

# Thermo Scientific Dionex UltiMate 3000 Diode Array and Multiple-Wavelength Detectors

Fast, sensitive, and rugged UV-Vis detection

Integrating hardware, software and separation chemistry, Thermo Fisher Scientific offers UHPLC to everyone – for all needs – establishing the new standard in conventional LC.

The Thermo Scientific™ Dionex™ UltiMate™ DAD 3000 detector is a high-resolution, 1024-element diode array detector (DAD) available in Rapid Separation (200 Hz) and Standard (100 Hz) versions. It operates with the Thermo Scientific™ Dionex™ Chromeleon™ Chromatography Data System software to provide a variety of spectra views, including 3-D plotting and automated chromatogram handling. The high resolution and low-noise performance of the DAD-3000 family makes it ideal for the most sensitive and accurate library searches and peak purity analyses.

The detector is also available as a multiple wavelength detector (MWD) in Standard (100 Hz) and Rapid Separation (200 Hz) versions.



- Data collection at up to 200 Hz using a maximum of eight single-wavelength data channels and one 3-D field (3-D only with DAD-3000 (RS)) for best support of ultrafast separations
- Standard versions operate at up to 100 Hz data collection rate for optimum support of 62 MPa (9000 psi) UltiMate 3000 Standard systems
- Accurate compound confirmation with a 1024-element, high resolution photodiode array
- Flexibility in both UV and Vis applications with 190–800 nm wavelength range
- Low-noise over the full spectral range using deuterium and tungsten lamps
- Fast and accurate wavelength verification using a built-in holmium oxide filter
- The detector can be upgraded with the Thermo Scientific™ Dionex™ UltiMate™ 3000 pH and Conductivity Monitor (PCM-3000) for accurate monitoring pH gradients
- Excellent reliability and reproducibility with low baseline drift (typically < 500  $\mu$ AU/h)
- Simplified routine maintenance with front access to pre-aligned cells and lamps
- ID chips on flow cells and lamps for identification and life-span monitoring
- Chromeleon CDS software for full control and flexible data handling
- Front-panel display for easy monitoring of detector status to maximize uptime
- Flow cells for semi-micro, semi-analytical, analytical, and semi-preparative applications
- Flow cells available in stainless steel and biocompatible versions

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Table 1. DAD-3000/MWD-3000 design features and highlights

DAD-3000/MWD-3000 Series Design Features and Highlights	Their Benefit to You
Deuterium and tungsten lamps support a wide detection wavelength range from 190 nm to 800 nm.	Good signal-to-noise ratio across the wavelength range. High application flexibility.
A 1024-element photodiode array optimizes spectral resolution.	Accurate compound confirmation.
Up to eight channels of single-wavelength data collection. Simultaneously, the DAD can acquire 3-D data.	Simultaneous quantitation under individually-optimized conditions.
Up to 200 Hz data collection rate, including 3-D data (under Chromeleon 7.1 software control).	Best chromatographic separation efficiency even with ultrafast separations.
Excellent linearity, typically up to 2.0 AU.	Combines drug assay and impurity profiling in pharmaceutical analysis with no need to reinject at a different dilution.
Variable slit for Rapid Separation versions of the DAD and the MWD.	Achieve best spectral resolution with the narrow slit setting, improve noise performance with the wide slit setting.
Flow cell range covers semi-micro, semi-analytical, analytical, and semi-preparative flow rate applications, in stainless steel and biocompatible versions.	Flow cell easily adaptable to the column format in use.
Upgrade an MWD to a DAD for 3-D UV field acquisition support.	Split your investment in diode array technology. Purchase the instrument you need today and adapt it to your future application needs later.
Fast and tool-free exchange of lamps and flow cells from the detector front.	Maintenance tasks are easy to do.
Lamps and flow cells equipped with ID chips for identification (e.g., type and serial number) and lifespan monitoring.	History is traceable even when the flow cell or lamp is placed in another DAD-3000 or MWD-3000 series module.
Chromeleon software monitors the lifespan of the lamps and alerts users when to change them.	Enables users to plan ahead for required maintenance increasing overall productivity.
Qualification period is saved in the module.	Avoids the use of unqualified equipment, even when the module is switched to another system.
Powerful Chromeleon software tools allow immediate on-line review of 3-D data and extraction of single wavelength channels from the 3-D field. The software's advanced search and peak purity algorithms help you to quickly create spectra libraries and identify unknown compounds as well as impurities.	Makes it easy, fast, and convenient to extract the information you need.
PCM-3000 upgrade for pH and conductivity monitoring.	The combination of UV-Vis detector and PCM-3000 is ideal for monitoring salt- or pH-gradient separations for e.g. monoclonal antibodies or other biomolecules.

