputs either concentration/mass or temperature, which are always positive numeric values.

Navigating the user interface

When operating the detector:

1. Press Enter or ▲ and ▼ to navigate among editable fields. A heavy border appears around the active field after you complete an entry.
2. Press Enter to advance to the next active field.
3. If you make an error, press CE (Clear Entry) to undo any changes and return to the active entry field.
4. An active field containing a choice list has a number to the right of the field within the thick border. To display a choice list, press Enter, and then take one of these actions:
 - Press the corresponding number key to select an item immediately.
 - Use ▲ and ▼ to scroll through the list, and then press Enter.

Tips:

- If you know the number corresponding to the desired choice, you can press that number without pressing Enter first.
- The ▲ and ▼ keys do not increase or decrease numeric fields. To change field entries, use the numeric keypad.

Navigating to and from the Home screen

Pressing HOME brings you to the Home screen from most screens. From the Home screen, you can access the following secondary functions by pressing Next:

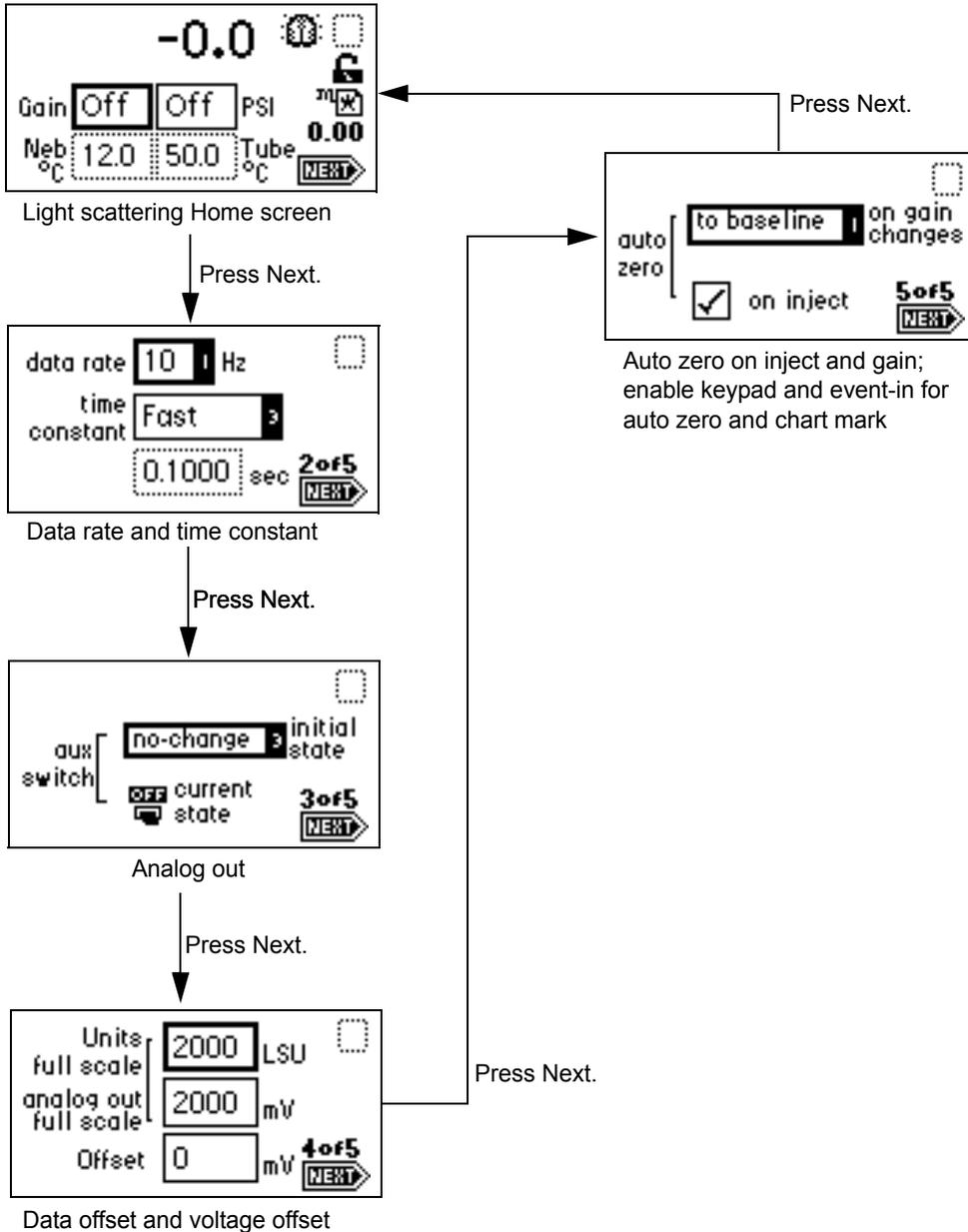
- Data rate and filter time constant
- Enable/disable auxiliary switch output
- LSU offset (data offset)
- Maximum voltage output
- Voltage offset
- Enable/disable and select the auto zero function

Tip: The parameters you enter into the secondary function fields become part of the current method conditions and are stored when you store the method.

See also: [“Programming methods and events” on page 3-34.](#)

When you press Next, the detector displays four additional Home screens, labeled 2 of 5, 3 of 5, 4 of 5, and 5 of 5.

Secondary functions of the Home screen



Preparing to start a run

You must set up the detector before you can start a run to make light scattering measurements with a detector. To start a run, you can press Run/Stop or trigger the detector by means of the inject start terminals on the rear panel. When you start a run, the detector performs an auto zero function (if enabled).

Tip: The auto zero on inject function must be enabled (default) for the detector to perform an auto zero.

Primary and secondary functions

Access the primary and secondary functions via the Home screen or by pressing Next.



Caution: Changing the sensitivity (LSU-FS) setting affects only the 2-V output. The digital output at the Ethernet connector remains unchanged.

Gain – Controls the full-scale sensitivity of the detector by defining the gain factor from 1 to 1000. Each gain setting has a linear relationship with the actual light scattering signal.

Gas pressure – Gas pressure is controlled at the nebulizer by a pressure regulator. This function monitors the condition of gas flow through the nebulizer. For the high-flow and low-flow nebulizers, the maximum gas pressure is 410 kPa (4.1 bar, 60 psi).

Filter time constant – Allows you to adjust the noise filter (time constant) to achieve the optimum signal-to-noise ratio.

Primary and secondary function (method) parameters

Function	Units	Range	Default
Data rate	Hz	10, 20, 40, or 80 Hz	10 Hz
Gain		0 to 1000	0
Filter time constant	sec	0 to 5.0 sec	1.0 sec
Sample full-scale	LSU	0.1 to 2000.0 LSU	2000 LSU

Primary and secondary function (method) parameters (Continued)

Function	Units	Range	Default
Sample offset	mVDC	±2000 mVDC	0 mVDC
Lamp state		On, off	On
Gas pressure	PSI	Off, 140 to 400 kPa (1.4 to 4.0 bar, 20 to 60 psi)	Off
LSU-FS	LSU-FS	10 to 2000	2000 LSU
Analog out	mV	10 to 2000	2000 mV
Auto zero on inject		YES, NO	YES
Auto zero on gain change		Disable, Zero, Maintain Baseline	Maintain Baseline
Nebulizer heater level	% Heating, Cool, Off	Heater level, 0 to 100 or Cool	Cool
Drift tube heater set-temp	°C	Off, 5 to 100 °C	Off
Drift tube heater alarm band	°C	±5 to 25 °C	±20 °C
Column heater set-temp	°C	Off, 5 to 150 °C	Off
Column heater alarm band	°C	±5 to 25 °C	±20 °C
Temperature source		Drift Tube, Nebulizer, Column	Nebulizer
Temp output offset	mV	±2000 mV	0 mV
Threshold level		Off, 0 to 2000	Off

Primary and secondary function (method) parameters (Continued)

Function	Units	Range	Default
Threshold switch mode		On, Off, Pulse, Rectangular Wave	On
PULSE switch mode period	sec	0.1 to 60.0 sec	0.1 sec
RECT WAVE switch mode period	sec	0.1 to 60.0 sec	0.2 sec
Number of timed events		0 to 50	0

Setting up a run

Start a run by pressing the Run/Stop key. Before starting a run, you must set the detector operating parameters before data can be acquired.

To set up a run

1. Press HOME to return to the Home screen.
2. Set the drift tube heater temperature (see [page 3-18](#)).
3. Set the gain and gas pressure (see [page 3-19](#)).
4. Equilibrate the detector for about an hour.
5. Make sure the stop flow output switch is reset (see [page 3-21](#)).

You need to program several other parameters, depending on the functions you want to perform during a run. See [page 3-15](#) for function descriptions, fields, screen number, type of function, display units, allowable ranges, and default settings for the Home screen and the secondary function screens. You can view the properties of common chromatographic solvents in the table on [page 6-4](#).

Setting the nebulizer and drift tube temperature

The nebulizer cooler cools the nebulizer tube wall providing a cold surface for mobile phase eluent droplets to condense and flow to waste. This reduces the amount of solvent that is sprayed into the drift tube in the vaporization process and allows the drift tube temperature to run lower, therefore increasing the sensitivity of semi-volatile samples.

The nebulizer heater, which is regulated by a heater power level setting, is located in the same oven as the drift tube heater. The nebulizer heater allows preheating of the sample solution to the set heater power level via a resistive heat wrap that surrounds the nebulizer tube.

From the Nebulizer and Drift Tube Temperature Control Home screen, you control the nebulizer heater, nebulizer cooler, and drift tube heater temperature independently.

Tips:

- The drift tube temperature must be sufficiently high to remove all solvent; otherwise, detector noise occurs.
- Too high a drift tube temperature can vaporize the sample and cause loss of sensitivity.
- The nebulizer temperature must be at least 5 °C below the drift tube temperature.

To set the nebulizer and drift tube temperature

1. Press Temp °C.

Result: The Nebulizer Heater/Cooler and Drift Tube Heater Temperature Control Home screen appears.

Nebulizer and Drift Tube Temperature Control Home screen

	Neb Htr/Clr	Tube Temp	
set	Cool	Off	°C
cur. temp	12.0	50.0	°C
	limit (+/-)	20	1 of 2 NEXT

2. To toggle between Heating %, Cool, and Off, press CE when the “set” field is active:
 - a. If you selected Heating %, you must specify the nebulizer heater power level setting in the set field. You can now view any nebulizer temperature changes in the “cur. temp” field.
 - b. If you selected Cool, thereby turning on the nebulizer cooler, you cannot enter any values in the “set” field. However, you can view any nebulizer temperature changes in the “cur. temp” field.

Tip: The Cool setting is the default.
 - c. If you selected Off, both the nebulizer heater and cooler are turned off.
3. Specify the drift tube heater temperature in the “set” field.



Warning: The flash point is the lowest temperature at which a flame can propagate through the vapor of a combustible material to its liquid surface. A chemical’s flash point is determined by the vapor pressure of the liquid. Only when a sufficiently high concentration is reached, can a solvent vapor support combustion (see [page 6-4](#) for the flash points of common solvents).

Setting the gain and gas pressure

The gain setting controls the full-scale sensitivity of the detector by defining the gain factor from 1 to 1000. Each gain setting relates linearly with the actual light-scattering signal. The gas pressure setting monitors the condition of gas flow through the nebulizer. For the high-flow and low-flow nebulizers, the maximum gas pressure to 410 kPa (4.1 bar, 60 psi).



Caution: To avoid flooding the nebulizer and detector, Waters recommends leaving the nebulizer gas flowing, at full or reduced rate, when the mobile phase pump is shut down or the solvent flow is set to zero.

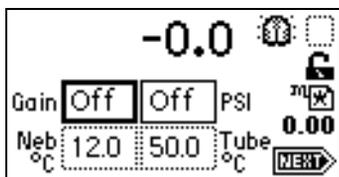
Tips:

- Gas pressure should be high enough to prevent extended exposure time of the sample in the drift tube area. Gas pressure that is too low could cause higher-than-desired dispersion of particles and, consequently, loss of sensitivity.
- Gas pressure should be high enough to prevent the formation of large particles that could cause detector noise.

To set the gain and gas pressure

1. Press Home. The Gain and Gas Pressure Home screen appears.

Gain and Gas Pressure Home screen



2. Enter the gain amount in the Gain field. Once you enter a gain amount, the photomultiplier tube (PMT) is activated.
3. To turn off the PMT, enter 0 in the Gain field.
4. Specify a gas pressure of at least 450 kPa (4.5 bar, 65 psi) in the PSI field to activate the gas valve.

Recommendation: When operating the instrument with an unlimited gas source, such as a nitrogen generator, use a low gas flow when the instrument is idle.

5. To shut off the gas valve, enter 0 in the PSI field.



Caution: To prevent the detector from flooding, ensure that no liquid is flowing into it when you specify a gas value of 0.

Setting the column heater module temperature

In the Column Heater Temperature Control Home screen, you control the temperature of the column heater module (see [page 2-33](#)).

To set the column heater module temperature

1. Press Temp °C, Next. The Column Heater Temperature Control Home screen appears.

Column Heater Temperature Control Home screen

col htr	set	current	+/-	
Off		N/A	20	°C
aux output	Nebulizer			
offset	0	mV		
				2 of 2 NEXT

2. Specify the column heater temperature in the “set” field.

Result: You can now view any changes in the current field.

Resetting the stop flow output switch



Warning: Fire and explosion hazard. Failure to connect the stop flow output could cause the detector to flood.

A dedicated switch, “stop flow,” becomes active when a heater, gas flow, or lamp failure occurs. Once the cause of the error is corrected, the stop flow output switch can be reset by reactivating the faulty detector function or pressing DIAG 1, Reset Flow & Diags.

Requirement: To automatically stop the chromatographic flow to the system in the event of an error condition or hardware failure, the Stop Flow signal must be connected to the chromatographic pump.

Operating the trace and scale functions

The trace function allows you to display an LSU signal for the last n minutes (up to 60) of detector operation.

- Press TRACE to display the LSU signal acquired over the last 30 minutes by default. The LSU signal updates once every 20 seconds.
- Press Scale (press Shift, TRACE) to display the scaled trace with T1 (ending time) displayed (-30 for the last 30 minutes) by default.

Change the ending time parameter to any number from 3 to 60. You can use the Scale function to zoom in on a particular section of the trace.

To display the Scale parameters

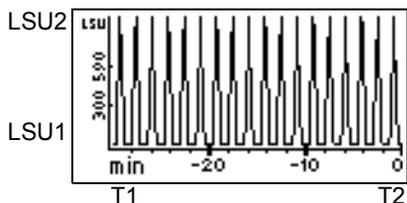
1. Press Scale.
2. Press Next to display T2 (starting time). The default is 0.
3. Press Next again to display LSU1 (starting or low light-scattering signal). The default is auto-scaled.
4. Press Next again to display LSU2 (ending or high light-scattering signal). The default is auto-scaled.

By entering appropriate times and light scattering numbers in the four scaling parameter boxes, you can zoom in on one section of the current light scattering trace.

- For LSU1 and LSU2, press CE to reset to auto-scaled.
- T1 represents the left-hand side of the trace, or ending time, to be displayed. The default is -30.
- T2 represents the right side of the trace, or starting time. The default is 0.

