

ACQUITY UPLC Photodiode Array e λ Detector

Getting Started Guide

71500160703/Revision B

Waters

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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 ACQUITY UPLC[®] Photodiode Array Extended λ (PDA e λ) detectors.

Intended use of the ACQUITY UPLC PDA e λ detector

Waters designed the ACQUITY UPLC PDA e λ 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.

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1

ACQUITY UPLC PDA $e\lambda$ Detector Optics Principles

To use the detector's operating software (Empower™ or MassLynx™) effectively, you must understand the principles that underlie operation of the detector's optics and electronics.

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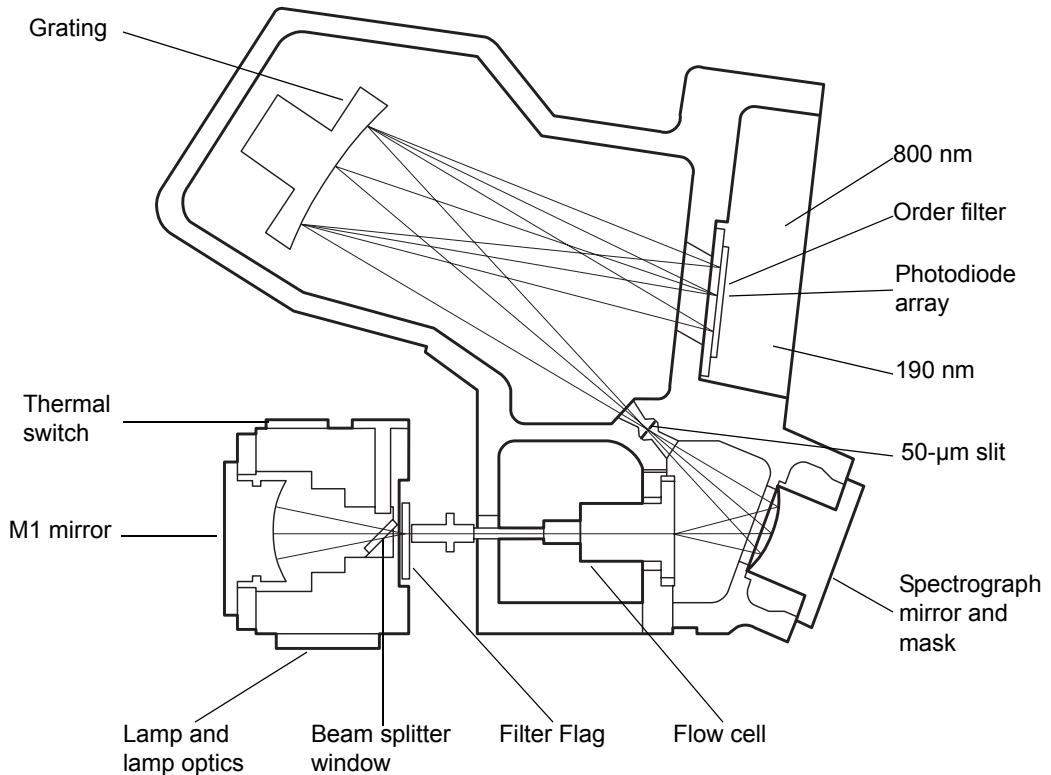
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Detector optics

The detector is an ultraviolet/visible light (UV/Vis) spectrophotometer. With a photodiode array of 512 photodiodes and an optical resolution of 1.2 nm, the detector operates within a range of between 190 and 800 nm.

The light path through the optics assembly of the detector is shown in the figure below.

Optics assembly light path



The following table describes the optics assembly components.

Optics assembly components

Component	Function
Lamp and lamp optics	Focuses light from the deuterium source lamp, and via a mirror, directs it through a beam splitter to the flow cell.
Beam splitter window	Used to help minimize air infiltration into the lamp housing.
Filter flag	Influences the light entering the flow cell. Flag settings include <ul style="list-style-type: none"> • Shutter—Prevents light from entering the flow cell. In the shutter position, dark counts are measured at each pixel and subsequently subtracted from observed signal counts to give true signal counts. • Open—Allows light to pass into the flow cell. It is the normal setting when performing runs. • Erbium—Inserts an erbium filter into the light beam that allows the wavelength calibration to be checked or updated. • UV blocking filter—Inserts a UV blocking filter into the light beam that minimizes light with wavelengths shorter than, approximately, 210 nm.
Flow cell	Houses the segment of the flow path (containing eluent and sample) through which the polychromatic light beam passes.
Shunt	Diagnostic tool used in place of the light-guiding flow cell to emulate light transmission without fluid flow.
Spectrograph mirror and mask	The mirror focuses light transmitted through the flow cell onto the slit at the entrance to the spectrographic portion of the optics. The mirror mask defines the size of the beam at the grating.
Slit	Determines wavelength resolution and intensity of light striking the photodiodes. The width of the slit is 50 μm .
Grating	Disperses light into bands of wavelengths and focuses them onto the plane of the photodiode array.

Optics assembly components (Continued)

Component	Function
Order filter	Reduces the contribution of second-order diffraction of UV light (less than 340 nm) to the light intensity observed at visible wavelengths (greater than 340).
Photodiode array	An array of 512 photodiodes arranged linearly. The diode width (50- μm), together with a 50- μm slit, yield single wavelength resolution of 1.2 nm.

Calculating absorbance

The detector computes absorbance by subtracting the dark current (see “[Dark current](#)” on page 1-12) and reference spectrum from the acquired spectrum. Absorbance is based on the principles of Beer’s law.

Beer’s law

The relationship between the quantity of light of a particular wavelength arriving at the photodiode and the concentration of the sample passing through the flow cell is described by the Beer-Lambert law (commonly called Beer’s law). Beer’s law is expressed as $A = \epsilon lc$ where

A = dimensionless quantity measured in absorbance units

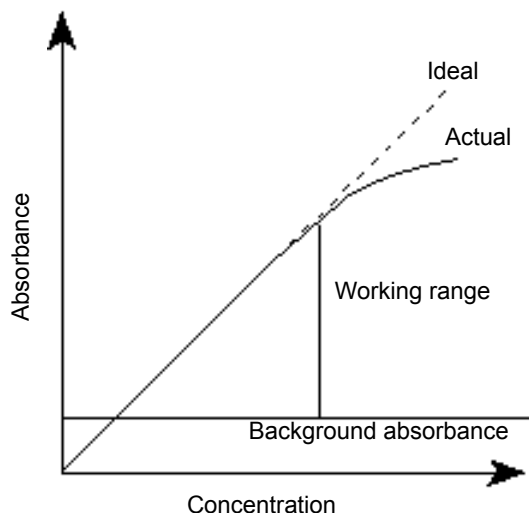
ϵ = constant of proportionality known as the molar extinction coefficient

l = path length, in centimeters (1.0 cm in the detector’s normal flow cell)

c = concentration in moles per liter

Beer’s law applies only to well-equilibrated dilute solutions. It assumes that the refractive index of the sample remains constant, that the light is monochromatic, and that no stray light reaches the detector element. As concentration increases, the chemical and instrumental requirements of Beer’s law may be violated, resulting in a deviation from (absorbance versus concentration) linearity. The absorbance of mobile phase can reduce the linear range by the amounts shown in [Appendix C](#).

Absorbance as a function of concentration

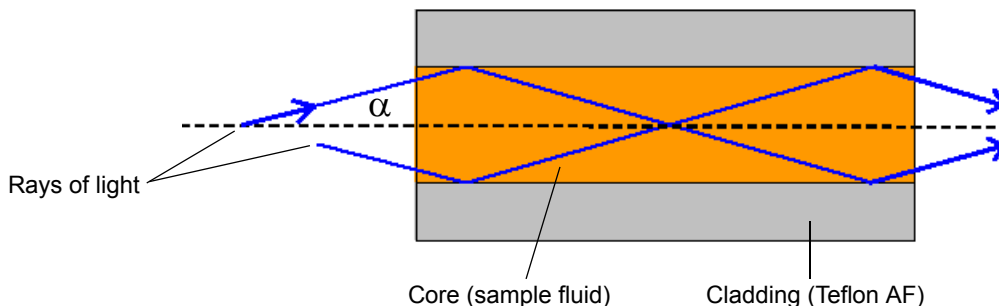


Light-guiding flow cell operating principles

Small-bore, high-capacity columns like those used in UPLC produce small-volume peaks. To avoid bandspreading and maintain concentration, the detector flow cell volume must be correspondingly small. A good rule of thumb is to hold cell volume to 1/10th or less than the peak volume. To achieve the required volume reduction with conventional absorbance detector flow cells, the pathlength must be reduced to avoid a drastic cut in light throughput. Reduced pathlength results in less analytical sensitivity as predicted by Beer's law, but high light levels are necessary to preserve a high signal-to-noise ratio.

Fortunately, a small-volume light-guiding flow cell can be designed with optimum pathlength and high light throughput. Such a flow cell is analogous to an optical fiber, where the core is the fluid sample and the cladding is Teflon[®] AF, a unique, chemically inert, amorphous fluoropolymer made by DuPont. The refractive index of Teflon AF is lower than that of water or other HPLC mobile phases. Light rays entering the liquid core, within the cone half-angle, α , are totally internally reflected when they meet the Teflon AF boundary. These rays are transmitted through the flow cell, theoretically without loss, except for absorption by the sample.

Light transmission through a light-guiding flow cell



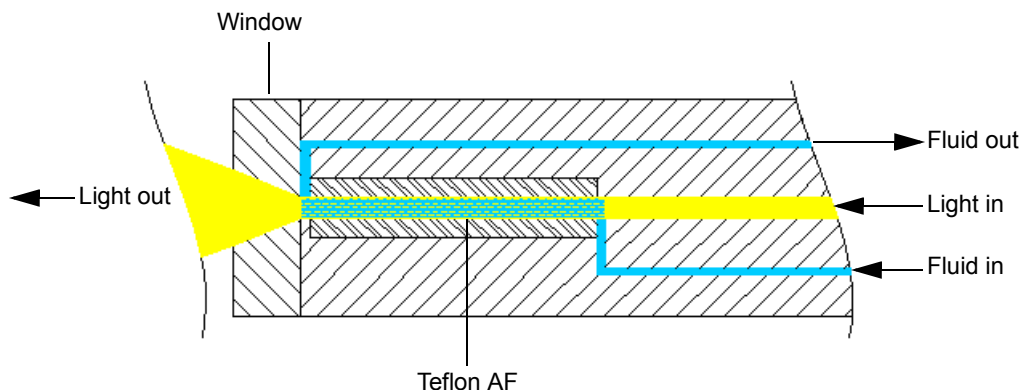
This information complements the foregoing illustration:

- The core of the light guide is the fluid sample with refractive index n_1 .
- The cladding is a Teflon AF tube with refractive index n_2 . Index $n_2 < n_1$.
- The cross-sectional area of the tube is A and the length d . Cell volume = Ad .

In the figure on [page 1-6](#), two rays of light are shown reflecting from the core-cladding interface. In a flow cell, the number of “bounces” depends on the length of the Teflon AF tube, its inside diameter (lumen), and the ray angle, “ α ”. The light beam (which represents the energy transmitted through the cell) is comprised of many such rays, up to a maximum whose angle is theoretically set by the refractive index of the core and cladding. In the ACQUITY UPLC PDA $e\lambda$ detector, this angle is mechanically controlled by components external to the flow cell so that the variation in refractive index arising from different mobile phases does not materially influence the efficiency of the transmitted energy.

The following schematic diagram of the flow cell shows the light-guiding portion of the cell inside the cell assembly.

Light-guiding portion of flow cell



The sample fluid is introduced and removed from the flow cell via PEEK™ tubing. Probe radiation from the lamp housing is focused onto the input face of the optical fiber that forms one end of the flow cell. Light travels down this optical fiber until it encounters the fluid channel defined by the internal diameter of the Teflon AF tube. The light then exits the optical fiber and enters the fluid-filled Teflon AF tube. As the light passes through this tube, it interacts with the sample stream. Any absorption by the fluid reduces the light intensity. The reduction is subsequently converted to absorbance. The light exits the flow cell through a fused silica window where it projects onto the slit of the spectrograph. A concave grating then disperses and projects the light onto the photodiode array.

Tip: Unlike other flow cell designs, where the light beam is designed to avoid striking the internal walls of the cell, light-guiding relies on internal reflections from the walls of the Teflon AF tubing. Consequently, it is important to maintain flow cell cleanliness by following the recommended procedures described in [Chapter 4](#). With such care, the instrument and flow cell should provide you continuous sensitive detection.



Caution: To ensure the detector cell is properly aligned and calibrated, the flow cell must be filled with flowing solvent before you power-on the detector. An empty flow cell will cause a calibration error. Refer to the recommended procedures described in [Chapter 4](#) for more information.

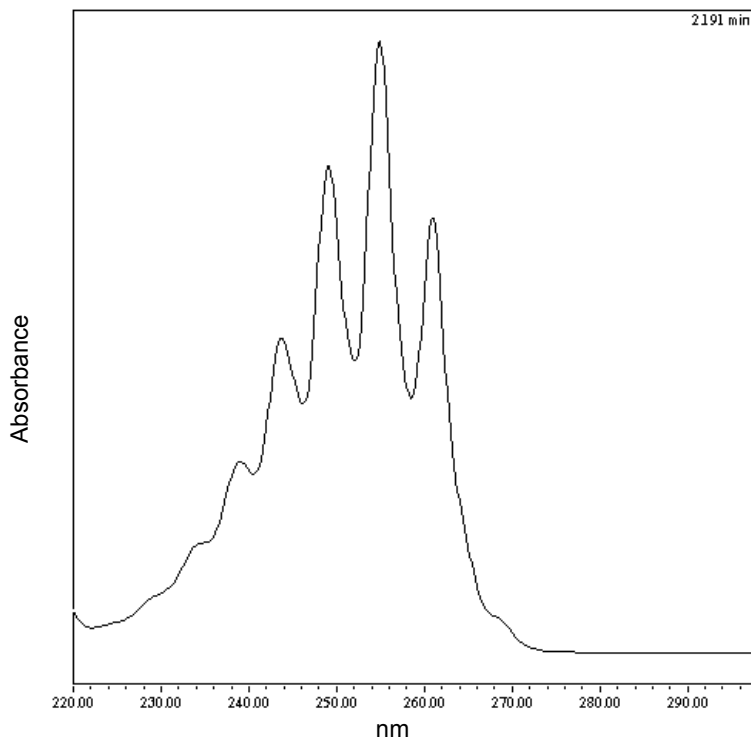
Resolving spectral data

Together with photodiode spacing, the detector's 50- μm wide slit determines the intensity and bandwidth of the light that strikes the photodiode array. Variations in intensity and bandwidth provide the means to distinguish among similar spectra.

The grating images the slit onto the photodiode array. The angle of diffraction from the grating determines the wavelength that strikes a particular photodiode in the array.

The following figure shows an absorbance spectrum of benzene. Note that the wavelength resolution is sufficient to resolve five principal absorption peaks.

