

PAL3 Series 2 Autosampler

Overview for gas chromatography samples

General specifications

Dimensions

	50 cm X-Axis	85 cm X-Axis	120 cm X-Axis	160 cm X-Axis
Width	600 mm (23.6 in)	915 mm (36.6 in)	1,270 mm (50.8 in)	1768 mm (70.7 in)
Depth	795 mm (31.8 in)	795 mm (31.8 in)	795 mm (31.8 in)	795 mm (31.8 in)
Height	770 mm (30.8 in)	770 mm (30.8 in)	770 mm (30.8 in)	770 mm (30.8 in)

Weight

Weights without optional modules

RSI 50 cm	RSI 85 cm	RSI 120 cm	RTC 120 cm	RSI 160 cm	RTC 160 cm
12.24 kg (29.68 lbs)	14.05 kg (30.97 lbs)	16.09 kg (35.47 lbs)	18.79 kg (41.42 lbs)	18.42 kg (40.61 lbs)	21.12 kg (46.46 lbs)

Environmental conditions

Operating Temperature Range	5 to 40 °C (41 to 104 °F)
Non-Operating (Storage) Temperature Range	–30 to +65 °C (–22 to 149 °F)
Altitude	Up to 3,000 m above sea level

Sample capacity

	50 cm X-Axis	85 cm X-Axis	120 cm X-Axis	160 cm X-Axis
Ambient	2 tray holders 420 1 mL vials 324 2 mL vials 90 10/20 mL vials 6 microtiter/deep-well plates	4 tray holders 840 1 mL vials 648 2 mL vials 240 10/20 mL vials 12 microtiter/deep-well plates	6 tray holders 1,260 1 mL vials 972 2 mL vials 360 10/20 mL vials 18 microtiter/deep-well plates	9 tray holders 1890 1 mL vials 1458 2 mL vials 405 10/20 mL vials 27 microtiter/deep-well plates
Temperature Controlled (4 to 40 °C)	Maximum 1 Peltier stack Up to with 6DW stacks: 420 1 mL vials 324 2 mL vials 90 10/20 mL vials 6 microtiter/deep-well plates	Maximum 3 Peltier stacks Up to with 6DW stacks: 1,260 1 mL vials 972 2 mL vials 240 10/20 mL vials 18 microtiter/deep-well plates	Maximum 4 Peltier stacks Up to with 6DW stacks: 1,680 1 mL vials 1,296 2 mL vials 360 10/20 mL vials 24 microtiter/deep-well plates	Maximum 6 Peltier stacks Up to with 6DW stacks: 2500 1 mL vials 1944 2 mL vials 540 10/20 mL vials 36 microtiter/deep-well plates

Compatible modules

	RSI	RTC
Agitator	✓	✓
Barcode Reader	✓	✓
Centrifuge, 8 × 2 mL Vials	✓	✓
Centrifuge 2 × 10 mL, 2 × 20 mL, 4 × 2 mL Vials	✓	✓
Cool On-Column Tool	✓	✓
Dilutor (Single or Multi)	✓	✓
Fast Wash Module	✓	✓
Headspace	✓	✓
ITEX Dynamic Headspace	✓	✓
Large Wash Module	✓	✓
Micro SPE Solid Phase Extraction		✓
Peltier Stack (2- or 6-Racks or Plates)	✓	✓
Solvent Module	✓	✓
SPME	✓	✓
SPME Arrow	✓	✓
Tray Cooler	✓	✓
Vortex Mixer	✓	✓

Typical power consumption

The PAL3 operates with a primary 200 W power supply, which powers the core components for typical workflows including the robotic system, electronics, and control of standard modules (e.g., Agitator, Tools, Drives, etc.). Some power-intensive modules such as the Tray Cooler, Cooled Stack, or Centrifuge Module, have their own 200 W power supply.

Total power consumption depends on system configuration and operation. Some guidelines are as follows:

- Standby mode on typical configuration uses < 20 W.
- When the robotic arm is in motion, power consumption typically increases by approximately 15 W.
- Active heating of a module or tool will further increase the overall power usage during the time of the heating.