## Design Overview

The DAD-3000 optical bench design includes two light sources – deuterium and tungsten lamp – together with 1024 diodes and powerful electronics (Figure 1). Polychromatic light passes through the flow cell. The dispersed wavelengths are simultaneously detected by the diode array. This ensures the same sensitivity for single- and multi-wavelength operation, providing convenient, optimized, and sensitive quantification of main compounds and related impurities.

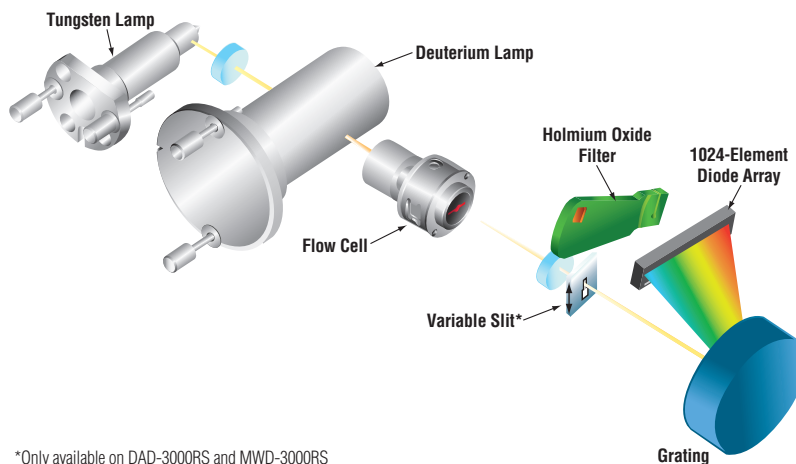
## Reliable Quantification

Noise levels when using the wide slit are  $\pm 8 \mu\text{AU}$  with a typical baseline drift of  $< 0.5 \text{ mAU/h}$  at 254 nm (flowing mobile phase). The low noise and baseline drift allow for detection of weak signals (good signal/noise ratio) and consistent, reproducible integration. A typical detector linearity up to 2.0 AU shows correlation coefficients of  $> 0.999$  and a residual standard deviation below 5% with caffeine. The wide linearity range allows reliable quantification of primary and side products in the same run.

## Sensitivity and Spectral Resolution

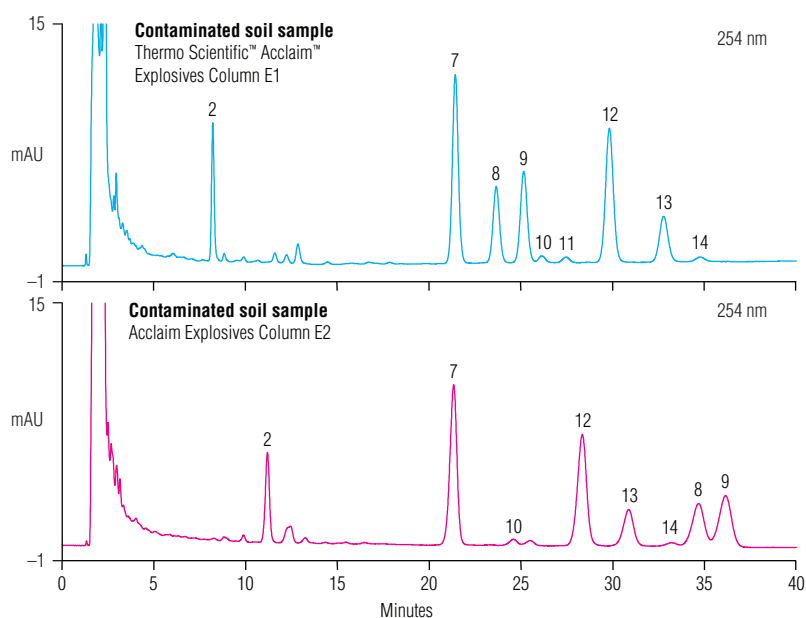
When acquiring spectral data for peak identification and/or peak purity analysis, high resolution spectra are essential. At the same time, it is important to obtain good signal-to-noise ratios for detection of weak signals. The DAD-3000's family electronics are designed to provide high spectral resolution in combination with low noise.