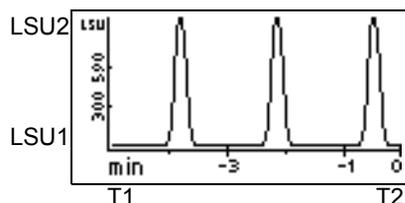
The following screen shows a 30-minute trace of simulated peaks.

30-minute scaled trace of continuous, simulated peaks, with T1 changed to -30



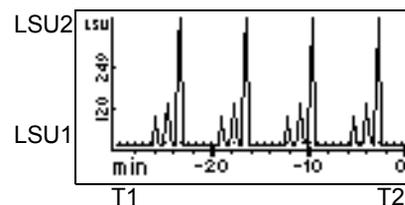
The following screen shows a 5-minute, scaled trace (or zoom) of the 30 screen shown above. T1 is changed to -5. T2 is changed to 0. LSU1, and LSU2 remain as auto-scaled.

Scaled trace for 5 minutes changing T1 to -5



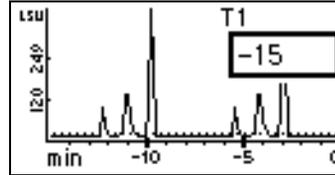
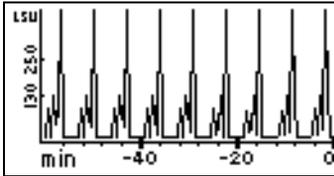
The following screen shows a 30-minute, scaled trace similar to that shown in the first screen, with the starting light scattering or LSU1 changed from auto-scaled to -10. T1 remains at -30, T2 at 0.

Scaled trace for 30 minutes changing LSU1 to -10



The following screens show a 60-minute trace on Channel A scaled to the last 15 minutes of data. T1 is changed to -15.

Scaled trace changing T1 to -15



As you modify the output using the scale function, the trace function continues to display the detector output in real time on either or both channels.

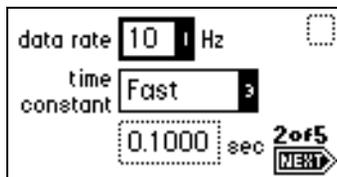
Setting the data rate

This function allows you to set the data rate to 10, 20, 40, or 80 Hz.

To set the data rate

1. From the Home screen, press Next. The data rate and time constant function screen appears.

Data rate and time constant function screen



2. Use Enter and the numeric keypad or ▲ and ▼ to select the appropriate data rate.

Setting the filter time constant

This function allows you to adjust the noise filter (time constant) to achieve the optimum signal-to-noise ratio. The detector uses a Hamming filter to process the sample's signal. The filter time constant can be adjusted from 0 to 5.0 seconds in 0.1 increments. When the time constant value is set to zero, the Hamming filter is disabled.

Setting the switch output

The detector has a general purpose switch output that can be controlled manually, by run time, or by sample level. On the third Home screen, it displays the current setting of the method and the switch output. Changing the initial value, On or Off, also changes the current state of the switch output.

For information on programming the switch output by time or by level, see [page 3-37](#).

Setting the analog signal output

The fourth Home screen contains the sample signal analog output parameters, the units full scale value, the analog output full-scale value, and its offset. These settings only affect the sample signal's analog output, not the digital data processed by the data system using the Ethernet communications data link.

The units full scale value defines the maximum signal value that can be represented using the analog output. Likewise, the analog output full-scale value defines the maximum output voltage value that will be used to represent the units full-scale value. For example, using the default values, the units full-scale value of 2000 is represented as a 2000-mV output on the analog outputs. Reducing the units full-scale value to 1000 means that the 2000-mV analog output will represent a 1000-LSU signal. This also increases the analog output sensitivity from 1 LSU/mV to 0.5 LSU/mV.

Changing the analog output full-scale value reduces the sensitivity of the analog output. For example, changing the analog output full-scale value to 1000 mV reduces the analog output sensitivity from 1 LSU/mV to 2 LSU/mV. The analog output sensitivity can be improved by also reducing the units full-scale value to 1000 LSU to obtain a 1 LSU/mV sensitivity.

The offset data field provides a way to raise the analog output signal to meet the detection signal requirements of some data loggers.

Setting auto zero options

The fifth Home screen contains options for setting various auto zero options, either when the gain is changed or at the start of a run (on inject).

When the gain amount is modified from the front panel, a downloaded method, or a timed event, the following can occur:

- The auto zero adjustment can be recalculated. This can be done based on the detector's baseline signal, or to no signal (zero).
- The auto zero adjustment can be reset to zero.

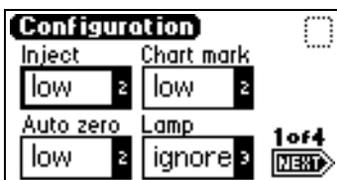
Based on the setting of the On Inject check box at the start of a run, the detector either evaluates the auto zero adjustment based on no signal (zero), or it resets the auto zero adjustment to zero.

Configuring the detector

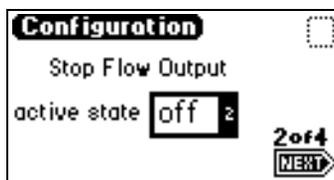
Press CONFIGURE (press Shift, DIAG). The first of four Configuration screens appears.

Tip: Other functions, such as specifying event inputs and enabling pulse periods, are also available in the Configuration screens.

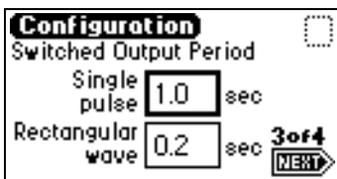
Configuration screens



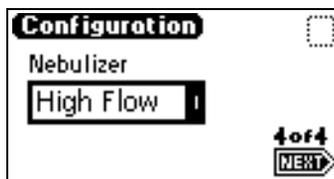
Configuration screen 1 of 4



Configuration screen 2 of 4



Configuration screen 3 of 4



Configuration screen 4 of 4

Configuring event inputs

You can also use CONFIGURE to edit event input settings and specify switched output settings.

Four editable entry fields appear on the first Configuration screen: Inject, Chart mark, Auto zero, and Lamp.

- Inject – You can specify the Inject input to signal the start of a run. This event resets the runtime clock and applies initial method conditions immediately:
 - High – Start run when contact closure changes from Off (open) to On (closed).
 - Low – Start run when contact closure changes from on (closed) to off (open).
 - Ignore – Do not respond to inject-start input.

Use Enter and the numeric keypad or ▲ and ▼ to select the appropriate entry.

- Chart mark – You can specify the input to create a chart mark on signal output. To determine the response of the channel, use the chart mark function.
 - High – Create chart mark(s) when contact closure changes from Off (open) to On (closed).
 - Low – Create chart mark(s) when contact closure changes from On (closed) to Off (open).
 - Ignore – Do not respond to chart mark input.

Use Enter and the numeric keypad or ▲ and ▼ to select the appropriate entry.

- Auto zero – You can configure the auto-zero input to auto zero light scattering readings on signal output. To determine the response of the channel, use the auto zero function.
 - High – Auto zero the channel when contact closure changes from Off (open) to On (closed).
 - Low – Auto zero the channel when contact closure changes from On (closed) to Off (open).
 - Ignore – Do not respond to auto-zero input.

Use Enter and the numeric keypad or ▲ and ▼ to select the appropriate entry.

- Lamp – You can configure the lamp input level to ignite or extinguish the tungsten lamp on or off from an external device as follows:
 - High – Ignite the lamp on when contact closure is On (closed).
 - Low – Ignite the lamp on when contact closure is Off (open).
 - Ignore – Do not respond to lamp input.

Use Enter and the numeric keypad or ▲ and ▼ to select the appropriate entry.

The default for Inject, Chart mark, and Auto zero is low; the default for the Lamp parameter is Ignore.

Tip: Controlling the lamp state by the event input overrides keypad control.

Configuring stop flow output



Warning: Fire and explosion hazard. Failure to connect the stop flow output could cause the detector to flood.

The stop flow output is an output switch. Its default active state is On, which can be changed to Off on the second configuration screen.

When the active state is Off, the stop flow output is normally On, until a stop flow error condition occurs. At that point, the stop flow output is changed to the Off state.

Requirement: To automatically stop the chromatographic flow to the system in the event of an error condition or hardware failure, the Stop Flow signal must be connected to the chromatographic pump.

Setting pulse periods

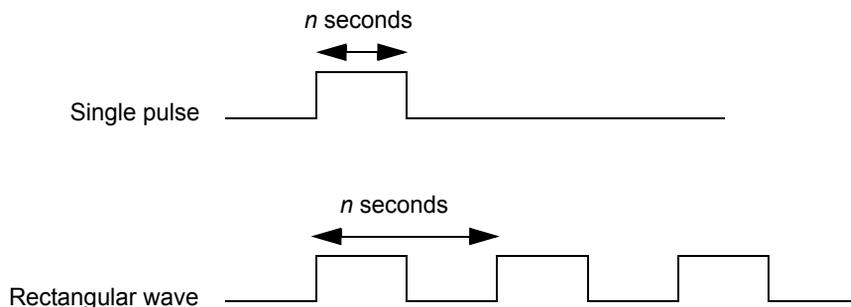
You use the third configuration screen to set pulse width or to activate a rectangular wave on the switch.

- Single pulse (in seconds) – If the switch is programmed to generate a pulse as a timed or threshold event, then the period of the signal (single pulse width) is as specified in this field (range is 0.1 to 60 seconds).
- Rectangular wave (in seconds) – If the switch is programmed to initiate a rectangular wave as a timed or threshold event, then the period of the

signal (the width of one pulse period in a rectangular wave or pulse train) is as specified in this field (range is 0.1 to 60 seconds).

The following figure shows the difference between a single pulse and a rectangular wave.

Setting the pulse period or signal width on the switch



Selecting the type of nebulizer

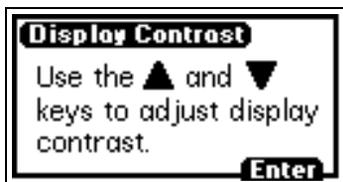
You use the fourth configuration screen to select the appropriate nebulizer for your flow rate range:

- High flow – 0.3 to 3 mL/minute
- Low flow – .05 to .5 mL/minute

Setting the display contrast

Adjust the contrast of a displayed screen using the Display Contrast function. When you press Contrast (press Shift, 6), the Display Contrast screen appears.

Display Contrast screen



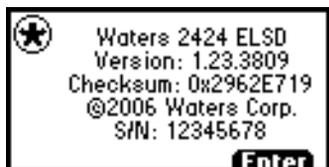
Press ▲ and ▼ to adjust the contrast of the display, and then press Enter.

Displaying system information

Press System Info (press Shift, 4) to display information about the detector, including the serial number, the software version number with checksum, and the version date, if applicable.

Press Enter to return to the Home screen.

Example of a system information screen

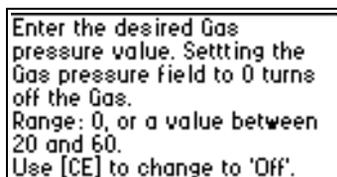


Tip: See the detector release notes for the actual checksum and version.

Using help

The detector offers limited context-sensitive Help. When you press ? (press Shift, HOME) from a point in the program with which a Help screen is associated, the screen appears. If Help is unavailable for the function you are working on, you do not receive a response.

Example of a Help screen



Press Enter to return to the previous screen.

Operating the detector

Tip: If you are operating the detector under the control of an external data system, you can program any parameters not controlled by the external data system at the front panel of the detector, before the external system takes control.

Standalone operation

When using the detector as a standalone instrument, you can store as many as 10 methods containing up to 50 timed events each. An asterisk in the method number field on the detector Home screen indicates current conditions, not a stored method. See [page 3-34](#) for information on how to store a method.

Auto-optimizing gain and LSU-FS

You must select a gain setting for the photomultiplier tube before a chromatographic injection. The proper setting maximizes the signal on the internal analog-to-digital converter without exceeding the signal's maximum potential limit. If the gain is too high, the signal can overload the signal collection electronics. If the gain is too low, sensitivity is reduced, and the signal-to-noise ratios are degraded.

Using the Auto Gain diagnostic, you run a single, trial chromatogram after which the detector suggests ideal gain values. If you run timed-event gain changes, the detector adjusts the values to determine the ideal gain setting for each critical timed-event region. At the end of the run, a report of the ideal gain values appears on screen. The report is based on a computation that maximizes use of one-half the range of the electronics, so a 2× margin accommodates any variations in signal intensity. Based on this report, you adjust the gain values in the method, including its timed event table, to optimize the performance of the method.

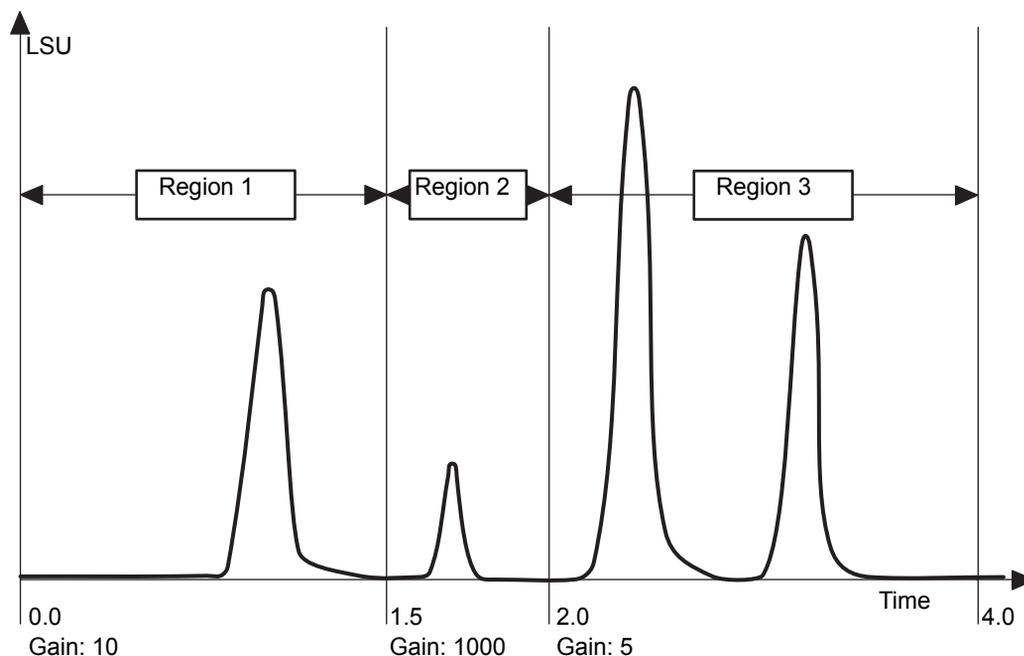
Besides the ideal gain settings, the detector also monitors the maximum signal level throughout the entire run. It recommends a minimum LSU-FS value, which applies to the entire chromatogram and is displayed when you use the analog outputs during data collection. This value is also computed assuming a 2× margin for error.