Agitator

Sample Capacity	Six heated vial positions for 2/10/20 mL vials (Spacers for 2 mL and 10 mL are optionally available)
Temperature Control	30 to 200 °C Selectable in 1 °C increments
Agitation	Orbital interval shaking, speed selectable from 250 to 750 rpm
Dimensions	Width 114 mm (4.5 in)
	Depth 180 mm (7.1 in)
	Height 176 mm (6.9 in)
Weight	2.38 kg (5.25 lbs)

Vortex mixer

Sample Capacity	1 vial treated at once
Agitation	Orbital interval shaking, speed selectable from 250 to 2,000 rpm
Dimensions	Width 82 mm (3.3 in)
	Depth 180 mm (7.1 in)
	Height 170 mm (7.0 in)
Weight	2.10 kg (4.63 lbs)

1D Barcode reader

Approved Vial Sizes	1, 2, 10, 20 mL
Dimensions	Width: 30 mm (1.18 in)
	Depth: 273 mm (10.75 in)
	Height: 128 mm (5.04 in)
Weight	0.83 kg (1.83 lbs)
Supported Barcode Symbols	UPC-A, UPC-E, EAN-13, EAN-8, Code-128, EAN128/GS1-128, Code 39 3 of 9, 2 of 5 interleaved, and ISTB 128

Fast wash module

Dimensions	Width 60 mm (2.4 in)
	Depth 315 mm (16.7 in)
	Height 135 mm (5.3 in)
Weight	0.75 kg (1.7 lbs)

Peltier stack modules

	2DW	6DW
Sample Capacity	2 racks for 54 2 mL vials 2 racks for 15 10 mL vials 2 racks for 70 1 mL vials 2 microtiter or deep-well plates with 96 or 384 positions	6 racks for 54 2 mL vials 6 racks for 15 10 mL vials 6 racks for 70 1 mL vials 6 microtiter or deep-well plates with 96 or 384 positions
Temperature Control	4 to 40 °C in 0.1 °C increments	
Dimensions	Width 197 mm (7.8 in)	Width 197 mm (7.8 in)
	Depth 425 mm (16.7 in)	Depth 425 mm (16.7 in)
	Height 103 mm (4.1 in)	Height 230 mm (9.1 in)
Weight	3.6 kg (7.9 lbs)	8.1 kg (17.8 lbs)

SPME conditioning module

Temperature Control	30 to 350 °C in 1 °C increments
Dimensions	Width 44 mm (1.7 in)
	Depth 190 mm (7.5 in)
	Height 166 mm (6.5 in)
Weight	1.2 kg (2.6 lbs)

Dilutor module

Number of Channels	Available for single (2 port) or up to five diluents (6 port)
Dimensions	Width 115 mm (4.5 in)
	Depth 260 mm (10.2 in)
	Height 430 mm (16.9 in)
Weight	Single dilutor 2.3 kg (5.1 lbs), multidilutor 4.9 kg (10.8 lbs)

Centrifuge modules

Dimensions	Width 222.6 mm (87.6 in)	
	Depth 326.2 mm (128.4 in)	
	Height 185.0 mm (72.8 in)	
Weight	10.5 kg (23.2 lbs)	
Sample Capacity	2 mL centrifuge: 8 vial positions for 2 mL vials	Multicentrifuge: 4 vial positions for 2 mL vials or 2 vial positions for 10 mL vials or 2 vial positions for 20 mL vials

Heatex stirrer

Agitation	Cycloid shaped mixing, speed selectable from 0 to 1,600 rpm (0 to 200 cycloidal loops)
Dimensions	Width 85 mm (3.4 in)
	Depth 188 mm (7.4 in)
	Height 177 mm (7.0 in)
Weight	2.6 kg (5.7 lbs)

Tray cooler

Dimensions	Width 213 mm (8.4 in)
	Depth 446 mm (17.6 in)
	Height 187 mm (7.4 in)
Temperature Range	4 to 40 °C
Sample Formats	(with matching insert) 1 mL, 2 mL, 10 mL, 20 mL vials, and microtiter plates
Sample Capacity	Three sample racks. Each rack can hold 70 1 mL, 54 2 mL, or 15 10/20 mL vials depending on rack