Figure 2 shows an example of an explosive residue analysis. One sample was automatically injected on two columns of varying selectivity. Target analytes were confirmed by spectral match, even at very low concentrations. Chromeleon's customizable reporting functions provide instantaneous access to results, list confirmed or unconfirmed target analytes, quantify the substances, and define their peak purity.



\*Only available on DAD-3000RS and MWD-3000RS

Figure 1. Light from the tungsten lamp is focused through an aperture in the deuterium lamp. The combined light then passes through the flow cell and diffraction grating to the diode array.



Column:		Acclaim Explosives Column E1				Acclaim Explosives Column E2							
No.	Name	RT (min)	Peak Purity Match	Ref. Spectra Match	Amount (pgm)	RT (min)	Peak Purity Match	Ref. Spectra Match	Amount (pgm)	Confirmation	Peak Purity (Pure >= 95%)	Average Amount	% R.L. Amount Deviation
2	RDX	8.217	1000	1000	1.15	11.183	1000	1000	1.15	Confirmed	Pure	1.15	0.00
7	2,4,6-Trinitrotoluene	21.433	1000	1000	1.57	21.333	1000	1000	1.47	Confirmed	Pure	1.52	6.37
8	4-Amino-2,6-Dinitrotoluene	23.659	1000	1000	0.99	34.692	999	1000	1.04	Confirmed	Pure	1.01	4.85
9	2-Amino-4,6-Dinitrotoluene	25.167	1000	1000	0.99	36.167	999	1000	1.00	Confirmed	Pure	0.99	1.17
10	2,6-Dinitrotoluene	26.159	960	994	0.10	24.583	881	998	0.11	Confirmed	Impure	0.11	7.44
11	2,4-Dinitrotoluene	27.458	936	956	0.05	n.s.	n.s.	n.s.	n.s.	Unconfirmed	Impure		
12	2-Nitrotoluene	29.633	1000	1000	3.01	28.380	1000	1000	2.76	Confirmed	Pure	2.89	8.20
13	4-Nitrotoluene	32.792	999	1000	1.30	30.875	999	1000	1.20	Confirmed	Pure	1.25	8.21
14	3-Nitrotoluene	34.792	922	994	0.11	33.200	919	990	0.10	Confirmed	Impure	0.11	5.76
1	HMX	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	Not Present			
3	1,3,5-Trinitrobenzene	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	Not Present			
4	1,3-Dinitrobenzene	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	Not Present			
5	Nitrobenzene	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	Not Present			
6	Tetryl	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	Not Present			

Figure 2. DAD-3000 example following EPA method 8330 for explosives residues. A customized report takes results from both separations and visualizes if a compound is confirmed and pure.

## Rapid Separation LC Detectors

A typical peak requires 30 data points for accurate and precise integration. Up-to-date UHPLC separations can result in very narrow analyte peaks. These can even reach widths of only 0.25 s, requiring more than 100 Hz data collection rate.

The Rapid Separation diode array detectors easily meet this requirement with data collection rates of up to 200 Hz. This detector performance provides highly accurate, precise integration and retention time recognition for any separation challenge.

Figure 3 shows how detectors with non-sufficient data collection rates compromise the peak integration. Peak area precision and retention time recognition are adversely affected at the same time.

## UV Spectra Acquisition

The DAD-3000RS provides up to eight single data channels and full spectral scans at 200 Hz for even the most challenging applications. Figure 4 shows the separation of 10 analytes, uracil and nine alkylphenones, in 10 seconds. The full spectral scan can easily keep up with this speed. Peak identification and peak purity analysis are as convenient and powerful as for conventional LC separations. Combining these features with the low noise specification, the DAD-3000RS is ideal for ultrafast analyses and ready to meet future challenges.

## Optimize for Best Sensitivity or Spectral Resolution

Both rapid separation versions, the DAD-3000RS and the MWD-3000RS, provide a variable slit at the entrance of the spectrograph. This is an effective tool to further adapt the detector to the application requirements. A narrow slit provides the highest spectral resolution, resolving even very fine absorbance spectra, such as for pyrene (Figure 5). However, UV absorbance bands are typically 30 nm and wider. In these cases, a broad slit results in the highest detection sensitivity. More light passes through the spectrograph, reducing both short-term noise and the limit of detection.