Method optimization

Before using the Auto-Optimize diagnostic, a chromatogram of the sample should be run to establish the approximate retention time of the peaks of interest. A timed event table should be constructed, consisting of gain-change timed events at times corresponding to sections of baseline between the peaks. For example, if the RT of peak 1 is 0.9 minutes, and the RT of peak 2 is 1.75 minutes, a gain change timed event should be entered at 1.5 minutes. The goal is to provide retention time demarcation points at which a gain change could be tolerated without disrupting the integration of peaks in the

chromatogram. The minimum requirement for the Auto Gain diagnostic to function is for you to set the initial conditions. No timed events are necessary. This means, however, that the detector recommends only one gain value setting for all of the peaks in the chromatogram, with no segregated peak region optimization.

Gain optimized chromatograph



Recommended method development approach

You should use a method with two timed event changes to optimize this chromatogram. The first gain setting change could occur at 1.5 minutes, just before the small peak best detected at a gain of 1000. The next change would occur at 2.0 minutes. You need not to be concerned with the initial gain setting. The only requirement for the first timed event is that some gain

setting takes place. An initial method table could resemble what is shown in the following table.

Method development

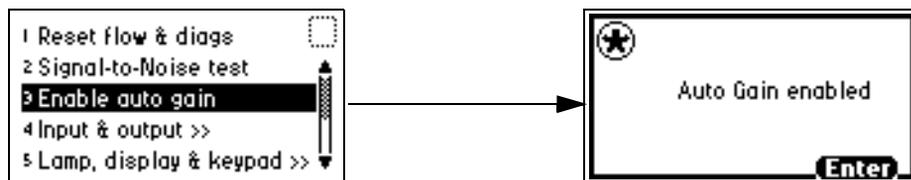
Event time	Event
Initial (0.0)	Gain = 10
1.5	Gain = 100
2.0	Gain = 10

You can develop methods by entering the method information into the detector using the keypad or by retrieving a previously created method from a stored memory location.

If you are using Empower software, you must enter the method into the detector's Instrument Method Editor. Under Empower control, the method is downloaded to the detector when you make an injection or if the method is set up.

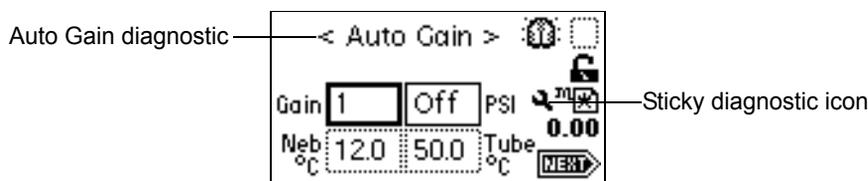
Once you program the method into the detector (or Empower editor), press DIAG, and then press 3 Enable Auto Gain. The Auto Gain enabled screen appears.

Selecting the Auto Gain diagnostic



The diagnostic will run during the next injection. The sticky diagnostic (wrench) icon appears on the front panel, and <Auto Gain> appears in the emission field.

Auto Gain diagnostic screen



You can start the injection via a trigger from an injector input to the Inject Start event input on the rear panel. You can also press Run/Stop on the front panel while the sample is injected into the fluid stream.

Requirement: Synchronize the start trigger with the chromatography so that the timed events occur at the proper times relative to the peaks.

Select Make Injection if you are running under Empower control, or start the injection through other devices (such as the Alliance 2695 Separations Module).

When the run is completed, press Run/Stop, Reset. The detector displays a recommended LSU-FS value and a table of gain values.

Gain values

Event time	Best gain
0	10
1.5	1000
2.0	5

Programming methods and events

Overview of methods

The detector allows the storage and retrieval of up to 10 methods. The detector refers to the stored methods as 1 through 10. If you are operating using a stored method, the method number appears on the Home screen. An asterisk in the method number icon indicates that the current conditions are not stored.

If you edit a parameter, you are editing the current conditions (Method *). You may store the method in one of the 10 available method storage slots, or you

can replace the current method with one of the methods previously stored. When you retrieve a previously stored method, you replace the existing method conditions with those of the stored method.

The method number displayed on the Home screen is that of the retrieved method until you make a change. Any parameter change alters the current conditions so that the original recalled method is no longer in effect, causing the method number to change to an asterisk.

The operating parameters at the time of system shutdown are restored on startup. However, any timed events or thresholds associated with the method are deactivated when power is restored. On startup, you always see an asterisk inside the method icon on the Home screen.

When the detector is operating under remote control, the remote icon appears.

Programming timed events

You can program up to 50 timed events, to the nearest 0.01 minute. As you enter timed events, each new event appends to the end of the timed event list. You can enter a time that is not in sequence with the events entered previously, and the timed event list is sorted when you press Next. The detector allows programming of the timed events listed in the following table.

Timed event parameters

Number	Event	Range	Default
1.	Gain	0 to 1000	Off
4.	Chart mark		
5.	Auto zero		
6.	Lamp	On, Off	Off
7.	Auxiliary switch	On, Off, Pulse, Rect wave	Off
8.	Gas pressure	140 to 410 kPa (1.4 to 4.1 bar, 20 to 60 psi)	Off
9.	Threshold	0 to 2000 LSU	Off

To program a new timed event

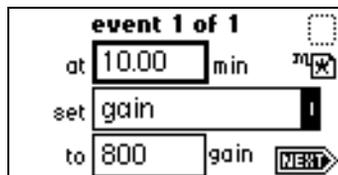
1. Press METHOD (press Shift, TEMP °C). The Method choice list appears.

Method choice list



2. Press 1 Timed events. An active field for entering the time of the event appears.
3. Enter the time for the event. When you begin entering the time, additional fields appear.

Timed events screen



4. Press Enter to enter the time. To advance to the “set” field (Events choice list), press ▼.
5. Press Enter again to display the choice list, or, if you know the event number, press the number for the event you are programming.
6. Enter the appropriate selection in the “to” field, if the field appears.
7. Press Next to advance to a new timed event.
8. To delete a timed event, press CE when the time field is active to change it to Off.
9. Press HOME to return to the Home screen, and then press Run/Stop to start the method.
10. Press Reset (press Shift, Run/Stop) to reset the run clock to 0.

If the detector is configured with the 700 Series Autosampler or another external device, the inject start signal programmed from that device starts the method.

Tip: If you are working in real time under current conditions (method *), and a power failure or shutdown occurs, you lose all timed or threshold events if you did not store them as a method (see [page 3-38](#)).

Programming threshold events

You can program threshold events to control the auxiliary switch.

Below the specified threshold, the switch is set as shown in the table, below. You can program the switch parameters listed in the table.

Threshold events “to” parameters

Number	Set to	Below threshold switch state
1.	On	Off
10.	Off	Off
11.	Pulse	Off
12.	Rect wave (rectangular wave)	Off

To define the pulse period, or the frequency of a wave, see [page 3-26](#).

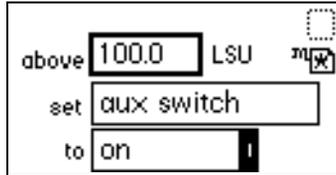
To program a threshold event

1. Press METHOD (press Shift, TEMP °C) on the detector keypad. The Method choice list appears.
2. Press 2 Threshold events. An active field (LSU) for entering the threshold appears. When you begin to enter a number in the LSU field, additional fields appear.

Tip: The threshold selection provides the means to modify this initial Threshold value as a timed event.

3. Press Enter to advance to the “set” field, or press ▲ and ▼ to move among the three fields.

Threshold events screen



4. When the “set” field is active, press Enter to display the threshold events choice list, or press the number corresponding to the event you are programming.
5. When the “to” field is active, press Enter to display the switch state options, or press the number corresponding to the threshold parameter you are programming.

Storing a method

A method consists of all programmable parameters on the Home and associated screens, as well as timed and threshold events. You can store the current method by selecting a location from 1 to 10.

To store a method

1. Press METHOD. The Method choice list appears.
2. Press 4 Store method *. A method number field appears.

Tip: No warning message appears when the method number you select is already used by a previously stored method. When you enter a number and press Enter, the current method conditions are stored, overwriting any previous method stored in the same slot.

Method number field



3. Enter a number from 1 to 10 (inclusive), and press Enter. A brief message (“Storing * as method *n*”) appears. When the display returns to the Method choice list, the method number you selected appears within the method icon. That method remains active until you retrieve another method or reset the detector to default conditions (Method *).

Retrieving a method

To retrieve a previously stored method

1. Return to the Method choice list by pressing METHOD.
2. Press 3 Retrieve a method. The last method number stored or retrieved appears in the method number slot box.
3. Specify the number of the method you wish to retrieve and press Enter.
Result: A brief message (“Retrieving method *n*”) appears.
4. When the display returns to the Method choice list, the method number you specified appears within the method number icon.

Viewing events within a method

To view timed and threshold events that make up a stored method

1. Retrieve the method. Once you enter the method number to retrieve, the Method choice list appears with the method number displayed within the method number icon.
2. Press 1 to view the timed events or 2 to view the threshold events of the method.
3. If you change a timed or threshold event within a method, the asterisk appears (Method *) indicating that the method (*) is no longer the same as the stored method you retrieved in step 1. You can then store the method containing the altered event(s) in the same storage slot.

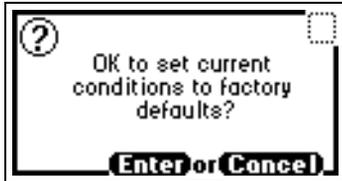
Resetting a method

Resetting a stored method is a two-step process. First, you reset the current conditions to the defaults; and then you save the defaults in one of the storage locations. The table on [page 3-15](#) lists the parameter default settings.

To reset one or more methods

1. Press METHOD. The Method choice list appears.
2. Press 5 Reset method *. A message screen appears.

Reset method message



3. If you press Enter
 - all timed events are deleted.
 - all threshold events are disabled.
 - all other operating parameters of the method (LSU-FS, etc.) are set to defaults.

If you press Cancel (press Shift, 0), the Method choice list appears.

Tip: To prevent losing the current conditions before you clear the method, store them in one of the available storage slots. When you clear the storage slots, you can restore the previous conditions.

4. Press 4 Store method, and enter a storage location number.
5. To clear other stored methods, repeat step 4.
6. When you return to the Home screen by pressing HOME, the method number icon displays an asterisk.

Clearing events

You may want to clear only timed and threshold events without resetting any other operating parameters.

To clear active events

1. Return to the Method choice list by pressing METHOD.

2. Press 6 Clear events. A message screen appears.

Clear events message



3. If you press Enter
 - all timed and threshold events in the method are cleared.
 - all other operating parameters of the method (LSU-FS, etc.) are unaffected.

If you press Cancel (press Shift, 0), the Method choice list appears.

4. When you return to the Home screen by pressing HOME, the method number icon displays an asterisk.

Conserving lamp life

To conserve the tungsten lamp, extinguish it while allowing the detector to remain powered-on. You can do this in three ways:

- Manually
- By programming a timed event
- By programming the lamp itself via the external contact closure

Tip: If you are operating the detector remotely, you can program the controller to extinguish the lamp without using the detector's front panel.

Recommendation: Regardless of whether you program the lamp to shut off or extinguish it manually, ensure that the "lamp off time" value is greater than 4 hours.

To manually extinguish and reignite the lamp, use the Lamp key. When the lamp is extinguished, the Home screen displays the words "Lamp off" and the lamp icon appears with an X through it.

Press the Lamp key (press Shift, 1) for these purposes:

- Extinguish the lamp or ignite it manually
- Display the number of times the lamp has ignited
- Display the hours and minutes the lamp has been ignited
 - during the current run
 - since installation

To turn off the lamp manually from the detector front panel

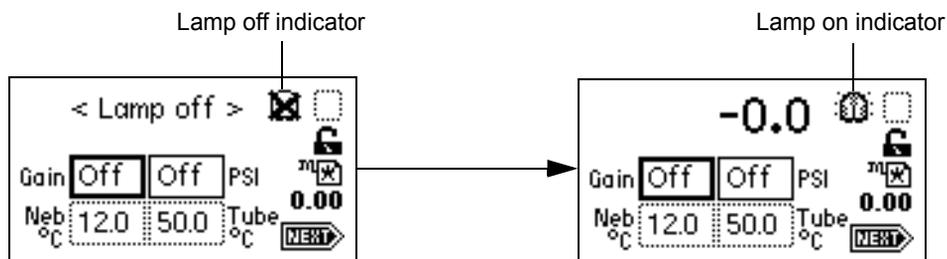
1. Press Lamp (press Shift, 1). The lamp control screen displays this information:
 - The amount of time, in hours and minutes, the lamp has been ignited since the most recent startup
 - The total time the lamp has been ignited since its installation
 - The number of times the lamp has been ignited

Lamp control screen



2. Press Lamp (press Shift, 1) again to extinguish the lamp. The Home screen appears with an X through the lamp indicator icon and the words “Lamp off”.

Lamp off/on sequence



To ignite the lamp manually (when the lamp icon on the Home screen has an X)

1. Press Lamp (press Shift, 1). The lamp control screen appears again with 0 hours and 00 minutes in the “Lamp has been on” field.
2. Press Lamp (press Shift, 1) again to turn the lamp on. Once the lamp is ignited, the Home screen appears with the X removed from the lamp icon.

You can conserve lamp life by programming its automatic operation via a timed event method.

To program the lamp to turn on or turn off, select the Timed events option in the Method choice list, or program the lamp through one of the external contact closures.

- See [page 3-15](#) and [page 3-34](#) for more information on programming lamp operation using a timed event.
- See [page 3-27](#) for more information on programming the lamp through the external contact closure.

Changing chromatographic conditions

Requirement: When the detector is plumbed to the chromatographic system, and the buffer type or pH of the mobile phase is changed, you must remove the previous buffered mobile phase from the fluid path.



Caution: Failure to remove all traces of buffered mobile phase from the fluid path before changing new conditions could result in buffer precipitation and consequent clogging of the nebulizer.

To change chromatographic conditions

1. Set the drift tube temperature at the appropriate desolvation temperature setting.
Tip: 50 °C (122 °F) is an appropriate desolvation temperature for most solvents.
2. To remove mobile phase from the fluid path of the detector, replace the buffered mobile phase with 100% HPLC-quality water, and flush the system for 10 minutes at 3 mL/min.

3. If the new mobile phase is miscible with water, replace the 100% HPLC-quality water with new mobile phase, and equilibrate the system for 10 minutes at 3 mL/min.

Shutting down the detector

Before you power-off the detector, you must remove any buffered mobile phase present in the fluid path.



Caution: To avoid damaging the column, remove all buffers from it before you shut down the detector.

To shut down the detector

1. Remove all buffers from the column and detector.
2. Flow nonbuffered mobile phase through the system.
3. Turn off the pump.
4. Allow the nebulization gas to flow through the detector for a few minutes to drain the evaporation tube and detection chamber.
5. Stop the gas flow.
6. Power-off the power to the detector.

Tips:

- The last set of selected parameters is retained in memory and becomes the default condition when the detector is powered-on again.
- It is not harmful to leave the detector powered-on overnight when the instrument is not in use. To increase the life of the lamp, extinguish it.
- Do not allow solvent flow to continue if no gas flow is present. However, you may let the nebulizer gas flow at full or reduced rate even in the absence of solvent flow (that is, when the mobile phase pump is turned off or the flow rate is set to zero).