LCMS-P module

Technical data

Item	Description
Needle	Gauge 22, Pst 3, Length 51 mm Optional: Gauge 23, Pst AS, Length 51 mm
Pump Module	2 solenoid diaphragm pumps, self-priming Flow rate range: 100 mL/min at atmospheric pressure
Transfer tubing	PFA tube ID 0.787 mm (1/32") / OD 1.58 mm (1/16") including connection fittings and guiding wire, length of transfer tubing: 1300 mm
Solvent Reservoir Kit (2 pcs)	100 mL borosilicate glass bottle including: – Glass Filter, 40 µm pore size (1000-SV) – Aspiration Tubing (PFA)
Wetted Parts	Tubing from Wash Bottle to Pump: – Tubing: PFA – Frit: Glass Filter Pumps: Ryton PPS and Kalrez (FFPM) Transfer tubing from Pump to LCP Tool: – Tubing: PFA LCP manifold: PEEK Warning: Do not bring tetrahydrofuran (THF), dimethyl sulfoxide (DMSO), chlorinated organic solvents, concentrated mineral acids such as nitric, phosphoric or sulfuric acids, or any related compounds, in contact with PEEK.
Electrical Connectors	2 x PALbus for daisy chaining M12, 4 position, male, reserved for future use
PAL Firmware	Version 2.1.0 or higher

Dimensions

(LCMS-P module including mounting) in mm (inches)

Width	63 (2.48)
Depth	270 (10.62) 350 (13.78) including connectors
Height	85 (3.35) 550 (21.65) including transfer tube
Bench Space	Consider bench space for the Wash Solvent reservoir Bottles, size 1000 mL (or as required)

Weight in kg (pounds)

Pump Module	0.370 (0.82)
Mounting Bracket	0.220 (0.49)
Associate Cable	0.15 (0.33)
Solvent Reservoir Kit	Aspiration kit 0.06 (0.13) Reservoir bottle 1000 mL 0.58 (1.28)

Analytical specifications

GC liquid samples

Repeatability

Specifications

Alkane	RSD (Area)
C ₁₄	≤0.6%
C ₁₅	≤0.6%
C ₁₆	≤0.6%

Conditions

Alkane Agilent FID Performance Test Solution (p/n 18710-60170)
Evaluation Sample Kit, 0.218 g/L C ₁₄ /C ₁₅ /C ₁₆ in hexane
2 mL vials filled with 0.5 mL sample

PAL sample control method:

GC liquid injection

Sample Volume	1 µL
Air Volume	1 µL
Vial Penetration Depth	30 mm
Preclean with Solvent 1	3
Preclean with Sample	1
Fill Volume	3 µL
Fill Speed	1 µL/s
Fill Strokes	5
Pullup Delay	2,000 ms
Injector Penetration Depth	40 mm
Inject Speed	50 µL/s
Pre-Inject Delay	4,000 ms
Post Inject Delay	2,000 ms
Post Clean with Solvent 1	3

GC Method:

SSL (split/splitless injector model)

Mode	Split
Heater	280 °C
Pressure	52.268 kPa
Total Flow	137.6 mL/min
Septum Purge Flow	5 mL/min
Gas Saver	20 mL/min after 2 min
Split Ratio	50:1
Split Flow	130 mL/min

Oven

Equilibration Time	0.5 min
Max Temperature	300 °C
Temperature Program	80 °C for 1 min, then 25 °C/min to 200 °C for 1 min

Column

Constant Flow	
Pressure	52.268 kPa
Flow	2.6 mL/min
Average Velocity	50.19 cm/s

FID

Heater	300 °C
H ₂ Flow	30 mL/min
Air Flow	400 mL/min
Make-Up Flow	25 mL/min

GC column/injector liner

Column	Phenomenex ZB5, 15 m × 0.32 mm, 0.25 µm, 5% diphenyl, 95% dimethyl polysiloxane
Liner	Agilent: Split Liner 4 mm × 6.3 × 78.5, glass wool nondeactivated

Carryover

Specifications

Alkane	Carryover in blank 1 (ppm)	Carryover in blank 2 (ppm)
C14	≤40	Not detectable
C15	≤40	Not detectable
C16	≤40	Not detectable