Benzene spectrum at 1.2 nm resolution



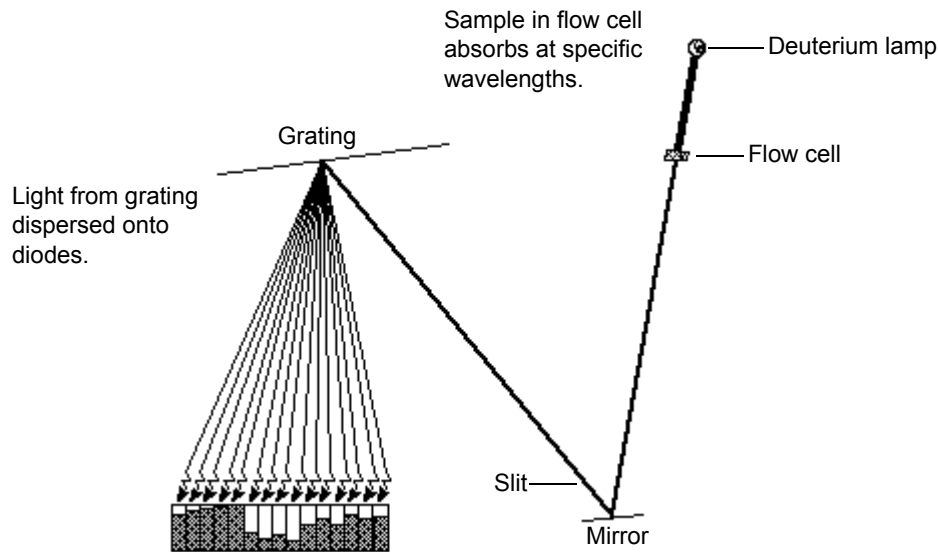
Measuring light at the photodiode array

The photodiode array detector measures the amount of light striking the photodiode array to determine the absorbance of the sample in the flow cell.

The array consists of 512 photodiodes arranged in a row. Each photodiode acts as a capacitor by holding a fixed amount of charge.

Light striking a photodiode discharges the diode. The magnitude of the discharge depends on the amount of light striking the photodiode.

Photodiodes discharged by light



The detector measures the amount of current required to recharge each photodiode. The current is proportional to the amount of light transmitted through the flow cell over the interval specified by the diode exposure time.

Exposure time

The detector recharges each diode and reads the recharging current one diode at a time. The interval between two readings of an individual diode is the exposure time. The detector requires less than 5 msec to sequentially read all of the diodes in the array and process the data. The minimum exposure time is 5 msec. You can set exposure time from 5 to 500 msec. For example, if an exposure time is set to 50 milliseconds, the detector performs as follows:

1. Recharges diode 1 and reads the current required to recharge diode 1
2. Recharges diode 2 and reads the current required to recharge diode 2
3. Sequentially recharges and reads the current required to recharge all the remaining 510 photodiodes
4. Waits approximately 45 msec before beginning the recharge-and-reading sequence, with diode 1, after all diodes have been recharged and read.

You set the exposure time parameter in the General tab of the PDA eλ Instrument Method Editor. You can specify either Auto Exposure or Exposure Time. For details, refer to the Empower or MassLynx online Help.

Tip: For best signal-to-noise performance, adjust the wavelength range to optimize autoexposure computations. For details, refer to the Empower or MassLynx online Help.

Using the Auto Exposure parameter

The Auto Exposure parameter allows the detector's optics to calculate the optimum exposure time needed to recharge the diodes based on lamp energy, lamp spectrum, mobile phase absorbance, and the chosen wavelength range using a single deuterium light source of 190 to 800 nm. To minimize detector noise, Auto Exposure adjusts the exposure time to approximately 85% of full scale for the diode generating the highest signal within the selected wavelength range.

With Auto Exposure enabled, the detector performs as follows:

- Produces the highest signals possible, consistent with not saturating due to overexposure
- Calculates exposure time at the start of a sample set based on maximum light intensity within the selected wavelength range
- Limits the exposure so that no diode within the given wavelength range discharges more than approximately 85%
- Provides proper settings for signal-to-noise and dynamic range for each run

The Auto Exposure time setting may not optimize performance for certain combinations of sampling rates, wavelength ranges, or filter time-constant settings required for your analysis. If this is the case, you can set the exposure time manually, in the instrument editor.

Optimizing the signal-to-noise ratio

To optimize signal-to-noise ratios, choose an acquisition wavelength range that includes only the wavelengths of interest. It is also important that the range be one in which the mobile phase absorbs only minimally (see [Appendix C](#)). The signal-to-noise ratio may also be improved by increasing the Spectral Resolution parameter. For example, you can choose to operate at 3.6 nm instead of at 1.2 nm resolution.

Optimizing filter constants

The filtering constant you select affects the peak intensity. To increase sensitivity, decrease the filter time constant.

Selecting the appropriate sampling rate

A sufficient number of points must fall across a peak to define its shape. Thus, at very low sampling rates, the definition between peaks is lost. Empower uses the index of the data point closest to the end time, minus the index of the data point closest to the start time, to calculate the Points Across Peak value for each integrated peak in the chromatogram.

Tip: The Points Across Peak value appears in the Peaks table, at the bottom of the Review Main window. If the Points Across Peak field is not visible, right-click anywhere in the table, and then click Table Properties. Click the Columns tab, and then scroll down to find the Points Across Peak field. Clear the check box, and then click OK.

If the Points Across Peak value for the narrowest peak of interest is less than 15, you must specify a higher sampling rate in the instrument method. If the value is greater than 30, you should specify a lower sampling rate in the instrument method.

Set the sampling rate to the lowest value required to achieve 15 or more points across the narrowest peak. Excessively high sampling rates can slow the system with more data than you need for your analysis.

Computing absorbance data points

The detector calculates absorbance values before transmitting the data to the database (Empower or MassLynx). The detector calculates absorbance as follows:

- It computes the absorbance at each diode using the dark current and reference spectrum (see [“Calculating absorbance” on page 1-4](#)).
- It averages the absorbances at a particular wavelength, as specified in the spectra-per-second sample rate, and reports the average as a single data point (see [“Resolution” on page 1-13](#)).
- Also, the detector can apply a filter when calculating absorbance (see [“Filtering data” on page 1-14](#)).

Dark current

Photodiodes produce thermally excited charge even when they are not exposed to light. The amount of thermally excited charge produced is called *dark current*.

When a dark current update is necessary, the detector closes the shutter to take a dark current reading for each diode. The shutter closes after the exposure time is calculated and stays closed for the same interval as the exposure time.

The detector subtracts the dark current values from the current values recorded during absorbance measurements for both the sample and the reference spectra.

Reference spectrum

Immediately after the dark current measurement and before any components elute, the detector records a reference spectrum. The reference spectrum is a measure of lamp intensity and mobile phase absorbance. With the shutter open, the reference spectrum is determined over the interval specified in the exposure time.

Tips:

- For best results, the reference spectrum should represent the initial mobile phase.
- For extremely long exposure times, the dark current and reference spectrum readings can take several seconds to finish.

Absorbance

The ACQUITY UPLC PDA eλ detector calculates the absorbance for each diode at the end of each exposure time using the following equation:

$$\text{Absorbance}_n = \log \left[\frac{(S_n - D_n)}{(R_n - D_n)} \right] \text{ where}$$

S = obtained during sample analysis

D = obtained during the dark current test

R = obtained from the reference spectrum

n = diode number

Resolution

The data the detector reports to the database (Empower or MassLynx) can be the average of a number of data points. After calculating absorbance, the detector averages absorbance values based on spectral resolution and sample rate.

Averaging spectral data based on resolution

Spectral resolution (or bandwidth) is the wavelength interval (in nanometers) between data points in an acquired spectrum. The detector's minimal resolution setting is 1.2 nm. For example, in 3D mode, the detector averages six adjacent diodes for each reported wavelength when the spectral resolution is set in the software to 3.6 nm. In 2D mode, absorbance values are computed based on the bandwidth setting.

Averaging chromatographic data based on sample rate

Sample rate is the number of data points acquired per second. The number of times the photodiodes are read during the sample rate interval depends on the exposure time. For example, if exposure time is 25 msec, and sample rate is 20 Hz, then readings per data point are

$$\frac{1 \text{ sec}}{20 \text{ samples}} \times \frac{1 \text{ exposure}}{25 \text{ msec}} \times \frac{1000 \text{ msec}}{1 \text{ sec}} = 2 \frac{\text{exposures}}{\text{sample}}$$

The readings are averaged and reported as a single data point.

Combining spectral resolution and sample rate

A high value of the spectral resolution parameter and sample rate have opposite effects on noise and spectral detail. In normal use, high spectral resolution indicates a numerically small spectral resolution parameter.

Tip: The data storage rate is based on wavelength range, spectral resolution, and sample rate. Specify these parameter values in the General tab of the PDA eλ Instrument Method Editor. For details, refer to the Empower or MassLynx online Help.

Filtering data

In the General tab of the PDA eλ Instrument Method Editor (for details, refer to the Empower or MassLynx online Help or the ACQUITY UPLC Console online Help) you can apply an optional noise filter (via the Digital Filtering parameter) to the data acquired. The following table lists the digital filter settings for the allowable data rates.

Digital Filter Settings for Data Rates

Data Rate	Slow	Normal	Fast
1	10.000	4.000	1.000
2	5.000	2.000	0.500
5	2.000	0.800	0.200
10	1.000	0.400	0.100
20	0.500	0.200	0.050
40	0.250	0.100	0.025
80	0.125	0.050	0.0125

Median baseline filter

The median baseline filter enhances the detector's baseline stability by decreasing the baseline's curvature, facilitating the development of integration methods. The filter's primary purpose is to reduce the effects of mobile phase gradient separations that demonstrate gradual compositional changes. Note that it should not be applied in cases where abrupt gradient changes, such as steps, are evident.

Generally, the filter does not significantly change peak area, peak height, peak width or retention times. However, it can create baseline distortions around very wide peaks, and these distortions can affect peak area. Therefore, it is not recommended for situations where peak widths (measured at 5% height) are greater than 5% of run time.

In the ACQUITY UPLC PDA e λ detector, the filter works with 2D channels only. It cannot be applied to 3D or extracted 2D channels. When the MBF data mode is selected for a channel, the presentation of the data in the real-time data display plot is delayed by a percentage (~25%) of the runtime. A countdown clock, in the instrument control panel, indicates the length of the delay.

2 Setting Up the Detector

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Before you begin

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

Tip: Use this guide in conjunction with the ACQUITY UPLC system documentation and online Help.

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

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*.

Installing the detector

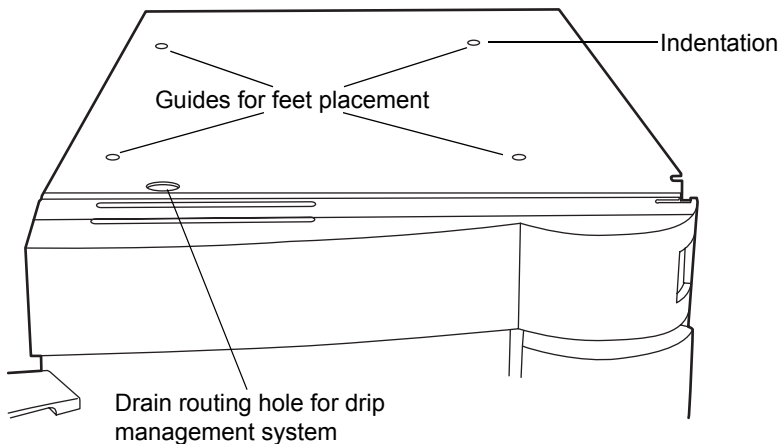
To install the ACQUITY UPLC PDA eλ detector



Warning: If only one person is to install the detector he or she should do so using a mechanical lift.

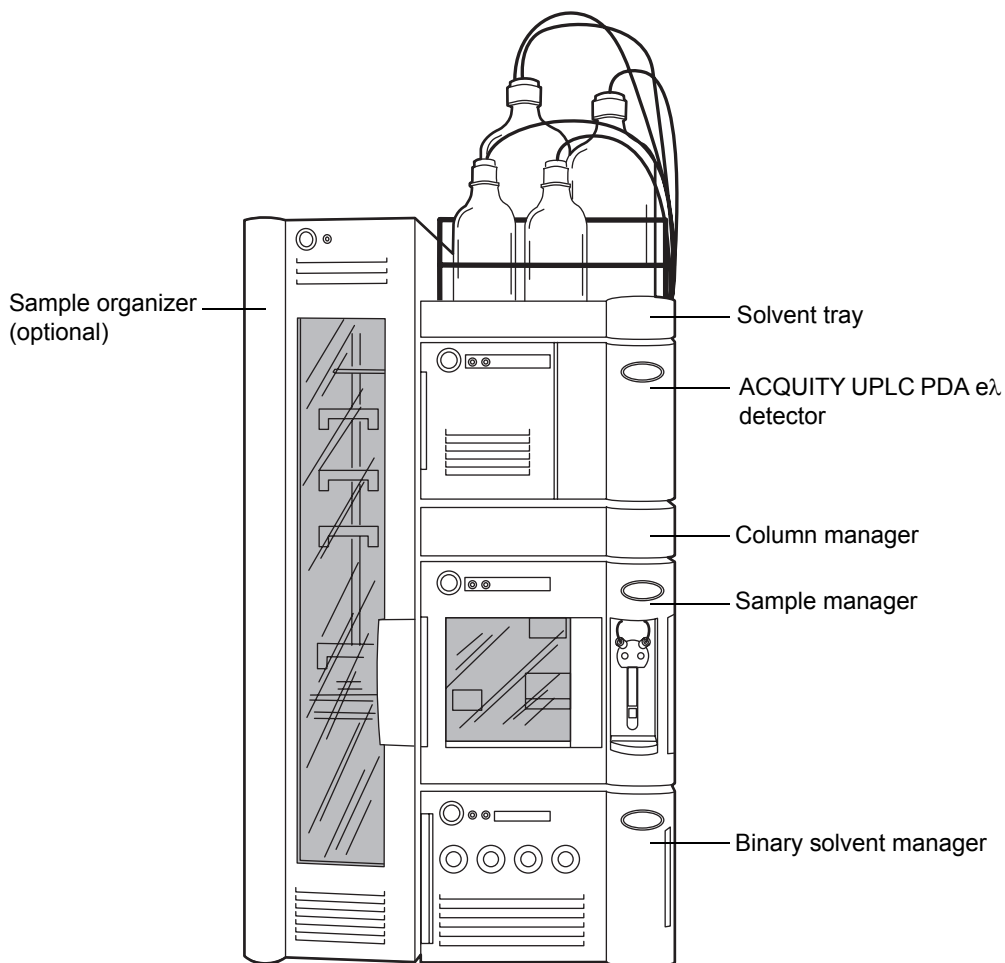
1. Place the detector atop the column manager, ensuring that the feet are properly positioned in the indentations of the column manager. This aligns the detector's drip tray over the drain routing hole, on the top left side of the column manager.

Proper placement for drip management system



2. Place the solvent tray module atop the detector.

ACQUITY UPLC PDA e λ detector installed in ACQUITY UPLC system



Plumbing the detector



Warning: Using incompatible solvents may cause severe damage to the instrument and injury to the operator. Refer to Appendix C of the *ACQUITY UPLC System Operator's Guide* for more information.

Plumbing the detector involves connecting the flow cell and installing a backpressure regulator, if necessary.