Periodic maintenance

To maintain the best performance from your detector, remove the mobile phase from the fluid path once each week.

To perform periodic maintenance

Tip: To avoid damaging the column, remove it before you remove the mobile phase from the fluid path.

1. Set the drift tube temperature at the appropriate desolvation temperature setting.

Tip: 50 °C (122 °F) is an appropriate desolvation temperature for most solvents.

2. Replace the buffered mobile phase with 100% HPLC-quality water, and flush the system for 10 minutes at 3 mL/min.

4 Maintaining the Detector

Contents:

Topic	Page
Contacting Waters technical service	4-2
Maintenance considerations	4-2
Replacing the lamp cartridge	4-3
Replacing the nebulizer	4-6
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Cleaning the drift tube	4-12
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Contacting Waters technical service

If you are located in the USA or Canada, report malfunctions or other problems to Waters Technical Service (800 252-4752). Otherwise, phone the Waters corporate headquarters in Milford, Massachusetts (USA), or contact your local Waters subsidiary. The Waters' Web site includes phone numbers and e-mail addresses for Waters locations worldwide. Visit www.waters.com.

When you contact Waters, be prepared to provide this information:

- Detector serial number
- Problem symptom(s)
- Nebulizer and drift tube temperatures
- Heater set points and levels
- Flow rate
- Filter setting
- System operating pressure
- Gas pressure
- Solvent(s)
- System configuration (other components)

For complete information on reporting shipping damages and submitting claims, see the document *Waters Licenses, Warranties, and Support Services*.

Maintenance considerations

Perform the procedures in this chapter when you discover a problem with a 25X5 QGM component or during preventive maintenance. For information about isolating problems in the 25X5 QGM, consult the console's online Help.

Safety and handling

Observe these warning and caution advisories when you perform maintenance operations on your 25X5 QGM.



Warning: To prevent injury, always observe Good Laboratory Practices when you handle solvents, change tubing, or operate the system. Know the physical and chemical properties of the solvents you use. See the Material Safety Data Sheets for the solvents in use.



Warning: Avoid electric shock:

- Do not open the detector cover. The components within are not user-serviceable.
- Power-off and unplug the detector before performing any maintenance operation on the instrument.



Caution: To avoid damaging electrical parts, never disconnect an electrical assembly while power is applied to the detector. To completely interrupt power, set the module's power switch to "off", and then unplug the power cord from the AC outlet. Wait 10 seconds thereafter before you disconnect an assembly.

Spare parts

Replace only parts mentioned in this document. For spare parts details, see the Waters Quality Parts Locator on the Waters Web site's Services & Support page.

Replacing the lamp cartridge

Recommendation: Because lamp alignment is critical to proper detector operation, it is recommended that only Waters pre-aligned lamp cartridges be used.

Required Materials

- #2 Phillips screwdriver
- Lamp cartridge

To replace the lamp cartridge

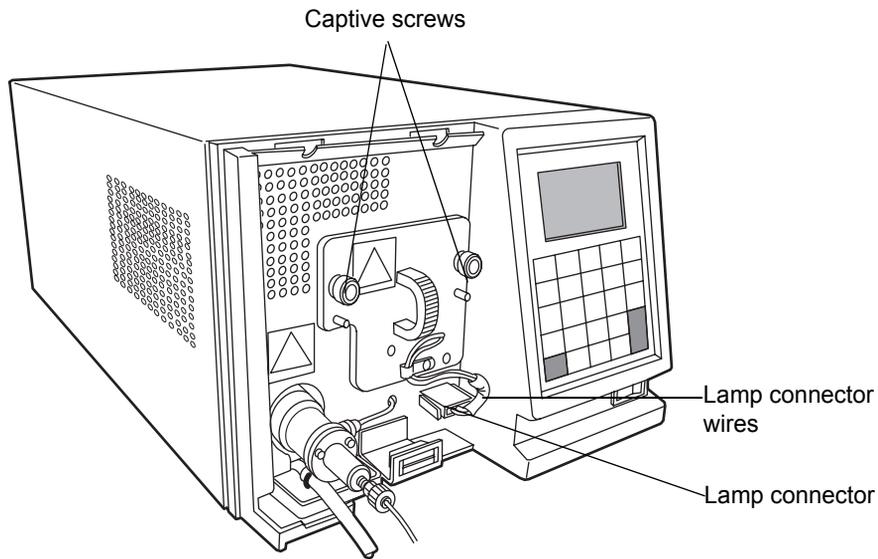
1. Power-off the detector, and disconnect the power cable from the rear panel.

Alternative: To save time, leave the detector powered on for 15 minutes after you power-off the lamp. Doing so will allow the fan to blow cool air on the lamp, cooling it faster.



Warning: The lamp and lamp housing can be hot. Wait 30 minutes (or 15 minutes with the fan running) after powering-off the detector for these components to cool before touching them.

2. Allow the lamp to cool for 30 minutes (or 15 minutes with the fan running), and then remove the left-front panel cover.
3. Using a Phillips screwdriver, completely loosen the two captive screws and pull the assembly out slightly to relieve stress on the lamp connector wires.



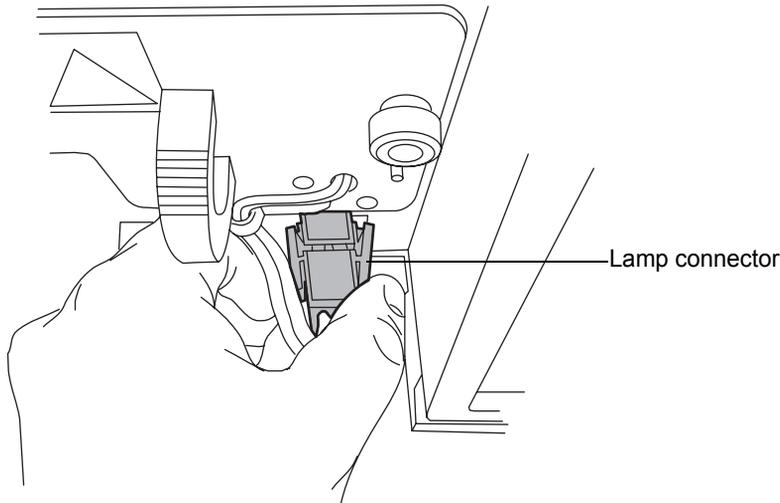


Warning: To avoid electric shock, power-off and unplug the detector before detaching the lamp power connector from the detector.



Caution: To avoid damaging the detector's electronics, power-off and unplug the detector before detaching the lamp power connector from the detector.

4. Disconnect the lamp connector from the front panel.



5. Remove the lamp cartridge assembly and replace it with a new one.
6. Reconnect the lamp connector.



Caution:

- Do not touch the new lamp with your bare fingers. Skin oils can greatly reduce the lifetime of the lamp. If fingerprints do get on the lamp, remove them with a lint-free tissue saturated with ethanol.
 - To avoid misaligning the lamp, do not touch the bulb height adjustment lever.
7. Push the assembly back in, and tighten the two captive screws with a Phillips screwdriver.

8. Replace the left-hand, front panel cover.
9. Power-on the detector, and enter the new lamp information (see [page 5-8](#)).

Replacing the nebulizer

Required material

Nebulizer

To replace the nebulizer

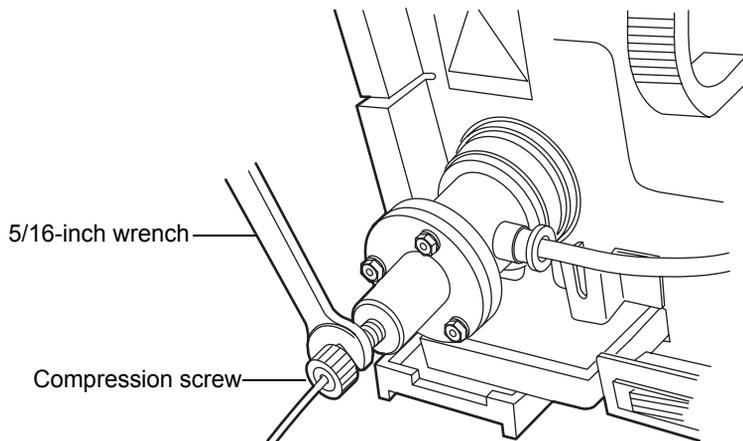
1. Stop the liquid flow.
2. Power-off the detector, and disconnect the power cable from the rear panel.



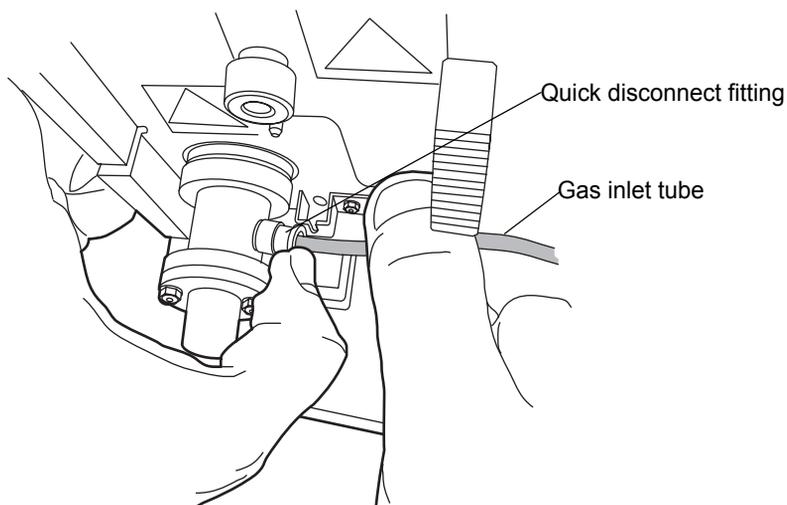
Warning: To avoid burn injuries, do not touch the nebulizer until its temperature cools to less than 30 °C, as displayed on the detector home screen. If its temperature exceeds 30 °C, let the nebulizer cool in one of two ways before touching it:

- Wait 30 minutes after powering-off the detector.
 - Wait 10 minutes after specifying Cool in the Nebulizer and Drift Tube Temperature Control Home screen (see [page 3-18](#)).
3. Remove the left-hand, front panel cover.

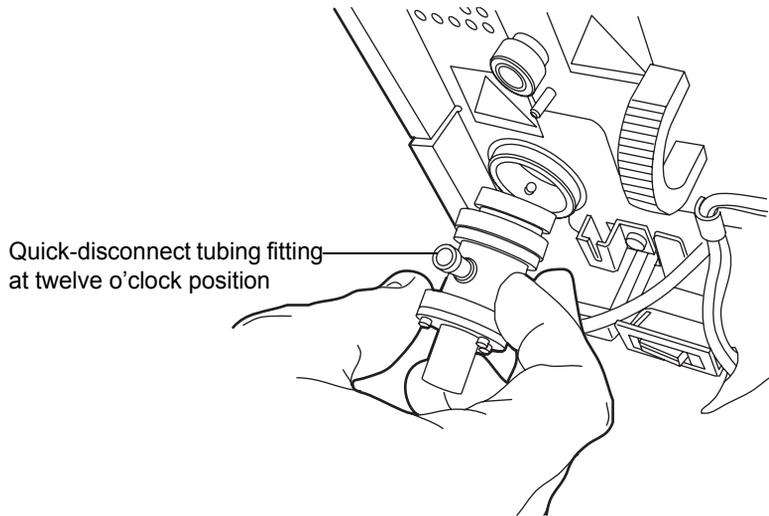
4. If a column or second detector is connected to the system, disconnect the solvent inlet tubing from the front of the nebulizer as follows:
 - a. Use a 5/16-inch wrench to loosen the compression screw that holds the inlet tubing in place.



- b. Remove the solvent inlet tubing from nebulizer.
5. Push in the quick-disconnect tubing fitting on the right-hand side of the nebulizer, and pull out the gas inlet tubing.



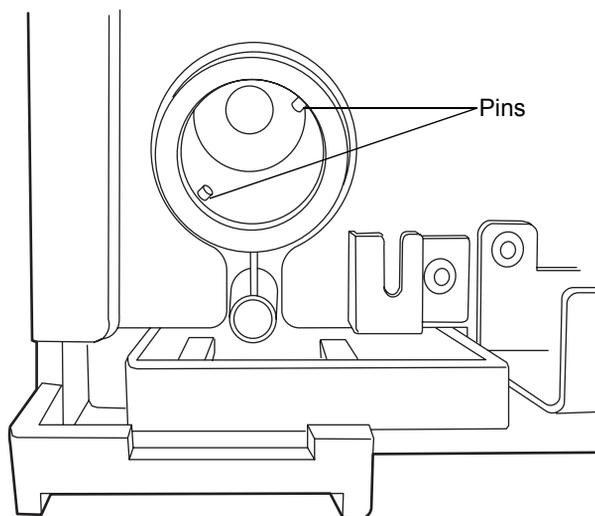
6. Push in and turn the nebulizer counterclockwise so that the quick-disconnect tubing fitting is at the twelve o'clock position. Then remove it from the nebulization chamber.



7. Remove the packing ring from the old nebulizer, and slide it onto the new nebulizer. If the old packing ring is damaged, replace it with a new one.

- Align the two pins inside the desolvation chamber with the grooves in the new nebulizer. The quick-disconnect tubing fitting will be at the twelve o'clock position.

Pins inside the desolvation chamber



- Push the nebulizer into the nebulization chamber, and turn it clockwise until it snaps into place.
- Insert the gas inlet tubing into the quick disconnect-tubing fitting on the right side of the nebulizer.
- Reconnect the solvent inlet tubing.
- Power-on the detector.

See also: [“Selecting the type of nebulizer”](#) on page 3-29.

Cleaning the nebulizer ultrasonically

To clean the nebulizer

- Stop the liquid flow, and remove the solvent inlet line.

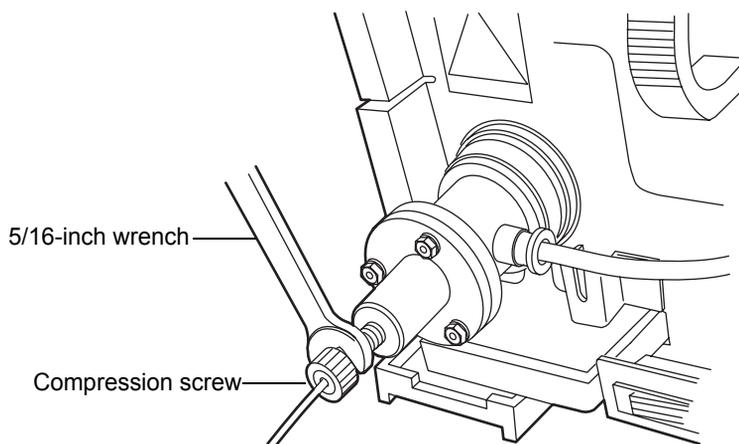
2. Power-off the detector, and disconnect the power cable from the rear panel.