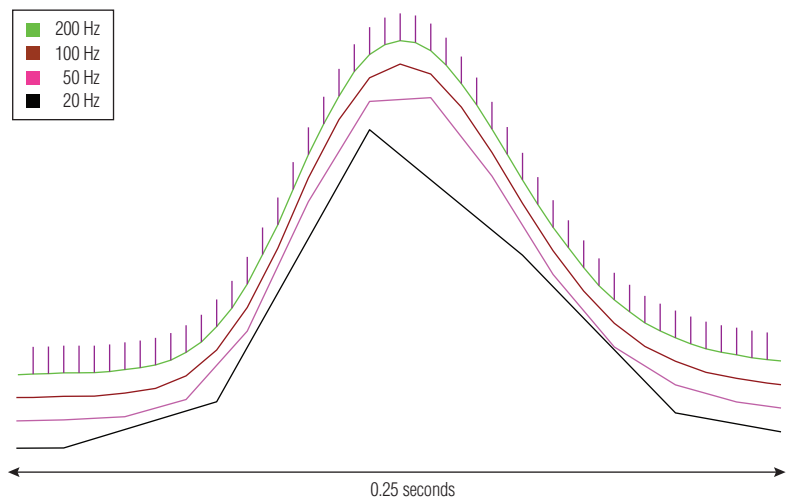


Figure 3. Ultrahigh data collection rates perfectly support the integration of the sharpest UHPLC peaks for highest precision of quantification and retention time.

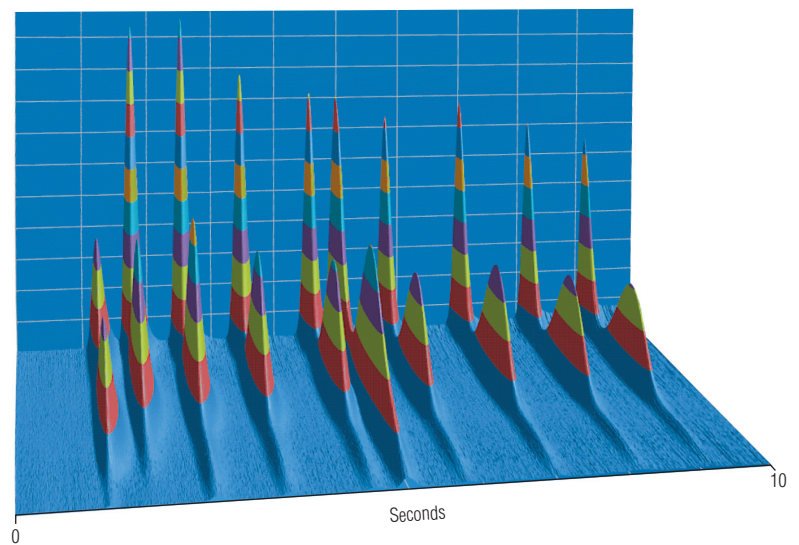


Figure 4. 200 Hz UV spectra acquisition easily supports the separation of 10 peaks in 10 seconds.

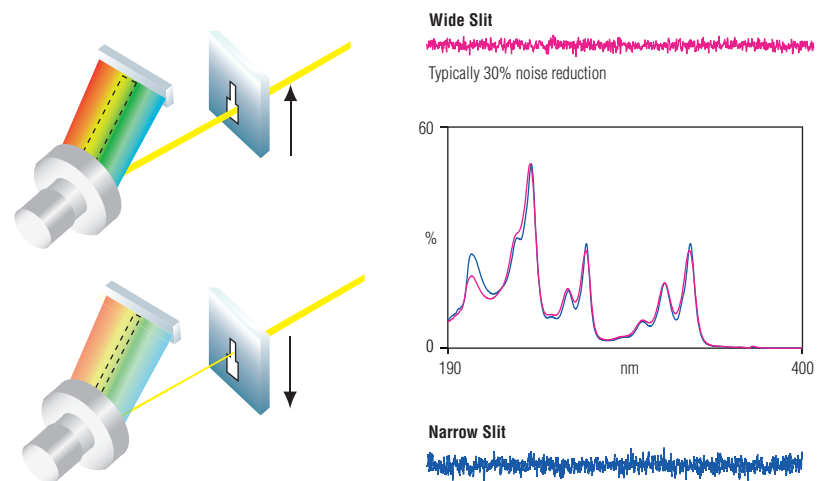


Figure 5. The variable slit of the DAD-3000RS and the MWD-3000RS is a tool to optimize for best spectral resolution or best detection sensitivity.