Although the inline degasser removes most of the gas (air) from solvents, some gas is reintroduced during partial loop injections. Under pressure, this gas remains in solution. However, because the post-column pressure is normally much lower than the pre-column pressure, the gas may come out of solution and produce an unstable baseline characterized by large, unexpected spikes.

A backpressure regulator maintains a minimum post-column pressure of 1724 kPa (17 bar, 250 psi), eliminating post-column outgassing and ensuring a smooth baseline.


Requirement: If the ACQUITY PDA e λ detector is the last detector in the system, the backpressure regulator is required for optimum performance.

Tip: If a mass spectrometer or other detector is connected downstream of the detector, a backpressure regulator should not be installed. The length of the tubing connecting to the mass spectrometer or other detector helps to maintain the backpressure on the flowcell.

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

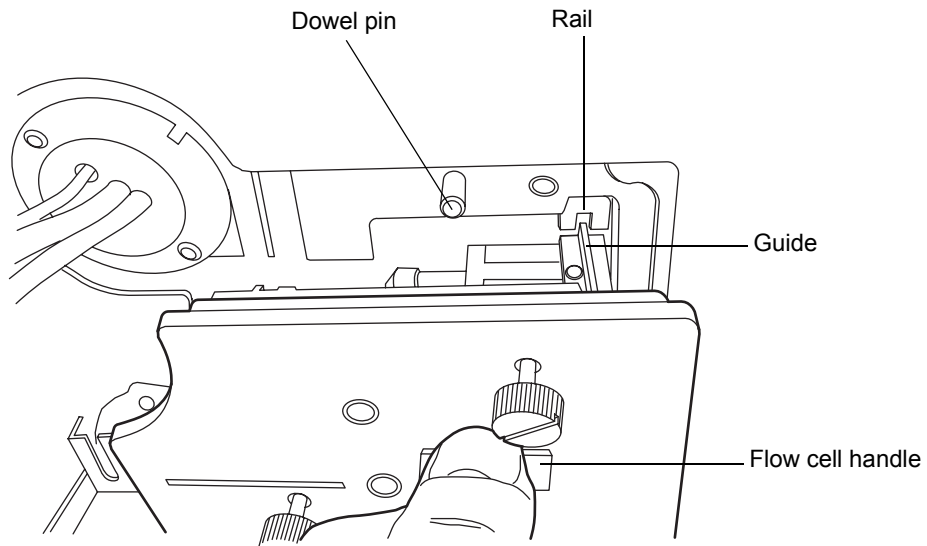
See also: *ACQUITY UPLC System Operator's Guide*.

To plumb the detector

Recommendation: If the detector is already powered on, in the console, select PDA e λ Detector from the system tree and click  (Lamp Off) to extinguish the lamp.

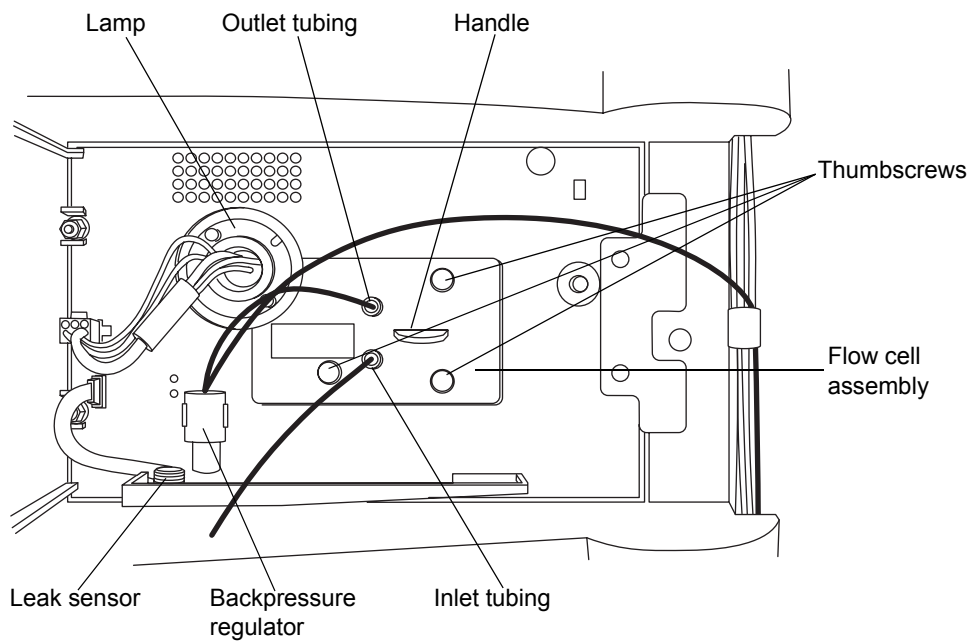
1. Open the detector's front panel door, and install the flow cell assembly, holding it squarely to the opening and then inserting it slowly so that

the guides on the front part of the flow cell flange engage the rails in the sample cell compartment.



2. After the flange and rails are engaged, continue inserting the flow cell until the dowel pins on the detector engage the corresponding holes on the cell holder.
3. Continue to insert the flow cell until the three thumbscrews align with their holes in the bulkhead.

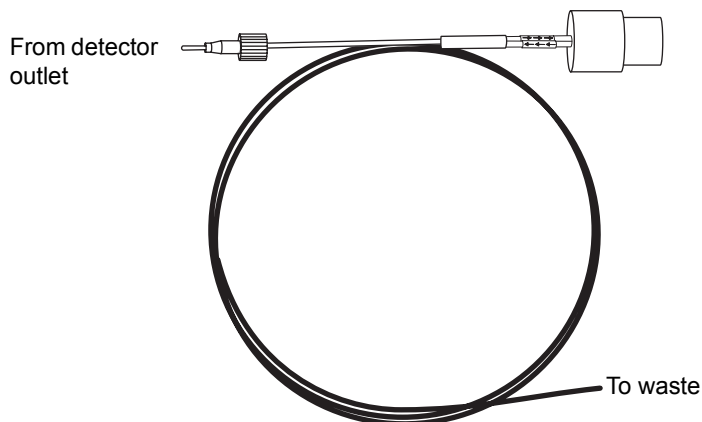
4. Hand tighten the thumbscrews.



5. Remove the protective cover from the PEEK cell inlet tubing, and connect the tubing to the flow cell inlet, confirming that the label on the tubing matches the type of detector and flow cell in your system.

6. Attach the short length of outlet tubing from the backpressure regulator to the outlet of the flow cell.

Backpressure regulator



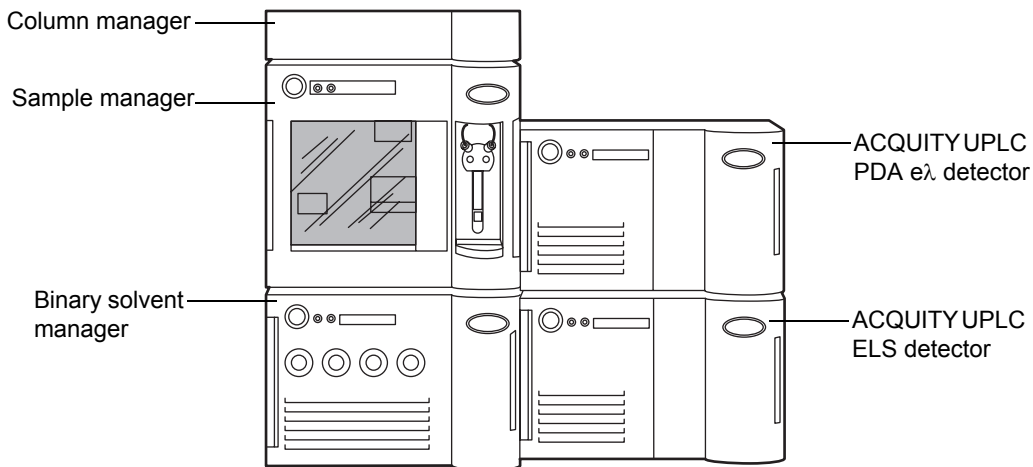
7. Route the long end of the outlet tubing from the backpressure regulator, through the channel clips along the front right side of the system, and into a suitable waste container.

Tip: If a mass spectrometer or other detector is connected downstream of the detector, a backpressure regulator should not be installed. The length of the tubing connecting to the mass spectrometer or other detector helps to maintain the backpressure on the flowcell.

Installing the multi-detector drip tray

If your ACQUITY UPLC system has more than one detector, you must install the multi-detector drip tray.

ACQUITY UPLC PDA e λ detector installed in a split ACQUITY UPLC system



Required materials

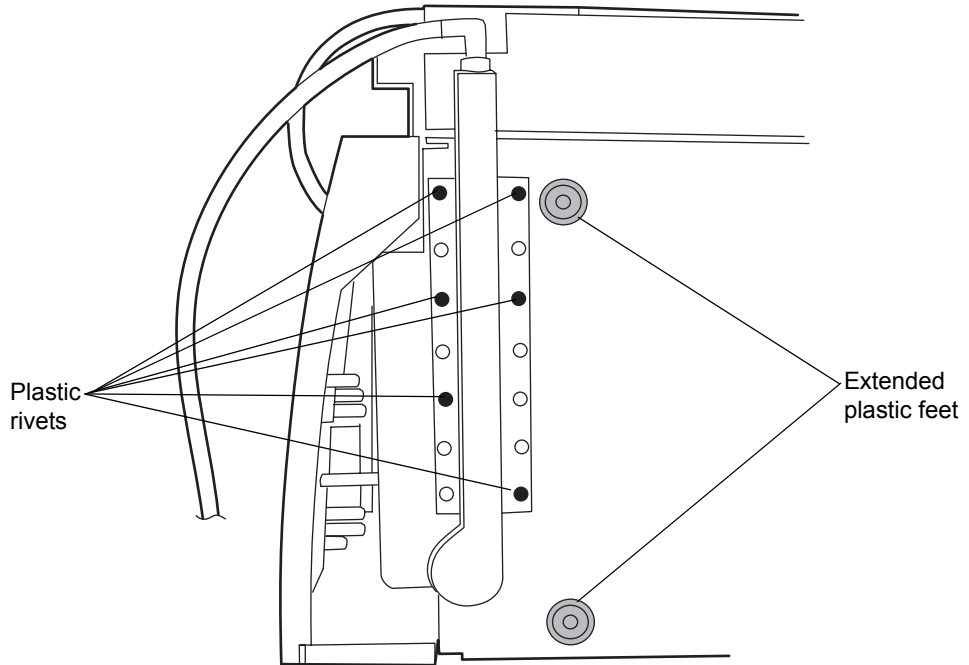
Multi-detector drip tray kit

To install the drip tray

1. Turn the ACQUITY PDA e λ detector so that it is resting on its left side.
2. Snap the extended plastic feet on to the bottom of the detector, and then snap the anti-skid pads on to the extended plastic feet.

3. Secure the drip tray to the bottom of the detector with the six plastic rivets provided in the multi-detector drip tray kit.

Installing the multi-detector drip tray



4. Return the ACQUITY PDA e λ detector to its original position atop the other detector.

Making Ethernet connections

To make Ethernet connections

1. Unpack and install the preconfigured ACQUITY workstation.
2. Connect one end of one Ethernet cable to the network switch, and then connect the other end to the Ethernet card, on the workstation.

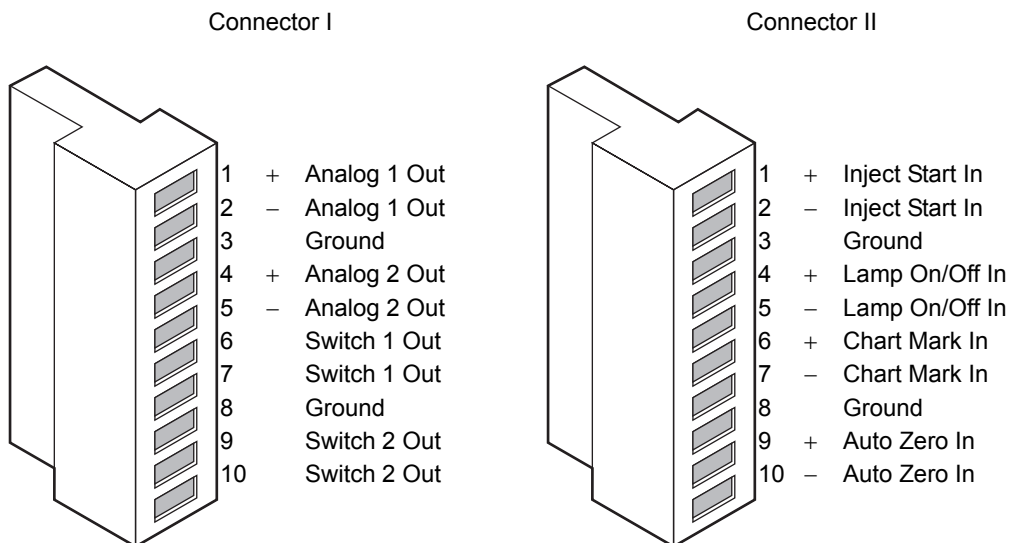
Tip: On preconfigured systems, the Ethernet card is identified as the Instrument LAN card.

3. Connect one end of one Ethernet cable to the back of the detector, and then connect the other end to the network switch.

I/O signal connectors

The detector's rear panel includes two removable connectors that hold the screw terminals for I/O signals. These connectors are keyed so that they can receive a signal cable inserted only one way.

I/O signal connectors



ACQUITY UPLC PDA eλ detector analog-out/event-in connections

Signal connections	Description
Analog 1 (Out)	Used for analog chart output functionality.
Analog 2 (Out)	Used for analog chart output functionality.
Switch 1 (Out)	Controlled by threshold and timed events.
Switch 2 (Out)	Controlled by threshold and timed events.
Inject Start (In)	Should not be used.
Lamp On/Off (In)	When triggered, it ignites or extinguishes the lamp.
Chart Mark (In)	Marks all data with a 0.1 AU tick mark.
Auto Zero (In)	Calculates an offset value that, when added to the sample signal, makes the resulting baseline signal zero for all wavelengths.

Connecting to the electricity source

The ACQUITY UPLC PDA eλ detector requires a separate, grounded electricity source. The ground connection in the electrical outlet must be common and connected near the system.



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 ACQUITY UPLC system to a common ground.

To connect to the electricity source

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

1. Connect the female end of the power cord to the receptacle on the rear panel of the detector.
2. Connect the male end of the power cord to a suitable wall outlet.

Alternative: If your system includes the optional FlexCart, connect the female end of the FlexCart's electrical cable (included in the startup kit) to the receptacle on the rear panel of the detector. Connect the hooded, male end of the FlexCart's electrical cable to the power strip on the back of the cart. Finally, connect the power strip's cable to a wall outlet operating on its own circuit.

3

Preparing the Detector for Operation

Contents:

Topic	Page
Starting the detector	3-2
Shutting down the detector	3-6

Starting the detector



Warning: Using incompatible solvents may cause severe damage to the instrument and injury to the operator. Refer to Appendix C of the *ACQUITY UPLC System Operator's Guide* for more information.




Starting the detector entails powering-on the detector and each system instrument individually, as well as the ACQUITY workstation. It also entails starting the operating software (Empower or MassLynx).



Caution:

- To ensure a long life for the light-guiding flow cell and proper detector initialization, use well-degassed eluents, making sure they are flowing before you power-on the detector.
- To minimize contaminants that can leave deposits on the flow cell's walls, flush new columns for 15 minutes before connecting the flow cell.