Warning: To avoid burn injuries, do not touch the nebulizer until its temperature cools to less than 30 °C, as displayed on the detector home screen. If its temperature exceeds 30 °C, let the nebulizer cool in one of two ways before touching it:

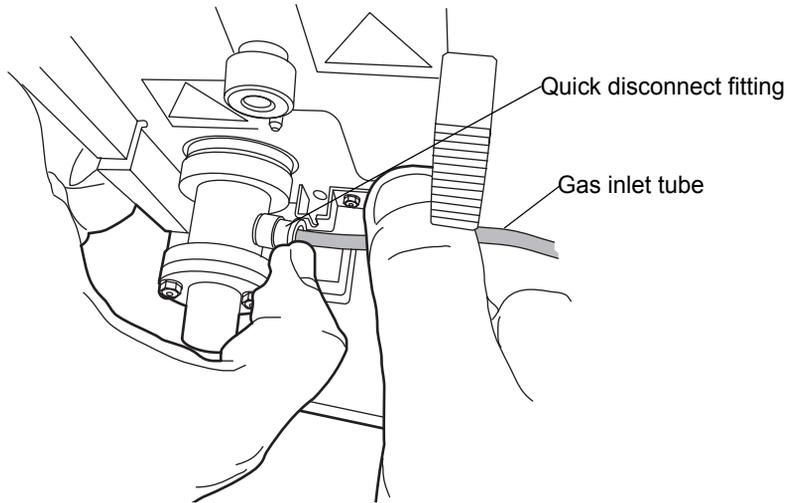
- Wait 30 minutes after powering-off the detector.
- Wait 10 minutes after specifying Cool in the Nebulizer and Drift Tube Temperature Control Home screen (see [page 3-18](#)).

3. Remove the left-hand, front panel cover.
4. If a column or second detector is connected to the system, disconnect the solvent inlet tubing from the front of the nebulizer as follows:
 - a. Use a 5/16-inch wrench to loosen the compression screw that holds the inlet tubing in place.

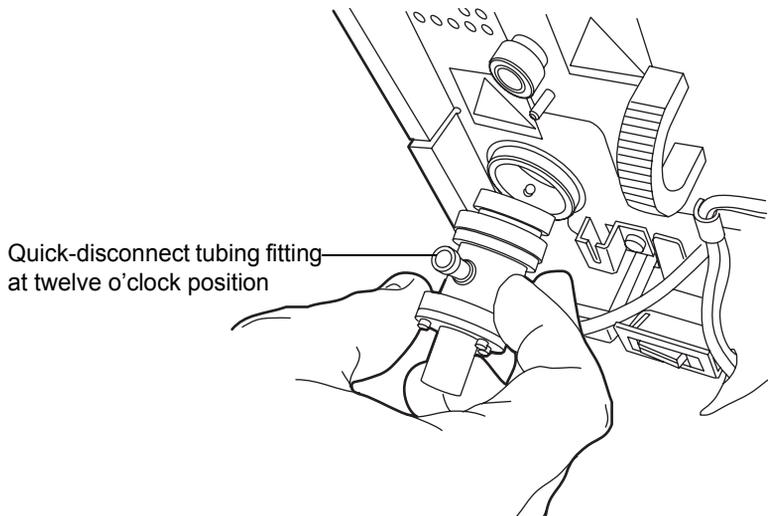


- b. Remove the solvent inlet tubing from the nebulizer.

5. Push in the quick-disconnect tubing fitting on the right-hand side of the nebulizer, and pull out the gas inlet tubing.

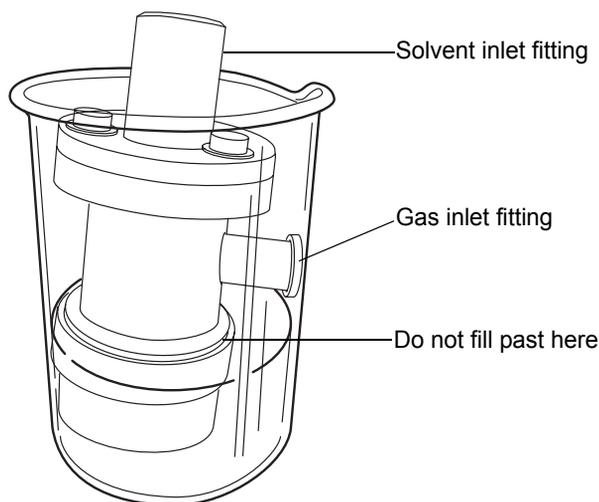


6. Push in and turn the nebulizer counterclockwise so that the quick-disconnect tubing fitting is at the twelve o'clock position. Then remove it from the nebulization chamber.



7. Remove the packing ring from the nebulizer.
8. Place the nebulizer upright in a beaker so that it stands up.

9. Pour 100% HPLC-grade water or a mixture of organic solvent compatible with your mobile phase into the beaker, but do not submerge the gas inlet fitting or solvent inlet fitting in the liquid.



10. Place the beaker in an ultrasonic bath for 10 to 15 minutes.
11. Remove the beaker from the bath.
12. Remove the nebulizer from the beaker.
13. Insert the gas inlet tubing into the quick-disconnect tubing fitting on the right side of the nebulizer, and place the nebulizer in a dry beaker so that it stands up.
14. Run gas at 410 kPa (4.1 bar, 60 psi) for 5 to 10 minutes through the nebulizer to blow out any excess liquid.
15. Reinstall the nebulizer (see [page 2-12](#)).
16. Reset the system to operating conditions and evaluate chromatography.

Cleaning the drift tube

To clean the drift tube

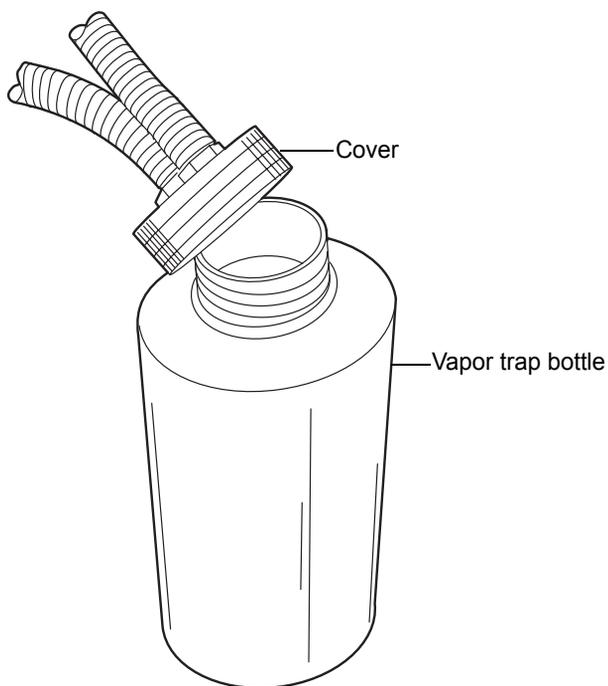
1. Increase the nebulizer power to 75%.
2. Set the drift tube temperature to 100 °C.

3. Remove the column.
4. Flush the system with 100% HPLC-quality water for 60 minutes at 1 mL/min.
5. Reassemble the detector for operation.
6. Reset the system to operating conditions and evaluate chromatography.

Servicing the vapor trap

To service the vapor trap

1. Unscrew the vapor trap bottle from the cover, and empty the contents of the bottle into an appropriate waste container.



2. Replace the vapor trap cover.

Replacing fuses



Warning: To avoid electric shock, power-off and unplug the detector before examining the fuses. For continued protection against fire, replace fuses only with those of the same type and rating indicated on the module.

The detector requires two 5.00 A, 250 V, 5 × 20 mm (IEC) fuses.

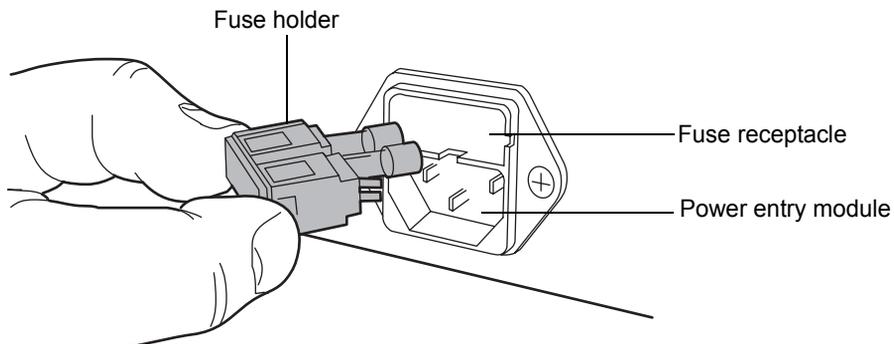
Suspect a fuse is open or otherwise defective when

- the detector fails to power-on.
- the display is blank.
- the fan does not operate.

To replace the fuses

Requirement: Replace both fuses, even when only one is open or otherwise defective.

1. Power-off the detector and disconnect the power cord from the power entry module.
2. Pinch the sides of the spring-loaded fuse holder, which fits above the power entry module on the rear panel of the detector. With minimum pressure, withdraw the spring-loaded fuse holder.



3. Remove and discard the fuses.
4. Make sure that the new fuses are properly rated for your requirements. Insert them into the holder and the holder into the power entry module, gently pushing until the assembly locks into position.

5. Reconnect the power cord to the power entry module.

Cleaning the instrument's exterior

Use a soft cloth, dampened with water, to clean the outside of the detector.

5 Diagnostic Functions and Troubleshooting

Consult this chapter when troubleshooting problems with the ELS detector. However, bear in mind that the detector measures only the bulk properties of a system. Therefore, the cause of an apparent detector problem may actually originate with the chromatography or other system instruments.

If you isolate a general chromatography problem, see [“Chromatography troubleshooting” on page 5-21](#). If you determine that a problem lies with the detector, refer to [“Error messages” on page 5-2](#).

Contents:

Topic	Page
Error messages	5-2
User-selectable diagnostic functions	5-2
General troubleshooting	5-13
Chromatography troubleshooting	5-21

Error messages

Startup error messages

Startup confidence tests are executed on detector startup. They run after the detector is powered-on, and they determine whether the detector's electronics are performing properly.

If one or more of the startup confidence tests fail, the detector beeps and displays an error message.

When you encounter an error message, use the Enter key to clear it and continue operating the detector while following any recommended corrective action.

Operational error messages

During initialization and operation, the detector might display an error message screen. Errors described on this screen can be catastrophic in nature, preventing further operation of the detector, suspending the light scattering display and halting output. The error messages can also be informational, advising you to take appropriate action.

When you encounter an informational error message, press Enter to clear the message and continue operating the detector, following any recommended corrective action.

When you encounter a catastrophic error, power-off and then power-on the detector. If the error persists, review [“General troubleshooting” on page 5-13](#). If you cannot resolve the problem, contact Waters Technical Service.

User-selectable diagnostic functions

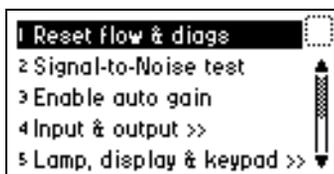
Overview

You can run diagnostic functions to troubleshoot the detector and verify that its electronics and optics are working properly.

To perform user-selectable diagnostic functions

1. Press DIAG on the detector's front panel. The detector displays the diagnostic functions.

Diagnostic functions menu



2. To access a specific diagnostic function, press the ▲ or ▼ key to navigate to the function you want to run and press Enter, or select a number between 1 and 9 that corresponds to the number on the detector keypad. Menu items that display further choices are accompanied by >>.

Diagnostic functions

Diagnostic function	Description
Reset flow & diags	Resets all diagnostic functions to default values. Resets the Stop Flow output. Removes sticky diagnostics and the wrench icon.
Signal-to-Noise test	Runs the signal-to-noise test.
Auto gain	Determines the optimum gain settings for a chromatogram.
Input & output	Lists diagnostic functions for contact closure inputs and single switch output: <ol style="list-style-type: none">1. Auto zero offset2. Fix voltage3. Contact closures & events4. Previous choices

Diagnostic functions (Continued)

Diagnostic function	Description
Lamp, display & keypad	Lists diagnostic functions for lamp, display, and keypad: 1. Change lamp 5. Lamp history 6. Test keypad 7. Test display 8. Previous choices
Gas & temp control	Lists diagnostic functions for gas and temperature control: 1. Gas control 9. Neb & drift heaters 10. Opt & col heaters 11. Previous choices
Sample & ref energy	Allows you to view the raw sample signal and reference energy signal information.
Service	Lists diagnostic functions used by Waters service personnel.

“Sticky diagnostics” tests

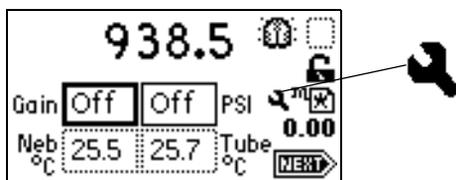
The detector uses two types of user-selectable diagnostic tests: persistent and nonpersistent. A persistent test, also called a “sticky diagnostic,” remains enabled until you disable it. Nonpersistent tests end, and previous operating conditions are restored as soon as you exit the test.

When a sticky diagnostic is active, the detector Home screen displays a wrench icon.

- You can disable a sticky diagnostic by resetting it to the default settings.
- You can disable all active sticky diagnostics by pressing DIAG 1, Reset Flow & Diags.

If no sticky diagnostics are active, the wrench icon does not appear in the home screen.

Home screen with sticky diagnostics active



The user-selectable sticky diagnostics are Auto Gain and Simulate Peak.

To cancel a sticky diagnostic function, reselect it or select 1, Reset Flow & Diags from the Diagnostics menu.

Running diagnostic tests

The detector employs both user-selectable and service diagnostics. You access user diagnostics by pressing DIAG. Only qualified Waters service personnel can access service diagnostics. To exit any diagnostic when completed, press DIAG to return to the diagnostics menu or HOME to return to the Home screen.

Running the Auto Gain diagnostic function

When enabled, Auto Gain determines the optimum gain settings for a chromatogram. At the end of a run, the timed event table contains the optimum gain setting, and the function is disabled.

Tip: To access the timed event table, press Shift > METHOD, and then press 1 Timed Events.

To enable the Auto Gain diagnostic test

Press DIAG 3, Enable Auto Gain. The Auto Gain enabled screen appears.

Auto Gain enabled diagnostic test screen



Tip: To disable the Auto Gain diagnostic test, press Enter.

To disable the Auto Gain diagnostic test after it was enabled

1. Press DIAG on the detector front panel. The Diagnostic functions menu appears.
2. Press DIAG 3, Disable Auto Gain. The Auto Gain disabled diagnostic tests screen appears.

Auto Gain disabled diagnostic test screen



Tip: To reenable the Auto Gain diagnostic, press Enter.

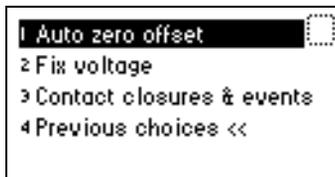
Input and output diagnostic functions

Use the input and output diagnostic functions for these purposes:

- To view and reset the sample signal's auto zero value
- To fix (establish) voltage
- To monitor two event output switches and four event input switches

To perform any of the input and output diagnostic functions, press DIAG 4, Input & output. The Input & Output diagnostic functions menu appears.