## Rapid Multiple Channel Detection

The Rapid Separation version of the Multiple Wavelength Detector offers high speed and sensitivity for both single and multiple wavelength data acquisition. Its diode array technology achieves multi-channel detection of up to eight channels without moving parts.

Regardless how many wavelengths are recorded, the detector can measure all wavelengths at the same high sensitivity and at a maximum data collection rate of 200 Hz. Up-to-date variable wavelength detectors achieve multiple wavelength detection by rapidly switching between alternate wavelengths, but this adversely affects short-term noise and reduces the maximum data collection rate significantly. The MWD does not have this limitation.

## Upgrade MWD to Full DAD Functionality

MWD detectors are based on photodiode array technology. The only difference from DAD detectors is that the MWD does not support the acquisition of 3-D spectra.

These 3-D spectra capabilities are field-upgradable, turning your MWD into a full-blown DAD. You may therefore stagger your investment in diode array technology, purchase the instrument you need today, and adapt it to your future application needs later.

## Ergonomic Design and Advanced System Monitoring

All fluidic parts of the MWD and DAD detector series can be accessed directly from the front. The door folds down, serving as a miniature lab bench to place tools and parts during maintenance (Figure 7).

The deuterium and tungsten lamps of the detector can also be accessed from the front by opening the fingertight nuts of the lamp cover. Changing these lamps is equally fast and easy. Modifications of flow cells or lamps are automatically tracked by integrated ID chips. All relevant information is stored in the lamp and moves with the detector if it is transferred to another LC system. Chromeleon constantly monitors these and various other counters to provide you with early warnings when a part is due for replacement. In addition, Chromeleon software monitors and verifies the instrument qualification status to meet your GLP compliance goals (Figure 8).

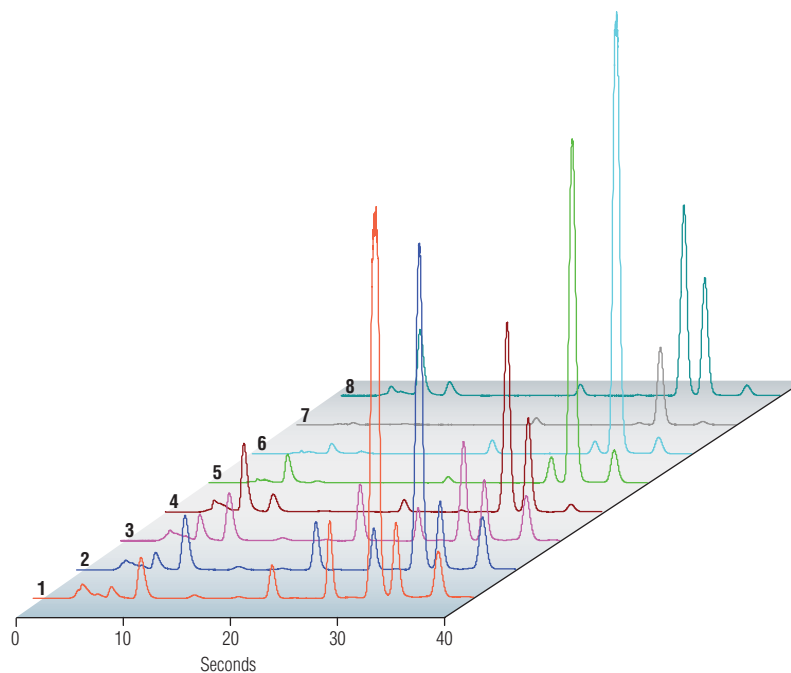


Figure 6. Sub-1 min softdrink analysis with simultaneous acquisition of eight different UV channels, measured with the MWD-3000RS.