If you must power-on the detector before the eluent is flowing, extinguish the lamp. You can do this in the Instrument Method Editor (Empower or MassLynx) by specifying a Lamp On event in the Events table. You may also extinguish the lamp in one of these ways:

- If Empower software controls the system, click  (Lamp Off) in the control panel at the bottom of the Run Samples window.
- If MassLynx software controls the system, click  (Lamp Off) in the control panel at the bottom of the Inlet Editor window.
- In the console, select PDA e λ Detector from the system tree and click  (Lamp Off).

See also: *ACQUITY UPLC System Operator's Guide*.

To start the detector

1. Power-on the workstation.
2. Press the power switch on the top, left side of the binary solvent manager door and sample manager door. Each system instrument “beeps” and runs a series of startup tests.

The power and lamp LEDs change as follows:

- Each system instrument's power LED shows green.
 - During initialization, each system instrument's status LED flashes green.
 - After the instruments are successfully powered-on, all LEDs show steady green. The binary solvent manager's flow LED and the sample manager's run LED remain unlit.
3. Start Empower or MassLynx. You can monitor the ACQUITY console for messages and LED indications.
 4. Flush the system with filtered, degassed, and sparged HPLC-grade methanol or acetonitrile.
 5. In the console, set the binary solvent manager to deliver the appropriate flow for the flow cell in your system.

Tip: Use only thoroughly degassed HPLC-grade solvents. Gas in the mobile phase can form bubbles in the flow cell and cause the detector to fail the Reference Energy diagnostic test.

6. Pump mobile phase for at least 15 minutes.
7. Ensure the detector cell is filled with solvent and free of bubbles.



Caution: The detector can fail to initialize correctly if the cell contains air. To avoid damaging the light-guiding flow cell, do not ignite the detector lamp when no solvent is flowing through the cell or when it is dry.

8. Press the power switch on the front panel to power-on the detector.
Result: The detector runs a series of startup diagnostic tests while the lamp LED blinks green. The lamp LED shows steady green when the lamp is ignited.
9. When the lamp LED is steady green, start Empower or MassLynx software, and download an instrument or inlet method.
Result: The ACQUITY Console displays messages and visual signals.
10. For best results, wait one hour for the detector to stabilize before acquiring data.

Monitoring detector LEDs

Light emitting diodes on the detector indicate its state of functioning.

Power LED

The power LED, to the left of the detector's front panel, indicates when the detector is powered-on or powered-off.

Lamp LED

The lamp LED, to the right of the power LED, indicates the lamp status.

Lamp LED indications

LED mode and color	Description
Unlit	Indicates the detector lamp is extinguished.
Constant green	Indicates the detector lamp is ignited.
Flashing Green	Indicates the detector is initializing or calibrating.
Flashing red	Indicates an error stopped the detector. Information regarding the error that caused the failure can be found in the console.
Constant red	Indicates a detector failure that prevents further operation. Power-off the detector, and then power-on. If the LED is still steady red, contact your Waters service representative.

About the detector control panel

If Empower software controls the system, the detector's control panel appears at the bottom of the Run Samples window. If MassLynx software controls the system, the detector's control panel appears at the bottom of the Inlet Editor window.



Detector control panel



The detector control panel displays the acquisition status and shutter position. You cannot edit detector parameters while the system is processing samples.

The following table lists the items in the detector control panel.

Modifiable detector control panel items

Control panel item	Description
Lamp On/Off LED	This image mimics the actual lamp on/off LED mode unless communications with the detector are lost. Clicking it opens the lamp control window.
Status	Displays the status of the current operation.
Shutter	Displays the shutter position (Open, Closed, Erbium, or UV blocking).
 (Lamp On)	Ignites the detector lamp.
 (Lamp Off)	Extinguishes the detector lamp.

You can access additional functions by right-clicking anywhere in the detector control panel:

Additional functions in the detector control panel

Control panel function	Description
Autozero	Resets the detector offsets.
Reset PDA eλ	Resets the detector, when present, after an error condition.

Additional functions in the detector control panel (Continued)


Control panel function	Description
Help	Displays the console Help.

Shutting down the detector

Shutting down for less than 24 hours

If a few hours will pass before the next injection, slow the flow rate in the interim to a few tenths of a mL/min to conserve solvent. Keep the detector operating and the column heater at operating temperature during this period.


To shut down the detector for less than 24 hours

1. Continue to pump the initial mobile phase mixture through the column. Doing so maintains the column equilibrium necessary for good retention time reproducibility.
2. To lengthen lamp life, extinguish the detector lamp by clicking  (Lamp Off) in the detector control panel.

Requirement: If you are running under MassLynx control, ensure the shutdown method's Auto-Shutdown function is deactivated.

Shutting down for more than 24 hours

To shut down the detector for more than 24 hours

1. Extinguish the detector lamp by clicking  (Lamp Off) in the detector control panel.
2. Remove buffer salts and additives by flushing with water.
3. Flush the column and flow cell with 100% pure organic solvent.

See also: Waters ACQUITY UPLC BEH Column Care and Use Instructions or ACQUITY UPLC HSS Column Care and Use Instructions.



Warning: Risk of electric shock. The power switch on each system instrument controls the basic operational state of that instrument. Nevertheless, some instrument circuits remain live after the instrument is switched off. To completely interrupt power to a system instrument, set the power switch to Off, and then unplug the instrument's power cord from the AC outlet.

4. Power-off the system.

Alternative: If you prefer to leave the system powered-on, turn off the column heater or reduce the column heater temperature to 40 °C (104 °F).



Caution: Before using any system or instruments that have been shut down under the recommended conditions, ensure that the new mobile phase and solvents are miscible with the recommended storage solvents: water/methanol or water/acetonitrile. If they are not directly miscible with the recommended storage solvents, use an intermediate solvent that is miscible with both the storage solvents and the new-analysis solvents to flush the storage solvents from the system.

5. Cap the flow cell inlet and outlet ports.

4 Maintaining the Detector

Contents:

Topic	Page
Contacting Waters technical service	4-2
Maintenance considerations	4-2
Maintaining the leak sensor	4-4
Maintaining the flow cell	4-11
Replacing the lamp	4-22
Replacing the fuses	4-25
Cleaning the instrument's exterior	4-26

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. Our Web site includes phone numbers and e-mail addresses for Waters locations worldwide. Go to www.waters.com.

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

- Any error messages
- Nature of the symptom
- Instrument serial numbers
- Flow rate
- Operating pressure
- Solvent(s)
- Detector settings (sensitivity and wavelength)
- Type and serial number of column(s)
- Sample type
- Empower or MassLynx software version and serial number
- ACQUITY workstation model and operating system version

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

Maintenance considerations

Safety and handling

Observe these warning and caution advisories when you perform maintenance on your detector.



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: To avoid electric shock, do not remove the detector's top cover. No user-serviceable parts are inside.



Caution:

- To avoid damaging electrical parts, never disconnect an electrical assembly while power is applied to the detector. To completely interrupt power to the detector, set the power switch to Off, and then unplug the power cord from the AC outlet. After power is removed, wait 10 seconds before you disconnect an assembly.
- To prevent circuit damage due to static charges, do not touch integrated circuit chips or other system instruments that do not require manual adjustment.

Proper operating procedures

To ensure your system runs efficiently, follow the operating procedures and guidelines in [Chapter 3](#).

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.

Recommendations:

- To prevent dirt from getting into the optics assembly, always keep the detector door closed whenever a flow cell is not installed in the detector.
- Filter and degas solvents to prolong column life, reduce pressure fluctuations, and decrease baseline noise.
- To conserve lamp life, extinguish the lamp while leaving the detector running but idle. Note, however, that you should do so only when the lamp will remain extinguished more than 4 hours.
- If you use buffered mobile phase, flush it from the detector before powering-off to prevent
 - plugging solvent lines and the flow cell
 - damaging instrument components
 - microbial growth

**Caution:**

- To ensure optimum performance of the light-guiding flow cell, ensure that eluent is flowing prior to powering-on the detector. If, however, you must power-on the detector before the eluent is flowing, extinguish the lamp first.
- If the light-guiding flow cell will not be used for a period of time, flush it with clean mobile phase, such as a water/acetonitrile or water/methanol mix, and either cap the flow ports or dry the flow cell with pure nitrogen or pure helium for 5 to 10 minutes.
- To avoid damaging the detector or column, remove the column and disconnect the detector before you flush the system.

Flushing the detector

To flush the detector



Caution: To avoid damaging the detector, do not exceed the 6895 kPa (69 bar, 1000 psi) pressure limitation of the flow cell.

1. Remove the column from the system.
2. Flush the system to waste with 100% HPLC-quality water at a rate of 1.0 ml/minute for 10 minutes.
3. Flush the system with a solution of 90:10 methanol/water for 10 minutes.

Maintaining the leak sensor

A leak sensor in the drip tray continuously monitors the detector for leaks. The sensor stops system flow when it detects accumulated, leaked liquid in its surrounding reservoir, and an error message describing the problem appears in the ACQUITY UPLC Console.

Resolving detector leak sensor errors

After approximately 1.5 mL of liquid accumulates in the leak sensor reservoir, an alarm sounds, indicating that the leak sensor detected a leak.



Warning: The leak sensor and its reservoir can be contaminated with biohazardous and/or toxic materials. Always wear clean, chemical-resistant, powder-free gloves when performing this procedure.



Caution: To avoid scratching or damaging the leak sensor

- do not allow buffered solvents to accumulate and dry on it.
- do not submerge it in a cleaning bath.

Required materials

- Clean, chemical-resistant, powder-free gloves
- Cotton swabs
- Nonabrasive, lint-free wipes

To resolve a detector leak sensor error

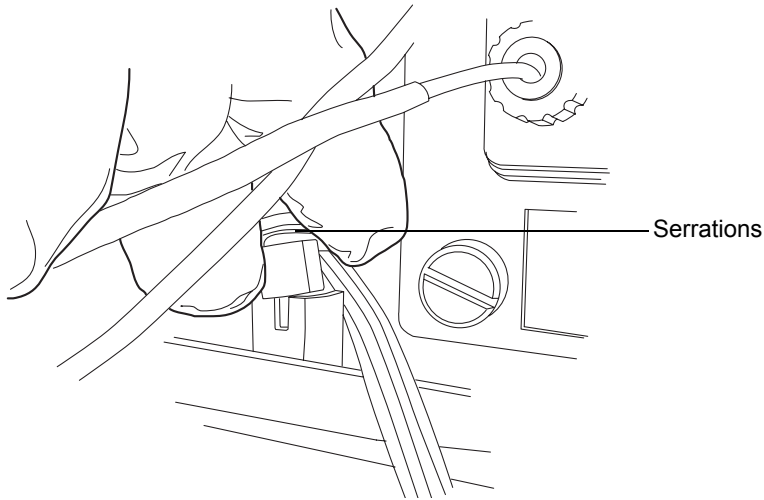
1. View the Leak Sensors dialog box in the ACQUITY UPLC Console to verify that the leak sensor detected a leak.

Tip: If a leak is detected, a “Leak Detected” error message appears.

2. Open the detector door, gently pulling its right-hand edge toward you.
3. Locate the source of the leak, and make the repairs necessary to stop the leak.

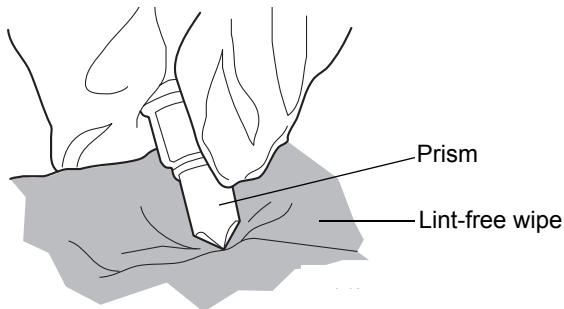
 **Caution:** To avoid damaging the leak sensor, do not grasp it by the ribbon cable.

4. Remove the leak sensor from its reservoir by grasping it by its serrations and pulling upward on it.

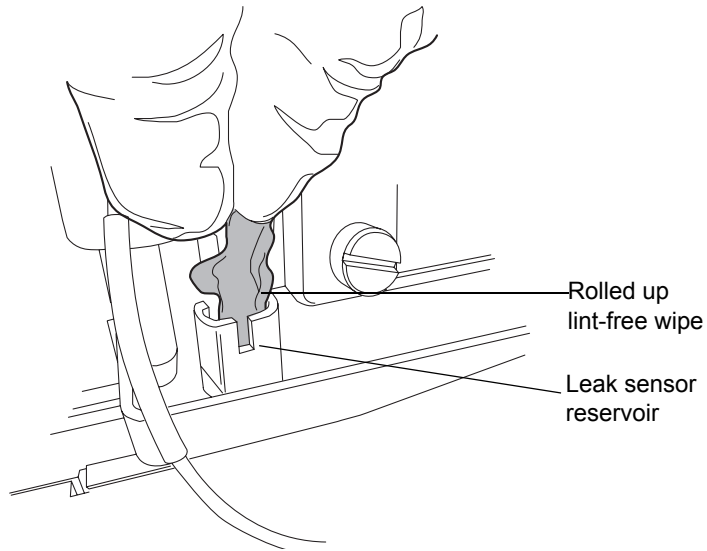


Tip: If you cannot easily manipulate the leak sensor after removing it from its reservoir, detach the connector from the front of the instrument (see [page 4-9](#)).

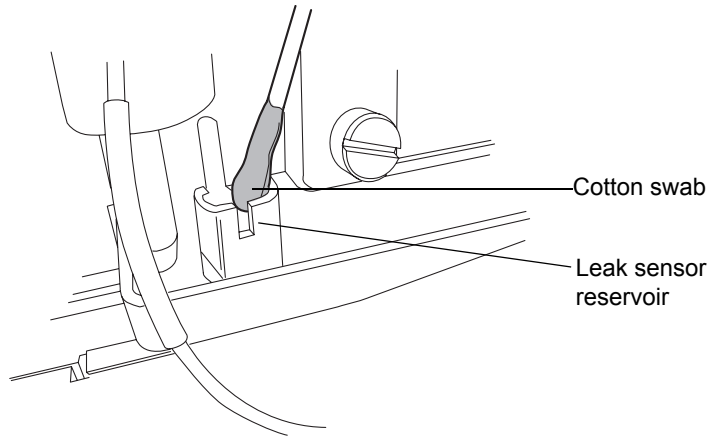
5. Use a nonabrasive, lint-free wipe to dry the leak sensor prism.