Conditions

Alkane mix, 6.0 g/L in cyclohexane, 1 µL injected
2 mL vials filled to 50%
Wash solvent: cyclohexane

PAL sample control method:

GC liquid injection

Sample Volume	1 µL
Air Volume	1 µL
Vial Penetration Depth	30 mm
Preclean with Solvent 1	3
Preclean with Sample	1
Fill Volume	3 µL
Fill Speed	1 µL/s
Fill Strokes	5
Pullup Delay	2,000 ms
Injector Penetration Depth	40 mm
Inject Speed	50 µL/s
Pre-Inject Delay	4,000 ms
Post Inject Delay	2,000 ms
Post Clean with Solvent 1	3

GC method:

SSL (split/splitless injector model)

Mode	Split
Heater	280 °C
Pressure	52.268 kPa
Total Flow	137.6 mL/min
Septum Purge Flow	5 mL/min
Gas Saver	20 mL/min after 2 min
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Oven

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Max Temperature	300 °C
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Column

Constant Flow	
Pressure	52.268 kPa
Flow	2.6 mL/min
Average Velocity	50.19 cm/s

FID

Heater	300 °C
H ₂ Flow	30 mL/min
Air Flow	400 mL/min
Make-Up Flow	25 mL/min

GC column/injector liner

Column	Phenomenex ZB5, 15 m × 0.32 mm, 0.25 µm, 5% diphenyl, 95% dimethyl polysiloxane
Liner	Agilent: Split Liner 4 mm × 6.3 × 78.5, glass wool non deactivated

GC needle discrimination

Specifications

Peak area C ₄₀ /C ₂₀ ≥ 0.98	Restek Florida Mix, 1 µL injected, 100 ms fast split/splitless injection
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Conditions

Restek Florida mix (p/n 31266) C ₈ , C ₁₀ , C ₁₂ , C ₁₄ , ...C ₄₀ , 500 µg/mL in hexane, diluted to 10 ppm with <i>n</i> -hexane
Syringe: Hamilton 10 µL, gauge 26s, 57 mm needle length, point style AS (p/n 207837)

PAL sample control method: GC liquid injection

Sample Volume	1 µL
Air Volume	1 µL
Vial Penetration Depth	30 mm
Preclean with Solvent 1	1
Preclean with Sample	1
Fill Volume	3 µL
Fill Speed	1 µL/s
Fill Strokes	10
Pullup Delay	2,000 ms
Injector Penetration Depth	35 mm
Inject Speed	10 µL/s, fast injection mode
Pre-Inject Delay	0 ms, fast injection mode
Post Inject Delay	0 ms, fast injection mode
Post Clean with Solvent 1	1

GC method:

Oven

Equilibration Time	0.5 min
70 °C for 1 min, then 25 °C/min to 340 °C for 1 min	

SSL (Split / Splitless Injector Model)

Heater	280 °C
Mode	Constant Flow, 2.5 mL/min (He)
Septum Purge Flow	5 mL/min
Gas Saver	20 mL/min after 2 min
Split Flow	80 mL/min
Splitless Time	0.8 min

GC Column

Constant Flow	
Flow	2.5 mL/min

FID

Heater	330 °C
H ₂ Flow	35 mL/min
Air Flow	350 mL/min
Make-Up Flow	30 mL/min

GC column/injector liner

Column	Thermo (p/n 26080001) 5% diphenyl, 95% dimethyl polysiloxane, 7 m × 0.32 mm 0.25 µm
Liner	Thermo (p/n 453A1925) (id 4 mm, with glass wool, 4.0 × 6.3 × 78.5)

Headspace samples

Syringe up to 150 °C

Repeatability

Specifications

Syringe	% RSD
Headspace 2,500 µL	<1

Conditions

n = 7
iso-Octane, 5 µL out of microcapillary in a 20 mL headspace vial, sealed immediately 500 µL injected

PAL sample control method:

headspace injection general

Sample Volume	500 µL
Incubation Temperature	90 °C
Incubation Time	600 s
Syringe Temperature	100 °C
Fill Speed	100 µL/s
Pullup Delay	10,000 ms
Pre-Inject Delay	2,000 ms
Inject Speed	100 µL/s
Injector Penetration Depth	40 mm
Post Inject Delay	5,000 ms
Purge Time	90 s