Input & Output diagnostic functions menu



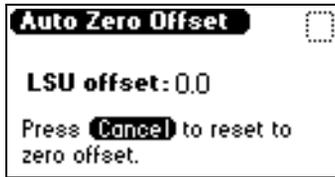
Displaying the Auto Zero offset

Using this diagnostic function, you view and reset the sample signal's auto zero offset value to zero.

To display the Auto Zero offset

1. From the Input & Output diagnostic functions menu, press 1, Auto zero offset. The Auto Zero Offset diagnostics screen appears.

Auto Zero Offset diagnostics screen



2. Press Cancel to reset the sample signal's auto zero value to zero.

Setting fixed voltage output

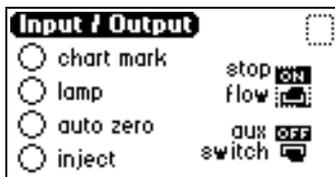
From the Input & Output diagnostic functions menu, press 2, Fix voltage, to establish voltage levels for the detector output and auxiliary output. Both must be fixed, but the values can be set independently. The valid range of voltages is ± 2000 mV for both channels. The voltage is driven on the selected channel (Detector Out or Auxiliary Out).

Monitoring contact closures and events

To monitor contact closures and events

1. From the Input & Output diagnostics menu, press 3, Contact closures & events, to monitor the four contact closure inputs and to control the two switch outputs.

Switch & events display diagnostic screen



The Input & Output diagnostic function allows real-time monitoring of the state of the contact closure inputs. A solid circle indicates the contact closure is closed (ON = High). An open circle indicates the contact closure is open (OFF = Low).

2. For the outputs listed, you can take the following actions:
 - a. Press Enter to display the active switch (surrounded by a dotted-line border).
 - b. Press any numerical key to change the status of the switch (from On to Off, or vice-versa).

Lamp, display, and keypad diagnostic functions

To access the lamp, display, and keypad diagnostic functions, press DIAG 5.

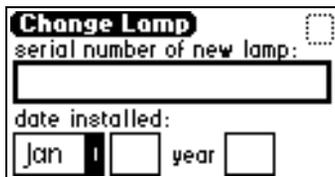
Change Lamp diagnostic function

Use the Change Lamp diagnostic function to enter the serial number and installation date of a new lamp.

To use the Change Lamp function

1. From the Lamp, display & keypad menu, press 1, Change lamp. The Change Lamp diagnostic screen appears.

Change Lamp diagnostic screen



The image shows a diagnostic screen titled "Change Lamp". It contains the following text and input fields: "serial number of new lamp:" followed by a large empty rectangular box; "date installed:" followed by a dropdown menu showing "Jan", a vertical bar, and an empty box; and "year" followed by an empty box. There is a dotted-line border in the top right corner.

2. Enter the serial number of the new lamp and the date it was installed; then press Enter. The second Change Lamp diagnostic screen appears.

Second Change Lamp diagnostic screen



The image shows a second diagnostic screen with a question mark icon in a circle in the top left corner. The text on the screen reads: "OK to store:", "SN 12345", and "Date 04Apr03 ?". At the bottom, there is a button labeled "Enter or Cancel". There is a dotted-line border in the top right corner.

3. Confirm your entries, and then press Enter. The third Change Lamp diagnostic screen appears.

Third Change Lamp diagnostic screen



4. Press Enter to exit the Change Lamp function.

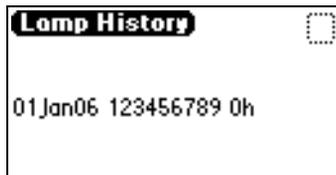
Lamp History diagnostic function

Use the Lamp History diagnostic function to view lamp use information.

To use the Lamp History function

From the Lamp, display & keypad menu, press 2, Lamp history. The Lamp History diagnostic screen appears.

Lamp History diagnostic screen



Test Keypad diagnostic function

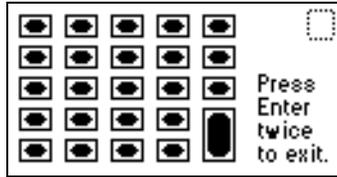
To use the Test Keypad diagnostic function

1. From the Lamp, display & keypad menu, press 3, Test keypad. A representation of the keypad appears.
2. Press any key to begin the test, and then press each key until you try all of them. If the keypad is operating properly, each key location is filled in

then cleared with another press of the key. If any key does not respond when pressed, contact your Waters service representative.

Tip: You must press Enter twice to exit the keypad diagnostic.

Test Keypad diagnostic screen



Test Display diagnostic function

To use the Test Display function

1. From the Lamp, display & keypad menu, press 4, Test display. The display fills from top to bottom and right to left. It then returns to the Lamp, display & keypad menu. If the display does not completely fill, either horizontally or vertically, contact your Waters service representative.
2. From the Lamp, display & keypad menu, press 5 to return to the Diagnostics menu.

Gas and temperature control diagnostic functions

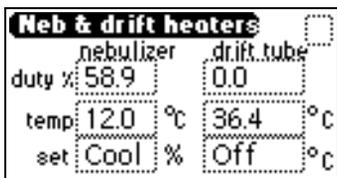
To access the gas and temperature control tests, press DIAG 6.

Viewing the nebulizer and drift tube temperature

To view the nebulizer and drift tube temperature

From the Gas & temp control menu, press 2, Neb & drift heaters, to run the nebulizer and drift tube heater temperature control test. The Nebulizer & Tube Heater Temperature Control screen appears.

Nebulizer and drift tube temperature control diagnostic screen



	nebulizer	drift tube
duty %	58.9	0.0
temp	12.0 °C	36.4 °C
set	Cool %	Off °C

Using the gas control diagnostic

With the Gas Control diagnostic function, you can control the gas pressure regulator and gas solenoid valve independently. The diagnostic screen displays the state of the gas pressure switch and the value of the pressure transducer. When the function ends, the original state of the gas regulator and gas solenoid valve is restored.

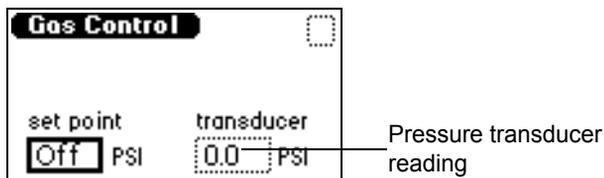
Tips:

- Gas Pressure should be high enough to prevent extended exposure time of the sample in the drift tube area. Gas pressure that is too low could cause higher-than-desired dispersion of particles and, consequently, loss of sensitivity.
- Gas pressure should be high enough to prevent the formation of large particles that could cause detector noise.

To use the gas control diagnostic

1. From the Gas & temp control menu, press 1, Gas control, to run the gas control diagnostic. The Gas Control diagnostic screen appears.

Gas Control diagnostic screen



2. Enter the gas pressure, in psi, in the set point field.
Requirement: Use at least 450 kPa (4.5 bar, 65 psi), to run the gas control diagnostic.
3. To stop gas flow, enter 0 in the set point field.

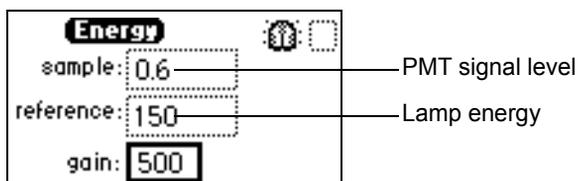
Sample and reference energy diagnostic function

With the sample and reference energy diagnostic function, you view raw sample, signal, and reference energy information, and you change the state of the lamp and gain.

To use the sample and reference energy diagnostic function

1. Press DIAG 7, Sample & ref energy. The sample and reference energy diagnostic screen appears.

Sample and reference energy diagnostic screen



2. Enter the gain value to view the difference between the raw sample signal and reference energy information.

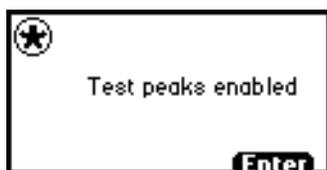
Generate Test Peaks diagnostic function

The Generate Test Peaks diagnostic function allows you to override sample signal input with a simulated Gaussian peak.

To use the generate test peaks function

1. Press DIAG 8, Generate test peaks. If the Generate Test Peaks diagnostic function is disabled, the Test peaks enabled diagnostic screen appears.

Test peaks enabled diagnostic screen



2. To disable the Generate Test Peaks function, press Enter.

General troubleshooting

This section suggests possible causes of errors and recommends troubleshooting actions. Keep in mind that the source of apparent detector problems can actually be the chromatography, or it can involve other system instruments.

Most detector problems are relatively easy to correct. If, after running the diagnostic functions applicable to your problem and troubleshooting the detector, you cannot correct an error condition, contact Waters' Technical Service department.

Power surges

Power surges, line spikes, and transient energy sources can adversely affect detector operations. Be sure that the electrical supply used for the detector is properly grounded and free from any of these conditions.

Detector troubleshooting

The following table contains general hardware troubleshooting for the detector.

Detector troubleshooting

Symptom	Possible cause	Corrective action
Analog output incorrect	LSU or maximum output setting changed	Reset the LSU or maximum output setting.
Column heater module not functioning	Column heater module is not powered on	Power-on the column heater module.
	Column heater module is not connected to the detector	Connect the column heater module to detector.
Detector inoperative	Fuse blown	Check that the front panel display is operational; if it is not, check or replace the AC rear panel fuse.
	No power at outlet	Check the outlet by connecting another electrical unit known to be in working order and see if it operates.
	Bad internal power supply or circuit board	Call Waters Technical Service (see page 4-2).
Front panel display fails to illuminate	Broken electrical connection	Check power connections.
	Fuse blown	Check and, if necessary, replace fuse(s).
	Bad LCD or control board	Call Waters Technical Service (see page 4-2).
Front panel displays odd characters	Faulty EPROMs Bad LCD control board	Call Waters Technical Service (see page 4-2).

Detector troubleshooting (Continued)

Symptom	Possible cause	Corrective action
Fumes detected in lab	Exhaust is restricted	Ensure the exhaust hose from the detector runs downward, toward the floor, and is unobstructed.
	Waste tube is not properly connected to the siphon drain, causing solvent to collect in the drip tray	Properly attach and route the waste tube.
Keypad not functioning	Keypad defective	<ol style="list-style-type: none">1. Power-off and then power-on the detector.2. Run the keypad diagnostic (see page 5-9).3. If the problem persists, call Waters Technical Service (see page 4-2).
Lamp not functioning	Lamp burned out	<ol style="list-style-type: none">1. Power-off and then power-on the detector.2. If the problem persists, replace the lamp cartridge (see page 4-3).

Power-on confidence check error messages

The following table contains power-on confidence check error messages, along with their descriptions, for the detector.

Power-on confidence check error messages

Error message	Possible cause	Corrective action
HW communications failure, multiplexed ADC	Cable loose or intermittent connector contact.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
HW communications failure, reference photodiode ADC	Personality board problem.	
HW communications failure, sample ADC		
Lamp or PMT signal too low	Weak lamp or bad alignment.	<ol style="list-style-type: none"> 1. Replace the lamp (see page 5-8). 2. Power the detector off, and then on. 3. If the problem persists, call Waters Technical Service (see page 4-2).
PMT dark current too high	Light entering the optics bench. Problem with PMT or personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
PMT dark current too low	Problem with PMT or personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
PMT not calibrated	Memory was reset and previous normalization information was reset.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).

Power-on confidence check error messages (Continued)

Error message	Possible cause	Corrective action
Reference dark current too high	Light entering optics bench. Problem with PMT or personality board.	1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Reference dark current too low	Problem with PMT or personality board.	1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Signal too high. Bad PMT or light leak in bench.	Light entering optics bench.	1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
System not normalized. Run diagnostic.	Memory was reset and previous normalization information was reset.	1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).

Operational error messages

The following table contains operational error messages, along with their descriptions, for the detector.

Operational error messages

Error message	Probable cause	Corrective action
Column heater fell below its set temperature	Heater failure (short circuit). Cable or connector short. Problem with personality board.	1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).

Operational error messages (Continued)

Error message	Probable cause	Corrective action
Column heater has been disconnected	The heater's connection is not connected or loose.	<ol style="list-style-type: none"> 1. Check Column Heater connection and connector. 2. Power-off and then power-on the detector. 3. If the problem persists, call Waters Technical Service (see page 4-2).
Column heater has not reached its set temperature	A run was started before the heater's temperature was within its alarm limits.	Allow the heaters to reach their set temperatures before starting a run.
Column heater rose above its set temperature	Heater failure (short circuit). Cable or connector short. Problem with personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Column heater temperature probe failure	The heater's temperature probe is not connected or has a loose connection. Problem with personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Configuration not found	A memory failure was detected, and it was reset to its default value.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).

Operational error messages (Continued)

Error message	Probable cause	Corrective action
Drift tube heater fell below its set temperature	Heater failure (short circuit). Cable or connector short. Problem with personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Drift Tube heater has not reached its set temperature	A run was started before the heater's temperature was within its alarm limits.	Allow the heaters to reach their set temperatures before starting a run.
Drift tube heater rose above its set temperature	Heater failure (short circuit). Cable or connector short. Problem with personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Drift tube heater temperature probe failure	The heater's temperature probe is not connected or has a loose connection. Problem with personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Lamp failure	Weak lamp or bad alignment.	<ol style="list-style-type: none"> 1. Replace the lamp (see page 5-8). 2. Power-off and then power-on the detector. 3. If the problem persists, call Waters Technical Service (see page 4-2).

Operational error messages (Continued)

Error message	Probable cause	Corrective action
Low input gas pressure	The gas input is below 450 kPa (4.5 bar, 65 psi). Defective low gas pressure limit switch.	<ol style="list-style-type: none"> 1. Check gas source. 2. Power-off and then power-on the detector. 3. If the problem persists, call Waters Technical Service (see page 4-2).
Method not found	A memory failure was detected, and it was reset to its default value.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Nebulizer heater rose above its set temperature	Heater failure (short circuit). Cable or connector short. Problem with personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Nebulizer heater temperature probe failure	The heater's temperature probe is not connected or has a loose connection. Problem with personality board.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
NV-RAM bad	A memory failure was detected, and it was reset to its default value.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Optics heater has been disconnected	The heater's connection is not connected or loose.	<ol style="list-style-type: none"> 1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).

Operational error messages (Continued)

Error message	Probable cause	Corrective action
Optics heater rose above its set temperature	Heater failure (short circuit). Cable or connector short. Problem with personality board.	1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).
Optics heater temperature probe failure	The heater's temperature probe is not connected or has a loose connection. Problem with personality board.	1. Power-off and then power-on the detector. 2. If the problem persists, call Waters Technical Service (see page 4-2).

Chromatography troubleshooting

This section contains chromatography troubleshooting tables that include symptoms, possible causes, and suggested corrective actions. These tables can help you isolate the possible causes of problems related to these factors:

- Abnormal baseline (drift, noise, or cycling) (see the [table titled “Abnormal baseline troubleshooting” on page 5-22](#)).
- Erratic or incorrect retention times (see the [table titled “Troubleshooting general chromatography problems” on page 5-27](#)).
- Poor peak resolution (see the [table titled “Peak resolution troubleshooting” on page 5-30](#)).
- Incorrect qualitative/quantitative results (see the [table titled “Incorrect results troubleshooting” on page 5-31](#)).