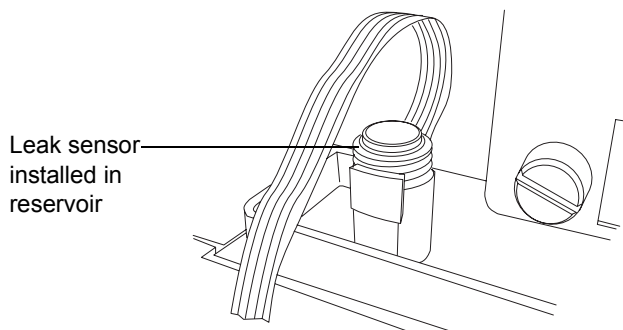
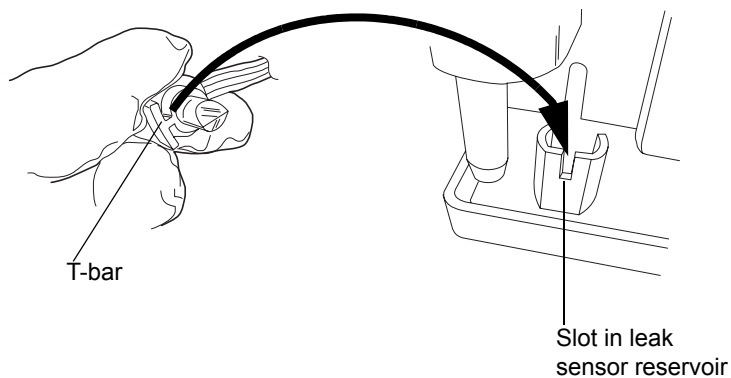
6. Roll up a nonabrasive, lint-free wipe, and use it to absorb the liquid from the leak sensor reservoir and its surrounding area.



7. With a cotton swab, absorb any remaining liquid from the corners of the leak sensor reservoir and its surrounding area.



- Align the leak sensor's T-bar with the slot in the side of the leak sensor reservoir, and slide the leak sensor into place.



- If you detached the connector from the front of the instrument, reattach it.
- In the ACQUITY UPLC Console, select your detector from the system tree.
- In the detector information window, click Control > Reset to reset the detector.

Replacing the detector's leak sensor



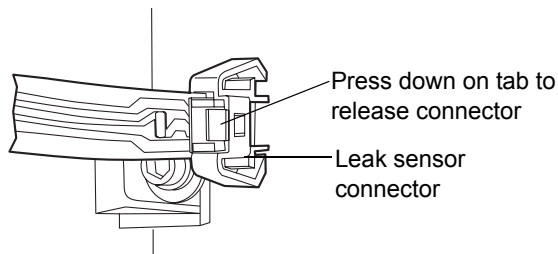
Warning: The leak sensor and its reservoir can be contaminated with biohazardous and/or toxic materials. Always wear clean, chemical-resistant, powder-free gloves when performing this procedure.

Required materials

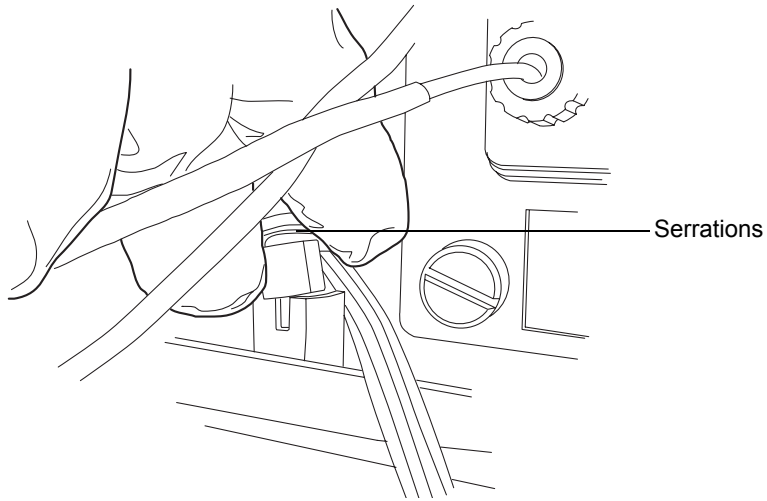
- Clean, chemical-resistant, powder-free gloves
- Leak sensor

To replace the detector leak sensor

1. Open the detector door, gently pulling its right-hand edge toward you.
2. Press down on the tab to detach the leak sensor connector from the front of the instrument.

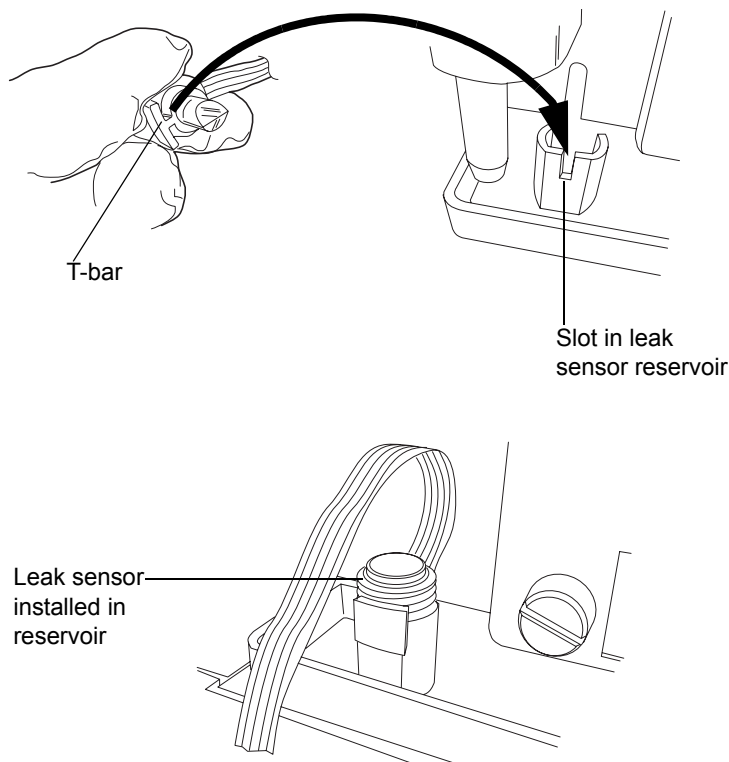


3. Remove the leak sensor from its reservoir by grasping it by its serrations and pulling upward on it.



4. Unpack the new leak sensor.

5. Align the leak sensor's T-bar with the slot in the side of the leak sensor reservoir, and slide the leak sensor into place.

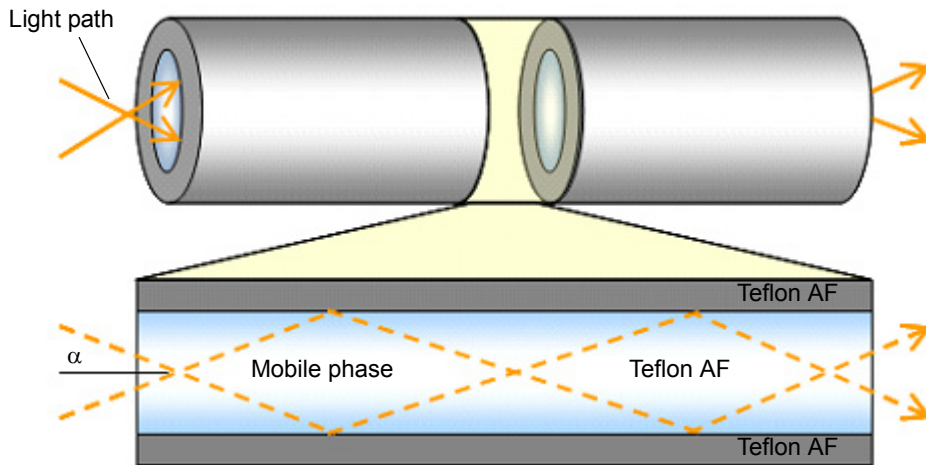


6. Plug the leak sensor connector into the front of the instrument.
7. In the ACQUITY UPLC Console, select your detector from the system tree.
8. In the detector information window, click Control > Reset to reset the detector.

Maintaining the flow cell

Waters light-guiding flow cells transport light and sample via Teflon AF tubing. The tubing transmits energy through low-volume flow cells, resulting in heightened analytical sensitivity. Light efficiently transmits tubing by means of a mechanism known as total internal reflection (TIR) in which the light remains within the fluid stream because the refractive index of the fluid exceeds that of the Teflon tubing material.

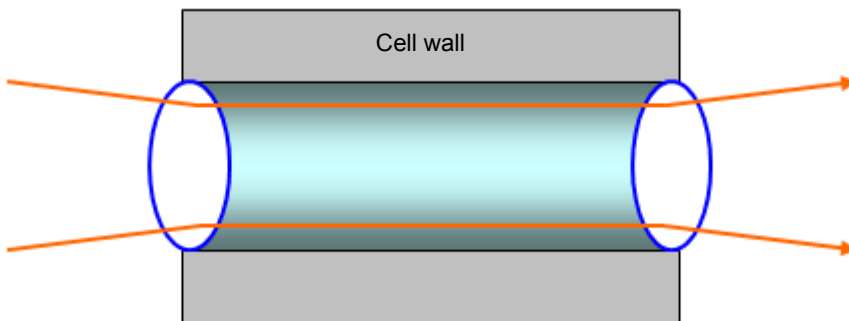
Light transmission through a light guiding flow cell



In the figure above, the light path through the cell is depicted by a pair of rays (dashed lines) that bounce off the cell wall. The energy carried by each ray is conserved after each bounce. One hundred percent of the light is reflected, hence the term “total internal reflection”. The Teflon AF tubing is an active component in the flow cell light path.

In contrast to the light-guiding flow cell, a conventional cell is typically an all-metal body with lenses at each end.

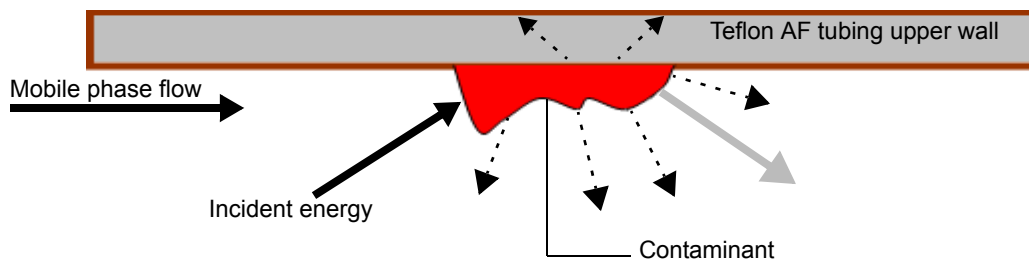
Light transmission through a conventional flow cell



The light path through a conventional flow cell is designed to avoid contact with the cell walls, primarily to prevent rays that encounter the walls from contributing to the measured signal. The energy associated with errant rays is highly variable depending on the mobile phase composition, quality of wall

finish (which is never 100% reflective), or the slow build-up of contaminants. The Teflon AF surface, however, is mirror-like, and the relatively slight RI-dependence associated with a well-maintained cell is negligible. Surface contamination, depicted by the red, irregularly shaped object in the next figure can lead to undesirable beam effects like scattering (dashed arrows) or absorption (gray, thick arrow), both of which decrease energy relative to the incident ray (black, thick arrow).

Unwanted beam effects from a light guiding flow cell



The operational differences between the light-guiding method, where light is transmitted through interactions with the cell wall, and the conventional method, which avoids such interactions, underscores these practical measures for maintaining the liquid core flow cell:

- Periodically determine flow cell transmission under conditions similar to those used to characterize a new cell. (Doing this typically means determining cell transmission with clean mobile phase.)
- Avoid fouling the flow cell by changing or disturbing upstream system components, as in the case when a new column is brought online.

Cleaning the flow cell

Clean the flow cell when it becomes contaminated with the residues of previous runs and also after each detector shutdown. A dirty flow cell can cause baseline noise, decreased sample energy levels, calibration failure, and other problems.

- Always flush the flow cell with mobile phase as your initial attempt to correct these problems. If there is still no improvement, flush the flow cell with pure organic solution, like 100% acetonitrile. If the problems persist, flush the flow cell with 1% formic acid for 30 minutes, and then flush with water until the formic acid is removed or until the pH is neutral. If flushing with the 1% formic acid solution also fails, perform a

system acid cleansing flush (see “Performing a system, acid-cleansing flush” on page 4-16). If there is still no improvement, call Waters Technical Service.



Caution:

- To prevent flow cell failure, do not connect any tubing or device that can create backpressure exceeding the flow cell’s maximum rating of 6895 kPa (69 bar, 1000 psi).
- The pressure through the flow cell must not exceed 6895 kPa (69 bar, 1000 psi). Increasing the flow rate usually increases the pressure. High-viscosity fluids generally increase the pressure through the flow cell and therefore require a lower flow rate. Allowable flow rates are based on the limit of pressure that each flow cell can withstand.




Warning: To avoid spills, empty the waste container at regular intervals.

Rule: Always use clean, well-degassed eluents.

Required materials

- 1% formic acid
- Clean, chemical-resistant, powder-free gloves
- Water (for flushing buffers)
- Intermediate solvent that is miscible in both the mobile phase and water
- Stainless steel unions (to replace the column during flushing)
- Wrench suitable for removing and replacing the column

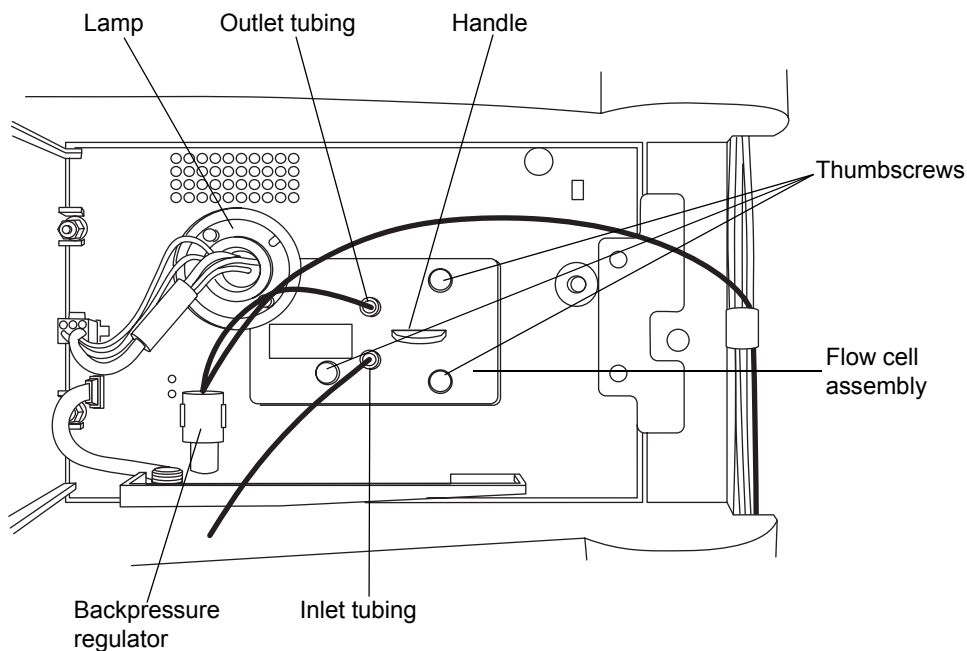
To clean the flow cell

1. In the detector control panel, click  (Lamp Off).
2. Stop the solvent flow and remove the column.
3. Replace the column with a union or piece of tubing.

4. If another instrument is downstream of the flow cell outlet, break the connection at the other instrument, and route the outlet tubing to waste while flushing.



Caution: Do not flush while connected to a mass spectrometer.



5. Flush the detector with HPLC-grade water.
Tip: If the mobile phase is not compatible with water, flush with an intermediate solvent first.
6. Pump an acid wash composition of 1.0% formic acid in water or 90% water/10% organic mixture.
7. Flush the flow cell for at least 4 hours at 0.05 to 0.1 ml/min.
Requirement: Do not exceed 6895 kPa (69 bar, 1000 psi).
8. Remove any other active detectors or instruments from the system.
9. Flush the detector with HPLC-grade water until the pH is neutral.
Tip: If the mobile phase is not compatible with water, flush with an intermediate solvent first.