GC Method:

Oven

Equilibration Time	0.5 min
Max Temperature	300 °C
200 °C for 2.5 min, isotherm	

SSL (split/splitless injector model)

Mode	Split
Heater	250 °C
Pressure	56.204 kPa
Total Flow	17.55 mL/min
Septum Purge Flow	5 mL/min
Gas Saver	20 mL/min after 2 min
Split Ratio	1:250
Split Flow	12.5 mL/min

GC column/GC injector liner

Column	Agilent: Retention Gap, FS deactivated, 0.100 mm, 5 m
Liner	Thermo: Straight Split Liner, 990 µL volume, 4 mm id

Carryover

Specifications

Syringe	Carryover in blank 1 (ppm)	Carryover in blank 2 (ppm)
Headspace 2,500 µL	1,000	500

Conditions

iso-Octane, 5 µL out of microcapillary in a 20 mL headspace vial, sealed immediately, 500 µL injected

PAL sample control method:

headspace injection general

Sample Volume	500 µL
Incubation Temperature	90 °C
Incubation Time	600 s
Syringe Temperature	100 °C
Fill Speed	100 µL/s
Pullup Delay	10,000 ms
Pre-Inject Delay	2,000 ms
Inject Speed	100 µL/s
Injector Penetration Depth	40 mm
Post Inject Delay	5,000 ms
Purge Time	90 s

LC samples

LCMS-P tool

Specifications

Syringe	Loop size (µL)	Injected Volume (µL)	Specification
100 µL	20	80	Full loop injection: RSD ≤ 0.1%
100 µL	20	10	Partial loop injection: RSD ≤ 0.5%
100 µL	2	8	Full loop injection: RSD ≤ 0.1%
100 µL	2	1	Partial loop injection: RSD ≤ 0.5%

LC conditions

Full Loop Injection: n = 10
4 x overfill Sample for 2 µL Loops: Caffeine, 80 µg/mL in H ₂ O : ACN = 90 : 10 v/v + 0.1 % TFA
Sample for 20 µL Loops: Caffeine, 8 µg/mL in H ₂ O : ACN = 90 : 10 v/v + 0.1 % TFA
Partial Loop Injection: n = 10
Sample for 2 µL Loops: Caffeine, 80 µg/mL in H ₂ O : ACN = 90 : 10 v/v + 0.1 % TFA
Sample for 20 µL Loops: Caffeine, 8 µg/mL in H ₂ O : ACN = 90 : 10 v/v + 0.1 % TFA
Injection Valve: Vici Valco Cheminert C72VX-1676D-CTC

PAL sample control method:

LC injection LCMS standard general

	Full Loop	Partial Loop
Sample Volume	80 µL (8)*	10 µL (1)*
Rear Air Gap	3 µL	3 µL (1)*
Front Air Gap	3 µL	3 µL (1)*
Rear Volume	5 µL	5 µL
Front Volume	5 µL	5 µL
Fill Speed	5 µL/s	5 µL/s
Inject Speed	5 µL/s	5 µL/s (1)*
Pre Inject Delay	500 ms	500 ms
Post Inject Delay	2000 ms	2000 ms
Pullup Delay	2000 ms	2000 ms
Post Clean with Solvent 1	1	1
Post Clean with Solvent 2	1	1
Valve Clean with Solvent 1	80 µL	80 µL
Valve Clean with Solvent 2	80 µL	80 µL
Stator Wash	Off	Off
Clean Valve Flow Rate	20 µL/s	20 µL/s

* Numbers in parentheses are valid for 2 µL loop size only,
all other numbers are valid for both loop sizes.

LC method

Gradient	Isocratic: 100 % A A = H ₂ O : ACN = 90 : 10 v/v + 0.1 % TFA
Runtime	2.0 min
Flow	0.5 mL/min
Detection	UV 273 nm
Flow Cell	L: 60 mm Volume: 4 µL
Column	HALO C18; 2.1 × 50 mm, 2.7 µm
Column temperature	40 °C
HPLC System	Agilent 1290 Infinity

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