Warning: To avoid chemical hazards, always observe safe laboratory practices when operating your system. Refer to the Material Safety Data Sheets shipped with solvents for handling information.

If your system exhibits symptoms *not* addressed in one of the tables, refer to [“General troubleshooting” on page 5-13](#). If you need further help, contact Waters Technical Service.

Abnormal baseline

Drift, noise, and cycling are common symptoms of an abnormal baseline.

Cycling

If the baseline is cycling, determine the period of the cycle and whether it is related to the flow rate or fluctuations in ambient temperature or pressure.

Refer to the following table to troubleshoot problems with your baseline.

Abnormal baseline troubleshooting

Symptom	Possible cause	Corrective action
Baseline drift	Mobile phase mixing problem causing improper evaporation.	Correct mobile phase composition. Use high-quality HPLC water and organic solvents.
	Drift tube temperature not optimized correctly.	Recalculate temperature for least volatile mobile phase during a gradient run. Reset temperature as necessary (see page 3-18).
	Column shedding particles during gradient run.	Recalculate temperature for least volatile mobile phase during a gradient run. Reset temperature as necessary (see page 3-18).
Baseline noise (regular)	Air in mobile phase or pump.	Degas mobile phase. Purge pump to remove air.
	Pump pulsations.	Incorporate pulse dampener into system. Correct pump check valve or pump seal problems.

Abnormal baseline troubleshooting (Continued)

Symptom	Possible cause	Corrective action
Baseline noise (irregular)	Improper volatilization of mobile phase.	Check drift tube temperature setting, optimize temperature (see page 3-18).
	Dirty nebulizer and/or drift tube.	Clean nebulizer and/or drift tube (see page 4-9) or call Waters Technical Service (see page 4-2).
	Varying or low gas flow.	Check gas flow setting. Optimize gas flow. Reset gas flow as necessary. Check source gas.
	Obstructed or full exhaust trap.	Check for kinks in exhaust line or empty condensate flask.
	Column leaking silica or packing material.	Replace column and flush it thoroughly before connecting it to the detector.
	Air trapped in system.	Flush system with strong solvent.
	Leaks.	Check system for loose fittings. Check pump for leaks or unusual noise. Change pump seals if necessary.
Broad peaks	Leak (especially between the column and detector).	Check for loose fittings.
	Tubing between column and detector too long or too large of an ID.	Use short piece of 0.005 - to-0.010-inch ID tubing.

Abnormal baseline troubleshooting (Continued)

Symptom	Possible cause	Corrective action
Change in peak height or loss in sensitivity	Nebulizer blocked.	Clean nebulizer and/or drift tube (see page 4-9).
	Dirty nebulizer and/or drift tube.	Clean nebulizer and/or drift tube (see page 4-9) or call Waters Technical Service (see page 4-2).
	Detector/recorder setting changed.	Check drift tube temperature and gas flow settings.
	Detector exhaust too strong.	Move exhaust hose further away from vacuum. See the figure “Exhaust system flow example” on page 2-11 .
Detector is making a gurgling sound	Detector exhaust too strong.	Move exhaust hose further away from vacuum. See the figure “Exhaust system flow example” on page 2-11 .
Drift tube not heating	Tube temperature not set correctly.	Adjust tube setting to correct temperature (see page 3-18).
	Oven temperature switch defect.	Contact Waters Technical Service.
Drift tube overheating	Tube temperature not set correctly.	Adjust tube setting to correct temperature.
	Temperature sensor malfunctioning.	Contact Waters Technical Service.
High solvent pressure	Blocked nebulizer.	<ol style="list-style-type: none"> 1. Clean the nebulizer (see page 4-9). 2. Replace nebulizer (see page 4-6).

Abnormal baseline troubleshooting (Continued)

Symptom	Possible cause	Corrective action
Nebulizer cooler not functioning	Nebulizer cooler malfunctioning.	<ol style="list-style-type: none"> 1. Ensure there is 5 cm (2 inches) clearance on the left side of the detector to allow venting for nebulizer cooling. 2. Power-off and then power-on the detector. 3. Allow 30 to 60 minutes for the detector to equilibrate. 4. If the problem persists, call Waters Technical Service (see page 4-2).
No mobile phase flow	Detector went into error and shut off pump.	Determine and fix the error, then restart the pump.
	Flow interrupted or obstructed.	Check mobile phase level in reservoirs. Check flow throughout system. Make sure mobile phase inlet filter is clean.
	Leak.	Check system for loose fittings. Check for leak or unusual noises. Change pump seals, if necessary.
	Air in pump head.	Prime the pump. Consult the operator's guide that accompanied the pump for more information.
No gas flow	Gas source valve closed.	Open gas valve and set to desired rate.
	Blocked nebulizer.	Clean or replace nebulizer (see page 4-9 and page 4-6).
	Source gas pressure too low.	Check gas source.

Abnormal baseline troubleshooting (Continued)

Symptom	Possible cause	Corrective action
No gas flow (continued)	Clogged inlet gas filter.	Contact Waters Technical Service to replace filter.
No power	Line unplugged.	Plug in power line.
	Blown fuse.	Replace fuse (see page 4-14).
No LCD display	Electrical problem.	Contact Waters Technical Service.
No peaks detected	Sample is volatile at detector conditions.	Modify method to use a more volatile mobile phase.
	Sample being retained on column.	Remove column. Connect injection valve directly to detector and inject into mobile phase. Peak should be seen immediately.
	Detector output signal not zeroed.	Press the Auto Zero key.
	No gain set.	Set gain (see page 3-19).
	Detector exhaust too strong.	Move exhaust hose further away from vacuum. See the figure “Exhaust system flow example” on page 2-11 .
	Drift tube temperature too high.	Decrease drift tube temperature (see page 3-18).
Rounded peaks	Detector time constants set too high.	Reduce setting to lowest value or value at which no further improvements are seen.
Spiking	Gas source contaminated or of low purity.	Use clean, dry, inert gas, usually 99.9% pure nitrogen.
	Drift tube dirty.	Clean drift tube. Contact Waters Technical Service.

Abnormal baseline troubleshooting (Continued)

Symptom	Possible cause	Corrective action
Spiking (continued)	Mobile phase contaminated or made of low quality material.	Check make up of mobile phase.
	Gas flow set too low.	Increase gas flow.

Erratic or incorrect retention times

When you troubleshoot retention time problems, determine whether the retention times:

- Change from run to run or are constant from run to run but outside the allowable range for the assay
- Vary due to pressure fluctuations that are short-term (with each pump cycle) or long-term (over the course of several minutes)
- Are associated with an absolute pressure change, that is, if the pressure is constant but higher or lower than the normal operating pressure
- Change suddenly at the end of a series of runs, which may indicate that air is dissolving in the mobile phase, that the mobile phase is degrading, or that the column is contaminated
- Change early in a series of runs and tend to become constant or fall within range after a few minutes, which can indicate that the column was not equilibrated or that the solvent is not properly degassed and sparged

Troubleshooting general chromatography problems

Symptom	Possible cause	Corrective action
Erratic retention times	Air bubble in pump head	Degas all solvents, prime pump (see page 6-7).
	Malfunctioning pump check valves	Clean, replace, or rebuild pump check valves.
	Leaking pump seals	Replace pump seals.
	Separation chemistry	Check mobile phase and column.

Troubleshooting general chromatography problems (Continued)

Symptom	Possible cause	Corrective action
Erratic retention times (continued)	Clogged solvent filters	Replace filters.
Increased retention times	Incorrect flow rate	Verify flow rate.
	Incorrect solvent composition	Change solvent composition.
	Column heater module not operating	Power-on column heater module.
	Column not equilibrated	Equilibrate column.
	Incorrect column or guard column	Use correct column or guard column.
Doubled retention times	Air bubble in pump head	Prime pump to remove bubble.
	Malfunctioning pump check valve(s)	Clean, replace, or rebuild pump check valve(s).
	Broken pump plunger	Replace the plunger.
Reduced retention times	Incorrect flow rate	Verify flow rate.
	Incorrect solvent composition	Change composition.
	High column temperature	Reduce column temperature (see page 3-21).
	Incorrect column pretreatment	See column manual.
	Column contaminated	Clean or replace column.
	Incorrect column or guard column	Use correct column or guard column.

Troubleshooting general chromatography problems (Continued)

Symptom	Possible cause	Corrective action
Reproducibility errors	Solvent not properly degassed/sparged	Degas or sparge solvent (see page 6-7).
	Incorrect chemistry or integration	Check chemistry or integration.
	Column not equilibrated	Equilibrate column.
	Injector problem	Troubleshoot injector.

Poor peak resolution

Before you address problems with peak resolution, be certain that peaks elute at the correct retention time. The most common causes of poor peak resolution can also appear as retention time problems.

If peak retention times are correct, determine whether poor resolution occurs throughout the chromatogram or at a single peak pair.

If efficiency of early peaks is poor, extra-column band broadening, such as auto injector or guard column failure, can be at fault. If peak efficiency is poor throughout the chromatogram, post-column band-broadening or loss of column efficiency can be the cause.

If only one peak in a chromatogram is badly-shaped, the peak component may be interacting with the column through a chemical mechanism different from the components in the other peaks. To troubleshoot this resolution problem, you need to understand the separation chemistry.

Use the following table to troubleshoot peak resolution problems that may be affecting your results.

Peak resolution troubleshooting

Symptom	Possible cause	Corrective action
Straight baseline, no peaks	No pump flow	Set pump flow rate.
	Lamp not operating	Check method. Lamp might be turned off. Call Waters Technical Service.
	Detector not zeroed	Auto zero detector baseline. Check cables between unit and recorder.
	Improper connection between the detector and the recorder	Auto zero detector baseline. Check cables between unit and recorder.
	No sample injected	Check injector.
	Leak in solvent path	Check fittings and drip tray.
	Bad column	Clean or flush or replace column. Call Waters Technical Service.
	Detector gas flow set to off	Turn gas flow back on.
	No gain set	Set gain (see page 3-19).
Flat-topped peaks	Detector not zeroed	Auto zero detector baseline.
	Incorrect recorder input voltage	Adjust recorder input voltage, or connect cable to correct port on recorder.
	Sample concentration or injection volume exceeds voltage output of detector	Decrease sample concentration or injection volume.

Incorrect qualitative and quantitative results

If a peak is incorrectly identified by a data system or integrator, ensure that the retention time is correct. If retention times are correct, and peak resolution is good, the cause of qualitative and quantitative errors is not likely to be chromatographic; it is more likely due to inadequate sample preparation or faulty processing of the data (integration).

Refer to the following table to troubleshoot problems with qualification and/or quantitation.

Incorrect results troubleshooting

Symptom	Possible cause	Corrective action
Decreased peak height	Leak in injector.	Troubleshoot injector.
	Degraded, contaminated, or improperly prepared sample.	Use fresh sample.
	Column contaminated.	Clean or replace column.
	Loss of column efficiency.	Clean or replace column.
	Change in mobile phase composition.	Correct mobile phase pH or ionic composition.
	Incorrect flow rate.	Change flow rate.
	Drift tube temperature too high.	Decrease drift tube temperature (see page 3-18).
	Nebulizer not spraying properly.	Clean/replace nebulizer.
Increased noise	Air bubble in flow path.	Replace column with union and purge flow path at 10 mL/min.
	Mobile phase not degassed.	Degas or sparge mobile phase.
	Contaminated mobile phase.	Use fresh mobile phase.

Incorrect results troubleshooting (Continued)

Symptom	Possible cause	Corrective action
Increased noise (continued)	Drift tube temperature too low.	Increase drift tube temperature (see page 3-18).
	Drift tube temperature too high.	Decrease drift tube temperature (see page 3-18).
	Nebulizer temperature too high.	Decrease nebulizer power level (see page 3-18).

6 Optimizing Detection and Preparing Solvents

Proper solvent selection and preparation are critical in differential evaporative light scattering detection to prevent baseline changes such as drift, noise, or an erratic baseline. This chapter presents information on

- detector performance
- common solvent problems
- solvent selection
- degassing a solvent



Warning: To avoid chemical hazards, always observe safe laboratory practices when handling solvents. Refer to the Material Safety Data Sheets shipped with solvents for handling information.

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Selecting a solvent	6-2
Solvent degassing	6-7
Optimization protocol	6-9

Optimizing detector performance

Optimizing the mobile phase

Particulate matter in the mobile phase increases the background and noise. In most cases, distilled water and HPLC-grade solvents are sufficient. When comparing solvents, the most critical parameter is the amount of residue after evaporation, which should be less than 1 ppm. For that reason, the mobile phase should contain volatile solvent modifiers, not nonvolatile ones, such as ammonium acetate, ammonium bicarbonate, formic acid, phosphoric acids, sulfuric acid, phosphates, and sulfates. MS-compatible, volatile solvent modifiers, such as CF_3COOH (Trifluoroacetic Acid) and CH_3COOH (Acetic Acid), can be used with the ELS detector.

Sample pretreatment

If the sample contains any particulate matter, filter it through a 0.2- μm or 0.45- μm filter before injection.

Column treatment

The chromatographic column contains microparticles to separate the compounds being analyzed. Under certain circumstances, the column packing undergoes chemical and/or mechanical breakdown, which can introduce particulate matter into the detector, increasing noise.

Column breakdown depends on particle size, the type of column used, column manufacturer, and the nature of the mobile phase. For example, high pH degrades silica-based columns.



Caution: To avoid damaging the nebulizer, flush columns with at least 10 column volumes of clean mobile phase before connecting them to the nebulizer. For example, flush a 2.1×50 column for 10 minutes at 0.5 ml/minute.

Selecting a solvent

An ideal solvent for your analysis has good solubility characteristics for your application, and gives satisfactory baseline noise performance.

Solvent quality

Use spectral-grade or HPLC-grade solvents to ensure reproducible results and minimal instrument maintenance.

A dirty or impure solvent can cause these problems:

- Baseline noise and drift
- Plugged columns
- Blockages in the fluid path

Preparation checklist

The following solvent preparation guidelines help to ensure stable baselines and good resolution:

- Filter solvents with a 0.45- μm filter.
- Degas and/or sparge the solvent.
- Protect solvents from shock and drafts.

Water

Use water only from a high-quality water purification system. If the water system does not provide filtered water, filter it through a 0.45- μm membrane filter before use. The total organic carbon reading should be as low as possible (<5 ppb).

Buffer compatibility

The detector cannot be used with nonvolatile solvents such as salt-buffer solutions. Volatile modifiers, such as acetic acid and ammonium formate, may be used successfully.

Mobile phase modifiers that are suitable for mass spectrometry (for example, ammonium acetate, ammonium bicarbonate, ammonium formate) can be used for evaporative light scattering detection in concentrations of less than 0.01 M, or 0.1% (v/v %). Higher concentrations of nonvolatile materials in the mobile phase cause greater baseline noise, lower sensitivity, and nebulizer and small bore tubing blockages. High purity mobile phases with low boiling points are recommended.



Caution: Nonvolatile buffers are not recommended for use with the detector. They cause noise and block fluid pathways.