10. Reattach the column.
11. Resume pumping mobile phase.

Tip: If the mobile phase is not miscible in water, first flush with an intermediary solvent.

Performing a system, acid-cleansing flush



Caution: If you are running a mass spectrometer, do not perform the system, acid-cleansing flush. Instead, call Waters Technical Service.

General system contamination can spread to the flow cell. If the system becomes contaminated, perform a system, acid-cleansing flush, which cleans the binary solvent manager, solvent manager, and flow cell.

To prepare the solvent

1. Prepare a mixture of 50:50 (v/v) methanol/water:
 - a. Measure 500 mL of water in a graduated cylinder.
 - b. In a separate graduated cylinder, measure 500 mL of methanol.
 - c. Add methanol to water, and mix for 5 minutes.
2. Prepare a mixture of 30:70 (v/v) phosphoric acid/water:
 - a. Measure 700 mL of water in a graduated cylinder.
 - b. In a separate graduated cylinder, measure 300 mL of phosphoric acid.
 - c. Add phosphoric acid to water, and mix for 5 minutes.
3. Fill a 1-L mobile phase reservoir with 100% water.
4. Fill a 1-L mobile phase reservoir with 100% isopropanol.

The cleaning procedure takes approximately 6 hours, once the solvents are prepared.

To perform the system, acid-cleansing flush



Caution: Failure to remove the bottle filters contaminates the flow path.

1. Remove the sample and solvent manager bottle filters.
2. Place all lines A1, A2, B1, B2 seal wash, weak needle wash and strong needles in 50:50 methanol:water.
3. Prime the solvent lines for 5 minutes each.
4. Prime the seal wash.
5. Prime the wash syringes and sample syringe for 4 cycles.
6. Connect a pressure restrictor in the fluid path, after the injector, to create 13,800 kPa (138 bar, 2000 psi) backpressure in the system.
7. Transfer 1 mL of mobile phase to an autosampler vial, and place the vial in position 1:A,1.
8. Create an instrument method with the following parameter values:
 - Flow rate = 0.5 mL/min
 - Gradient composition 50% A1:50% B1
 - Full loop injection
9. Make 30, full-loop injections from the vial containing the mobile phase.
10. Set the run time to 0.5 minutes.

Tip: This step should take approximately 30 minutes.
11. Repeat steps 1 through 8 using 100% isopropanol as the solvent.

Requirement: Do not pass effluent through optical detector for this wash step. Route the restrictor to waste.
12. Repeat steps 1 through 8 using 100% water as the solvent.

Note: Remove the Seal wash line from the mobile phase bottle prior to performing the phosphoric acid wash.
13. Repeat steps 1 through 8 using 30:70 (v/v) phosphoric acid/water as the solvent.
14. Continue pumping the phosphoric acid mixture for an additional 3 hours.

15. Repeat steps 1 through 8 using 100% water as the solvent.
16. Repeat steps 1 through 8 using 50:50 (v/v) methanol/water as the solvent.
17. Replace the sample and solvent manager bottle filters.

Replacing the flow cell



Caution:

- To avoid contaminating the flow cell, wear clean, chemical-resistant, powder-free gloves when handling, removing, or replacing it.
- To avoid damaging the flow cell, handle it with care. Do not disassemble the flow cell.

See also: *Controlling Contamination in Ultra Performance LC/MS and HPLC/MS Systems* (part number 715001307) on the ACQUITY UPLC System Bookshelf CD.

Required materials

- 1/4-inch, flat-blade screwdriver
- Clean, chemical-resistant, powder-free gloves
- Flow cell

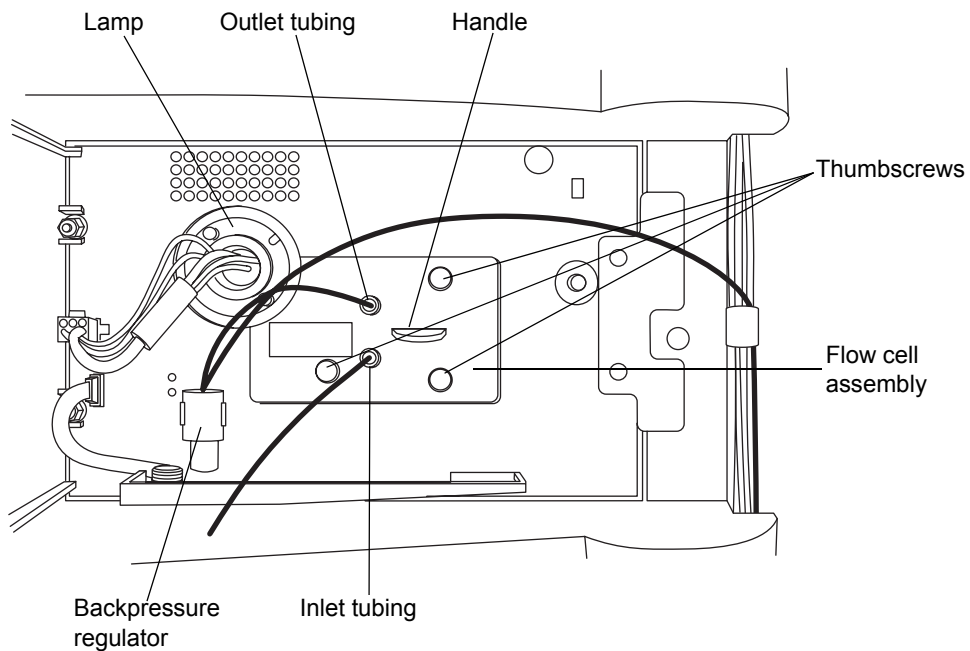
To replace the flow cell



Caution: To avoid damaging electrical parts, never disconnect an electrical assembly while power is applied to an instrument. To completely interrupt power to an instrument, set the power switch to Off, and then unplug the power cord from the AC outlet. After power is removed, wait 10 seconds thereafter before you disconnect an assembly.

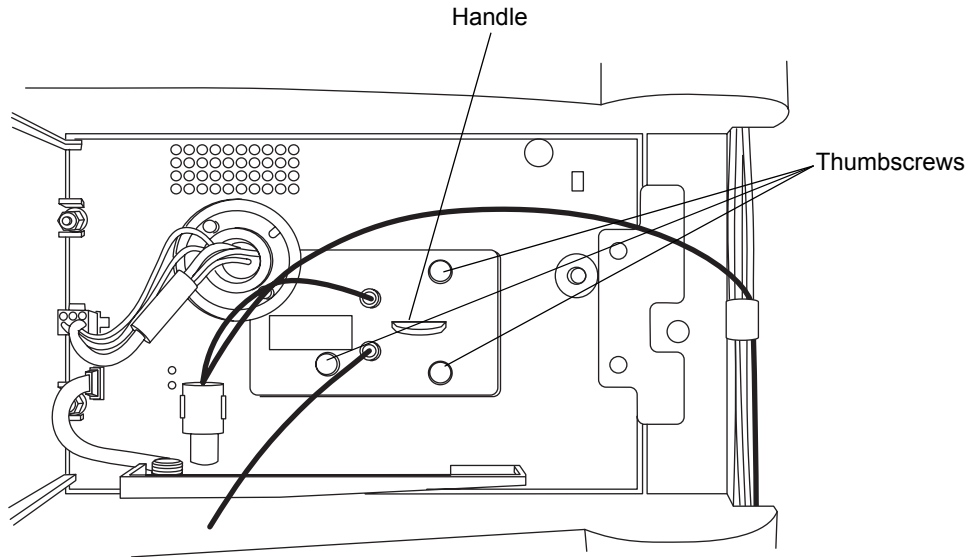
1. Power-off the detector.
2. Stop the solvent flow.
3. Open the detector door, gently pulling its right-hand edge toward you.

4. Disconnect the detector's inlet and outlet tubing from the main column connection.



5. Remove the flow cell:

- Using a 1/4-inch, flat-blade screwdriver, loosen the 3 thumbscrews on the flow cell assembly's front plate.
- Grasp the handle and gently pull the assembly toward you.

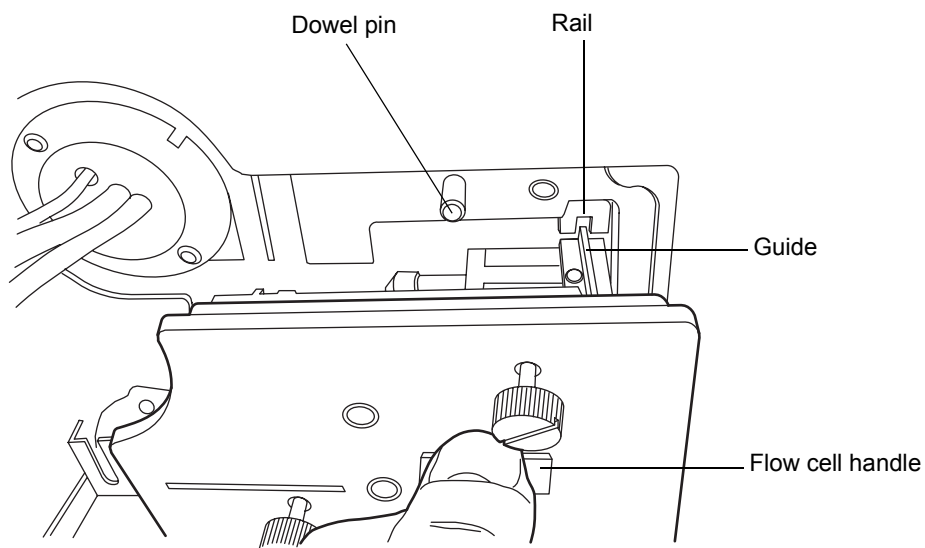


Caution: To avoid damaging the capillary tubing, do not touch it.

6. Unpack and inspect the new flow cell, ensuring the flow-cell type is correct for your application.

Tip: When replacing the flow cell, replace the flow cell inlet tubing with the tubing included with the new flow cell (see [“Plumbing the detector”](#) on page 2-4).

7. Square the flow cell assembly in front of the opening, and then insert it slowly so that the guides on the front part of the cell flange engage the rails in the sample cell compartment.



8. After the flange and rails are engaged, continue inserting the flow cell until the dowel pins on the instrument engage the corresponding holes on the cell holder.
9. Continue to insert the flow cell until the three thumbscrews align with their holes in the bulkhead.
10. Hand tighten the thumbscrews.
11. Connect the inlet tubing to the main column connection and flow cell inlet, and connect the outlet tubing to the flow cell outlet.
12. Close the detector door.
13. Before you power-on the detector, ensure the flow cell is filled with degassed, transparent solvent (acetonitrile or water) and free of air bubbles.

Replacing the lamp

Change the lamp when it repeatedly fails to ignite or when the detector fails to calibrate.

Tip: If you do not record a new lamp's serial number in the ACQUITY console, the date of the previous lamp installation remains in the detector's memory, voiding the new lamp's warranty.

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




Warning: To prevent burn injuries, allow the lamp to cool for 30 minutes before removing it. The lamp housing gets extremely hot during operation.



Warning: To avoid eye injury from ultraviolet radiation exposure

- power-off the detector before changing the lamp.
- wear eye protection that filters ultraviolet light.
- keep the lamp in the housing during operation.

To remove the lamp

1. Power-off the lamp:
 - To power-off the lamp manually, click PDA eλ Detector in the left pane of the console, and then click . The green LED on the console darkens as does the Lamp LED on the door.
 - To power-off the lamp using a timed event, see the instructions in the Empower or MassLynx online Help.
2. 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. Be sure to power-off the detector and

disconnect the power cable from the rear panel after 15 minutes has elapsed.



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

3. Allow the lamp to cool for 30 minutes (or 15 minutes with the fan running), and then open the door, gently pulling its right edge toward you.

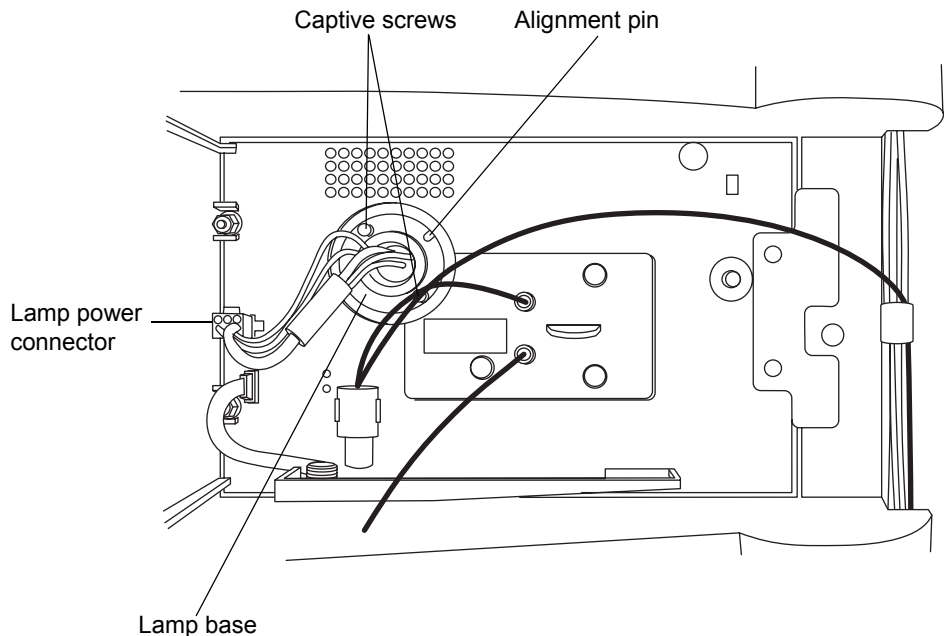


Warning: To avoid electric shock, power-off and unplug the detector before detaching the lamp power connector from the detector.



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

4. Detach the lamp power connector from the detector.





Warning: Lamp gas is under slight negative pressure. To prevent shattering the glass, use care when disposing of the lamp.



Caution: Do not touch the glass bulb of the new lamp. Dirt or fingerprints adversely affect detector operation. If the bulb needs cleaning, gently rub it with ethanol and lens tissue. Do not use abrasive tissue. Do not apply excessive pressure.

5. Loosen the two captive screws in the lamp base. Gently withdraw the lamp from the lamp housing.

To install the lamp

1. Unpack the new lamp from its packing material without touching the bulb.
2. Inspect the new lamp for particles or dirt. If necessary, clean the lamp with a gas duster or lens tissue.
3. Position the lamp so that the cut-out on the lamp base plate is at the 1 o'clock position, in line with the alignment pin on the lamp housing, and then gently push the lamp forward until it bottoms into position. Ensure that it is flush to the optics bench.



Caution: To prevent the lamp from binding and ensure that it is properly seated in the lamp housing, alternate between tightening the captive screws and pushing the lamp forward.

4. Tighten the two captive screws, and then reconnect the lamp power connector.
5. Power-on the detector, and then wait about 1 hour for the lamp to warm before resuming operations.

Tip: Cycling power to the detector (that is, powering-off and then powering-on the instrument) initiates the verification procedures.