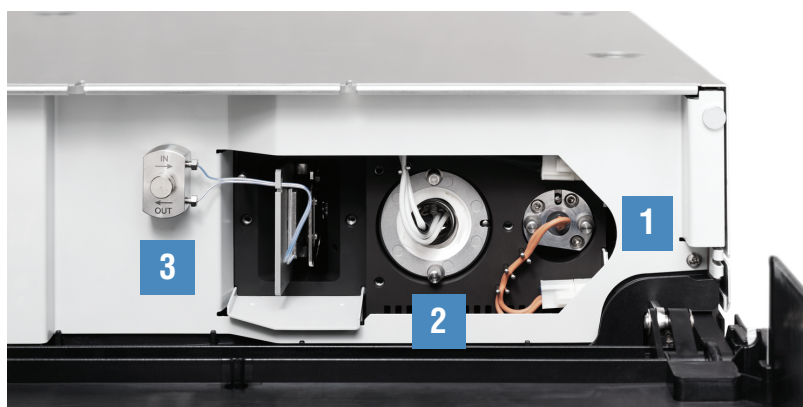


Figure 7. Ergonomic internal front design (after removal of flow cell/lamps covers): direct access to 1) the D2 and tungsten lamps, 2) the flow cell, and 3) the flow cell adapter block for easy operation and maintenance.

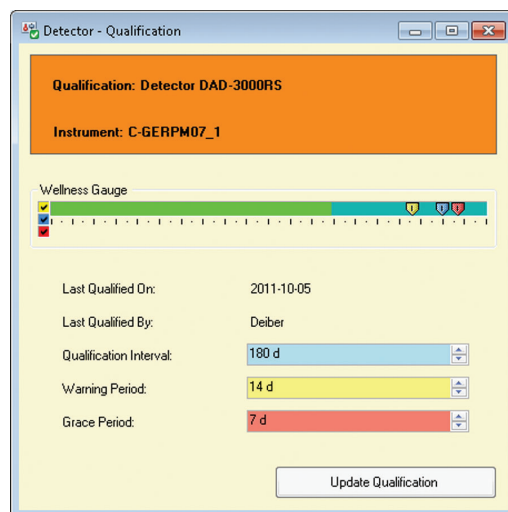


Figure 8. DAD-3000 automated qualification monitoring.

## Getting the Most from Your Spectral Data – with Ease

A typical diode array 3-D field contains a vast amount of information. Effective tools are needed to work with such volumes of data. Powerful Chromeleon software puts these tools at your fingertips and makes it easy to extract the information you need. With the DAD-3000 family, you can:

- Review your results in a single window
- Extract single-wavelength channels from your 3-D field
- Quickly create spectra libraries for known compounds
- Automatically identify unknown peaks based on a search of one or more spectral libraries
- Easily identify peaks that contain underlying impurities, using advanced peak purity algorithms
- Effectively report the results in a format of your choice

## Fast Access to Data and Results via the Peak Purity Analysis View

View all data in a single summary window, using a display style of your choice (Figure 9). Drag the vertical line to view the associated UV spectra at different points of the chromatogram. Drag the horizontal line to see the associated chromatogram for the selected wavelength. This makes it easy to find the best signal response. In fact, Chromeleon software can even perform this task for you automatically. After that, it is a simple step to extract either the chromatogram or the spectrum you need.

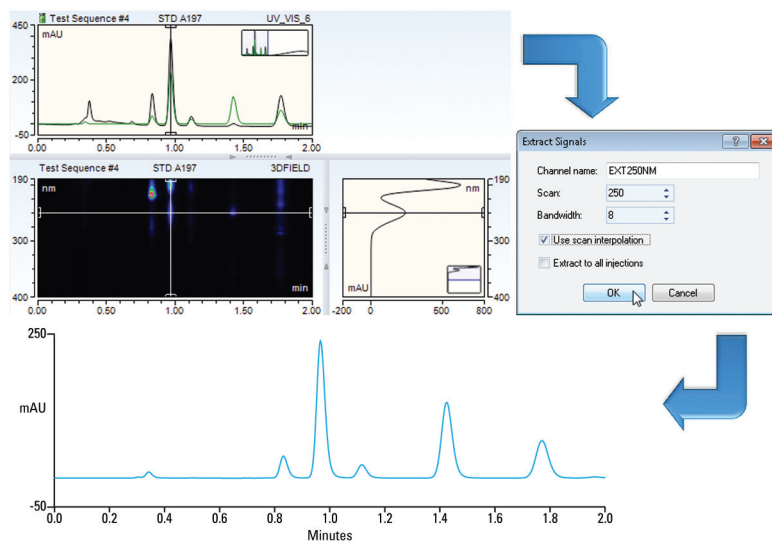


Figure 9. Convenient extraction of a single wavelength (250 nm) from 3-D field data of a UHPLC separation.