Organic solvent compatibility

The ELS detector is fully compatible with standard chromatographic solvents including both reversed phase and normal phase organic solvents. The limitations of detector solvent compatibility are limits imposed by the chromatographic system in use.

Tetrahydrofuran (THF)

When you use unstabilized THF, ensure that your solvent is fresh. Previously opened bottles of THF contain peroxide contaminants, which cause baseline drift.



Warning: THF contaminants (peroxides) can explode when concentrated or evaporated to dryness.



Warning: Do not use flammable solvents with air as the gas.

Properties of common solvents

The following table lists the properties for some common chromatographic solvents.

Properties of common solvents

Solvent	Vapor Pressure mm Hg (Torr)	Boiling Point (°C)	Flash Point (°C)
Acetone	184.5 at 20 °C	56.29	-20
Acetonitrile	88.8 at 25 °C	81.6	6
<i>n</i> -butyl acetate	7.8 at 20 °C	126.11	22
<i>n</i> -butyl alcohol	4.4 at 20 °C	117.5	37
<i>n</i> -butyl chloride	80.1 at 20 °C	78.44	-9
Chlorobenzene	8.8 at 20 °C	131.69	28
Chloroform	158.4 at 20 °C	61.15	
Cyclohexane	77.5 at 20 °C	80.72	-20
Cyclopentane	400 at 20 °C	49.26	-7
<i>o</i> -Dichlorobenzene	1.2 at 20 °C	180.48	66
Dichloromethane	350 at 20 °C	39.75	

Properties of common solvents (Continued)

Solvent	Vapor Pressure mm Hg (Torr)	Boiling Point (°C)	Flash Point (°C)
Dimethyl acetamide	1.3 at 25 °C	166.1	70
<i>N,N</i> -Dimethylformamide	2.7 at 20 °C	153.0	58
Dimethyl sulfoxide	0.6 at 25 °C	189.0	88
1,4-Dioxane	29 at 20 °C	101.32	12
Ethyl acetate	73 at 20 °C	77.11	-4
Ethyl alcohol	43.9 at 20 °C	78.32	15
Ethyl ether	442 at 20 °C	34.55	-45
Ethylene dichloride	83.35 at 20 °C	83.48	13
Heptane	35.5 at 20 °C	98.43	-4
Hexane	124 at 20 °C	68.7	-22
Iso-octane	41 at 20 °C	99.24	-12
Isobutyl alcohol	8.8 at 20 °C	107.7	28
Isopropyl alcohol	32.4 at 20 °C	82.26	12
Isopropyl myristate	<1 at 20 °C	192.6	164
Methanol	97 at 20 °C	64.7	11
Methyl <i>t</i> -butyl ether	240 at 20 °C	55.2	-28
Methyl ethyl ketone	74 at 20 °C	79.64	-9
Methyl isobutyl ketone	16 at 20 °C	117.4	18
<i>N</i> -Methylpyrrolidone	0.33 at 25 °C	202.0	86
Pentane	420 at 20 °C	36.07	-49
<i>n</i> -Propyl alcohol	15 at 20 °C	97.2	23
Propylene carbonate		241.7	135
Pyridine	18 at 25 °C	115.25	20
Tetrahydrofuran	142 at 20 °C	66.0	-14
Toluene	28.5 at 20 °C	110.62	4
1,2,4-Trichlorobenzene	1 at 20 °C	213.5	106
Triethylamine	57 at 25 °C	89.5	-9
Trifluoroacetic acid		71.8	

Properties of common solvents (Continued)

Solvent	Vapor Pressure mm Hg (Torr)	Boiling Point (°C)	Flash Point (°C)
Water	17.54 at 20 °C	100.0	
<i>o</i> -xylene	6 at 20 °C	144.41	17

Properties of volatile mobile phase modifiers

The following table lists the properties for volatile mobile phase modifiers.

Properties of volatile mobile phase modifiers

	pKa	pKb	pH range	Boiling Point (°C)
Acids				
Acetic Acid	4.75	9.25		116.00
Carbonic Acid	6.37	7.63		
Formic Acid	3.75	10.25		100.70
Trifluoroacetic Acid	0.30	13.70		71.80
Bases				
Ammonia	9.25	4.75		-33.35
Ethylamine	10.81	3.19		16.60
Methylamine	10.66	3.34		-6.30
Triethylamine	11.01	2.99		89.30
Buffers				
Ammonium Acetate			3.8 to 5.8	
Ammonium Carbonate			5.5 to 7.5 and 9.3 to 11.3	
Ammonium Formate			3.0 to 5.0	

Solvent degassing

Using degassed solvents is one of the most important steps in solvent preparation. Degassing provides

- stable baselines and enhanced sensitivity
- reproducible retention times
- stable pump or solvent delivery system operation

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

Solvent degassing methods

Solvent degassing helps you attain a stable baseline and also improves reproducibility and pump performance.

Three common methods used to degas solvents are

- sparging with helium
- reducing pressure by vacuum
- using sonication

These methods may be used individually or in combination.

Vacuum-ultrasound followed by sparging is the most effective technique for most solvents.

Sparging

Sparging removes gases from solution by displacing dissolved gases in the solvent with a less soluble gas, usually helium. Well-sparged solvent improves pump performance. Helium sparging brings the solvent to a state of equilibrium, which may be maintained by slow sparging or by keeping a blanket of helium over the solvent. Blanketing inhibits reabsorption of atmospheric gases.

Tip: Sparging may change the composition of mixed solvents.

Vacuum degassing

The inline vacuum degasser operates on the principle of Henry's law to remove dissolved gases from the solvent. Henry's law states that the mole fraction of a gas dissolved in liquid is proportional to the partial pressure of

that gas in the vapor phase above the liquid. If the partial pressure of a gas on the surface of the liquid is reduced, for example, by evacuation, then a proportional amount of that gas comes out of solution.

Tip: Vacuum degassing can change the composition of mixed solvents.

Ultrasonic agitation

High energy ultrasonic agitation drives energy into the solvent and causes the submicron-sized “bubbles” of gas to aggregate. As the gas bubbles aggregate, they become large enough to float out of the solvent and dissipate. Used alone, ultrasonic agitation degasses 4 liters of solvent in approximately 22 minutes.

Solvent degassing considerations

Select the most efficient degassing operation for your application. To remove dissolved gas quickly, consider the following.

Vacuum degassing

The longer a solvent is exposed to the vacuum, the more dissolved gases are removed. Two factors affect the amount of time the solvent is exposed to the vacuum:

- Flow rate – At low flow rates, most of the dissolved gas is removed as the solvent passes through the vacuum chamber. At higher flow rates, lesser amounts of gas per unit volume of solvent are removed.
- Surface area of the degassing membrane – The length of the degassing membrane is fixed in each vacuum chamber. To increase the length of membrane, you can connect two or more vacuum chambers in series.

The inline degasser is available as an option or factory-installed in the Waters Alliance Separations Module, XE model. Standalone inline degassers are also available.

Sparging

Helium sparging prevents reabsorption of atmospheric gases. Use this method to retard oxidation when you are using THF or other peroxide-forming solvents.

Ultrasound plus vacuum

Ultrasonic agitation combined with vacuum degasses solvent very quickly. This technique is less likely to change the composition of mixed solvents than vacuum alone because the mixed solvents are held under vacuum for only a short time (less than a minute is usually sufficient).



Warning: Do not apply vacuum to the brown glass bottles in which solvent is shipped. There is a high risk of implosion under these conditions. Use a thick-walled container designed for vacuum applications.

Optimization protocol

You must select the appropriate application operating parameters to obtain the best performance from your detector. Nebulizer gas flow rate, nebulizer temperature, and drift tube temperature must all be optimized for the best results.

Nebulizer gas pressure

Increased nebulizer gas flow rate causes a decreased signal response because of the resulting formation of smaller droplets that scatter less light. Lower gas flow rates tend to be more favorable because less gas is consumed and a better sensitivity is achieved. However, at some point this benefit is offset by an increase in baseline noise from the inefficient nebulization of the eluent, resulting in large droplets. The particle size of these droplets results in complex scattering mechanisms and poor detector performance. If you reduce the eluent flow, you must also reduce the nebulizer gas flow rate to maintain the optimum nebulized droplet size. Never decrease the nitrogen flow rate below 170 kPa (1.7 bar, 25 psi).

Nebulizer temperature

Note: Setting the nebulizer temperature high enough to boil the solvent can cause excessive baseline noise.

The detector starts more quickly when you decrease the temperature of the nebulizer chamber. The cooling option was added to effect faster equilibration.

Using the heater to increase the nebulizer temperature reduces solvent viscosity and the surface tension of sample droplets. It also increases the amount of analyte vapor in the drift tube, increasing signal levels. However, a heated nebulizer chamber can require a higher drift tube temperature, which can adversely affect temperature-sensitive samples. If your samples are temperature-sensitive, cooling the nebulizer increases sensitivity and permits a lower drift tube temperature, which can increase sensitivity even more.

Recommendation: In general, set as low a nebulizer temperature as possible.

Drift tube temperature

The effects of modifying the drift tube temperature are not as significant as those that result from changing the nebulizer gas flow rate. However, the evaporator temperature must be high enough to evaporate the solvent and sufficiently dry the particle plume without adversely affecting the sample. If the evaporator temperature is too low, the solvent can saturate the diffuser, resulting in high noise and spikes. If the drift tube temperature is too high, the sample may be volatilized, resulting in a small response.

Selecting the optimum temperature

When setting up a system, set the temperature of the drift tube to 50 °C if you are using reversed-phase chromatography. You can adjust these values during method optimization.

If you think your compound is thermally labile, you can use a lower temperature to improve detector sensitivity to minimize thermal loss. However, for a given solvent and flow rate, there is a point at which the noise in the chromatogram dramatically increases because all of the eluent is not vaporized. At higher flow rates, higher temperatures are required to minimize the noise level.

A Safety Advisories

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

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Warning symbols

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

Task-specific hazard warnings

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

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



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



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



Warning: (Risk of electric shock.)



Warning: (Risk of fire.)



Warning: (Risk of needle puncture.)



Warning: (Risk of injury caused by moving machinery.)



Warning: (Risk of exposure to ultraviolet radiation.)



Warning: (Risk of contacting corrosive substances.)



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



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



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

Specific warnings

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

Burst warning

This warning applies to Waters instruments fitted with nonmetallic tubing.



Warning: Pressurized nonmetallic, or polymer, tubing can burst. Observe these precautions when working around such tubing:

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

Mass spectrometer flammable solvents warning

This warning applies to instruments operated with flammable solvents.



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

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

Mass spectrometer shock hazard

This warning applies to all Waters mass spectrometers.



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

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



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

Biohazard warning

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



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

Chemical hazard warning

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



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

Caution symbol

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



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

Warnings that apply to all Waters instruments

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



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

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

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

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

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

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

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

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

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



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

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

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

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

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

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



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

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

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

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

警告: 當在有壓力的情況下使用聚合物管線時，小心注意以下幾點。

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



警告: 当有压力的情况下使用管线时, 小心注意以下几点:

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

경고: 가압 폴리머 튜브로 작업할 경우에는 주의하십시오.

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

警告: 圧力のかかったポリマーチューブを扱うときは、注意してください。

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



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

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

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

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

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

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

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

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

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



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



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



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



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



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



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



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



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

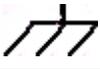
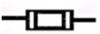


警告: 火災予防のために、ヒューズ交換では機器ヒューズカバー脇のパネルに記載されているタイプおよび定格のヒューズをご使用ください。

Electrical and handling symbols

Electrical symbols

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

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

Handling symbols

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

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

B Specifications

2424 ELS detector specifications

Physical specifications

Attribute	Specification
Height	20.3 cm (8.0 inches)
Depth	52.1 cm (20.5 inches)
Width	28.4 cm (11.2 inches)
Weight	14.7 kg (32.5 pounds)

Environmental specifications

Attribute	Specification
Operating temperature	4 to 30 °C (39.2 to 86 °F)
Operating humidity	20 to 95%, noncondensing
Shipping and storage temperature	-30 to 60 °C (-22 to 140 °F)
Shipping and storage humidity	0 to 95%, noncondensing
Acoustic noise (instrument generated)	<65 dBA

Electrical specifications

Attribute	Specification
Protection class ^a	Class I
Overvoltage category ^b	II

Electrical specifications (Continued)

Attribute	Specification
Pollution degree ^c	2
Moisture protection ^d	Normal (IPXO)
 Line voltages, nominal	Grounded AC
Voltage range	100 to 240 VAC nominal
Frequency	50 to 60 Hz
Fuse	5.00 A
Power consumption	200 VA

- a. **Protection Class I** – The insulating scheme used in the instrument to protect from electrical shock. Class I identifies a single level of insulation between live parts (wires) and exposed conductive parts (metal panels), in which the exposed conductive parts are connected to a grounding system. In turn, this grounding system is connected to the third pin (ground pin) on the electrical power cord plug.
- b. **Overvoltage Category II** – Pertains to instruments that receive their electrical power from a local level such as an electrical wall outlet.
- c. **Pollution Degree 2** – A measure of pollution on electrical circuits, which may produce a reduction of dielectric strength or surface resistivity. Degree 2 refers only to normally nonconductive pollution. Occasionally, however, expect a temporary conductivity caused by condensation.
- d. **Moisture Protection** – Normal (IPXO) – IPXO means that *no* Ingress Protection against any type of dripping or sprayed water exists. The X is a placeholder that identifies protection against dust, if applicable.

Operational specifications

Attribute	Specification
Nebulizer: <ul style="list-style-type: none"> • High-flow rate (standard with detector) • Low-flow rate 	<p>300 to 3000 $\mu\text{L}/\text{min}$, 1.80 standard liters per minute (L_s/min) at 170 kPa (1.7 bar, 25 psi)</p> <p>50 to 500 $\mu\text{L}/\text{min}$, 0.77 L_s/min at 170 kPa (1.7 bar, 25 psi)</p>
Gas	140 kPa (1.4 bar, 20 psi) to 410 kPa (4.1 bar, 60 psi)
Gain settings	0 to 1000
Time constant filter settings	0.0 to 5.0 seconds (Hamming)

Operational specifications (Continued)

Attribute	Specification
Two analog outputs ^a	Channel 1 = -0.1 to 2.1 VDC (selectable maximum data rates are 10, 20, 40, or 80 Hz) Channel 2 = -0.1 to 2.1 VDC (fixed maximum data rate is 10 Hz)
Four event inputs ^b	Input voltage: ±30 Volts max Low input voltage: <1.7 V High input voltage: >3.2 V
Two event outputs ^c	Type: Contact closure Voltage: ±30 Volts max Current, switching: 0.5 A Current, carry: 1.2 A
Temperature control	Nebulizer heater power: 0 to 100% Nebulizer cooler: Cooling/Off Drift tube heater: Ambient to 100 °C (212 °F)

a. Signal and Auxiliary.

b. Inject Start, Lamp On, Chart Mark, and Auto Zero.

c. One event output is dedicated to Stop Flow.

Optical specifications

Attribute	Specification
Evaporative light scattering optics	Lens relay system
Evaporative light scattering angle, θ	60 degrees
Photodiode	Energy reference
Photo detector	Evaporative light scattering signal; photomultiplier tube

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