6. In the console, select Maintain > Change Lamp.
7. Click New Lamp.
8. Type the serial number for the new lamp (see the label attached to the lamp connector wire), and then click OK.

Replacing the 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.

The detector requires two 100 to 240 VAC, 50 to 60 Hz, F 3.15-A, 250-V FAST BLO, 5 × 20 mm (IEC) fuses.

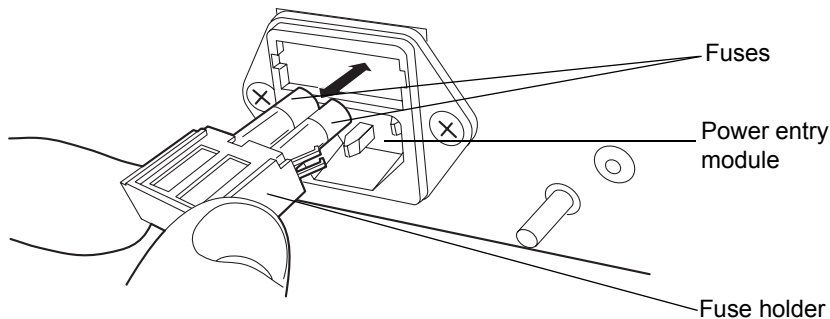
Suspect a fuse is open or otherwise defective when

- the detector fails to power-on.
- 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 is 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, and then 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 Spectral Contrast Theory

The spectral contrast algorithm compares the UV/Vis absorbance spectra of samples the detector collects. This chapter describes the theory on which the algorithm is based, explaining how it exploits differences in the shapes of the absorbance spectra. It also explains how spectral contrast represents those spectra as vectors, determining whether differences among them arise from the presence of multiple compounds in the same peaks (coelution) or from nonideal conditions like noise, photometric error, or solvent effects.

Contents:

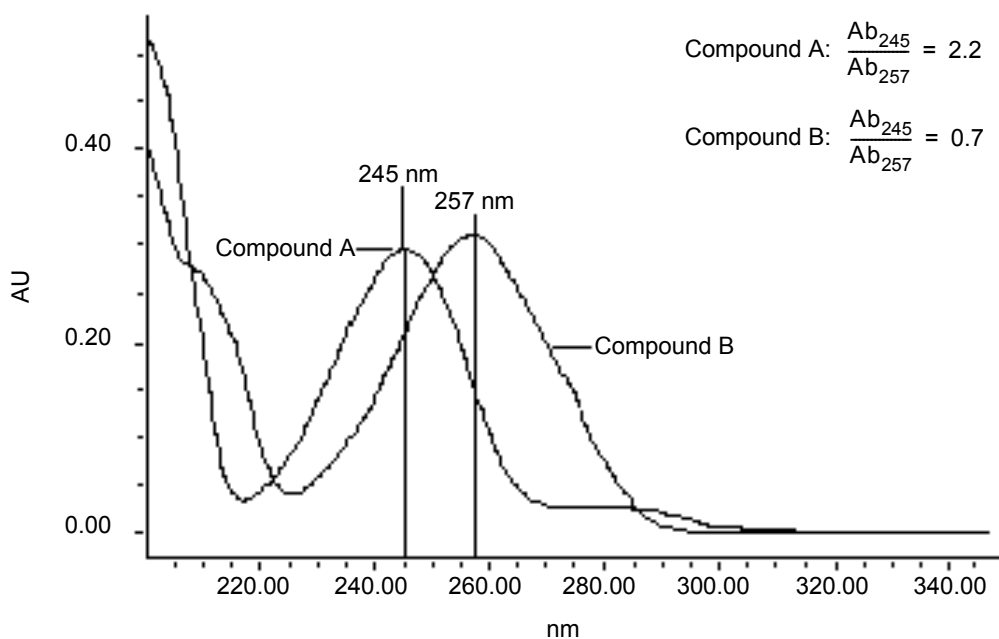
Topic	Page
Comparing absorbance spectra	5-2
Representing spectra as vectors	5-3
Spectral contrast angles	5-5
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Comparing absorbance spectra

When measured at specific solvent and pH conditions, the shape of a compound's absorbance spectrum characterizes the compound. The varying extent of UV/Vis absorbance occurring at different wavelengths produces a unique spectral shape.

The following figure shows the absorbance spectra for two compounds, A and B. The ratio of the absorbance at 245 nm to that at 257 nm is about 2.2 for compound A and 0.7 for compound B. Note that this comparison of a single wavelength pair's absorbance ratios yields little information about a compound. For more information, you must compare the ratios of multiple wavelength pairs.

Comparing spectra of two compounds



344.5063 nm, 0.4595 AU

Representing spectra as vectors

The spectral contrast algorithm uses vectors to quantify differences in the shapes of spectra, converting baseline-corrected spectra to vectors and then comparing the vectors. Spectral vectors have two properties:

- Length – Proportional to analyte concentration.
- Direction – Determined by the relative absorbance of the analyte at all wavelengths (its absorbance spectrum). Direction is independent of concentration for peaks that are less than 1.0 AU across the collected wavelength range.

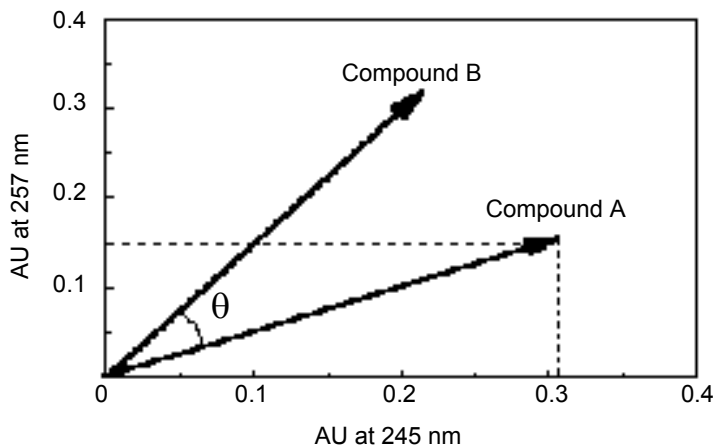
Vector direction contributes to the identification of a compound, since the direction is a function of the absorbance compound's spectrum. The ability of spectral vectors to differentiate compounds depends on the resolution of spectral features. As both wavelength range and spectral resolution increase, the precision of a spectral vector for the resultant spectrum increases. A detector-derived vector can include absorbances in the range of 190 to 800 nm. To enhance spectral sensitivity, set the bench resolution to 1.2 nm.

Tip: To prevent detector noise, don't include wavelengths where there is little or no analyte absorption.

Vectors derived from two wavelengths

The spectral contrast algorithm uses vectors to characterize spectra. To understand the vector principle, consider two vectors, in the figure below, which are based on the spectra depicted in the previous figure.

Plotting vectors for two spectra



In this figure, the axes reflect the absorbance units of the two wavelengths used to calculate the absorbance ratio of the previous figure. The head of the vector for Compound A lies at the intersection of the absorbance values (for Compound A), at the two wavelengths represented by each axis. The remaining vector is similarly derived from the spectrum of Compound B.

Compound B's vector points in a different direction from Compound A's. Expressed by the spectral contrast angle (θ), this difference reflects the difference between the two compounds' absorbance ratios at wavelengths 245 nm and 257 nm. A spectral contrast angle greater than zero indicates a shape difference between spectra (see [“Spectral contrast angles” on page 5-5](#)).

Finally, note that the length of the vectors is proportional to concentration.

Vectors derived from multiple wavelengths

When absorbance ratios are limited to two wavelengths, the chance that two different spectra share the same absorbance ratio is greater than if comparison is made using absorbance ratios at many wavelengths. Therefore, the spectral contrast algorithm uses absorbances from multiple wavelengths

to form a vector in an n -dimensional vector space, where n is the number of wavelengths from the spectrum.

To compare two spectra, the spectral contrast algorithm forms a vector for each spectrum in an n -dimensional space. The two spectral vectors are compared mathematically to compute the spectral contrast angle.

As with the two-wavelength comparison, a spectral contrast angle of zero in n -dimensional space means that all ratios of absorbances at corresponding wavelengths match. Conversely, if any comparison of ratios does not match, the corresponding vectors point in different directions.

Spectral contrast angles

Spectra of identical shape have vectors that point in the same direction. Spectra of varying shapes have vectors that point in different directions. The angle between the two vectors of any two spectra, the spectral contrast angle, quantifies the magnitude of the shape difference between the spectra. The *spectral contrast angle* expresses the difference in direction between the spectral vectors of two spectra.

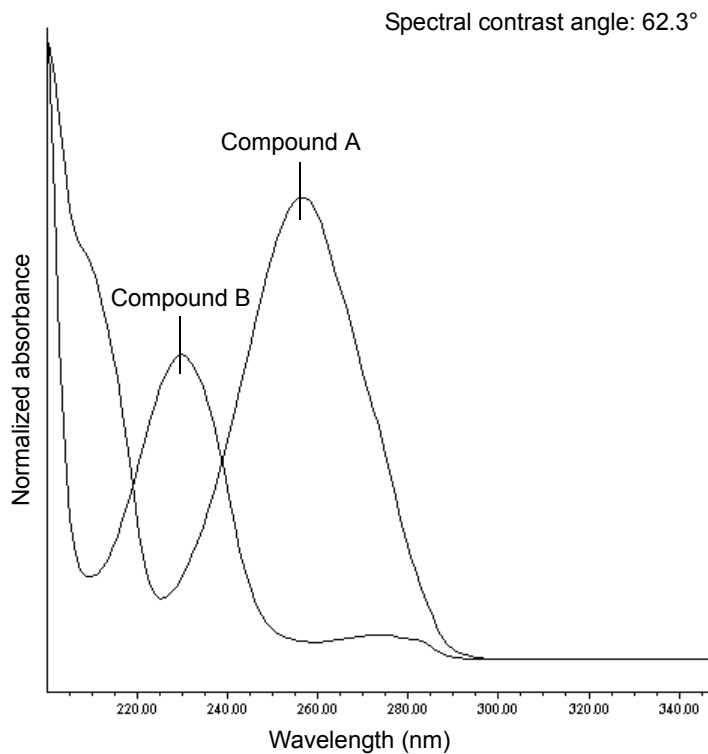
A spectral contrast angle can vary from 0° to 90° . A spectral contrast angle approaching 0° indicates little shape difference between the compared spectra. Matching a spectrum to itself produces a spectral contrast angle of exactly 0° . The maximum spectral contrast angle, 90° , indicates that the two spectra do not overlap at any wavelength.

To illustrate the relationship between the spectral contrast angle and spectral shape differences, consider the pairs of spectra shown in the next three figures.

Spectra with different shapes

In the following figure, the absorbance spectra of two compounds, A and B, are distinctly different. They therefore produce a large spectral contrast angle (62.3°).

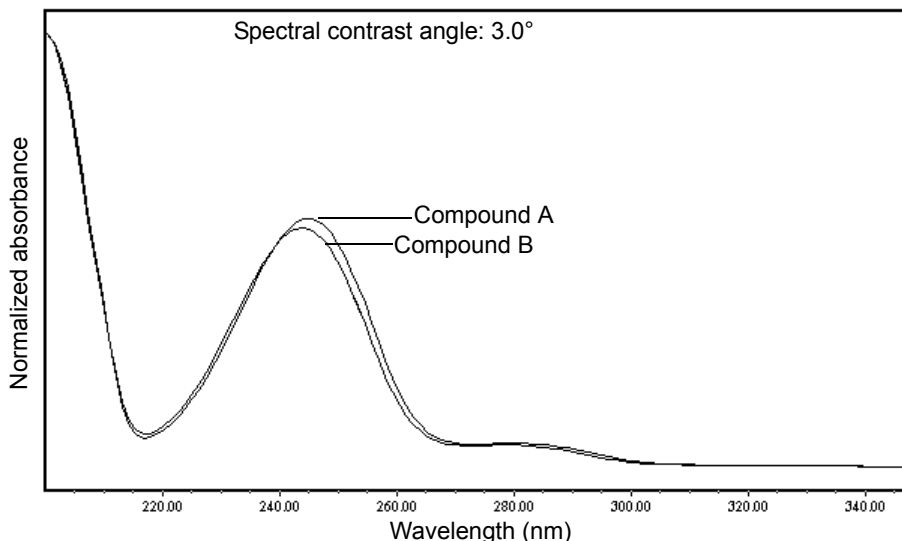
Spectra that produce a large spectral contrast angle



Spectra with similar shapes

In the following figure, the absorbance spectra of two compounds, A and B, are similar. They therefore produce a small spectral contrast angle (3.0°).

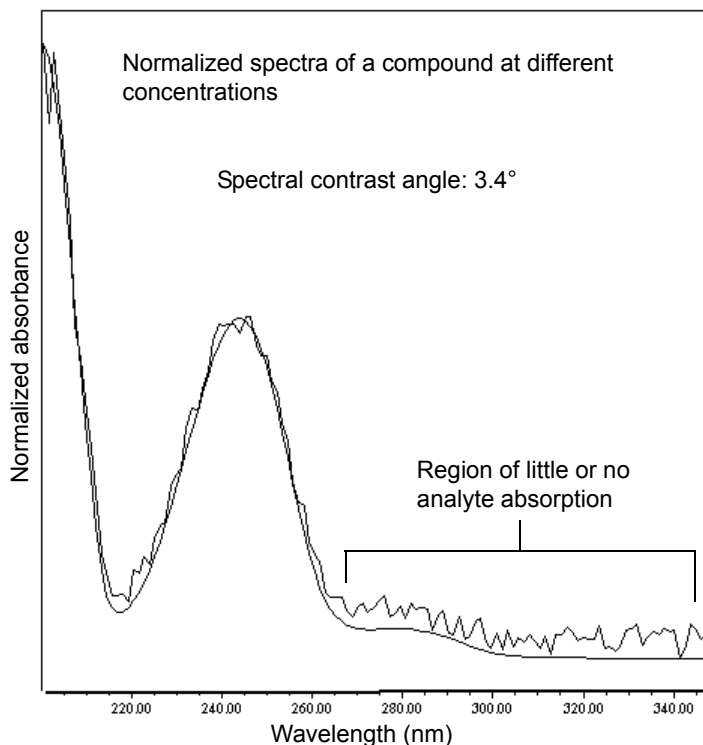
Spectra with a small spectral contrast angle



Differences between spectra of the same compound

Small but significant differences between absorbance spectra can occur because of factors other than those due to the absorbance properties of different compounds. For example, multiple spectra of the *same* compound may exhibit slight differences because of detector noise, photometric error, high sample concentration, or variations in solvent conditions. The spectra in the next figure, for example, show how instrument noise can affect the shape of an absorbance spectrum of one compound. This effect is most likely to occur at low concentrations, where the signal-to-noise ratio is low. Note that the spectral contrast angle between these absorbance spectra of the same compound is 3.4° .

Absorbance spectra of a compound at two concentrations



Undesirable effects

Shape differences between absorbance spectra can be caused by one or more of the following undesirable effects:

- Detector noise
- Photometric error caused by high sample concentration
- Variation in solvent composition

These sources of spectral variation can cause chemically pure, baseline-resolved peaks to exhibit a small level of spectral inhomogeneity. You can assess the significance of spectral inhomogeneity by comparing a spectral contrast angle to a threshold angle (see [“Threshold angle” on page 5-9](#)).