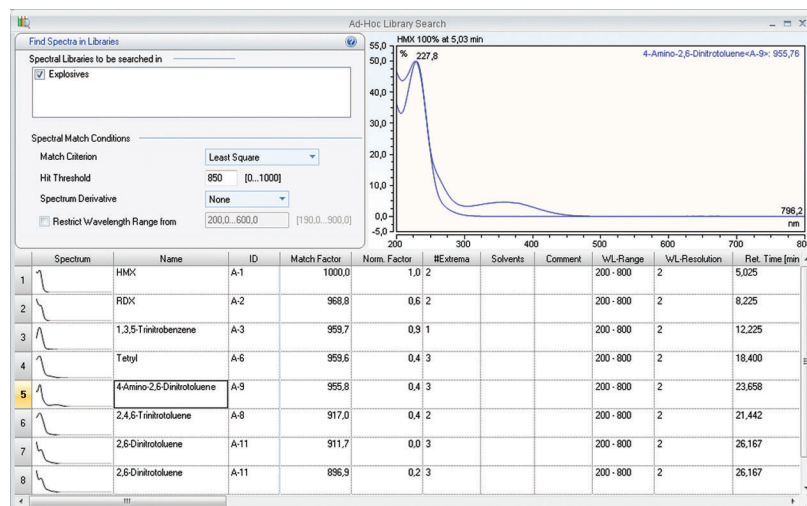


Figure 10. Spectral library screening.

## Assess Specificity in Seconds with Peak Purity Index

The Peak Purity Index can be overlaid with a chromatogram for straightforward identification of peaks that have an underlying impurity (Figure 11).

A pure peak has a consistent peak purity index. Any deviations indicate an underlying impurity. This at-a-glance technology can speed method development and help to ensure specificity.

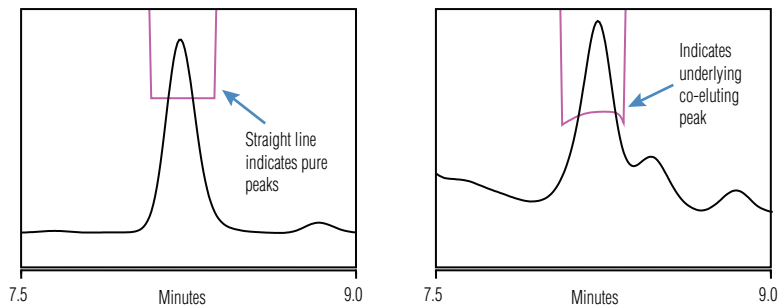


Figure 11. Peak purity examples.

## Application Flexibility

Four different flow cell sizes are available for the DAD/MWD-3000 series:

- Analytical flow cells suitable for HPLC and some UHPLC applications
- Semi-micro flow cells for best chromatographic resolution with small ID columns and narrow analyte peaks
- The semi-analytical flow cell designed for 3 mm ID column separations
- A 0.4 mm optical path length semi-preparative flow cell for UV detection of high-concentration analytes

This wide range of flow cells means you can adapt your system easily to your analytical needs.

## Accurate pH and Conductivity Monitoring

The PCM-3000 is an upgrade of the DAD-3000 and MWD-3000 series for accurate on-line pH and conductivity monitoring. The combination of UV-Vis with the PCM-3000 is ideal for pH or salt gradient ion-exchange chromatography of compounds, e.g. monoclonal antibodies, conductivity monitoring in gradient separations of biomolecules, and therefore a great addition to the Thermo Scientific™ Dionex™ UltiMate™ 3000 BioRS systems.

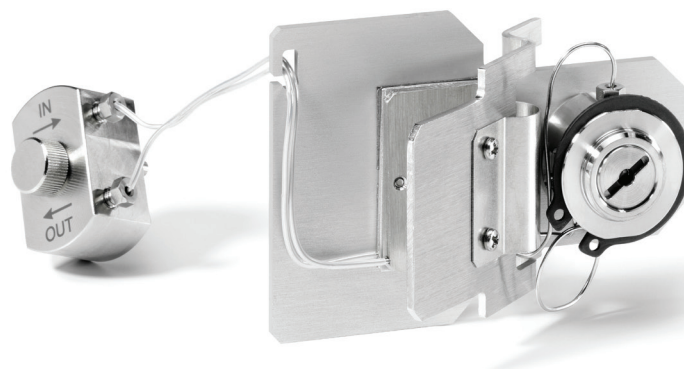


Figure 12. Flow cell design of UltiMate 3000 Diode Array Detectors.