Detector noise

Statistical and thermal variations add electronic noise to the detector's absorbance measurements. The noise, which manifests itself as fluctuations in the baseline, is known as baseline noise. The magnitude of any absorbance differences caused by statistical and thermal variations can be predicted from the instrument noise in the baseline region of a chromatogram.

Photometric error

At high absorbances (generally those greater than 1 AU), a combination of effects can produce slight departures (about 1%) from Beer's law due to photometric error. Although photometric errors at this level can negligibly affect quantitation, they can nevertheless be a significant source of spectral inhomogeneity. To minimize the effects of photometric error for all spectral contrast operations, the maximum spectral absorbance of a compound should be less than 1 AU. Keep in mind that the absorbance of the mobile phase reduces the working linear dynamic range by the amount of mobile phase absorbance at each wavelength. For examples of mobile phase absorbance, see [Appendix C](#).

See also: For more information about the effects of the photometric error curve, refer to *Principles of Instrumental Analysis*, third edition, by Douglas A. Skoog, Saunders College Publishing, 1985, pp. 168–172.

Solvent changes

As long as solvent concentration and composition do not change (isocratic operation), background absorbance, if any, by the solvent remains constant. However, change in solvent pH or composition, such as that which occurs in gradient operation, can affect the intrinsic spectral shape of a compound. (See the figure on [page 5-10](#)).

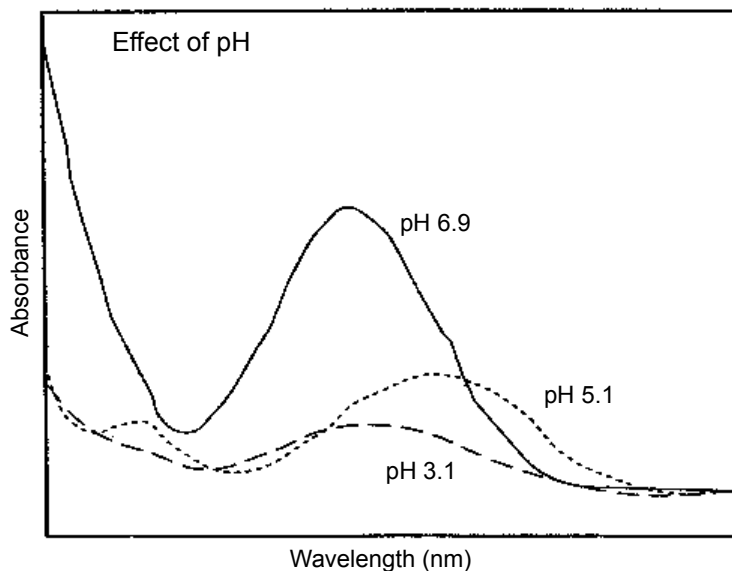
Threshold angle

In addition to computing spectral contrast angles, the spectral contrast algorithm also computes a threshold angle. The threshold angle is the maximum spectral contrast angle between spectra that can be attributed to nonideal phenomena.

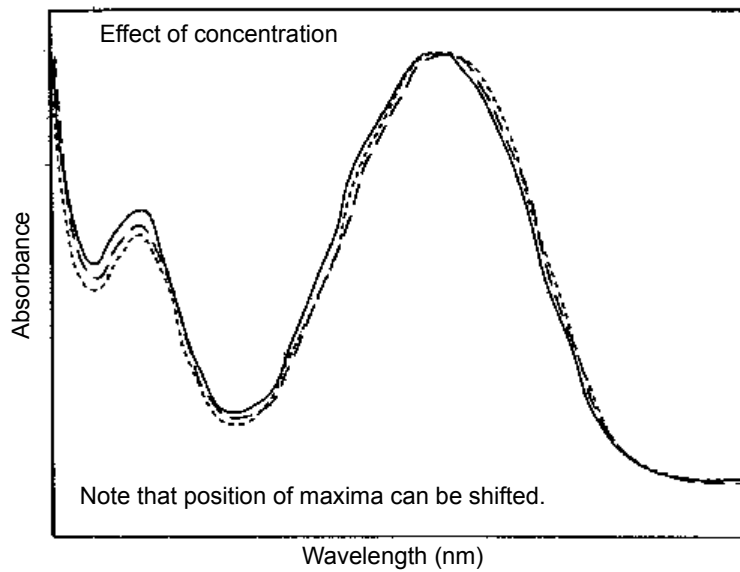
Comparison of a spectral contrast angle to its threshold angle can help determine whether the shape difference between spectra is genuine. In

general, a spectral contrast angle less than its threshold angle indicates that shape differences are attributable to nonideal phenomena alone and that no evidence exists for genuine differences between the spectra. A spectral contrast angle greater than its threshold angle indicates that the shape differences arise from genuine differences between the spectra. When automating the spectral contrast comparison, the maximum absorbance of the spectra must not exceed 1 AU.

Effects of pH on the absorbance spectrum of *p*-aminobenzoic acid



Effects of solvent concentration on the absorbance spectrum of *p*-aminobenzoic acid



A Safety Advisories

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

Contents

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

Warning symbols

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

Task-specific hazard warnings

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

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



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



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



Warning: (Risk of electric shock.)



Warning: (Risk of fire.)



Warning: (Risk of 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.
- Spegnere tutte le fiamme vive nell'ambiente circostante.
- Non utilizzare tubi eccessivamente logorati o piegati.
- Non utilizzare tubi non metallici con tetraidrofurano (THF) o acido solforico o nitrico concentrati.
- Tenere presente che il cloruro di metilene e il dimetilsolfossido provocano rigonfiamenti nei tubi non metallici, riducendo notevolmente la pressione di rottura dei tubi stessi.

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

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

警告: 當在有壓力的情況下使用聚合物管線時，小心注意以下幾點。

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



警告: 当有压力的情况下使用管线时, 小心注意以下几点:

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

경고: 가압 폴리머 튜브로 작업할 경우에는 주의하십시오.

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

警告: 圧力のかかったポリマーチューブを扱うときは、注意してください。

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



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

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

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

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

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

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

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

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

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



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



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



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



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



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



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



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



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







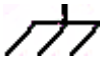
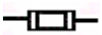



警告: 火災予防のために、ヒューズ交換では機器ヒューズカバー脇のパネルに記載されているタイプおよび定格のヒューズをご使用ください。

Electrical and handling symbols





Electrical symbols

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

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

Handling symbols

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

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

B Specifications

ACQUITY UPLC PDA e λ detector specifications

Physical specifications

Attribute	Specification
Height	20.57 cm (8.1 inches)
Depth	61 cm (24.0 inches)
Width	29.21 cm (11.5 inches)
Weight	15.6 kg (34.4 pounds)


Environmental specifications

Attribute	Specification
Operating temperature	4 to 40 °C (39.2 to 104 °F)
Operating humidity	<90%, noncondensing
Shipping and storage temperature	-30 to 60 °C (-22 to 140 °F)
Shipping and storage humidity	<90%, 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	100 to 240 VAC, 50 to 60 Hz, F 3.15-A, 250-V FAST BLO, 5 × 20 mm (IEC)
Power consumption	100 VA nominal

- 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.

Performance specifications

Attribute	Specification
Optics bench design	Spectrograph with photodiode array
Light source	30 W high-brightness deuterium lamp, 0.5 mm aperture, pre-aligned
Photodetector	512 element selective access photodiode array
Spectrograph entrance aperture	50 μm width
Second-order filter	Fixed, 340 to 800 nm
Wavelength calibration filter	Erbium filter, used at startup or on-demand

Performance specifications (Continued)

Attribute	Specification
Wavelength range	190 to 800 nm
Optical resolution	1.2 nm
Digital resolution	1.2 nm/pixel
Wavelength accuracy	±1.0 nm
Wavelength repeatability	±0.1 nm
Nitrogen purge	Purge fitting present on optics bench and rear panel
UV noise (shunt)	<p>≤15 μAU peak to peak</p> <p>Filter = 1 second, 30-second segments</p> <p>Wavelength = 230 nm</p> <p>Bandwidth = 3.6 nm (3-pixel bunch)</p> <p>Shunt = 240 μm (medium core)</p> <p>Data rate = 2 Hz</p>
UV noise – (wet ^a)	<p>≤20 μAU peak to peak</p> <p>Filter = 1 second, 30-second segments</p> <p>Wavelength = 230nm</p> <p>Bandwidth = 3.6 nm (3-pixel bunch)</p> <p>Flow cell = 10 mm analytical</p> <p>Solvent = degassed 90/10 water/acetonitrile at 0.4 mL/min</p> <p>Data rate = 2 Hz</p>
Drift ^b (dry with shunt)	<p>≤1000 μAU/hr</p> <p>Filter = 1 second</p> <p>Bandwidth = 3.6 nm</p> <p>Wavelength = 230 nm</p> <p>Environmental stability = ±2 °C/hr</p> <p>Shunt = 230 mm (medium core)</p> <p>Data rate = 2 Hz</p>
Linearity	Deviation at 2.0 AU ≤5%, propylparaben series at 257 nm, 10 mm analytical flow cell

Performance specifications (Continued)

Attribute	Specification
Digital data rate	1, 2, 5, 10, 20, 40, and 80 Hz
Analog output data rates	10, 20, 40, and 80 Hz (for respective sample rates) 10 Hz only (for sample rates of 1, 2, or 5 Hz)

- a. Perform wet testing with water/acetonitrile, 90/10, to minimize the effects of oxygen at 230 nm. Water/methanol, 90/10, can be substituted with appropriate solvent conditioning.
- b. ASTM drift tests require a temperature change of less than 2 °C/hour (3.6 °F/hour) over a one hour period. Larger ambient changes will result in larger drift. Better drift performance depends on better control of temperature fluctuations. To realize the highest performance, minimize the frequency and the amplitude of temperature changes to below 1 °C/hour (1.8 °F/hour). Turbulences around one minute or less can be ignored.

C Mobile Phase Absorbance

This appendix lists the absorbances, at several wavelengths, for commonly used mobile phases. Choose a mobile phase carefully to reduce baseline noise.

The best mobile phase for an application is transparent at the chosen detection wavelengths. Such a mobile phase ensures that any absorbance is attributable only to the sample. Absorbance by the mobile phase also reduces the linear dynamic range of the detector by the amount of absorbance the autozero function cancels, or “autozeroes,” out. Wavelength, pH, and concentration of the mobile phase affect its absorbance. Examples of several mobile phases are provided in the table below.

Mobile phase absorbance measured against air or water

	Absorbance at specified wavelength (nm)									
	200	205	210	215	220	230	240	250	260	280
Solvents										
Acetonitrile	0.05	0.03	0.02	0.01	0.01	<0.01	—	—	—	—
Methanol (not degassed)	2.06	1.00	0.53	0.37	0.24	0.11	0.05	0.02	<0.01	—
Methanol (degassed)	1.91	0.76	0.35	0.21	0.15	0.06	0.02	<0.01	—	—
Isopropanol	1.80	0.68	0.34	0.24	0.19	0.08	0.04	0.03	0.02	0.02
Unstabilized tetrahydrofuran (THF, fresh)	2.44	2.57	2.31	1.80	1.54	0.94	0.42	0.21	0.09	0.05
Unstabilized tetrahydrofuran (THF, old)	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	>2.5	2.5	1.45

Mobile phase absorbance measured against air or water (Continued)

	Absorbance at specified wavelength (nm)									
	200	205	210	215	220	230	240	250	260	280
Acids and bases										
Acetic acid, 1%	2.61	2.63	2.61	2.43	2.17	0.87	0.14	0.01	<0.01	—
Hydrochloric acid, 0.1%	0.11	0.02	<0.01	—	—	—	—	—	—	—
Phosphoric acid, 0.1%	<0.01	—	—	—	—	—	—	—	—	—
Trifluoroacetic acid	1.20	0.78	0.54	0.34	0.22	0.06	<0.02	<0.01	—	—
Diammonium phosphate, 50 mM	1.85	0.67	0.15	0.02	<0.01	—	—	—	—	—
Triethylamine, 1%	2.33	2.42	2.50	2.45	2.37	1.96	0.50	0.12	0.04	<0.01
Buffers and Salts										
Ammonium acetate, 10 mM	1.88	0.94	0.53	0.29	0.15	0.02	<0.01	—	—	—
Ammonium bicarbonate, 10 mM	0.41	0.10	0.01	<0.01	—	—	—	—	—	—
EDTA, disodium, 1 mM	0.11	0.07	0.06	0.04	0.03	0.03	0.02	0.02	0.02	0.02
HEPES, 10 mM, pH 7.6	2.45	2.50	2.37	2.08	1.50	0.29	0.03	<0.01	—	—
MES, 10 mM, pH 6.0	2.42	2.38	1.89	0.90	0.45	0.06	<0.01	—	—	—

Mobile phase absorbance measured against air or water (Continued)

	Absorbance at specified wavelength (nm)									
	200	205	210	215	220	230	240	250	260	280
Potassium phosphate, monobasic (KH ₂ PO ₄), 10 mM	0.03	<0.01	—	—	—	—	—	—	—	—
Potassium phosphate, dibasic, (K ₂ HPO ₄), 10 mM	0.53	0.16	0.05	0.01	<0.01	—	—	—	—	—
Sodium acetate, 10 mM	1.85	0.96	0.52	0.30	0.15	0.03	<0.01	—	—	—
Sodium chloride, 1 M	2.00	1.67	0.40	0.10	<0.01	—	—	—	—	—
Sodium citrate, 10 mM	2.48	2.84	2.31	2.02	1.49	0.54	0.12	0.03	0.02	0.01
Sodium formate, 10 mM	1.00	0.73	0.53	0.33	0.20	0.03	<0.01	—	—	—
Sodium phosphate, 100 mM, pH 6.8	1.99	0.75	0.19	0.06	0.02	0.01	0.01	0.01	0.01	<0.01
Tris HCl, 20 mM, pH 7.0	1.40	0.77	0.28	0.10	0.04	<0.01	—	—	—	—
Tris HCl, 20 mM, pH 8.0	1.80	1.90	1.11	0.43	0.13	<0.01	—	—	—	—

Mobile phase absorbance measured against air or water (Continued)

	Absorbance at specified wavelength (nm)									
	200	205	210	215	220	230	240	250	260	280
Waters® PIC® reagents										
PIC A, 1 vial/L	0.67	0.29	0.13	0.05	0.03	0.02	0.02	0.02	0.02	<0.01
PIC B6, 1 vial/L	2.46	2.50	2.42	2.25	1.83	0.63	0.07	<0.01	—	—
PIC B6, low UV, 1 vial/L	0.01	<0.01	—	—	—	—	—	—	—	—
PIC D4, 1 vial/L	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.01
Detergents										
BRIJ 35, 1%	0.06	0.03	0.02	0.02	0.02	0.01	<0.01	—	—	—
CHAPS, 0.1%	2.40	2.32	1.48	0.80	0.40	0.08	0.04	0.02	0.02	0.01
SDS, 0.1%	0.02	0.01	<0.01	—	—	—	—	—	—	—
Triton® X-100, 0.1%	2.48	2.50	2.43	2.42	2.37	2.37	0.50	0.25	0.67	1.42
Tween™ 20, 0.1%	0.21	0.14	0.11	0.10	0.09	0.06	0.05	0.04	0.04	0.03

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