Table 2. DAD-3000 and MWD-3000 flow cell options

Part Number	Description	Volume (μL)	Optical Path Length (mm)
6082.0100	Analytical Flow Cell, Stainless Steel	13.0	10.0
6082.0200	Semi-Analytical Flow Cell, Stainless Steel	5.0	7.0
6082.0300	Semi-Micro Flow Cell, Stainless Steel	2.5	7.0
6082.0400	Analytical Flow Cell, PEEK™	13.0	10.0
6082.0500	Semi-Micro Flow Cell, PEEK	2.5	7.0
6082.0600	Semi-Preparative Flow Cell, PEEK	0.7	0.4



Figure 13. The PCM-3000 is a high performance, easy-to-use, and cost effective solution for pH and conductivity monitoring.

## Specifications

Dimensions (h x w x d)	16 x 42 x 51 cm (6.3 x 16.5 x 20 in.)
Detection Type	Single-beam, reverse-optics design with concave holographic grating
Maximum Data Collection Rate )	200 Hz: DAD-3000RS (including 3-D acquisition) and MWD-3000RS (under Chromeleon 7.1 software control) 100 Hz: DAD-3000 (including 3-D acquisition) and MWD 3000
Wavelength Range	190 to 800 nm
Noise	Wide slit: <math>\pm 8 \mu\text{AU}</math> at 254 nm. Narrow slit: <math>\pm 10 \mu\text{AU}</math> at 254 nm response time 2 s (according to ASTM time constant ~1 s), 4 nm bandwidth, water at 1.0 mL/min
Drift	<math>< 1 \text{ mAU/h}</math> (typically <math>< 0.5 \text{ mAU/h}</math>) at 254 and 520 nm with water at 1.0 mL/min
Linearity	<math>< 3\% \text{ RSD}</math> and corr. coeff. >0.9995 up to 1.5 AU, typically <math>< 5\% \text{ RSD}</math> and corr. coeff. > 0.999 up to 2.0 AU
Light Source	Deuterium lamp, tungsten lamp, temperature control for both lamps
Wavelength Accuracy	$\pm 1.0 \text{ nm}$ , self-calibration with D-alpha line, verification with holmium oxide filter
Wavelength Precision	$\pm 0.1 \text{ nm}$
Pixel Resolution	<math>< 1 \text{ nm}</math>
Slit Width	Narrow or wide slit, settable for the DAD-3000RS and MWD-3000RS
PC Connection	All functions controllable via USB 2.0; integrated USB hub with three USB 2.0 ports
GLP Features	Automatic Instrument Qualification (AutoQ), System Wellness and Qualification Monitoring with Chromeleon software, lamp and cell ID chips
User Input/Display	LCD indicating system parameters, standby button, three LEDs for status monitoring, four function keys for initial operation and maintenance
Power Requirements	85-260 V, 50/60 Hz, max. 150 W

## Ordering Information

To order in the U.S., call 1-800-346-6390, or contact the Thermo Fisher Scientific office nearest you. Outside the U.S., order through your local Thermo Fisher Scientific office or distributor. Refer to the following part numbers.

Detectors	Part Number
DAD-3000RS Rapid Separation Diode Array Detector (without flow cell)	5082.0020
DAD-3000 Diode Array Detector (without flow cell)	5082.0010
MWD-3000RS Rapid Separation Multiple Wavelength Detector (without flow cell)	5082.0040
MWD-3000 Multiple Wavelength Detector (without flow cell)	5082.0030

Accessories	Part Number
Analytical flow cell, stainless steel, 13 $\mu\text{L}$	6082.0100
Semi-analytical flow cell, stainless steel, 5 $\mu\text{L}$	6082.0200
Semi-micro flow cell, stainless steel, 2.5 $\mu\text{L}$	6082.0300
Analytical flow cell, PEEK, 13 $\mu\text{L}$	6082.0400
Semi-micro flow cell, PEEK, 2.5 $\mu\text{L}$	6082.0500
Semi-preparative flow cell, PEEK, 0.7 $\mu\text{L}$	6082.0600
Upgrade MWD-3000RS to DAD-3000RS	6082.3045
Upgrade MWD-3000 to DAD-3000	6082.3035
PCM-3000 for DAD-3000 or MWD-3000 Series (Shipped with a pH and conductivity flow cell and a pH electrode)	6082.2000
Deuterium lamp	6074.1110
Tungsten lamp	6074.2000

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